Operative Neurosurgical Anatomy

Damirez T. Fossett
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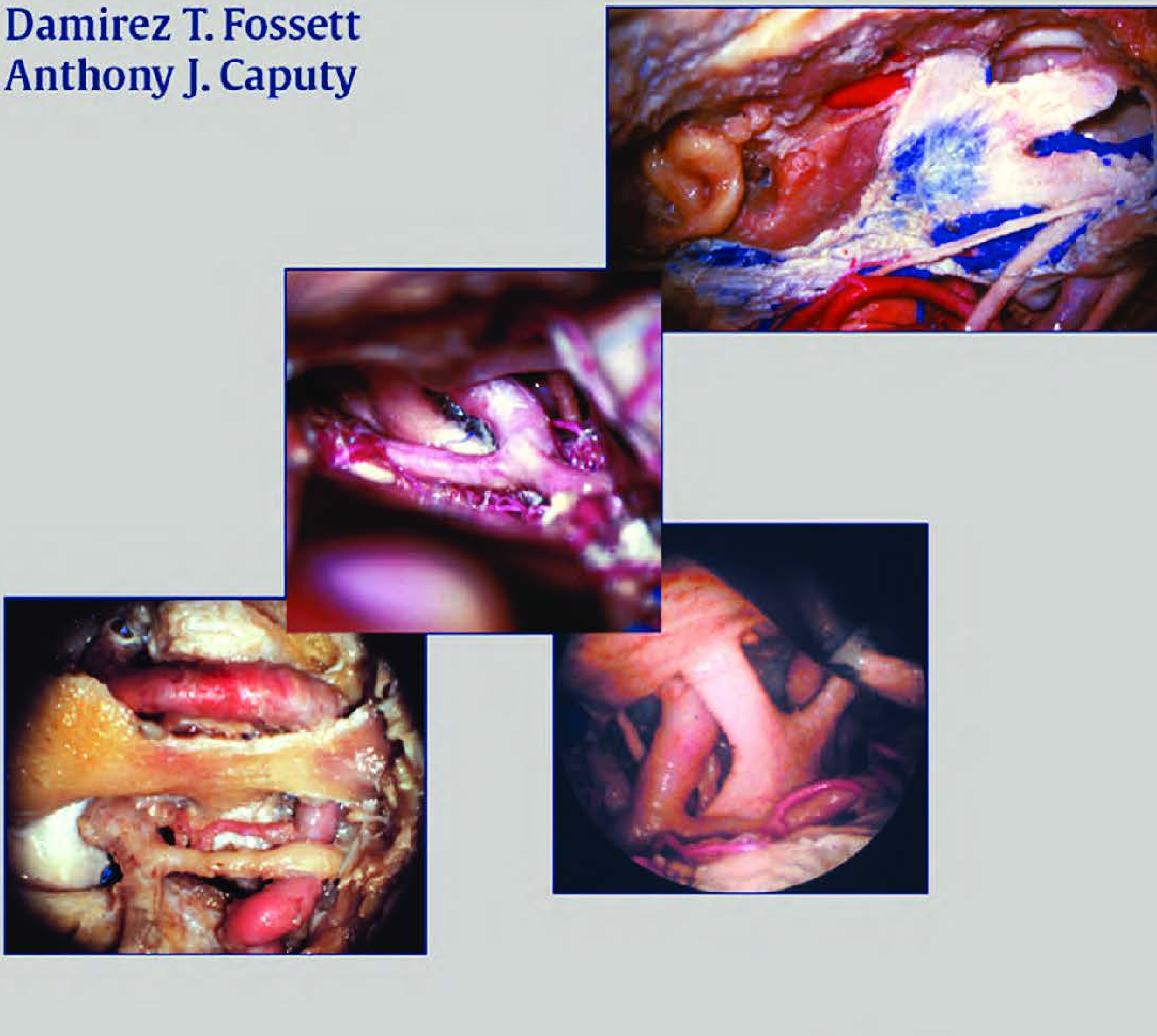

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FOREWORD

Surgery of the central and peripheral nervous systems is both a science and an art, requiring a high degree of technical skill as well as an artist's appreciation for meticulous detail. Before the skill and the art of neurosurgery can be successfully practiced, however, the most fundamental tenant, a firm knowledge of surgical neuroanatomy, must be acquired. Basic anatomy can be taught and learned in a number of different ways, but for the surgeon, it must be learned three dimensionally. Anatomic relationships must be understood without regard to the choice of approach or position of the patient for surgery. This forms the basis of surgical anatomy.

There is no dearth of texts that identify and illustrate the relationships of one structure to another. Likewise, there is no dearth of literature describing the technical aspects of various approaches to regions of the nervous system. The editors of *Operative Neurosurgical Anatomy* want the reader to obtain an appreciation of the three-dimensional surgical anatomy that will be encountered when performing various approaches to the nervous system. The anatomy is presented using cadavers placed in the proper surgical position for each approach, thus enabling the reader to visualize the anatomy as it will be seen in the operating room.

The ability to practice the skill and art of surgery successfully involves sound preoperative planning with regard to choice of approach and position. All this planning is for naught, however, if the surgeon cannot visualize the three-dimensional anatomy that will be encountered during the procedure. Certainly, the editors' presentation in *Operative Neurosurgical Anatomy* will help the surgeon practice the art and science of neurosurgery skillfully and successfully by making informed decisions about choice of approach and surgical position based on a masterful understanding of the three-dimensional anatomy that will be seen in the operating room.

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PREFACE

Operative Neurosurgical Anatomy is a collection of anatomic dissections organized to present anatomic relationships based on standard operative neurosurgical approaches. Conventional textbooks of anatomy define the anatomy based on the origin and the termination of a given structure and by the relationships and proximity of given structures to each other. *Operative Neurosurgcal Anatomy* is designed to present the relevant surgical anatomy and structural relationships by using anatomic specimens oriented in the operative position and dissected using standard surgical approaches.

Each chapter defines the pathologic indications and the constraints of the surgical approach. The surgical positioning and skin incision are presented with the intent of showing how these initial operative steps optimize the development of the three dimensional anatomic relationships at the surgical site. The details of the surgical technique with the relevant pitfalls, considerations, and pearls complete your study of the anatomy. A list of suggested readings are at the end of each chapter.

This book has four major sections that include cranial, spinal, peripheral nerve, and neuroendoscopy. The cranial section is framed around the basic fronto-temporal and the retrosigmoid approaches, with the incorporated chapters expanding and embellishing on these two basic approaches, in sequence, from a rostral-anterior to a basal-posterior direction. The spine approach section details the anatomy of the surgical approaches from the cranial cervical junction through the lumbar spine with the various anterior, posterior, and lateral techniques being defined by the vertebral column anatomy and pathologic concerns. The peripheral nerve section describes the surgical anatomy and the structural relationships encountered in the surgical approaches to the brachial plexus and to the peripheral nerves in the extremities. The final section on neuroendoscopic approaches defines the surgical anatomy through minimally invasive endoscopic techniques.

This book is structured to provide you with an appreciation of the three-dimensional anatomy and structural neuroanatomic relationships while being visually oriented with the perspective of the operative approach. It is hoped that the book will be found useful to practicing neurosurgeons and spine surgeons who want to refresh surgical techniques, to surgeons in training as an adjunct to the clinical experience, and to help students in their initial investigation of neuroanatomical relationships.

Damirez T. Fossett M.D.
Anthony J. Caputy M.D.

Acknowledgments

We are forever indebted to the families who have donated the bodies of their loved ones for the advancement of science and medicine. To give, in death, is perhaps the greatest sacrifice in life.

The editors acknowledge the work of those who assisted in the preparation of this book. We thank the department of anatomy, under the direction of Dr. Raymond Walsh, for invaluable assistance in our anatomic endeavors. We also extend our thanks to Ms. Pamela Godwin, who provided endless hours of indispensable photographic assistance in the preparation of this manuscript. The results of her momentous efforts are well represented in the photographs displayed in this book. Special thanks also to Mr. Julian Scarbrough, whose vast artistic talents are displayed throughout the book and whose computer graphic skills greatly aided in the labeling of the book's many photographs.

Finally, the Editors would like to acknowledge the efforts of Dr. Emel Avci, whose countless hours of meticulous lab dissections and photography provided much of the material presented in the cranial section of this text. Without her tireless efforts, this project would still be ongoing.

HARVEY HIRSCH AMMERMAN, MD (NOVEMBER 5, 1917-MARCH 26, 1993)

Dr. Harvey Ammerman graduated from the George Washington University Medical School in 1943. He served as deputy chief of psychiatry of the United States Army during World War II and subsequently as a general surgical resident. His neurosurgical training began as a fellow in neurosurgery at the Lahey Clinic in Boston from 1948 through 1950. He served as chief resident of neurosurgery at Emory University from 1950 through 1951 and later became a Diplomate of the American Board of Neurological Surgery and a Fellow of the American College of Surgeons.

Dr. Ammerman entered private practice in the Washington area in 1951 and that same year was appointed to the clinical faculty in the department of neurological surgery at the George Washington University, an association that continued for more than 40 years. Of his many professional accomplishments, honors, and awards, he was most gratified by his teaching faculty and the institution of the George Washington Neurosurgical Journal Club, which he founded in 1963. The journal club is ongoing and is one of the core teaching tools of the neurosurgical residency training program.

During Dr. Ammerman's long and accomplished career in Washington, D.C., he served as the chief of neurosurgery at both Howard University and Sibley Memorial Hospital. He was one the founding members of the National Capital Reciprocal Insurance Co., the American Physician's Fellowship Exchange Program, and Alpha Omega Alpha. A member of the Sibley Memorial Hospital board, he was named Physician of the Year in 1986. He was elected president of the District of Columbia Medical Society and later was a recipient of its meritorious service award.

Dr. Ammerman's dedication to the community extends well beyond the boundaries of Washington, D.C. He was involved in establishing the State of Israel.

Dr. Harvey Ammerman dedicated himself to family, medicine, and service to the community. He was a distinguished neurosurgeon and teacher. The Harvey H. Ammerman Neurosurgical Laboratory is his living legacy. Through it, excellence in neurosurgical training, education, and research continues.

The Harvey H. Ammerman Microsurgical Laboratory

HUGO VICTOR RIZZOLI, MD (AUGUST 20, 1916-PRESENT)

Dr. Rizzoli was horn in Newark, New Jersey, on August 20, 1916. He attended the Johns Hopkins University, where he received his baccalaureate in 1936 and his medical degree in 1940. After an internship in medicine at Johns Hopkins Hospital, he entered the surgery program, where he served as a Harvey Cushing Fellow from 1942 through 1943. In October 1944, he completed his training in neurosurgery as the last resident of Walter Dandy.

Dr. Rizzoli went on active duty in the Army Medical Corps late in 1944 and was stationed on Staten Island, New York, with Dr. Benjamin Whitcomb at Halloran General Hospital, the major medical treatment facility receiving casualties from the battlefields of Europe. In June 1945, Dr. Rizzoli was transferred to Walter Reed General Hospital. A few months later, he succeeded Dr. Barnes Woodhall as chief of the neurosurgical section, a position he held until his discharge from active duty, November, 1946.

After the war, Dr. Rizzoli entered private practice in Washington, D.C. He became chief of neurosurgery at the former Emergency Hospital before its merger into the Washington Hospital Center in 1958. His long voluntary affiliation with the George Washington University Hospital culminated in his appointment as the first chief of the department of neurological surgery in 1969.

As busy as he was, Dr. Rizzoli remained a civilian consultant at Walter Reed General Hospital for more than 30 years. He helped to establish the residency in neurosurgery in the early 1950s, and his presence in the operating room influenced many young neurosurgeons and benefited many soldiers and federal officials. For his outstanding contributions to the Army, Dr Rizzoli was presented the Commander's Award for Civilian Service in May, 1979.

Over his long career, Dr. Rizzoli has served as a member or officer in several national and international neurosurgery organizations. In 1984 the Congress of Neurological Surgeons recognized the immense professional stature of Dr. Rizzoli by bestowing upon him the distinction of Honored Guest. After retiring from the chairmanship in 1987, he remains academically and clinically active as Professor Emeritus at The George Washington University by continuing to see patients, teach medical students, and inspire neurosurgical residents in-training with his eclectic knowledge, wisdom, and breadth of experience. He is both widely and fondly acknowledged as a founding father of neurosurgery in the Washington, D.C., area, having trained 62 neurosurgical residents and mentored hundreds of neurosurgeons.

Dr. Rizzoli's life-long commitment to the education and training of neurosurgeons is the legacy that this book hopes to recognize and extend in the spirit of ongoing research, education, and training in neurosurgery.

PART I

CRANIAL APPROACHES

Specimen Preparation

Amal Nadel, James Agee, Damirez Fossett

Embalming Head Specimens

Injections are done with glutaraldehyde fluids through the carotid arteries draining through the accompanying veins. The flow rate of the injections is moderate and done at 10 to 15 lb of pressure. The patient's head should be massaged while the injection is being performed. The fluid mixture per gallon of water is as follows:

- DI-SAN, 6 oz
- PH-A,16 oz
- PK, 9 oz

Injection of Head Specimens

Cleaning the Vessels

1. Dissect and isolate the following vessels for infusion:
   a. Left and right jugular veins
   b. Left and right carotid arteries
   c. Left and right vertebral arteries
2. Insert beveled cut Tygon tubes (Norton Plastics, Rolling Meadow, IL) into isolated blood vessels.
3. Tie veins and arteries containing tubes with 2-0 silk sutures.
4. Isolate other veins, arteries, or cut surfaces and ligate to prevent leakage.
5. Flush repeatedly with saline solution using a 60-mL syringe to remove blood clots.
6. Clamp off all vessels, leaving the saline solution in them overnight.

Preparing the Injection Mixture

Microfil Injection

Microfil is used for injection only if the dissector is interested in staining vessels of the brain, including small ones. Because microfil is quite expensive, this method should be limited to detailed microanatomy work. Microfil solution mixture consists of the following:

- Red or blue microfil
- A diluent
- A catalyst

For arteries, the mixture should consist of the following:

- 100 mL of red dye
- 50 mL of diluent

The catalyst should be added gradually:

- 1/4 oz, mix time 5 min
- 1/8 oz, mix time 5 min
- 1/4 oz, mix time 5 min
- 1/4 oz, inject

For veins, use the same protocol, switching 100 mL of blue dye for the red dye.

Silicone Injection

Silicone is used if the dissector is interested in gross microanatomy work. Because silicone is a thick substance, it may not reach small vessels. The silicone mixture consists of the following:

- Silicone rubber (RTV 3110)
- Thinner (200)
- Powder paint (Crayola powder, blue and red)
- Catalyst

For arteries, the mixture should consist of the following:

- 25 mL of silicone
- 50 mL of thinner
- Red powder
- 3 mL of the RTV catalyst

For veins, the mixture should consist of the following:

- 60 mL of silicone
- 60 mL of the thinner
- Blue powder
- 3 mL of the RTV catalyst

Injecting the Vessels

1. Inject the mixture very slowly. When the mixture begins to come out of the contralateral vessel, clamp it, and inject a little more. First inject the carotids, next the vertebrals, followed by the jugular veins.
2. Leave clamps on all the blood vessels, wrap the specimen with a towel, and store it in a bucket for 24 to 48 hours before removing the clamps.

Storing Head Specimens

Place the specimen in a bucket with the following diffusion solution:

- PH-A,4 to 6 oz
- DI-SAN, 4 to 6 oz
- GX, 4 oz

Fill with water to cover completely, and refrigerate until ready to use.

The ingredients for the embalming and diffusion fluids can be purchased from Champion Co. (Springfield, IL). The microfil is from Flowtech, Inc. (Kalamazoo, MI). The silicone is from Dow-Corning Co. (Auburn, MI).

Chapter 2

FRONTOTEMPORAL APPROACH

Emel Avci, Chandrasekar Kalavakonda, Damirez Fossett

INDICATIONS FOR APPROACH

- All anterior circulation aneurysms
- High basilar tip and superior cerebellar artery aneurysms
- Frontal and anterior temporal arteriovenous malformations
- Lobar lesions of the cerebral hemispheres
- Sellar and suprasellar lesions

POSITIONING AND SKIN INCISION

The patient is placed in the supine position with the head held in Mayfield three-point fixation. The head is generally rotated 20 to 30 degrees toward the contralateral shoulder. More rotation can be used for anterior pathology and less rotation for more posterior pathology. The head is flexed slightly to bring the chin toward the ipsilateral clavicle and then extended to bring the maxillary eminence to the highest point in the field.

A curvilinear or bicoronal skin incision is placed behind the hairline (Fig. 2–1). The incision begins just anterior to the tragus of the ear and should not extend below the zygomatic root to protect the branches of the facial nerve. The incision should be made as close as possible to the tragus of the ear. Care should be taken to avoid transecting the underlying branches of the superficial temporal artery. The skin Rap is reflected anteriorly along with the pericranium. At the supraorbital ridge, care should be taken to identify and preserve the supraorbital nerve and vessel passing through the supraorbital foramen or notch. These can be released with the aid of a chisel or the B1 or C1 tools of the Midas Rex (Midas Rex, Fort Worth; Texas).

As the skin is reflected anteriorly, the galea will merge with the superficial layer of the temporalis fascia. A curvilinear incision can be made into the superficial fascial layer at the keyhole and carried toward the zygomatic root (Fig. 2–2). Anterior elevation of this fascia and fat pad away

FIGURE 2–1 Illustration of the curvilinear unilateral incision

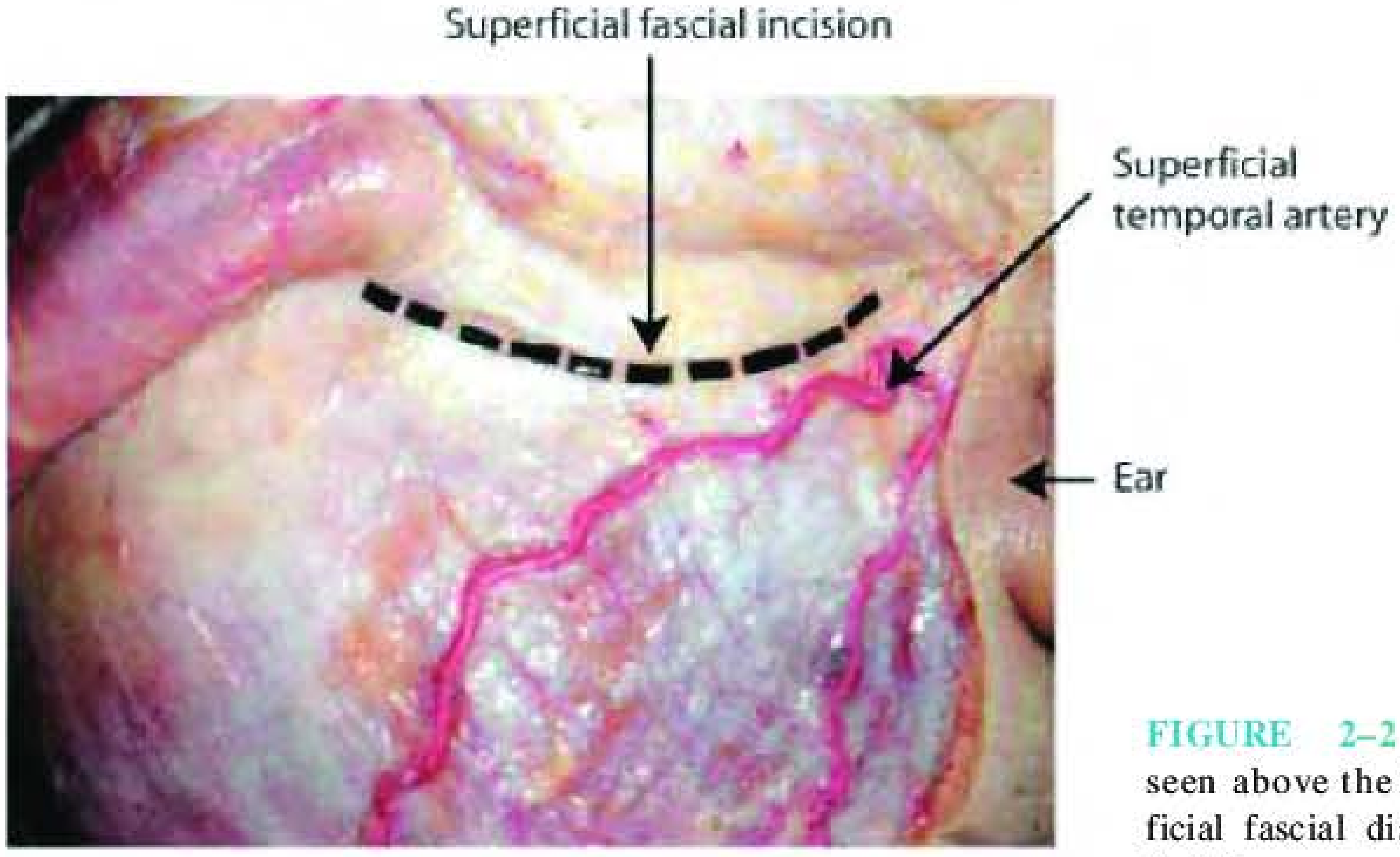


FIGURE 2–2 The branching superficial temporal artery can be seen above the temporalis fascia. The outlined incision is the superficial fascial dissection of the fat pad containing branches of the facial nerve.

from the underlying temporalis muscle avoids injury to the frontalis branch of the facial nerve that runs in this fat plane (Fig. 2–3). The temporalis muscle then is elevated as a separate layer and reflected anteriorly and inferiorly to expose the supraorbital ridge and the lateral rim of the orbit, providing optimum exposure for the development of a frontotemporal craniotomy (Fig. 2–4).

veins with the temporal lobe. Veins crossing the fissure are sacrificed. As the fissure opens, the distal branches of the middle cerebral artery, the M1-2 bifurcation, and finally the carotid bifurcation can be identified. Further dissection allows visualization of the optic-carotid triangle and the carotid-oculomotor triangle (Fig. 2–6C, D).

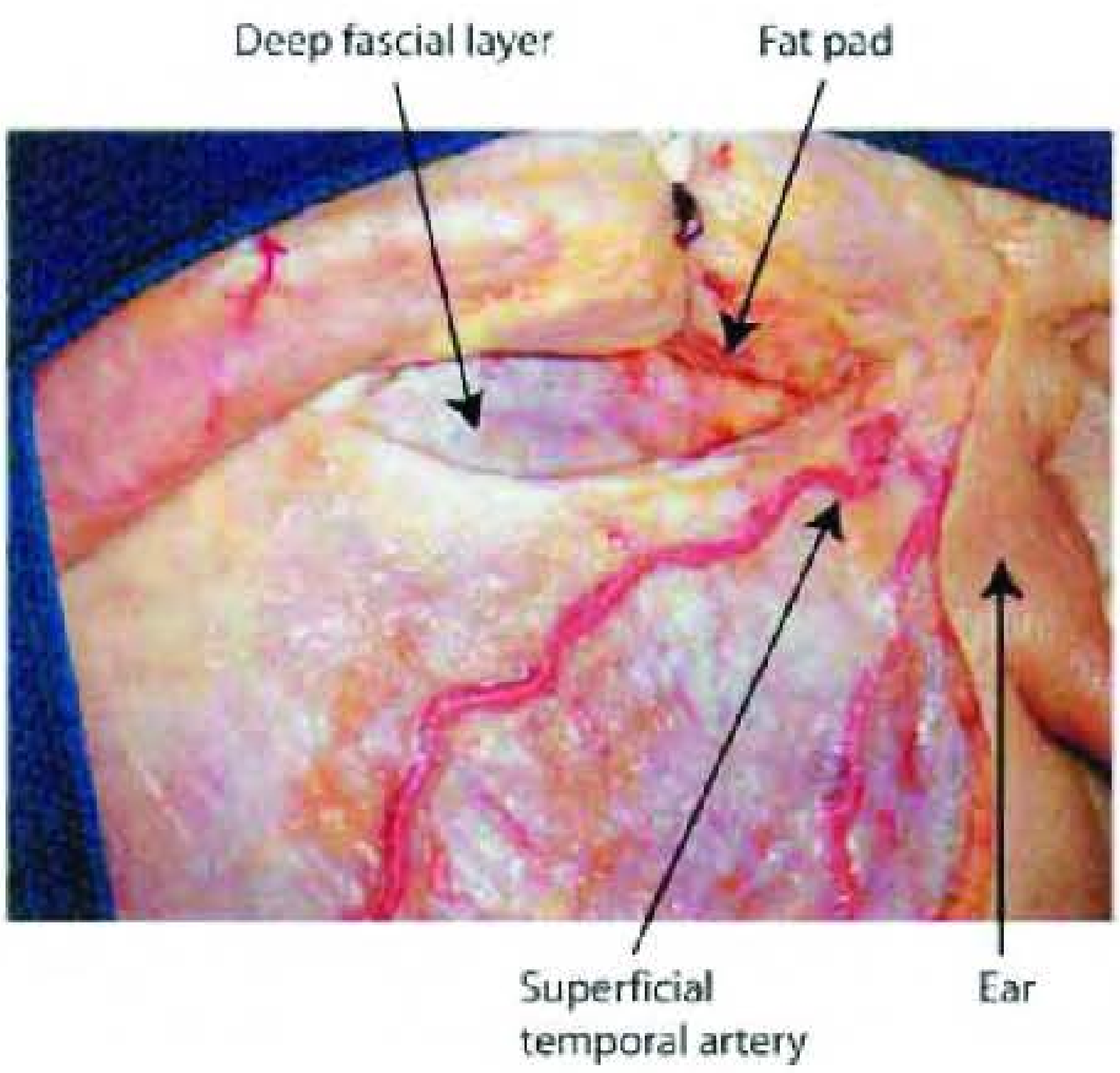


FIGURE 2–3 The fat pad has been elevated preserving the branches of the facial nerve.

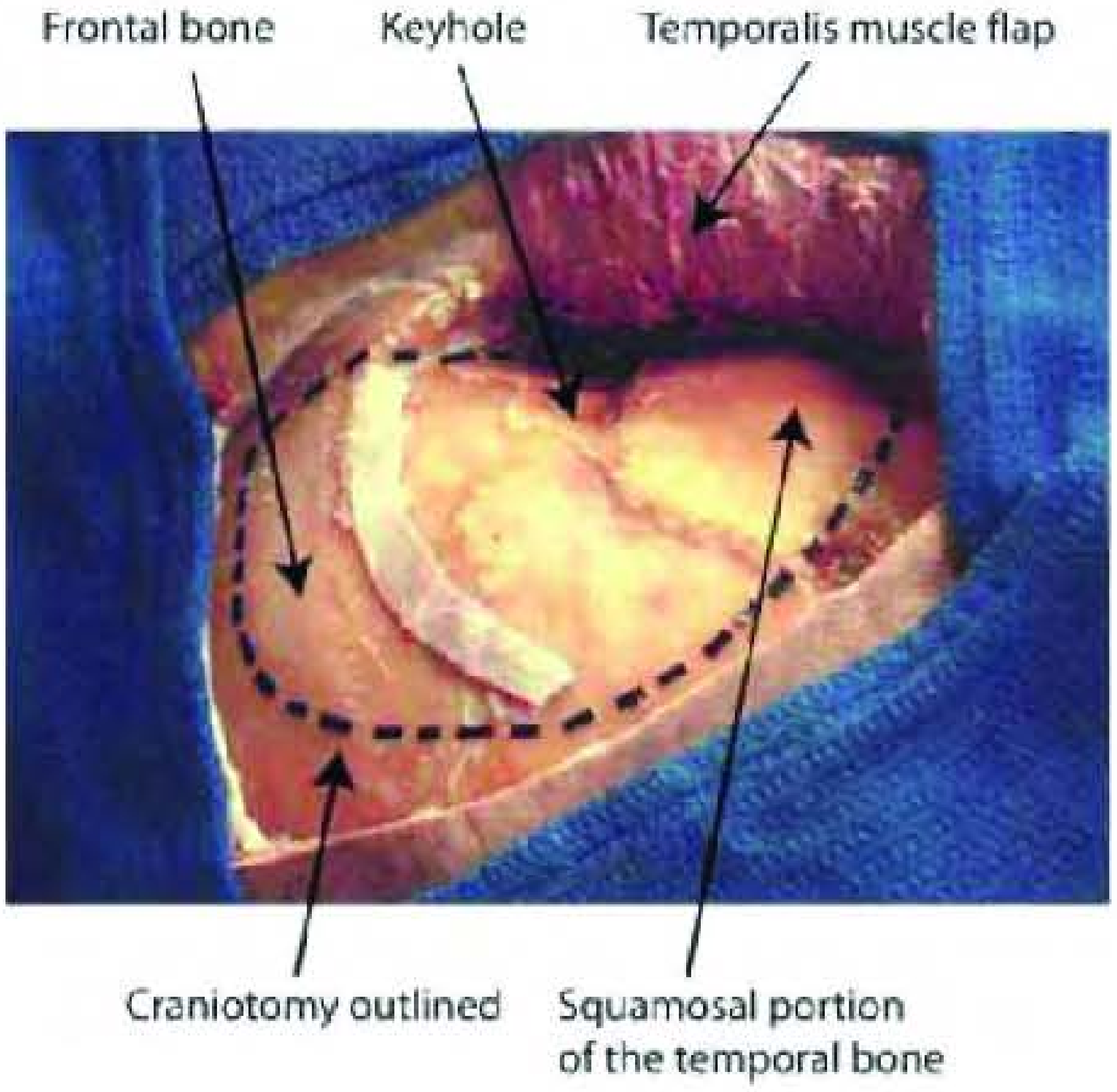


FIGURE 2–4 The temporalis is elevated. A standard frontotemporal bone flap is outlined.

SURGICAL TECHNIQUE

A bur hole is made at the McCarty keyhole, and generally a second one is made in the squamosal region of the temporal bone. The surgeon determines the number of bur holes to be made. After dissection of the dura from the overlying bone with the use of dural dissectors or a Fen field 3, the bur holes are connected with the B1 foot-plated tool of the Midas Rex or with a Gigli saw. The sphenoid ridge is made as flat as possible down to level of the meningo-orbital artery; this is accomplished by using a Leksell or Limpet rongeur (Codman Johnson & Johnson Professional Products Ltd., Maiden Head, Berkshire, U.K.) or the M8 tool of the Midas Rex (Midas Rex, Fort Worth, TX).

Typically, the dura is opened in a C-shaped fashion, with its base along the sphenoid ridge (Fig. 2–5). It is reflected anteriorly and anchored with stay sutures (Fig. 2–6A). Under the operating microscope, either a lateral-to-medial or a medial-to-lateral opening of the sylvian fissure can be made (Fig. 2–6B). If a lateral-to-medial dissection is to be made, two self-retaining retractors are positioned, one on the frontal lobe and the other on the temporal lobe to make the fissure taut. The sylvian fissure then is opened using an arachnoid knife, and the dissection is performed superior to the sylvian vein, reflecting the

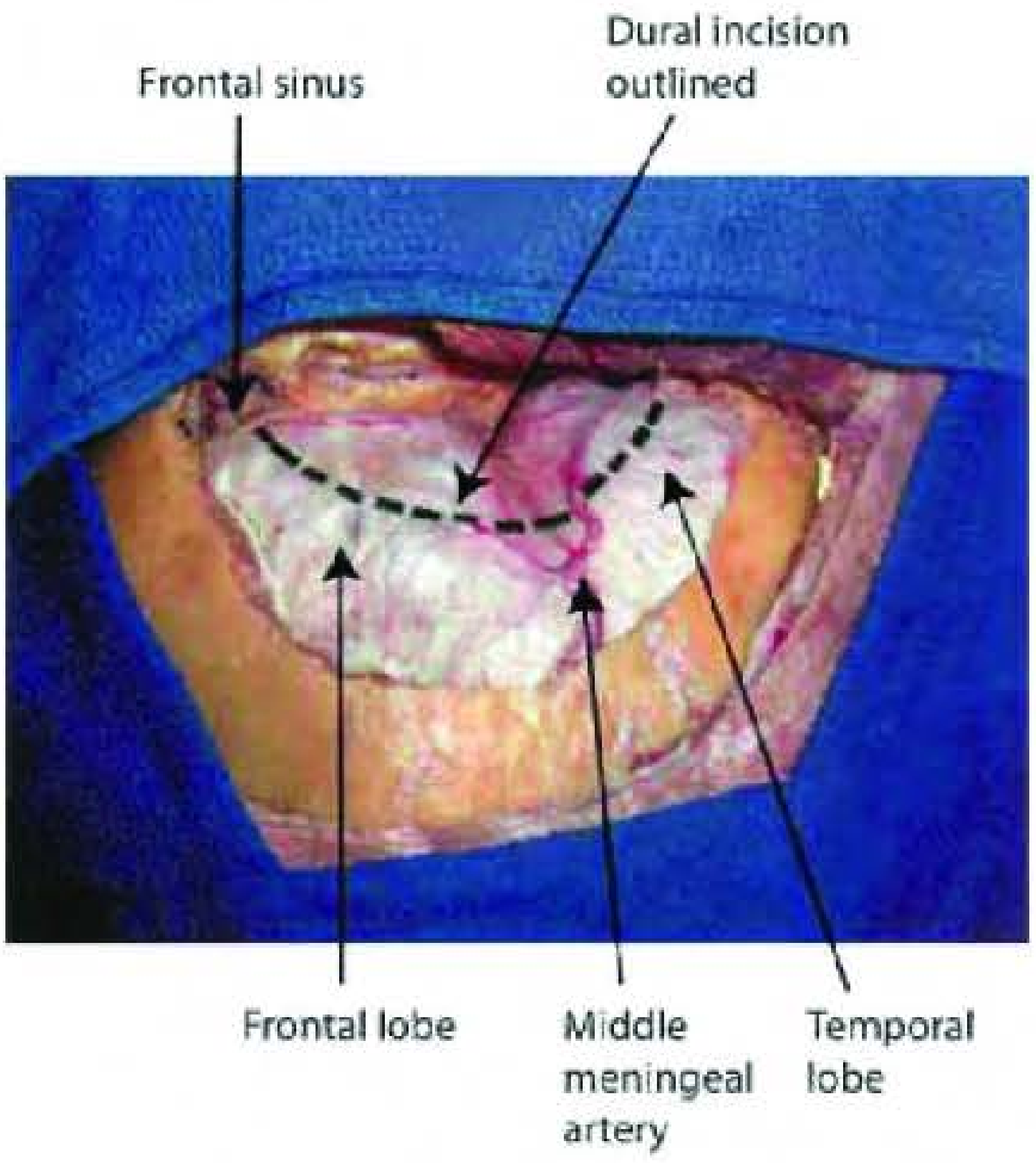
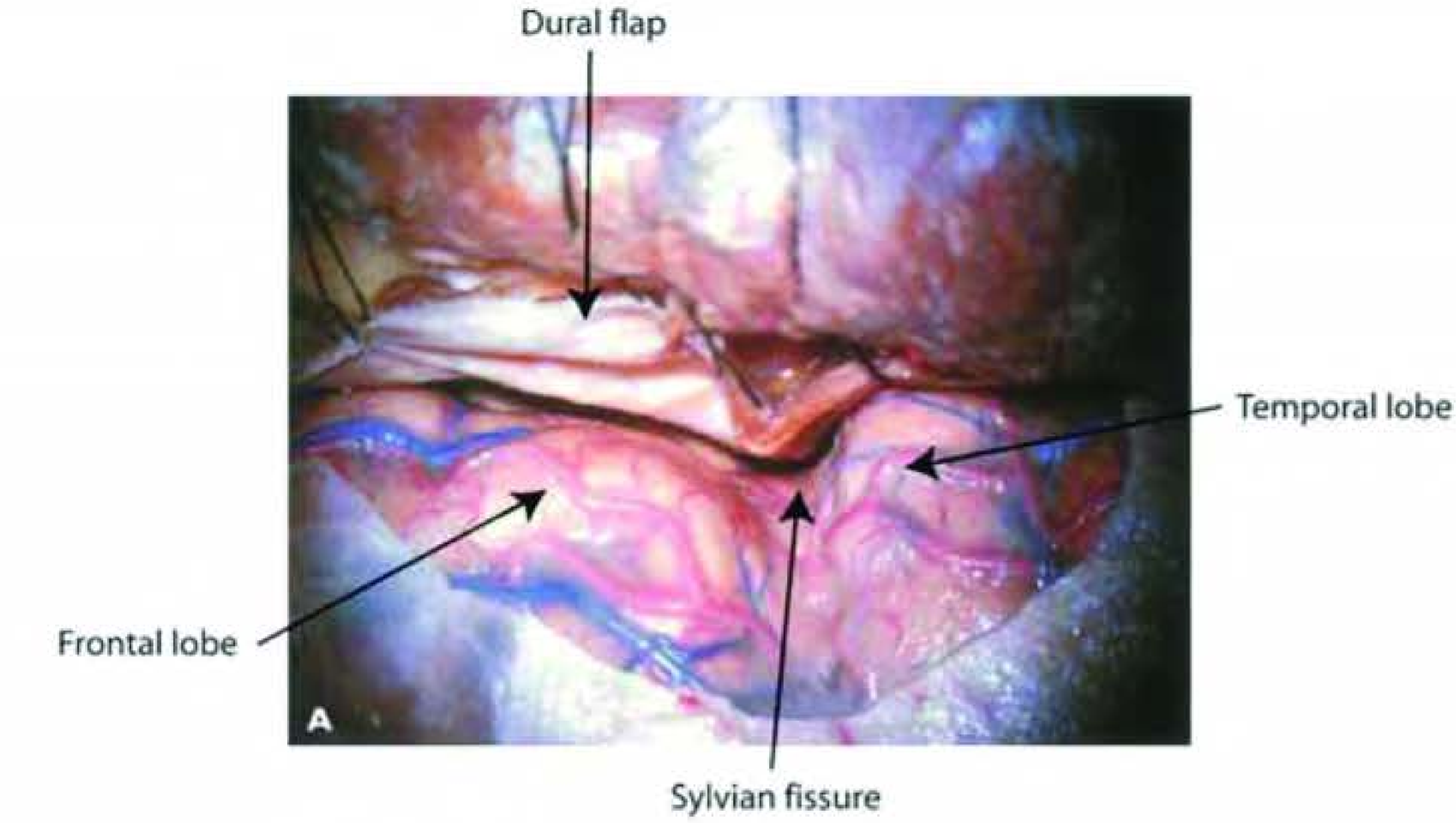


FIGURE 2–5 The dural incision is outlined.



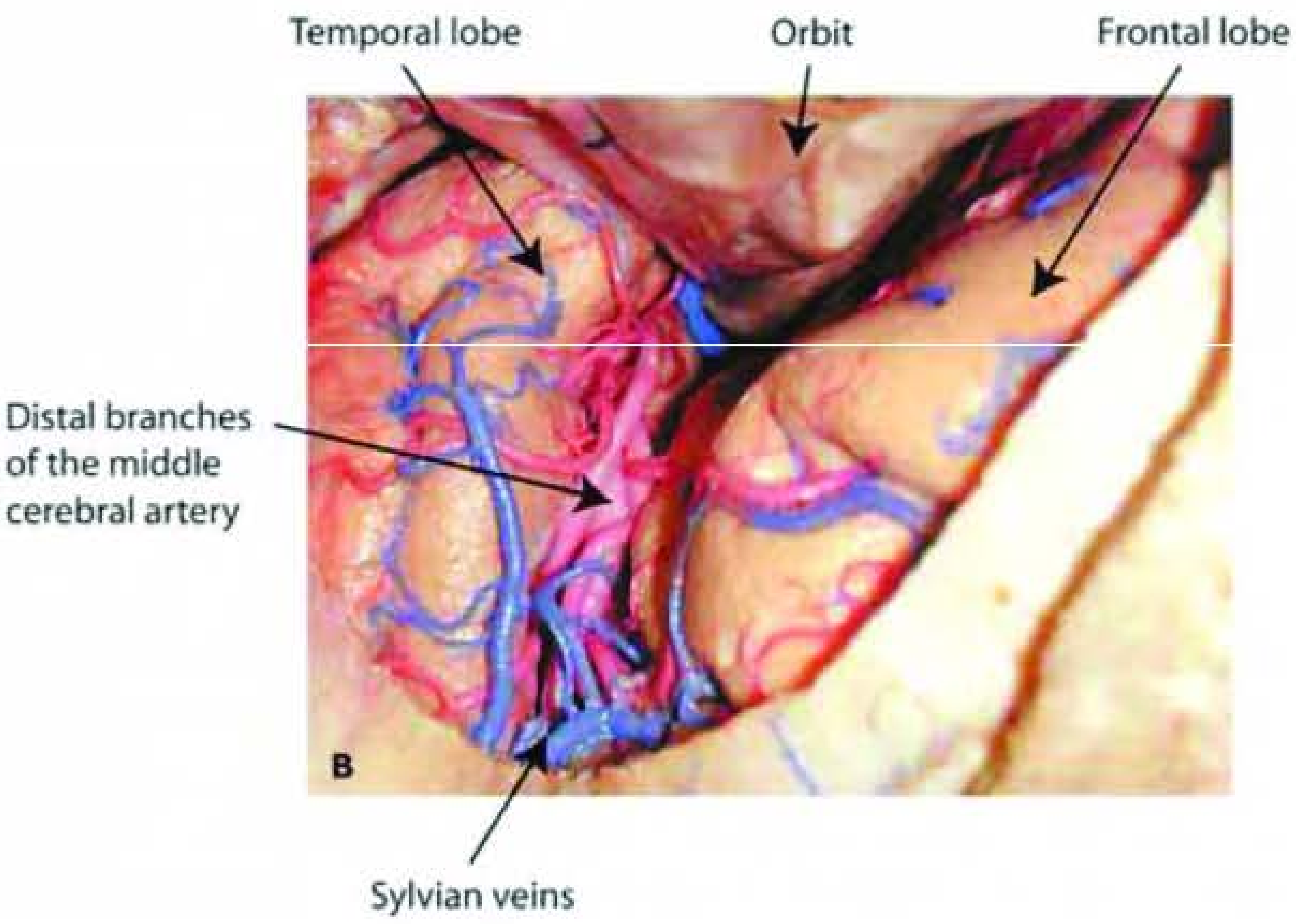
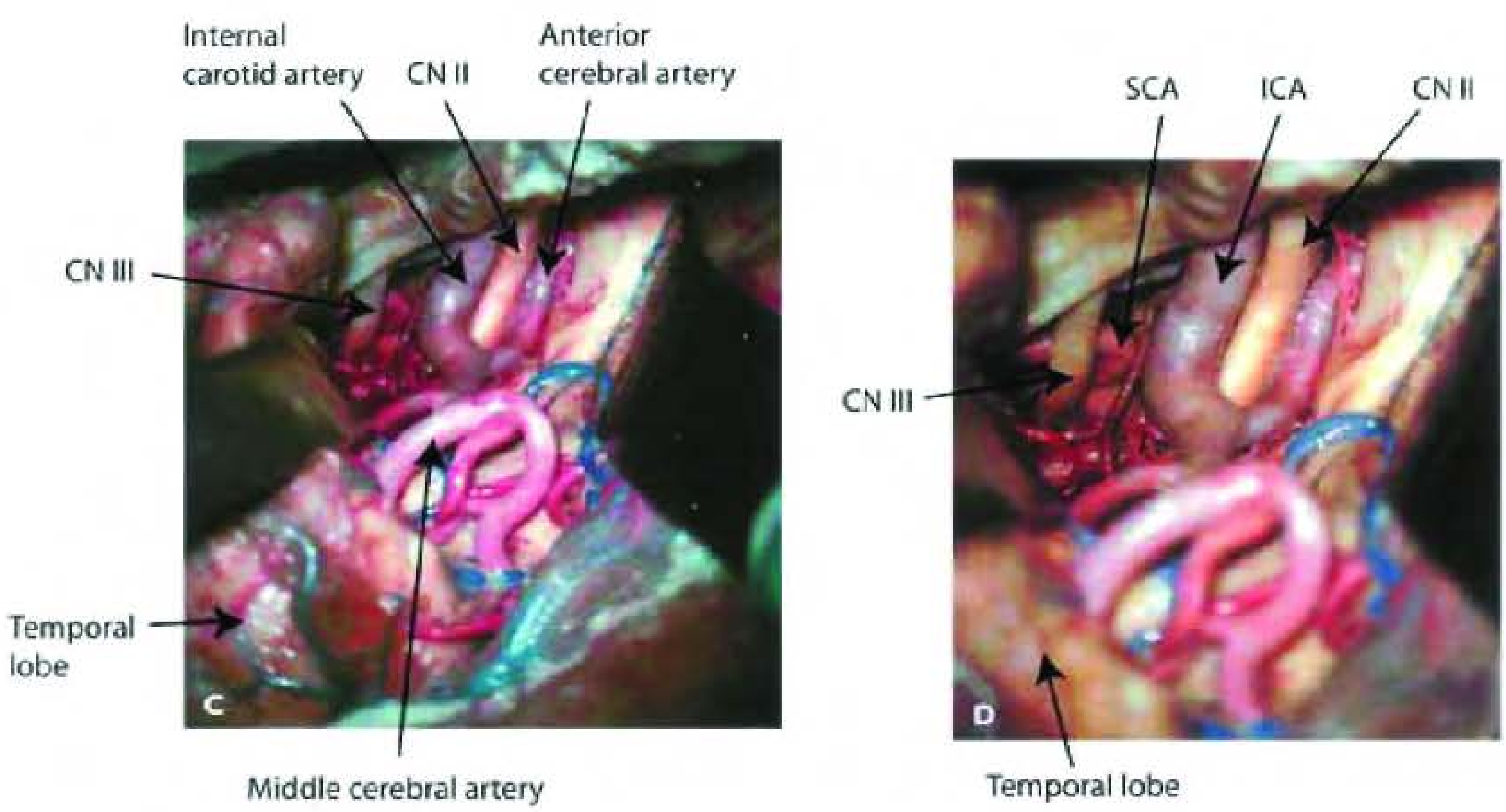
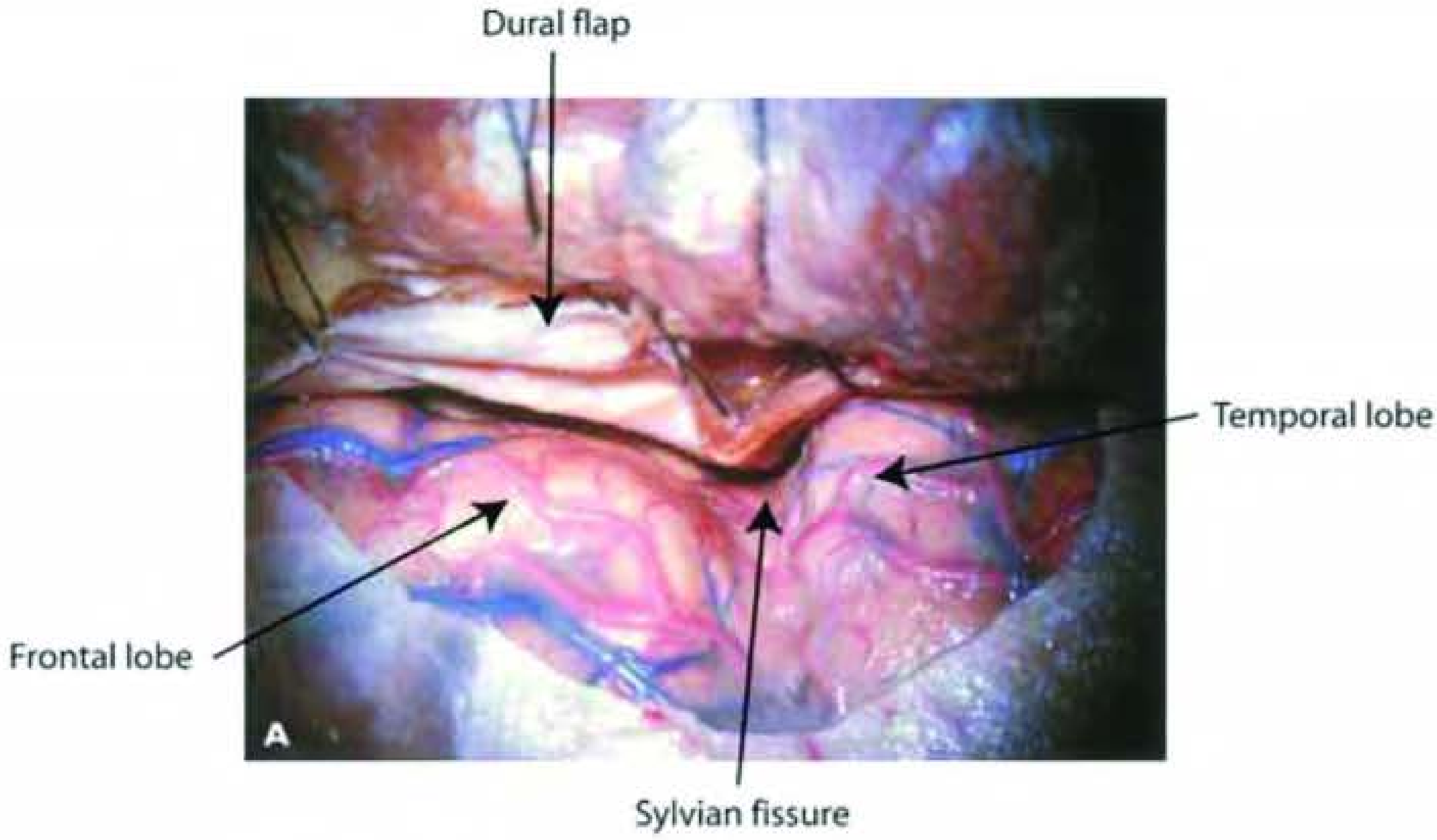


FIGURE 2–6 **A:** The dura is reflected to reveal the underlying frontal and temporal lobes and the sylvian fissure. **B:** The sylvian vein is seen superficially. The middle cerebral artery branches can be seen in me depths. **C:** Panoramic view after widely splitting in a lateral to medial fashion the sylvian fissure. **D:** High-power view after lateral to medial splitting of me sylvian fissure. SCA, superior cerebellar artery; ICA, internal carotid artery; CN, cranial nerve.





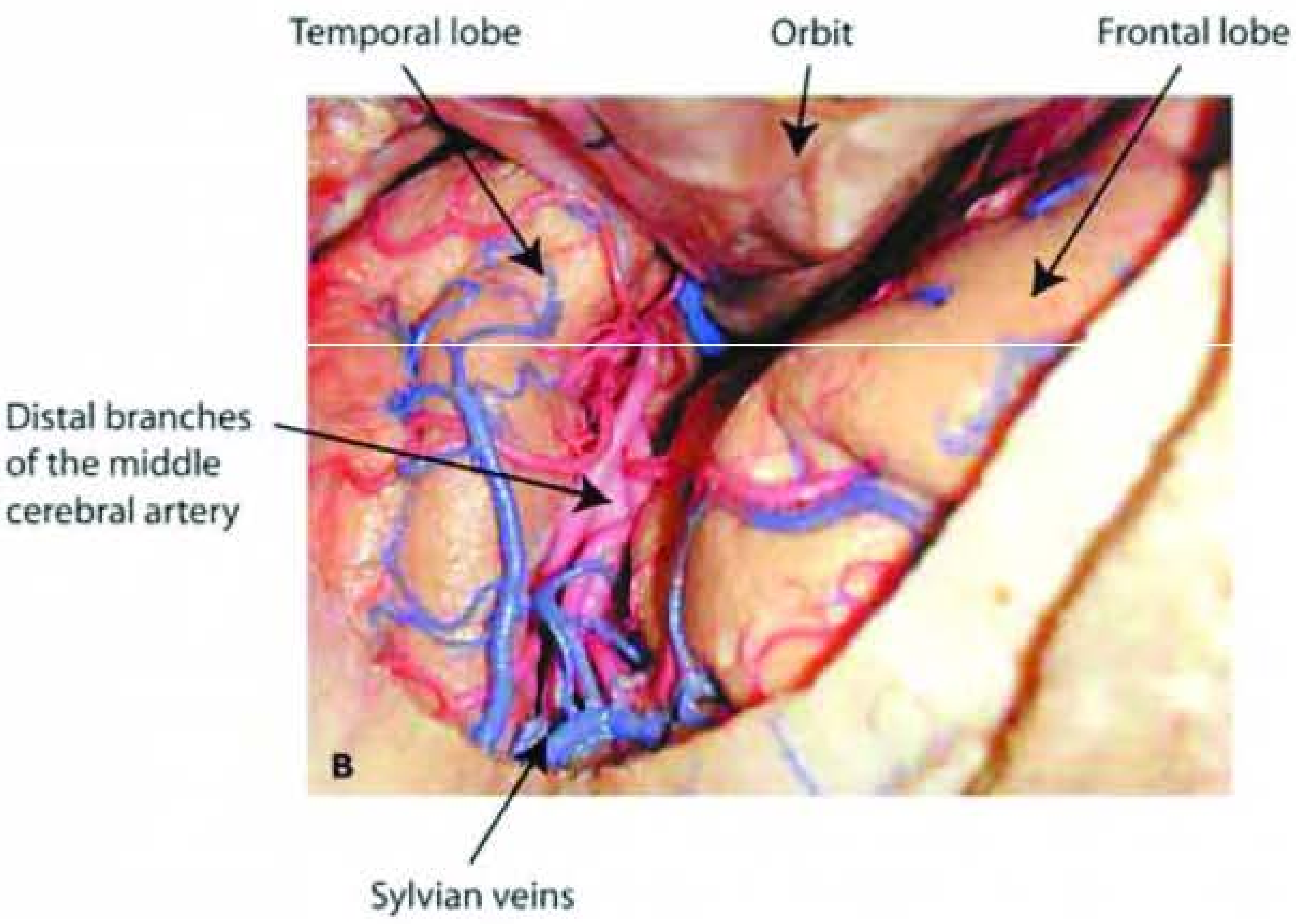
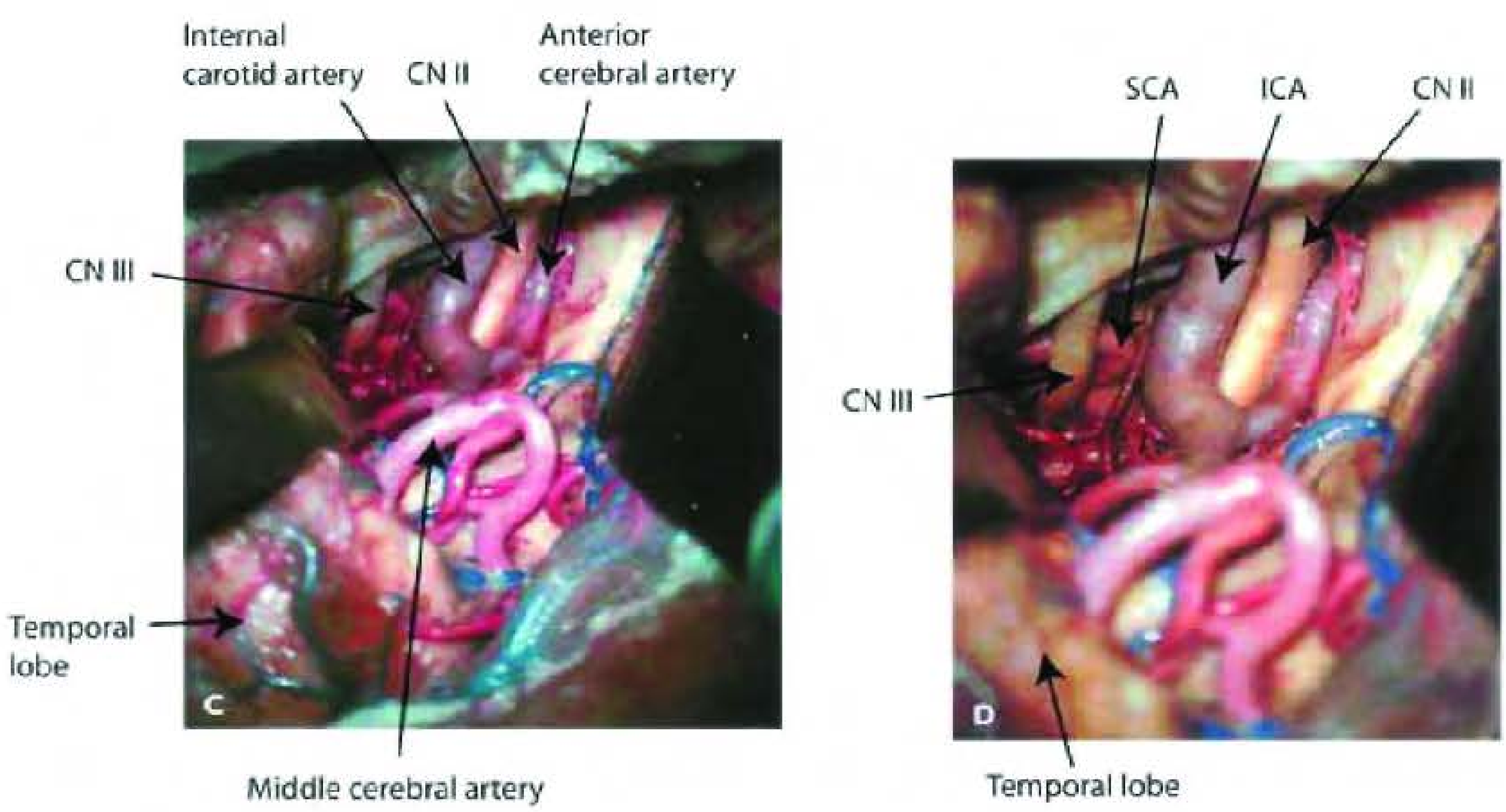


FIGURE 2–6 **A:** The dura is reflected to reveal the underlying frontal and temporal lobes and the sylvian fissure. **B:** The sylvian vein is seen superficially. The middle cerebral artery branches can be seen in me depths. **C:** Panoramic view after widely splitting in a lateral to medial fashion the sylvian fissure. **D:** High-power view after lateral to medial splitting of me sylvian fissure. SCA, superior cerebellar artery; ICA, internal carotid artery; CN, cranial nerve.



For a medial-to-lateral opening of the sylvian fissure, a self-retaining retractor is placed under the frontal lobe to expose the olfactory nerve. Following the olfactory nerve posteriorly allows easy identification of the optic nerve and the carotid artery lying laterally to it (Fig. 2–7). The optic-carotid cistern and the carotid-oculomotor cistern generally come into view easily and with little retraction. With the use of fine microdissectors, the arachnoid between the optic nerve and frontal lobe is incised and opened. The dissection of this arachnoid continues across the carotid artery to the region of the third nerve, thus opening the optic-carotid and carotid-oculomotor cisterns. Medially, the chiasmatic cistern can be opened in a similar manner. A medial-to-lateral dissection of the sylvian fissure then can be undertaken, occasionally with the aid of a temporal lobe self-retaining retractor (Fig. 2–8). Bridging temporal veins between the middle fossa dura and the temporal lobe are sacrificed. Proximally to distally along the carotid artery, the posterior communicating artery, the anterior choroidal artery, and the carotid bifurcation can be identified (Fig. 2–9). Progressive retraction of the frontal lobe allows visualization of the optic chiasm, anterior communicating complex, and, ultimately, the contralateral A1, carotid artery, and optic nerve as well as both A2 vessels (Fig. 2–10A). Perforators from the anterior communicating artery (AComA) complex should be appreciated as should be the artery of Heubner. With the optic chiasm well visualized, the lamina terminalis can be entered to expose the third ventricle (Fig. 2–10B). The pituitary stalk is visualized as it passes behind the optic chiasm. The membrane of Lilliquist can be opened between the optic nerve and carotid artery or between the carotid artery and third nerve. The posterior communicating artery then can be followed

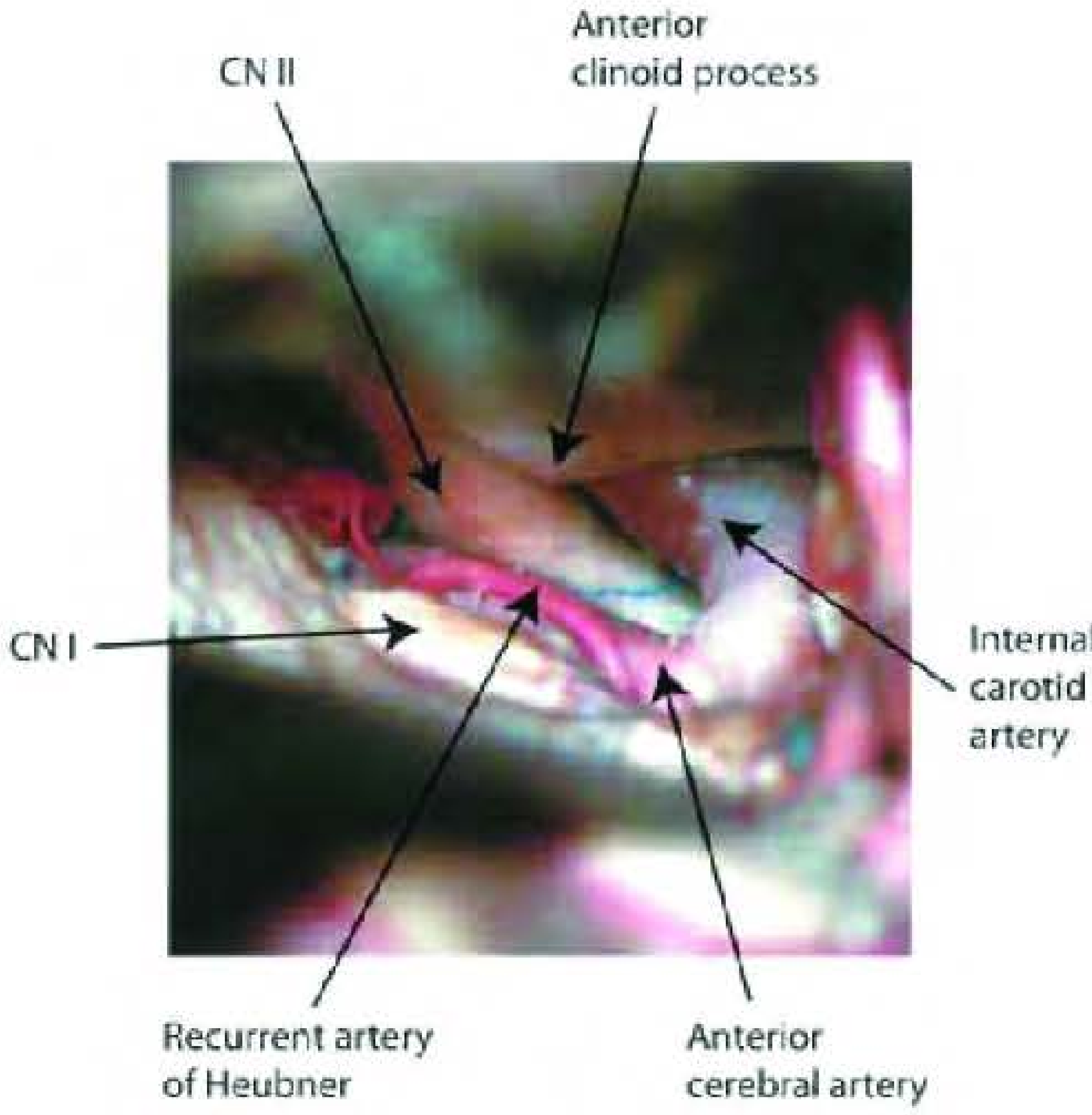


FIGURE 2–7 The olfactory nerve is identified. The carotid artery is seen lateral to the optic nerve. CN, cranial nerve.

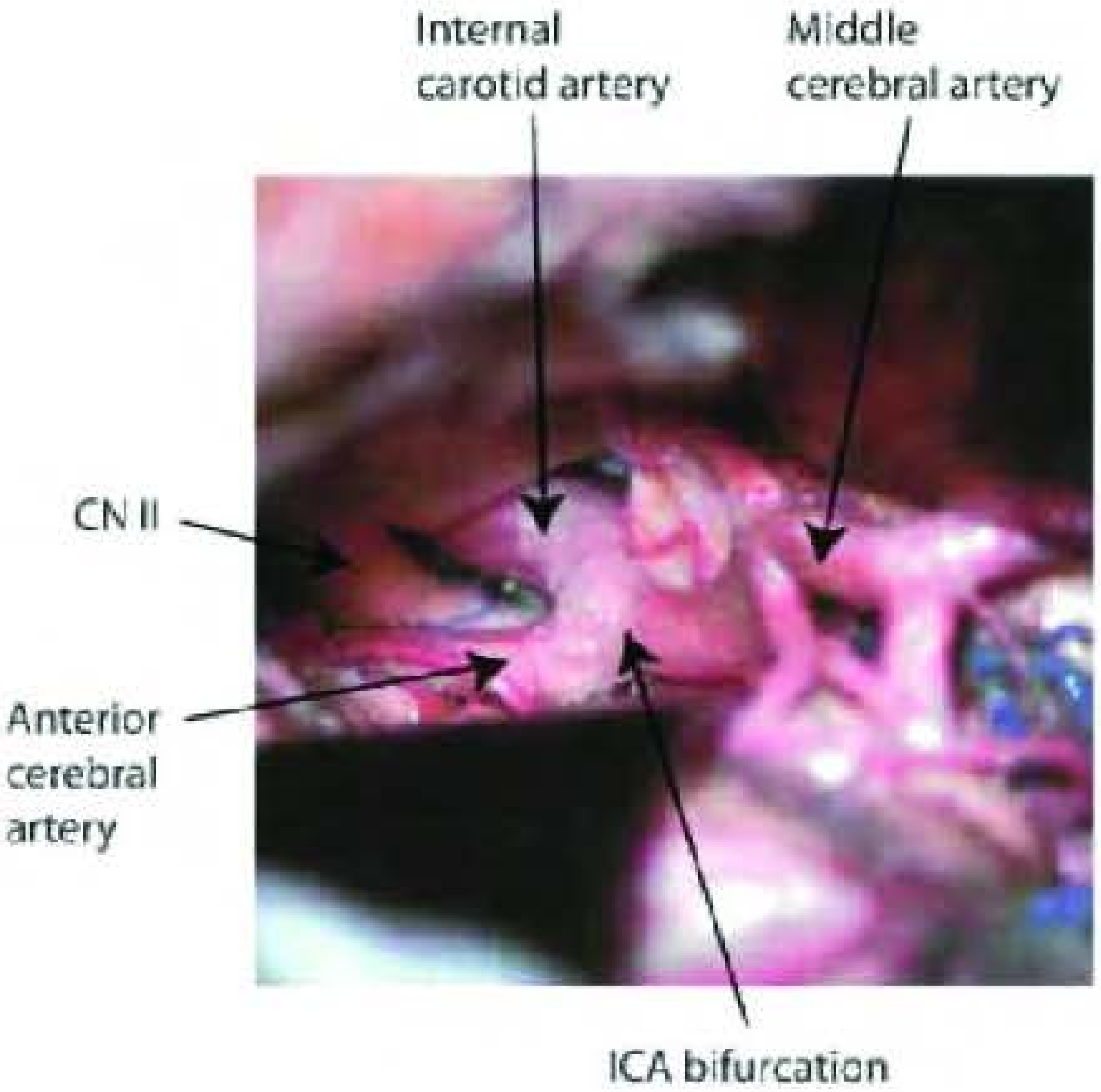


FIGURE 2–8 The sylvian fissure has been widely split to reveal the optic nerve and the carotid artery lying lateral to it. The internal carotid artery (ICA) bifurcation is easily visualized. The middle cerebral artery can be seen traversing the sylvian fissure. CN, cranial nerve.

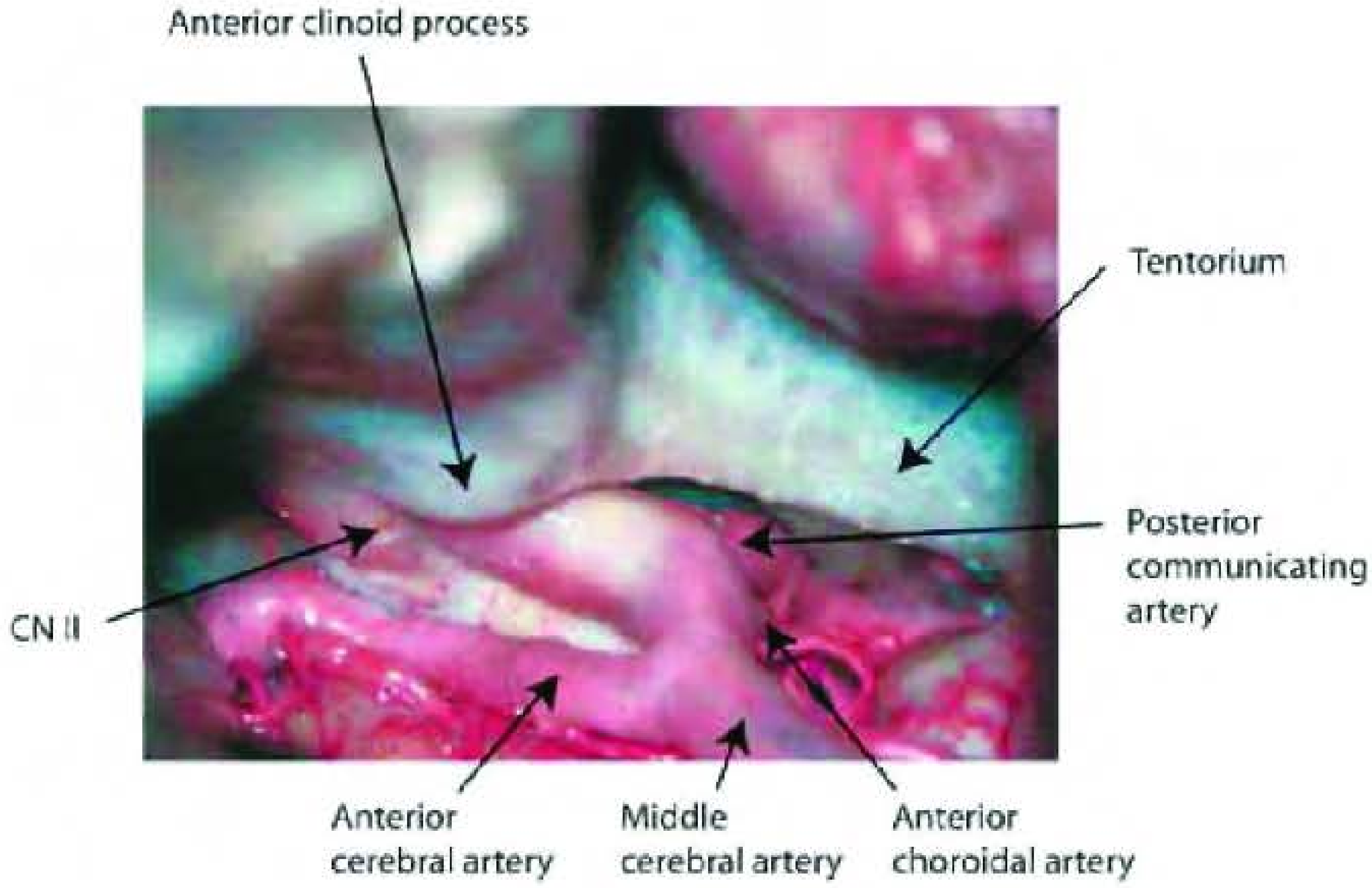


FIGURE 2–9 The carotid artery is seen lateral to the optic nerve. The posterior communicating artery and anterior choroidal artery arise from the internal carotid artery. The tentorium is seen laterally. CN, cranial nerve.

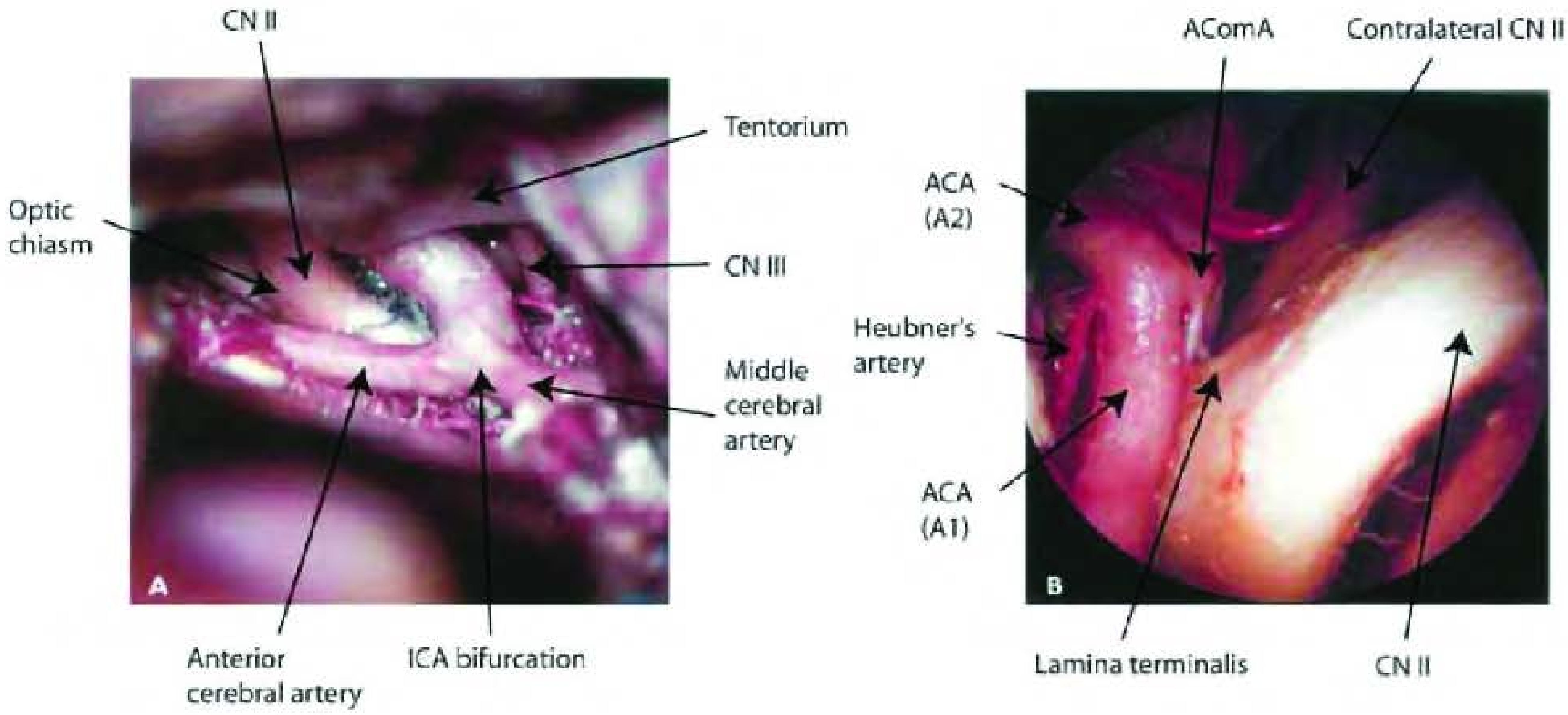


FIGURE 2–10 **A:** Retraction of the frontal lobe allows visualization of the optic chiasm and both optic nerves. Also seen are the ipsilateral internal carotid artery (ICA), middle cerebral artery, anterior cerebral artery (ACA), the third cranial nerve (CN III) and the tentotium. **B:** The contralateral structures can be reached via a transsylvian approach. The lamina terminalis is visualized and can be opened to expose the third ventricle. AcomA, anterior communicating artery.

to the P1-2 junction and, subsequently, to the basilar bifurcation (Figs. 2–11 through 2–14). If the basilar tip is high, the superior cerebellar arteries also can be visualized.

The dura is closed in a watertight fashion, and the craniotomy is replaced with the aid of microplates, wire, or heavy suture. The temporalis fascia is reapproximated, and the skin is closed in a multilayered fashion. A subgaleal drain may be left in place if needed.

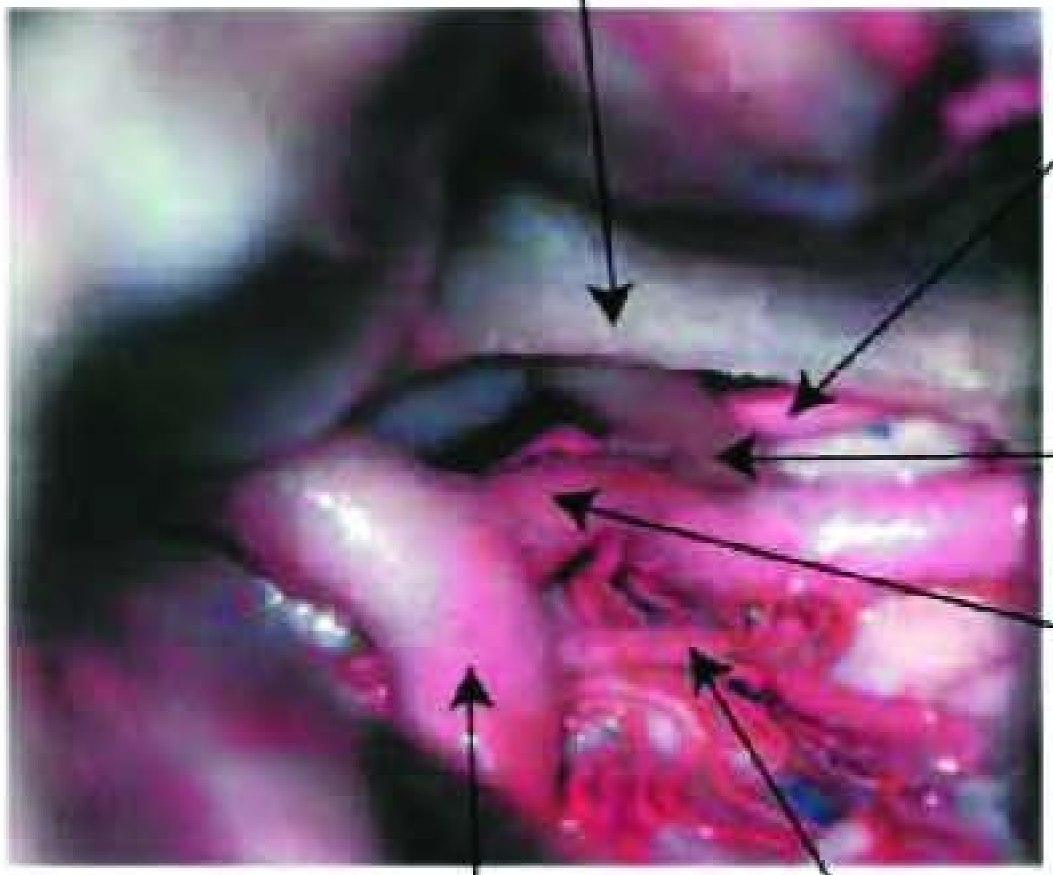


FIGURE 2–11 A fetal posterior communicating artery is disclosed. The superior cerebellar artery can be seen inferior to the third nerve. Note the small anterior choroidal artery. CN, cranial nerve.

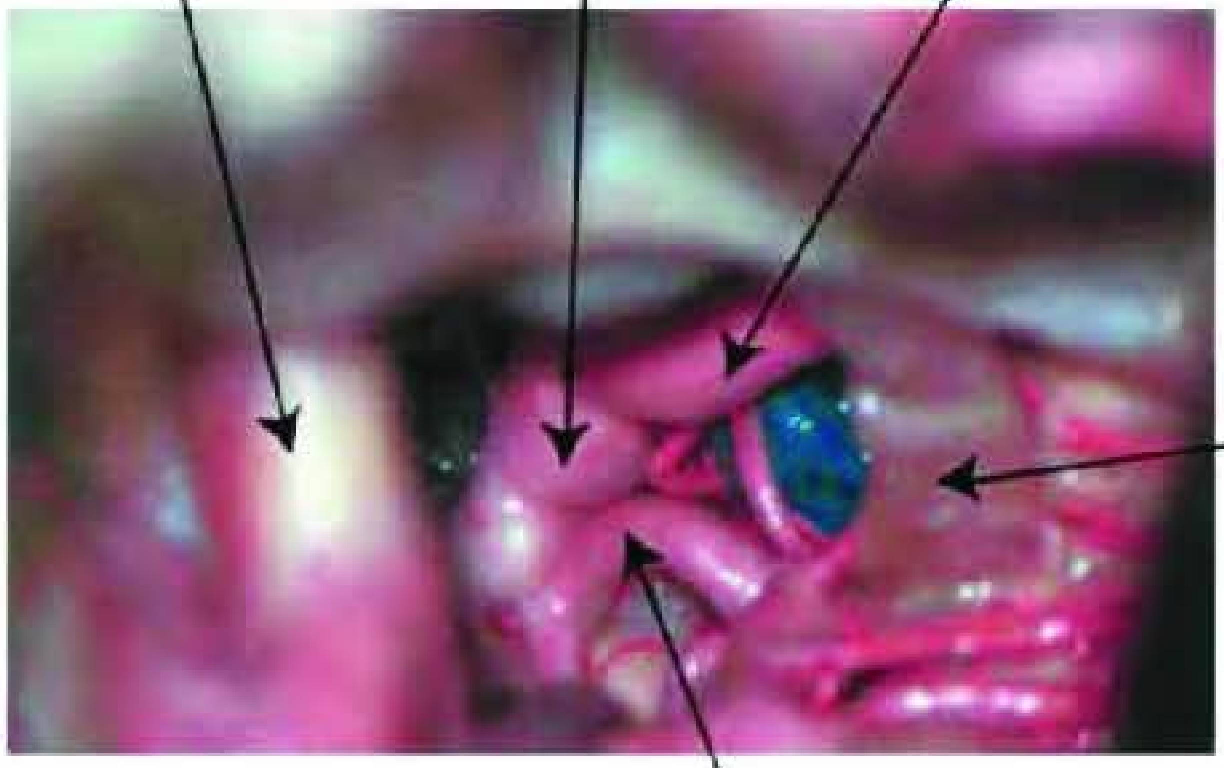


FIGURE 2–12 The basilar bifurcation is seen by entering the carotid-oculomotor cistern. The third nerve is seen between the posterior cerebral artery and the superior cerebellar artery. CN, cranial nerve.

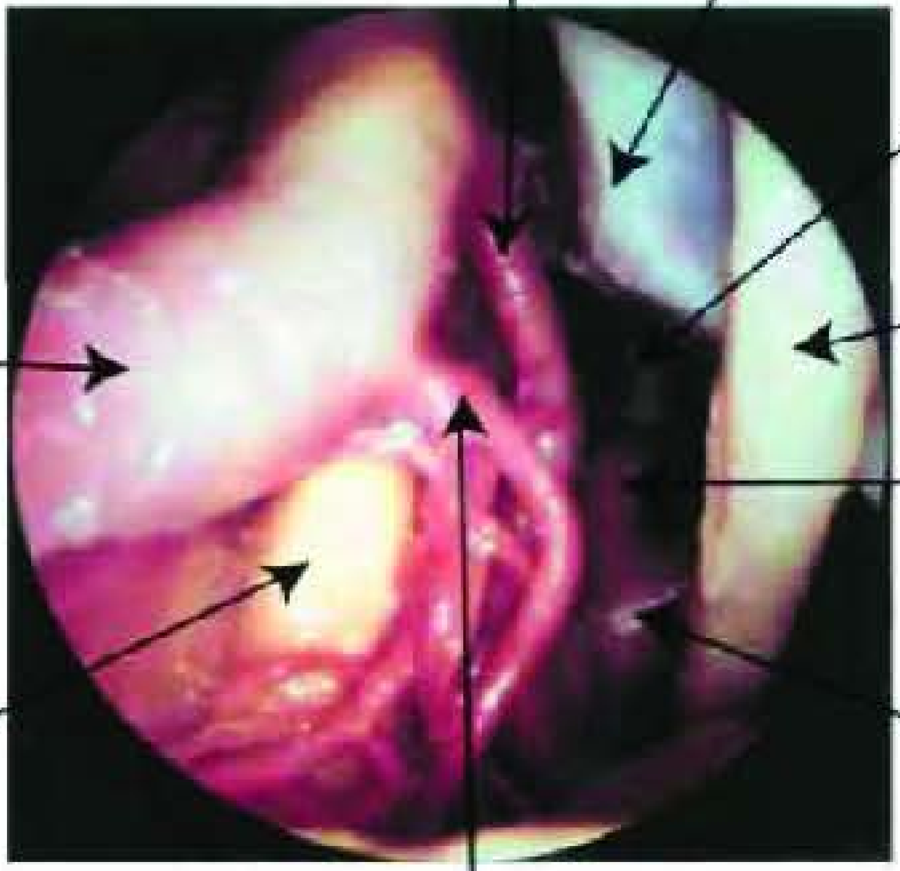


FIGURE 2–13 The contralateral third nerve, posterior clinoid, and basilar artery can be seen. CN, cranial nerve; ICA, internal carotid artery; SCA, superior cerebellar artery; PComA, posterior communicating artery.

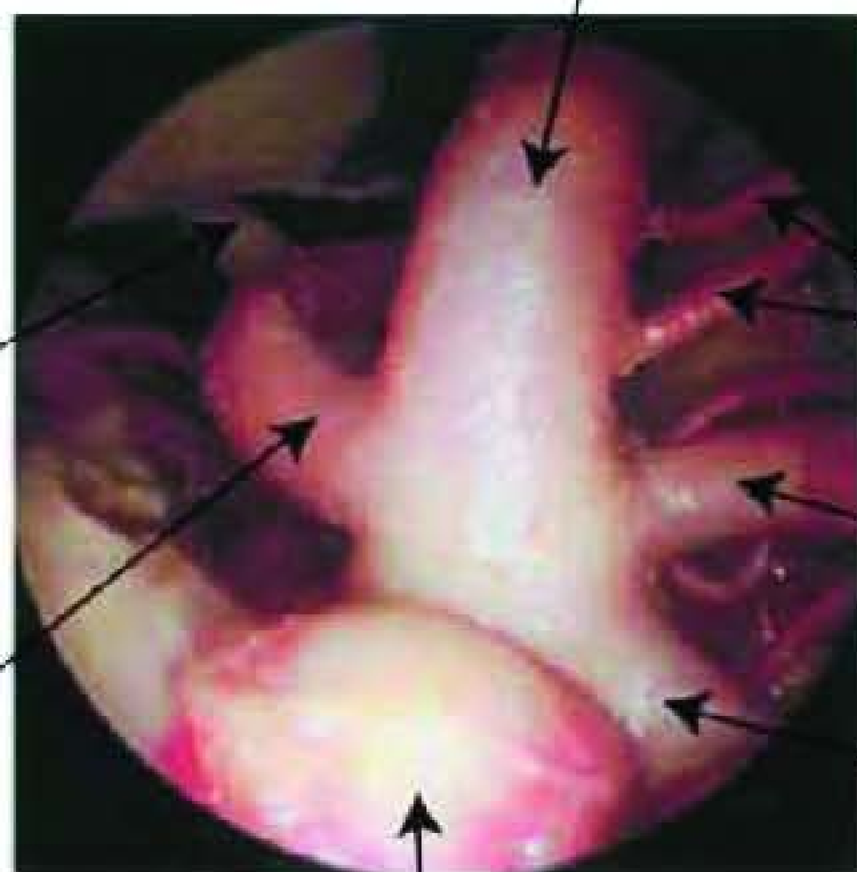


FIGURE 2–14 Endoscopic view of the upper basilar region. A basilar apex aneurysm is identified. CN, cranial nerve; PCA, posterior cerebral aneurysm; SCA, superior cerebellar artery.

PITFALLS, PEARLS, CONSIDERATIONS

- Supraorbital nerve palsy or avulsion
- Injury to facial nerve branches
- Entry into the orbit with the keyhole burr hole
- Injury to neurovascular structures with improper dissection technique
- Retraction injuries with improper technique

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Chapter 3

CRANIO-ORBITAL AND ORBITOZYGOMATIC APPROACHES

Chandrasekar Kalavakandra, Emel Avci, Damirez Fossett

INDICATIONS FOR APPROACH

- Minimizing frontal lobe retraction
- Anterior cavernous sinus lesions
- Orbital lesions
- Basal lesions of the middle cranial fossa
- Tentorial notch and upper clival lesions
- Anterior communicating artery aneurysms
- Paraclinoid carotid and ophthalmic artery aneurysms
- Basilar tip and upper basilar region aneurysms

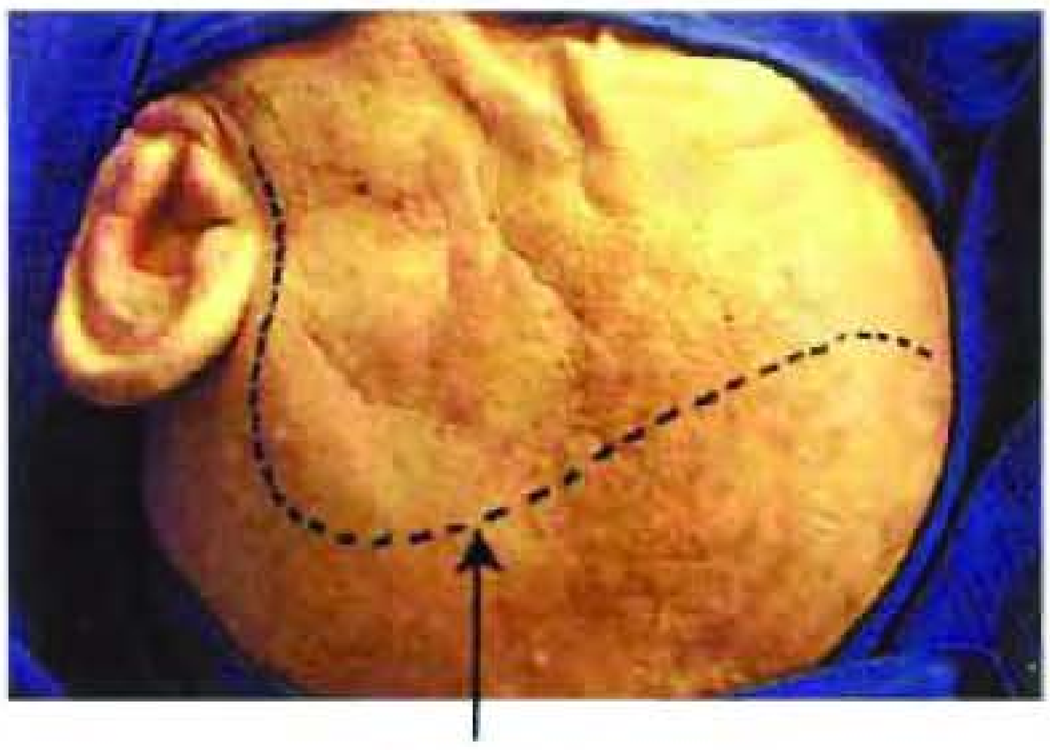


FIGURE 3–1 Illustration of the curvilinear unilateral incision.

POSITIONING AND SKIN INCISION

The patient is placed in the supine position with the head held in Mayfield three-point fixation. The head is generally rotated 20 to 30 degrees toward the contralateral shoulder. More rotation can be used for anterior pathology and less rotation for more posterior pathology. The head is flexed slightly to bring the chin toward the ipsilateral clavicle and then extended to bring the maxillary eminence to the highest point in the field.

A curvilinear or bicoronal skin incision is placed behind the hairline (Fig. 3–1). The incision begins just anterior to the tragus of the ear, and it should not extend below the zygomatic root in order to protect the branches of the facial nerve. The incision should be made as dose as possible to the tragus of the ear. Care should be taken to avoid transecting the underlying branches of the superficial temporal artery. The skin flap is reflected anteriorly along with the pericranium. At the supraorbital ridge, care should be taken to identify and preserve the supraorbital nerve and artery as they pass through the supraorbital foramen or notch (Fig. 3–2). These may be released with the aid of a chisel or the B1 or C1 tools of the Midas Rex (Midas Rex, Fort Worth, Texas).

As the skin is reflected anteriorly, the galea will merge with the superficial layer of the temporalis fascia. A curvilinear incision can be made in the superficial fascial layer at the keyhole and carried toward the zygomatic root (Fig. 3–2). Anterior elevation of this fascia and fat pad away from the underlying temporalis muscle a voids injury to the frontalis branch of the facial nerve that runs in this fat plane (Fig. 3–3). Note that the fat pad runs in the plane above the zygoma, whereas the temporalis muscle runs beneath the zygoma. The temporalis muscle then is elevated and

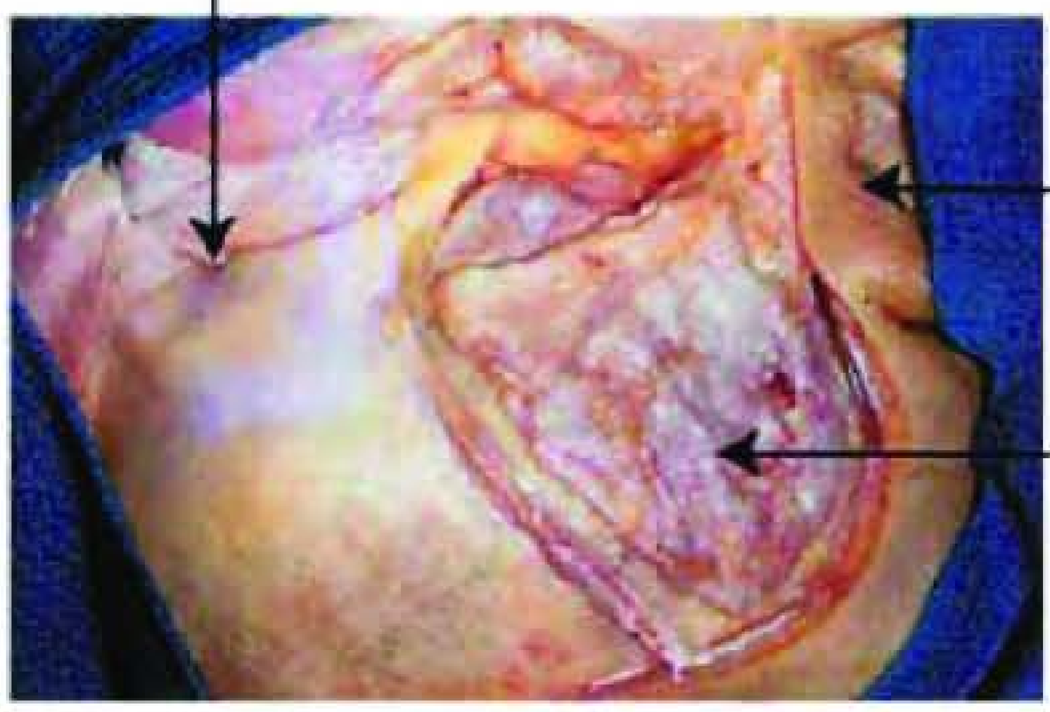


FIGURE 3–2 The supraorbital nerve and artery are seen exiting the supraorbital notch.

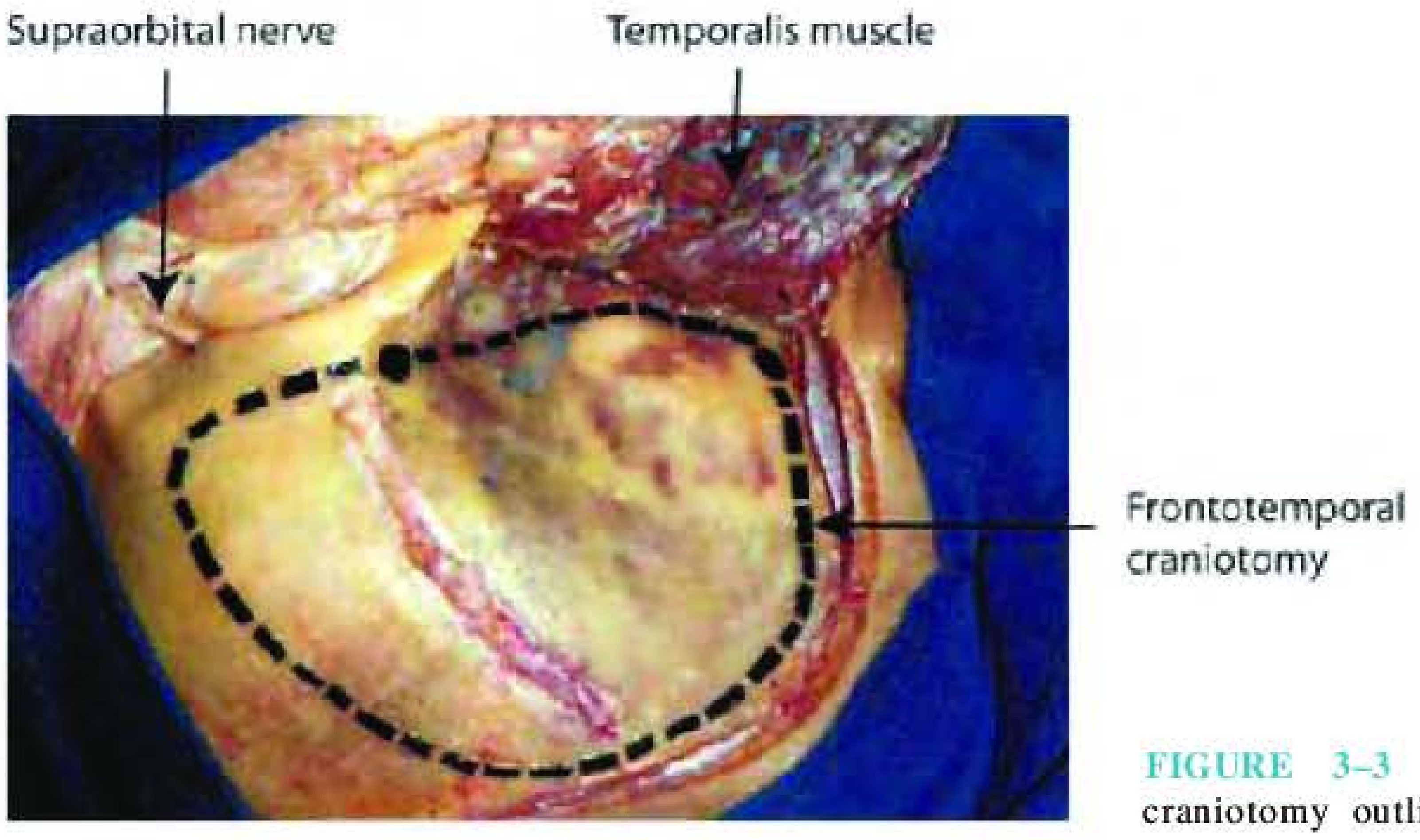


FIGURE 3–3 The temporalis muscle has been elevated and the craniotomy outlined.

reflected anteriorly and inferiorly to expose the supraorbital ridge and the lateral rim of the orbit (Fig. 3–3). The temporalis is also dissected from the under surface of the zygoma in preparation for the zygomatic osteotomy.

SURGICAL TECHNIQUE

A bur hole is made at the McCarty keyhole, and generally a second one is made in the squamosal region of the temporal bone. After dissection of the dura from the overlying bone with the use of dural dissectors or a Penfield 3, the bur holes are connected with the B1 foot-plated tool of the Midas Rex (Midas Rex, Fort Worth, Texas) or with a Gigli saw, and the craniotomy flap is lifted free.

ORBITAL OSTEOTOMY

The orbital osteotomy is performed as a separate maneuver following the craniotomy. The subfrontal dura is gently dissected away from the floor of the anterior fossa to the cribriform plate medially and to the sphenoid ridge posteriorly. The periorbita is separated from the roof of the orbit for a distance of 3 cm posteriorly from the supraorbital ridge, and it is also separated along the lateral wall of the orbit. Hand-held retractors are placed to retract the frontal dura away from the floor of the frontal fossa and to retract the periorbita from the roof of the orbit. Using a sagittal saw, a sagittal cut is made in the roof of the orbit from the cranial to the orbit side to a depth of at least 2.5 to 3 cm posterior to the supraorbital ridge. For a simple orbital Osteotomy, a second cut is made above the zygomatic process of the frontal bone and extended posteriorly as deep as possible within the orbit. The third cut is a coronal cut made across the roof of the orbit to connect the previous two cuts. This cut can be made using a narrow Kerrison rongeur or with the C1 tool of the Midas. Once all three cuts are made, the bone is gently grasped with an Allis forceps, any adherent periorbita is dissected away, and with gentle rocking the bone is loosened and removed. Any remaining orbital roof can be removed using a rongeur (Figs. 3–4 and 3–5).

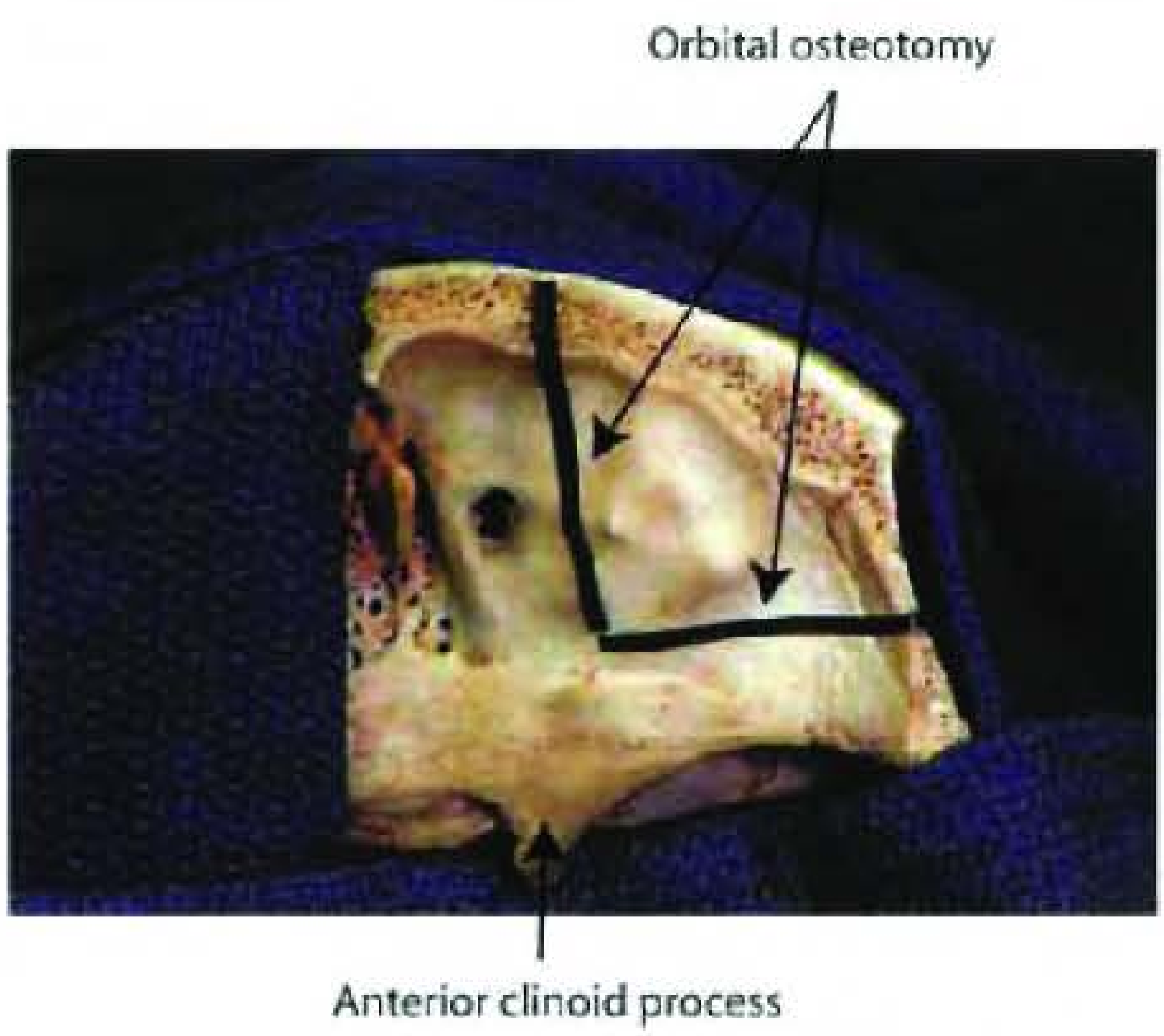


FIGURE 3–4 The coronal and sagittal cute through the orbital roof are outlined.

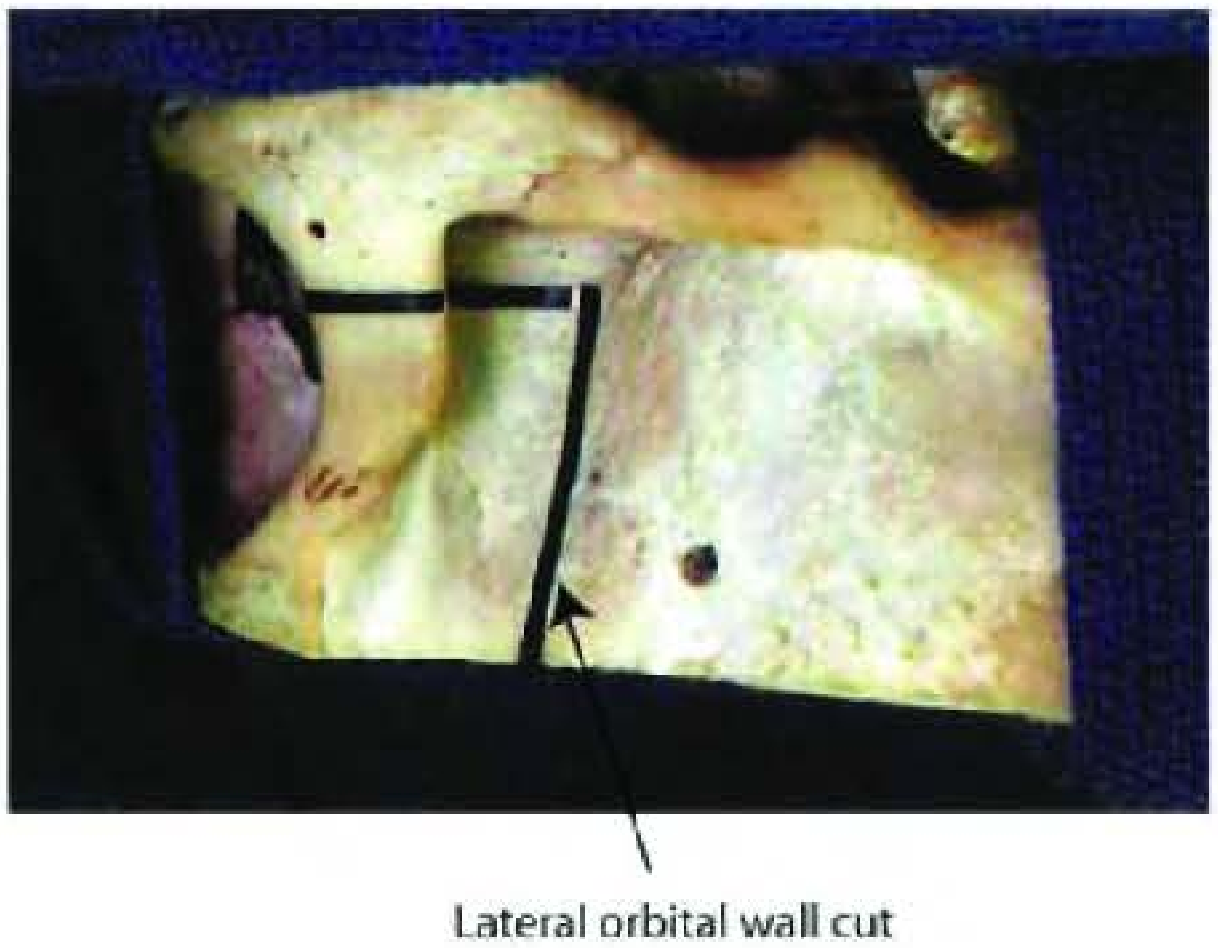


FIGURE 3–5 The lateral orbital wall cut is outlined.

ORBITOZYGOMATIC OSTEOTOMY

The orbitozygomatic osteotomy differs little from the preceding technique. The coronal cut across the roof of the orbit extends laterally from the sagittal cut to the inferior orbital fissure. A third cut is made parallel to, but several millimeters above, the zygomaticomaxillary suture. An excellent landmark is to begin this cut just superior to the zygomaticofacial foramen. This cut goes through the lateral wall of the orbit and extends to the inferior orbital fissure. The temporalis muscle, which runs under the zygoma to its infratemporal attachments, is reflected back to its normal position to enable an oblique cut through the posterior root of the zygoma (Fig. 3–6). The loose osteotomy is then grasped with an Allis forceps and gently rocked. Any adherent periorbital is separated, and any remaining bony connections are loosened with the aid of a chisel and hammer. The whole osteotomy is removed *en bloc*. The temporalis muscle then is reflected inferiorly fully exposing the floor of the temporal fossa (Fig. 3–7).

EXTRADURAL ANTERIOR CLINOIDECTOMY

Once the orbit has been removed, the anterior clinoid process (ACP) can be resected intradurally, extradurally, or with a combined technique. If it is to be resected extradurally, the dura is elevated further from the floor of the anterior cranial fossa to expose the planum sphenoidale and the entrance of the optic nerve into the optic canal. It is further separated from the sphenoid ridge and the floor of the middle cranial fossa. While separating along the sphenoid ridge, the meningo-orbital vessels are identified, cauterized, and transected. With gentle retraction of the dura and underlying frontal lobe, the anterior clinoid process then can be safely drilled extradurally.

The optic canal then is skeletonized using a medium-sized or small diamond bur. The bone is thinned on either side of the optic canal until only a thin rim remains, and this can be gently and easily removed with a dissector. The optic canal is unroofed completely in a 180-degree plane (Figs. 3–8 and 3–9A). After separating the dura over the ACP, it is cored out using a small diamond bur that remains within the confines of the cortical bone at all times (Fig. 3–9B). Adequate thinning ensures easy inward fracturing of the remaining cortical walls. The ACP then is freed from any remaining dural attachments, grasped with a small clamp, and freed (Fig. 3–9C). While drilling the ACP, keep in mind the surrounding structures: medially, the optic nerve; laterally, the third nerve in the wall of the superior orbital fissure; and anteroinferiorly, the carotid artery. The dura covering the inferior surface of the ACP extends posteriorly and inferiorly to form the distal dural ring of the internal carotid artery (ICA).

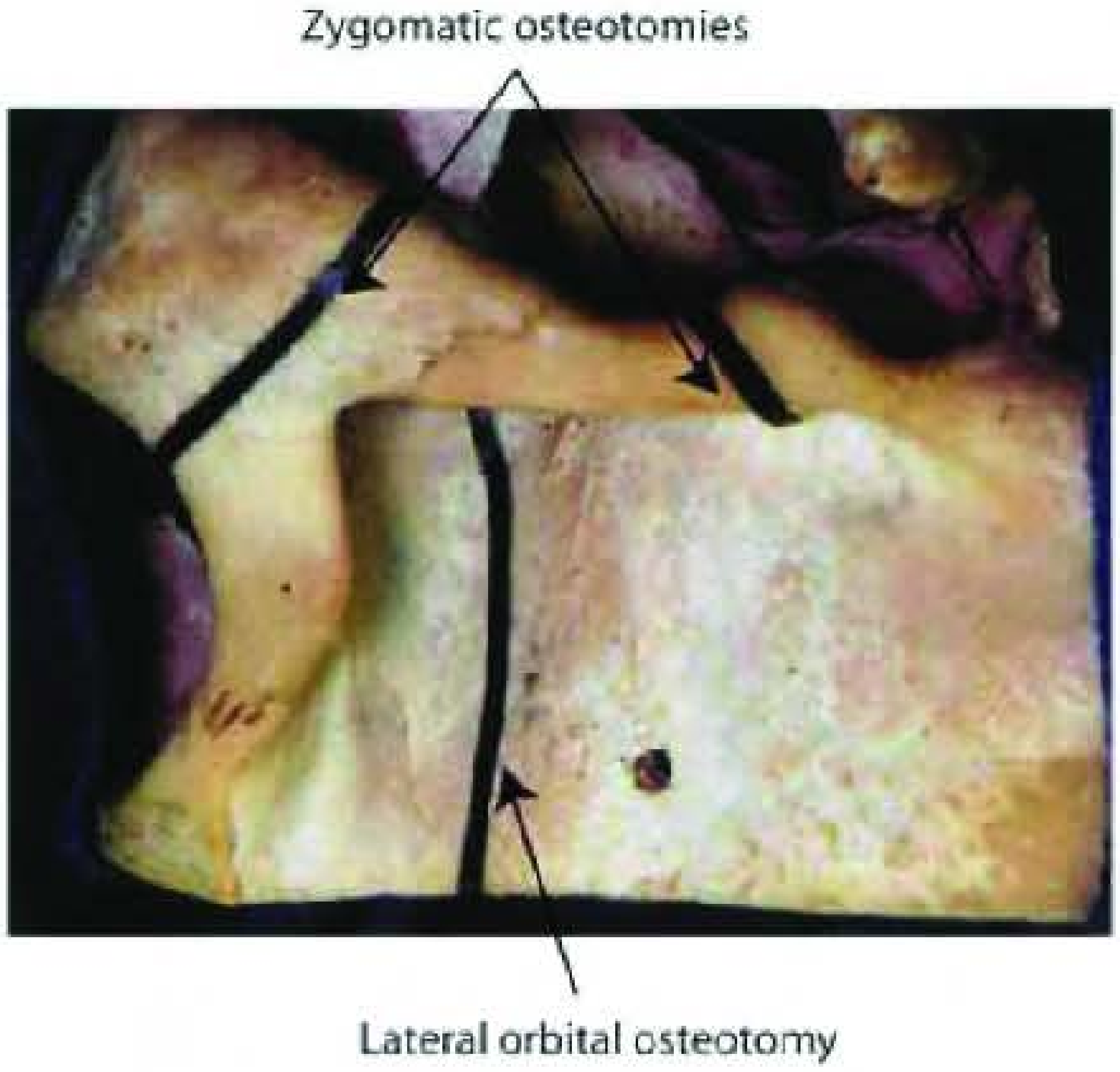


FIGURE 3–6 Lateral orbital and zygomatic cuts arc outlined for the orbitozygomatic osteotomy.

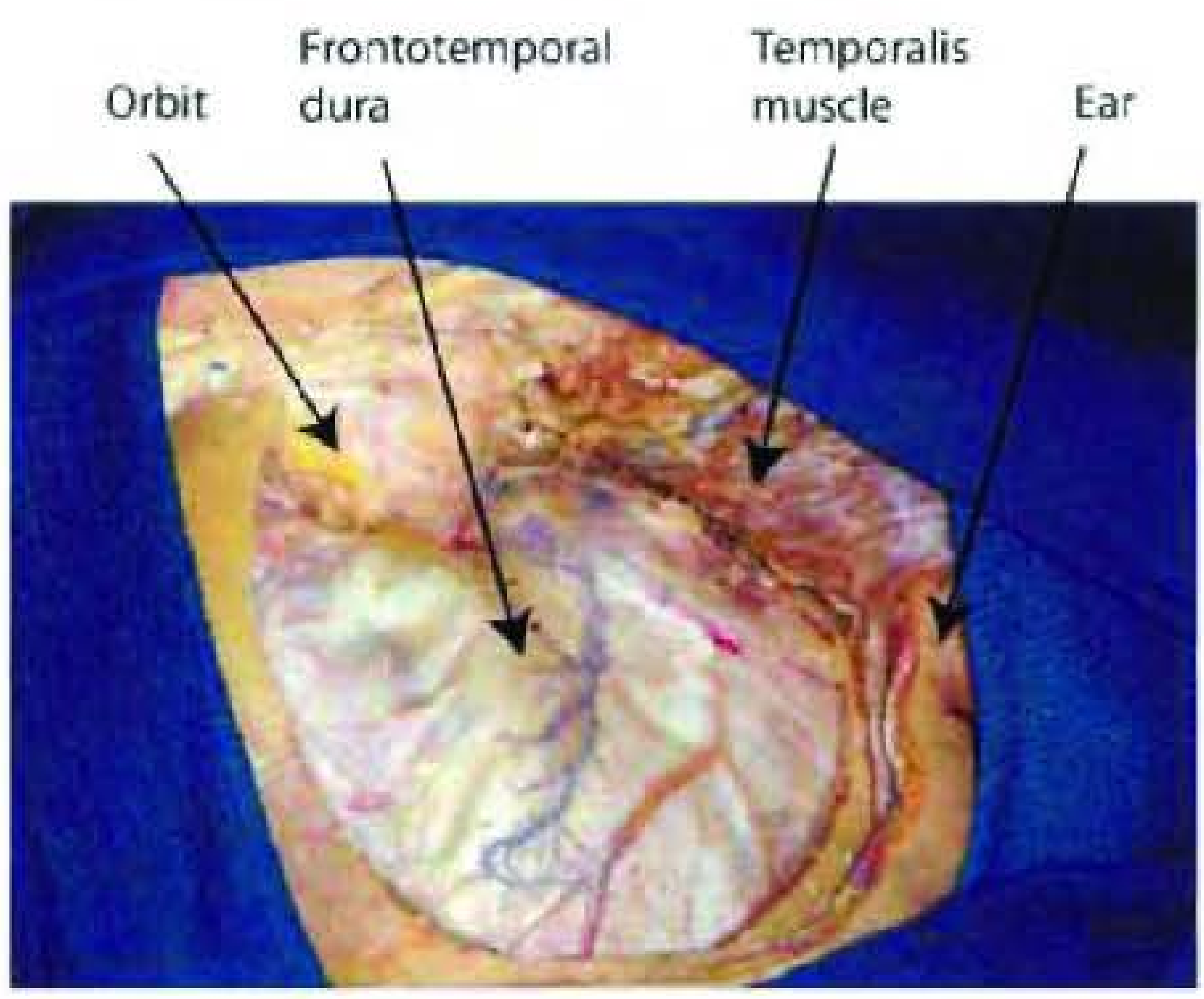


FIGURE 3–7 The dura is exposed after the cranial–orbitozygomatic osteotomy has been performed.

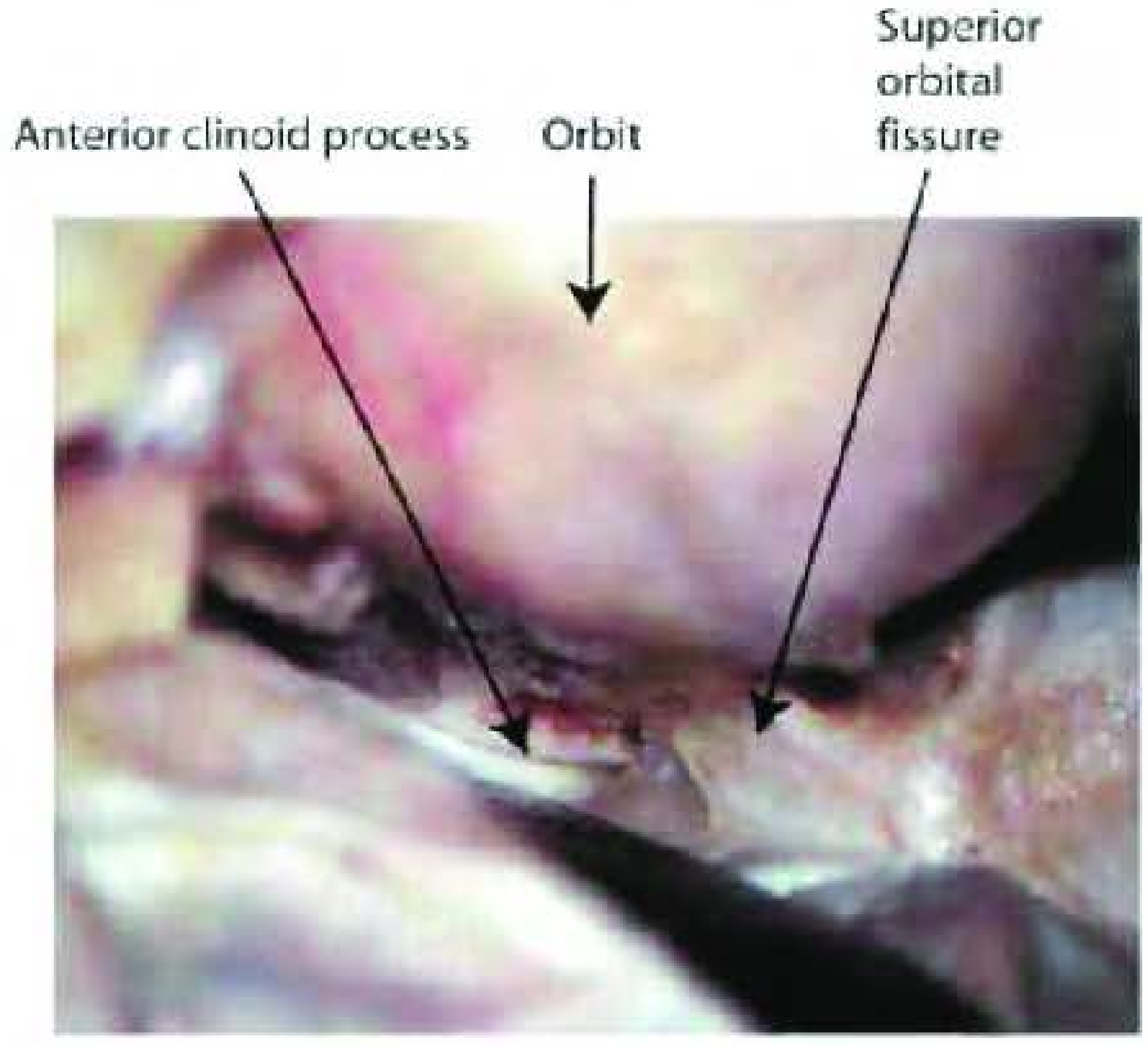
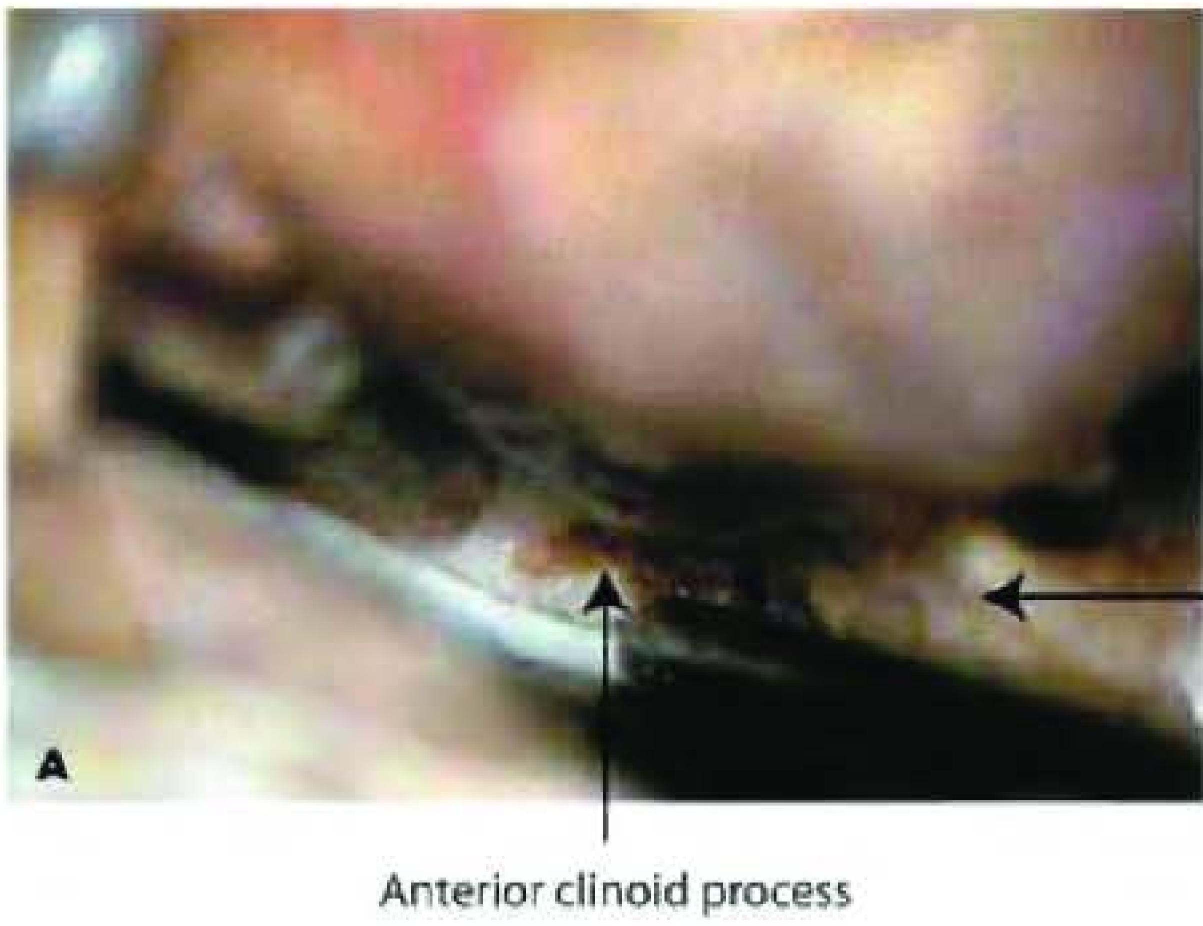
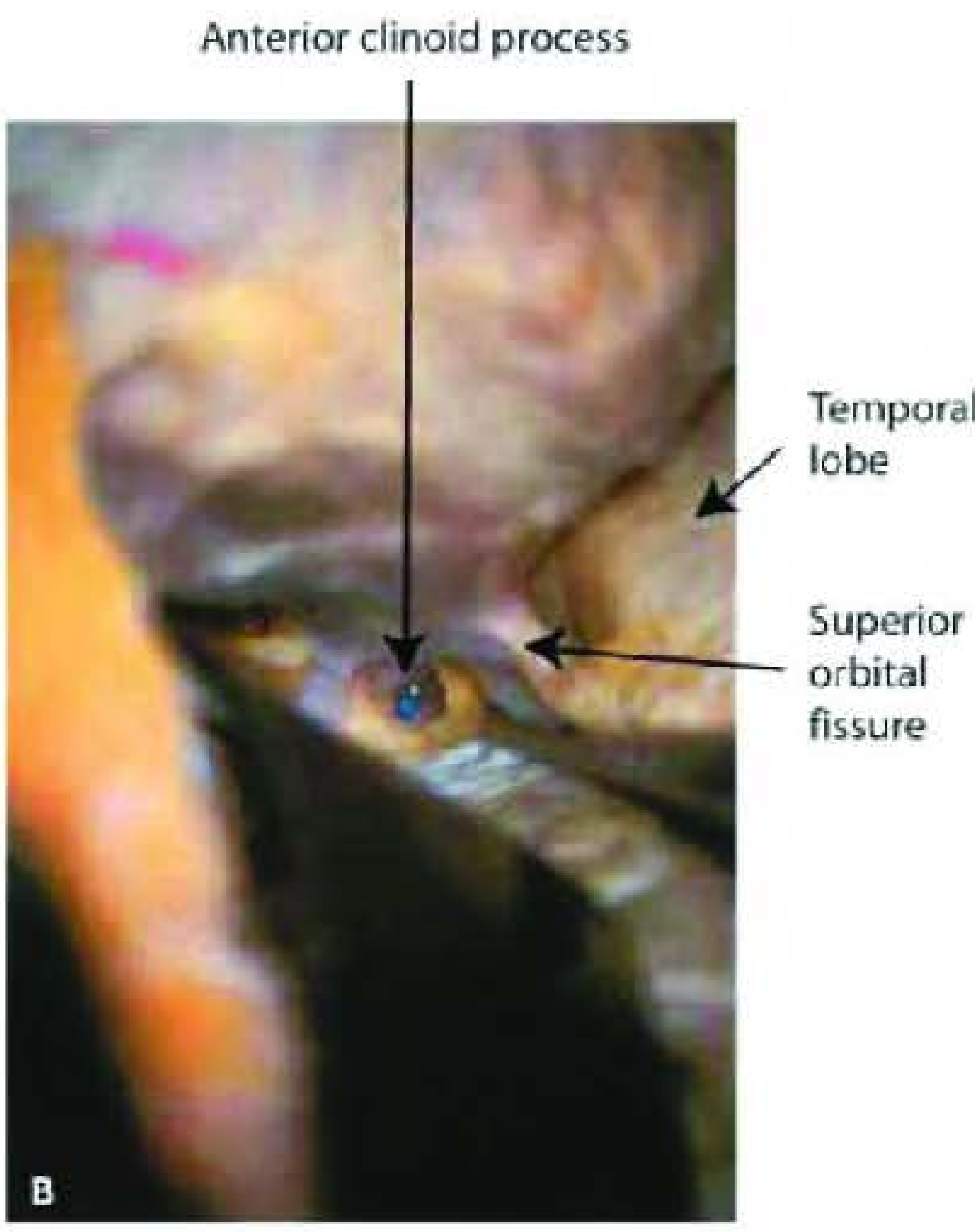
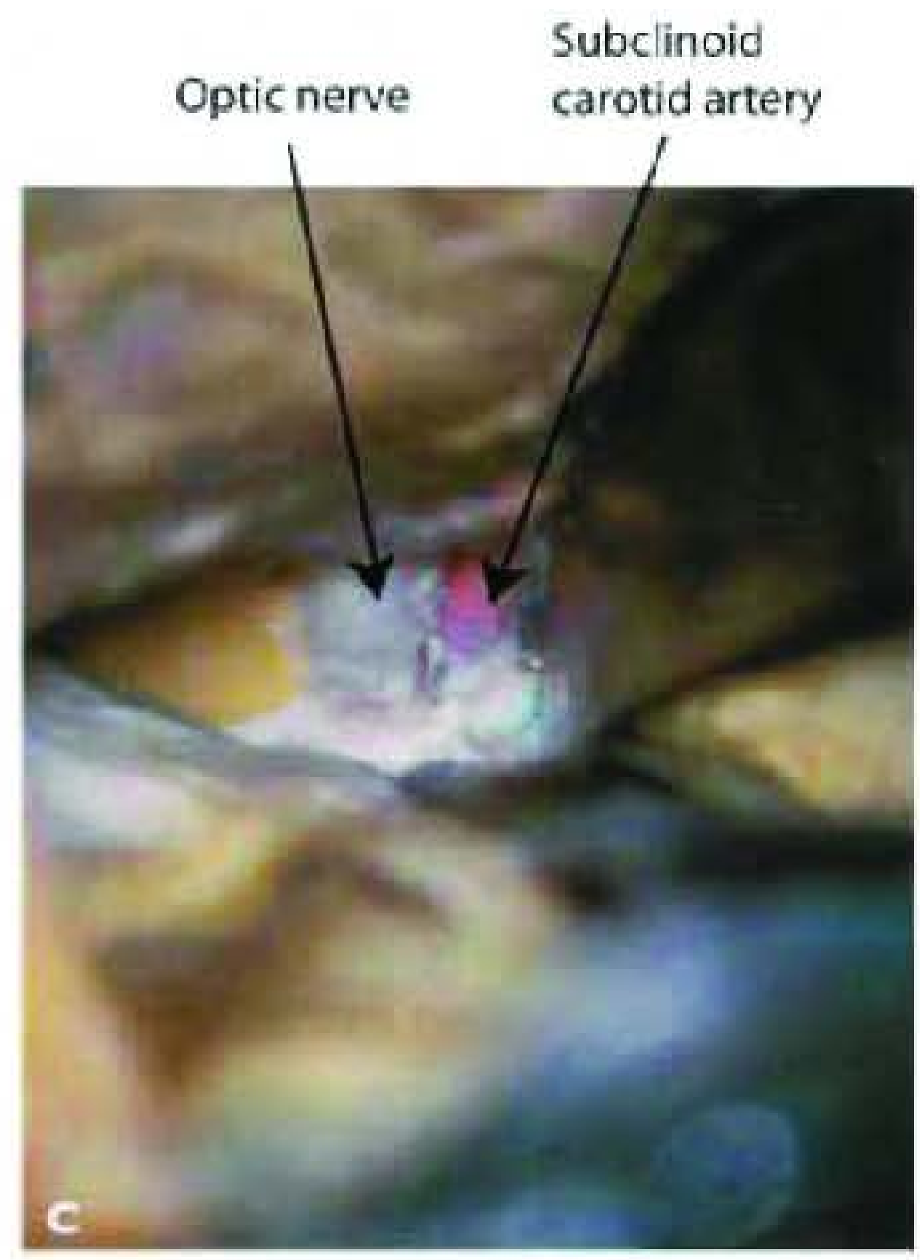


FIGURE 3–8 The extradural optic nerve is visualized.

FIGURE 3–9 **A**: The optic canal is unroofed extradurally. **B**: The anterior clinoid process (ACP) is cored out to thin the bone for fracturing. The extradural optic nerve is visualized. **C**: The ACP has been removed extradurally, and the optic nerve and carotid artery are visualized.







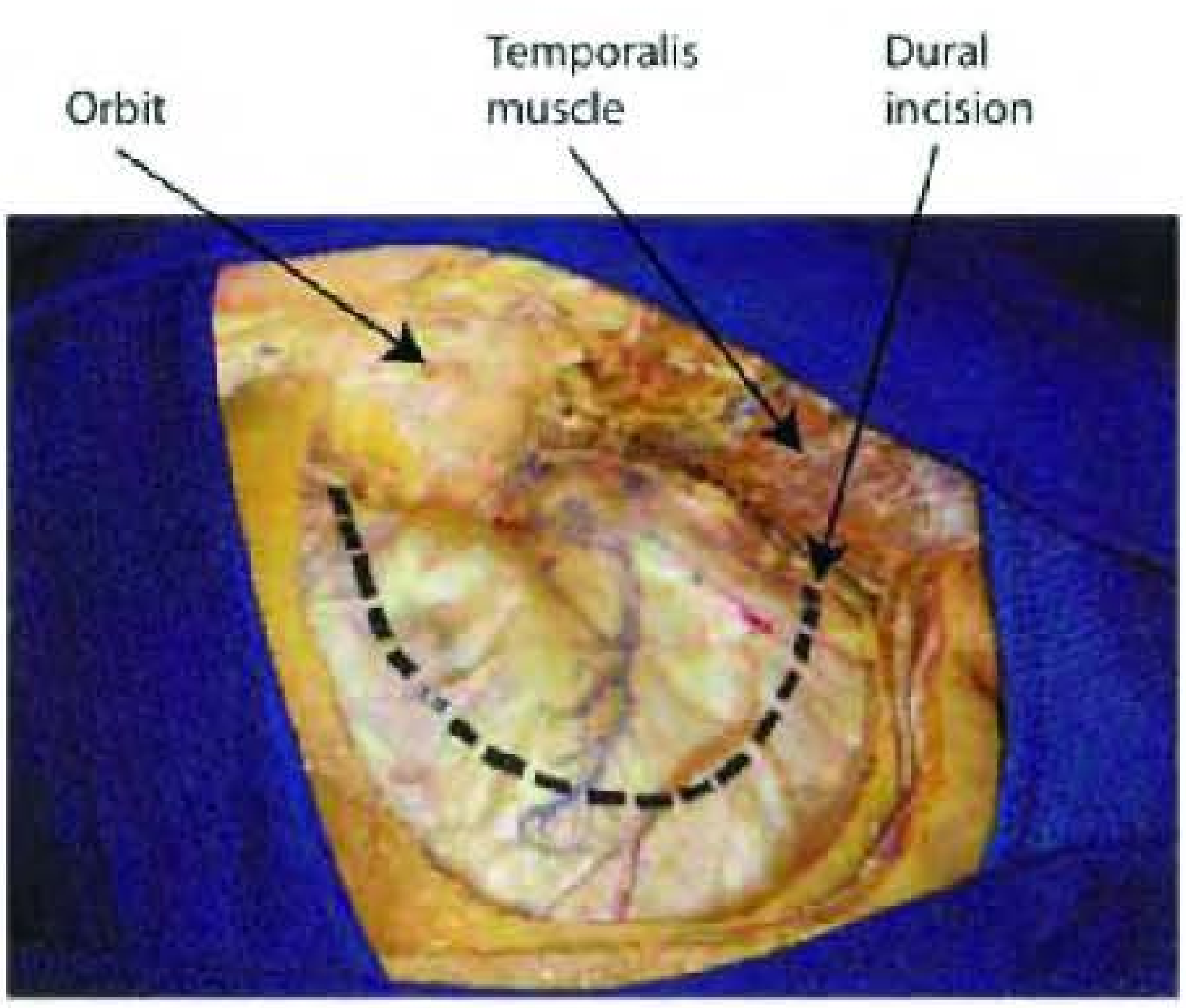


FIGURE 3–10 The curvilinear dural opening is outlined.

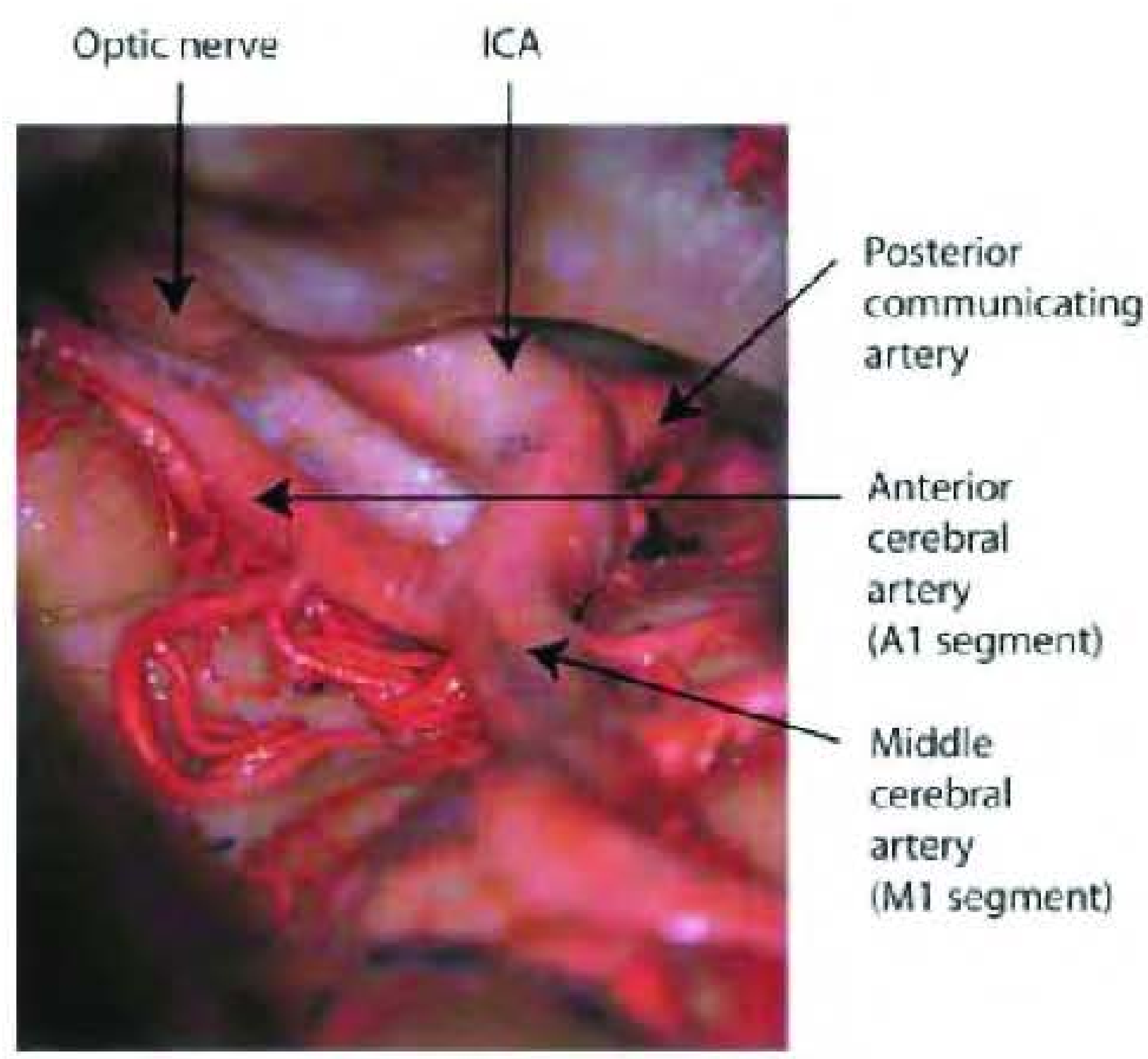


FIGURE 3–11 The sylvian fissure is widely split.

INTRADURAL ANTERIOR CLINOIDECTOMY

In patients with a long ACP or in the presence of vascular pathology, intradural removal is recommended. Typically, the dura is opened in a C-shaped fashion, with its base along the sphenoid ridge (Fig. 3–10). It is reflected anteriorly and anchored with stay sutures. Under the operating microscope, either a lateral-to-medial or medial-to- lateral opening of the sylvian fissure can be made. If a lateral-to-medial dissection is desired, two self-retaining retractors are positioned, one on the frontal lobe and one on the temporal lobe to make the fissure taut. The sylvian fissure is opened using an arachnoid knife. The dissection is carried superior to the sylvian vein, reflecting the veins with the temporal lobe. As the fissure opens, the distal branches of the middle cerebral artery, the M1-2 bifurcation, and finally the carotid bifurcation can be identified (Fig. 3–11).

For a medial-to-lateral opening of the sylvian fissure, a Self-retaining retractor is placed under the frontal lobe to expose the olfactory nerve. Following the olfactory nerve posteriorly allows easy identification of the optic nerve and carotid artery (Fig. 3–12). The optic-carotid cistern and the carotid-oculomotor cistern generally come into view easily with little retraction. Using fine microdissectors, the arachnoid between the optic nerves and frontal lobes is incised and opened. Dissection of this arachnoid continues across the carotid artery to the region of the third nerve, thus opening the optic-carotid and carotid-oculomotor cisterns. Medially, the chiasmatic cistern can be opened in a similar manner. A medial-to-lateral dissection of the sylvian fissure may be undertaken occasionally with the aid of a temporal lobe self-retaining retractor. Bridging veins between the temporal lobe and the dura of the middle fossa must be cauterized and transected.

After completion of the sylvian dissection, the dura over the anterior clinoid process is incised in a T- or U-shaped fashion (Figs. 3–13 and 3–14). Using a Rhoton 2 or 3 dissector (Baxter Healthcare Corp., McGaw Park, Illinois), the dura is stripped away from the anterior clinoid process. Using a high-speed diamond bur, the clinoid is drilled away

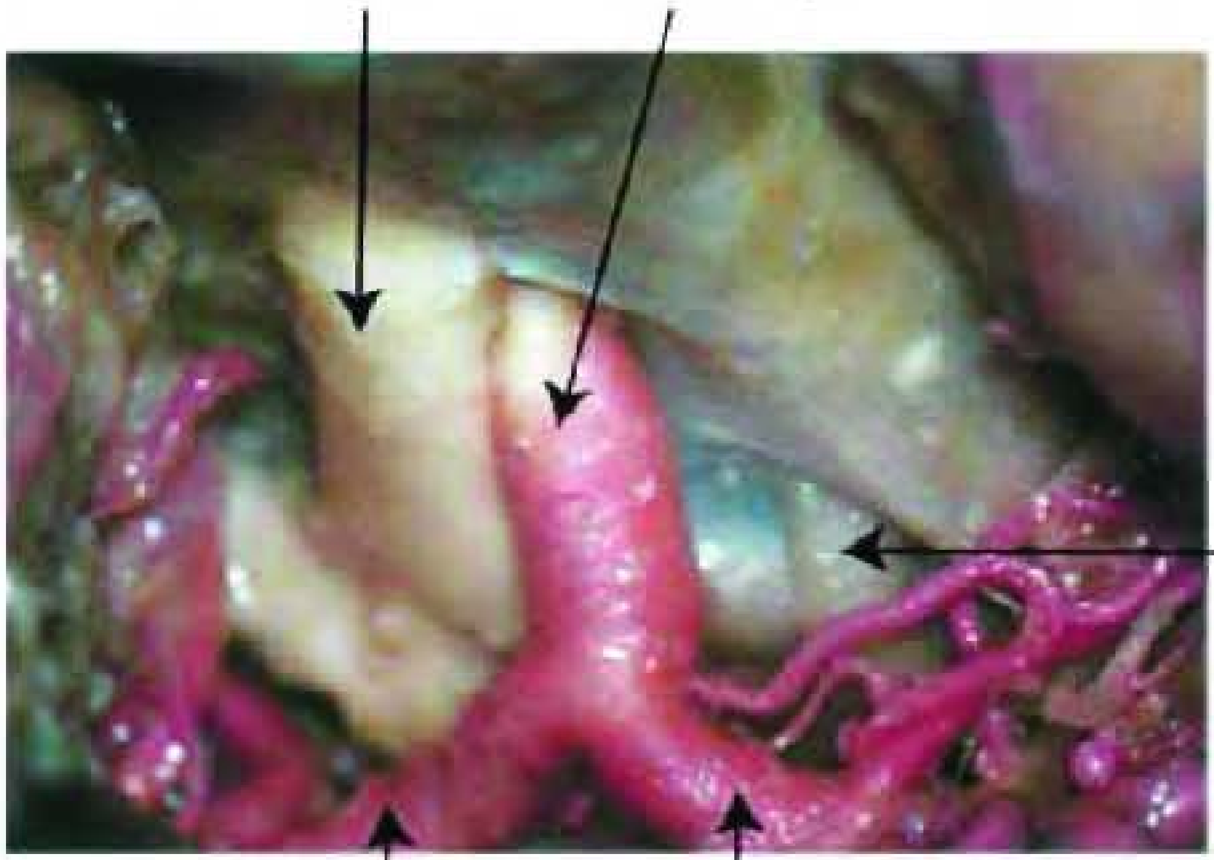


FIGURE 3–12 The optic nerve and carotid artery are visualized. CN, cranial nerve.

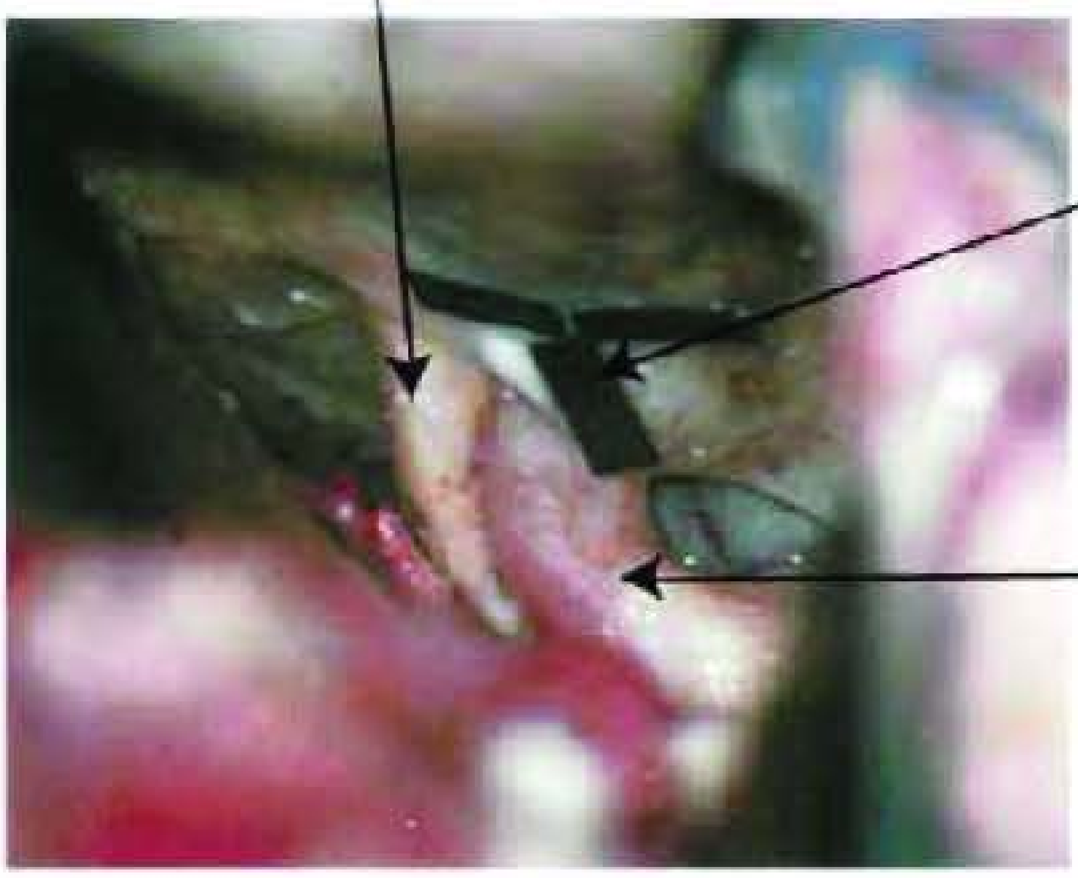


FIGURE 3–13 The T-shaped incision is outlined.

with the carotid and optic nerve under direct vision. The dura inferior to the clinoid process is contiguous with the distal dural ring. The optic strut is resected and the falciform ligament opened to allow mobilization of the optic nerve if necessary. The distal dural ring can be opened to expose the proximal segment of the ophthalmic artery as well as the paraclinoid carotid artery (Figs. 3–15 and 3–16).

For lesions in the middle cranial fossa, a wide opening of the sylvian fissure, coupled with resection of the zygoma, allows posterior, superior, and lateral retraction as needed on the temporal lobe. This allows structures along the floor and on the medial margin of the middle fossa, such as the cavernous sinus, gasserian ganglion, and branches of the fifth Cranial nerve to be identified and approached. The petrous carotid can be exposed using this approach. The anatomy in this region is presented in a later chapter.

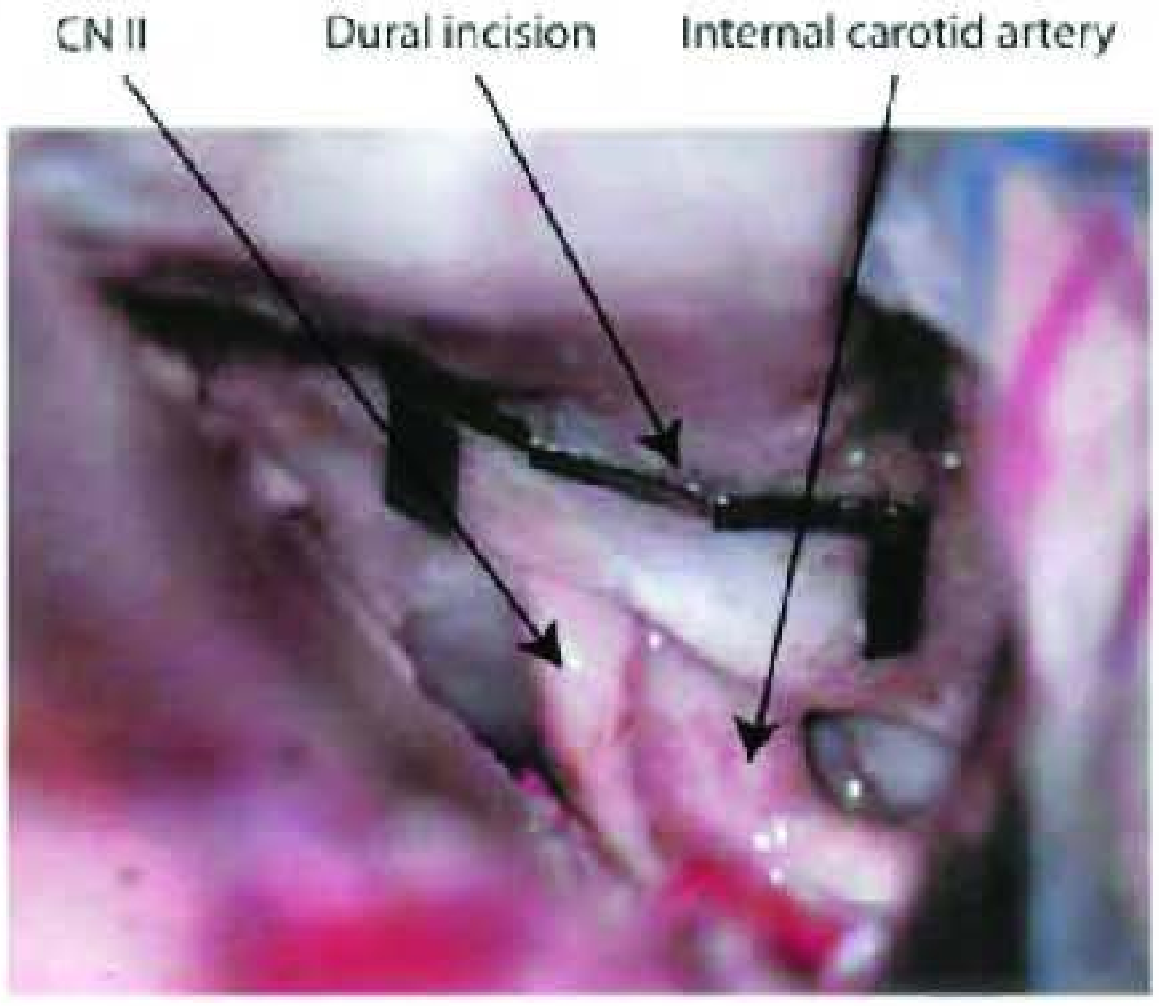


FIGURE 3–14 The U-shaped incision is outlined. CN, cranial nerve.

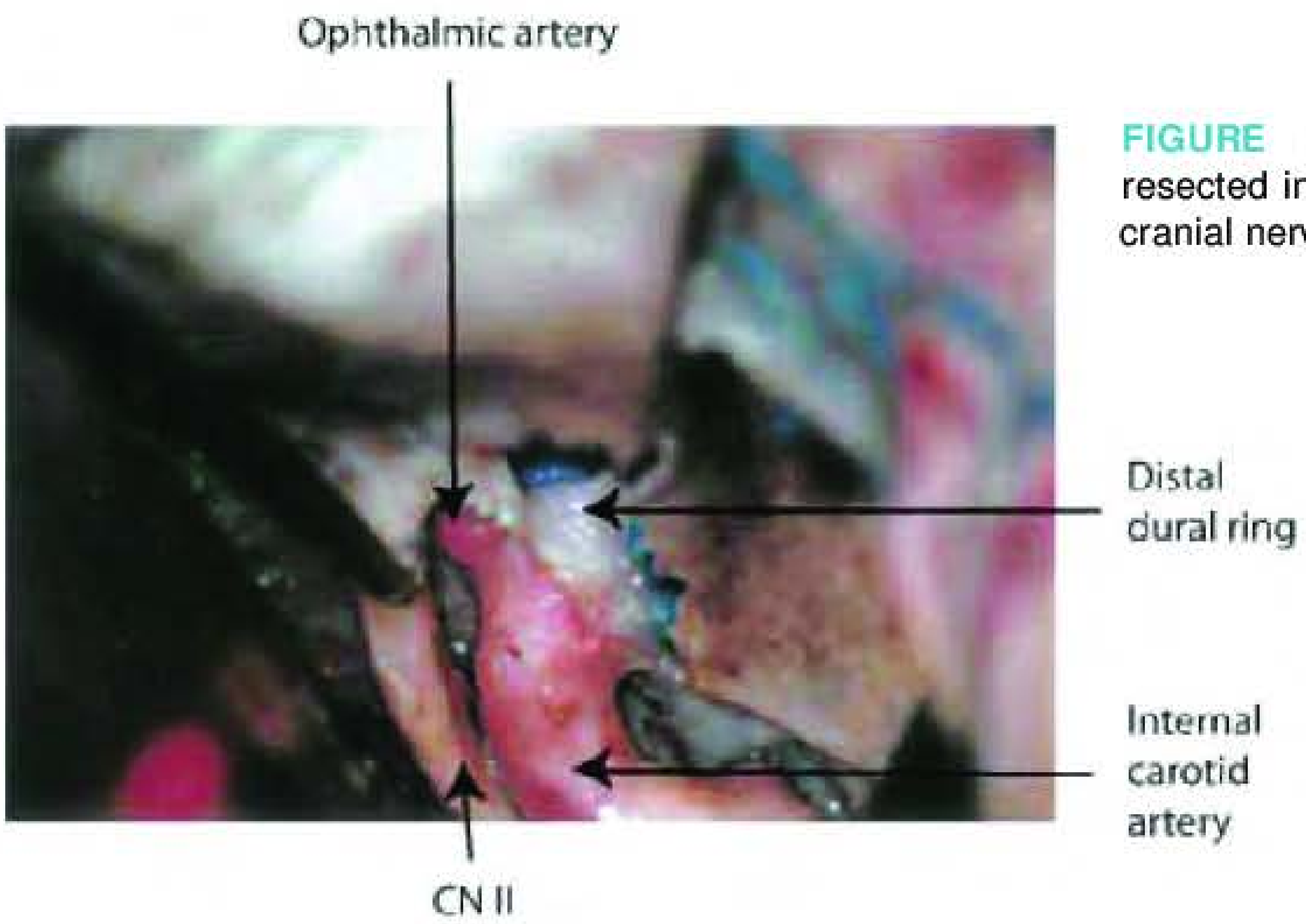


FIGURE 3–15 The anterior clinoid process (ACP) has been resected intradurally, and the ophthalmic artery is visualized. CN, cranial nerve.

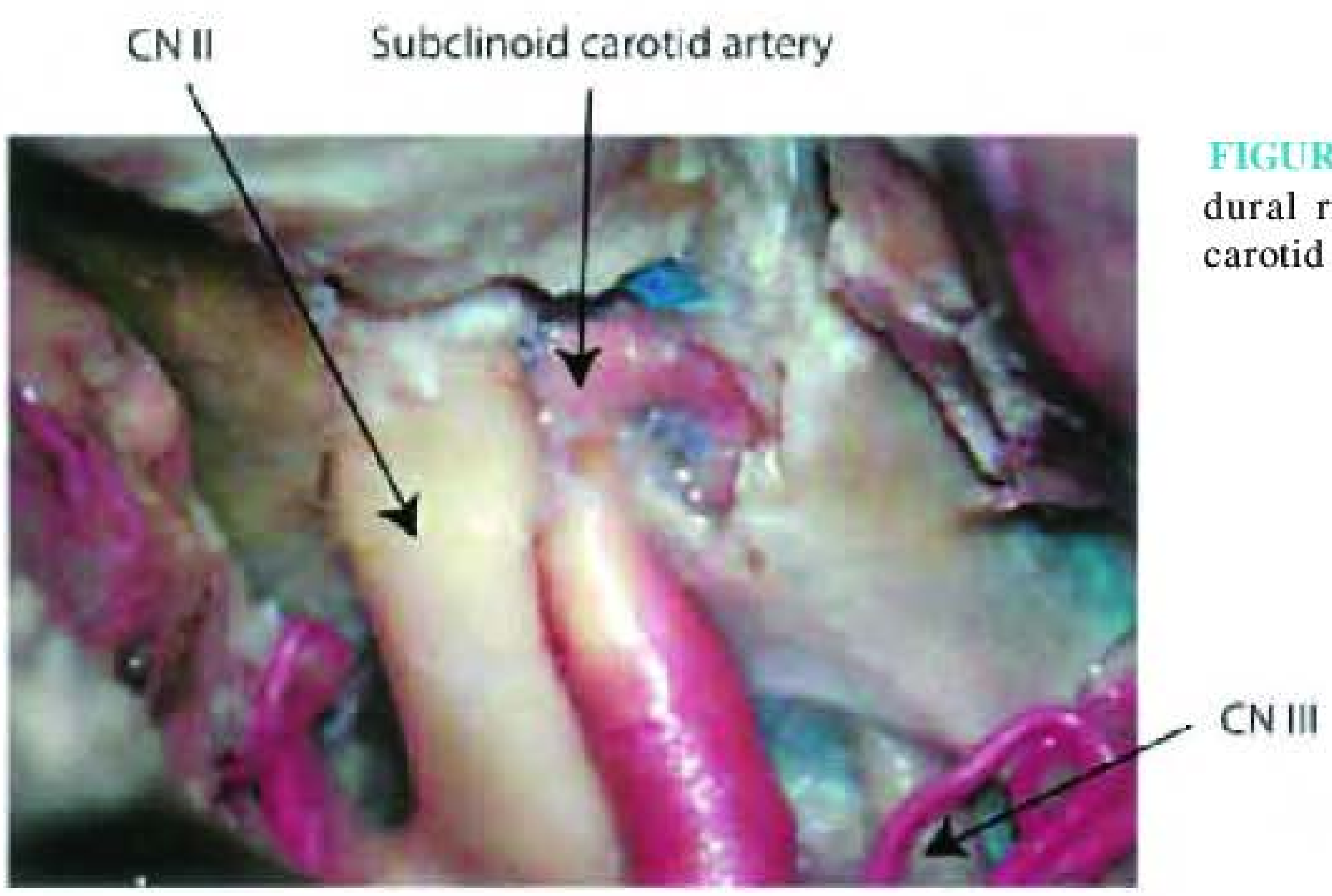


FIGURE 3–16 The clinoid has been drilled away and the distal dural ring opened to expose the clinoidal segment of the internal carotid artery.

PITFALLS, PEARLS, CONSIDERATIONS

- Injury to branches of the facial nerve by skin incision carried too inferior to the zygoma or too anterior to the tragus
- Injury to supraorbital nerve
- Enophthalmos if orbital roof cut is not deep enough within the orbit
- Vascular injury with complete extradural resection of the ACP
- Tearing of bridging veins
- Eye injury with poor osteotomy technique
- Frontal lobe retraction injury

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Chapter 4

Anterior Communicating Complex and Heubner's Artery

Emel Avci, Yalcin Kocaogullar, Damirez Fossett

Detailed knowledge of the microsurgical anatomy of the anterior communicating artery (AComA) and its perforating branches is important when performing the interhemispheric, translamina terminalis, subfrontal, or pterional approaches for neoplastic or vascular pathology (Fig. 4–1). The anterior communicating artery (AComA) is one of the most frequent sites of formation of saccular aneurysms with a reported incidence between 19 and 84%. For AComA aneurysms, as well as other parasellar pathology, detailed knowledge of the anatomy of the AComA complex, early recognition of anomalous AComA anatomy, and preservation of perforating branches are imperative.

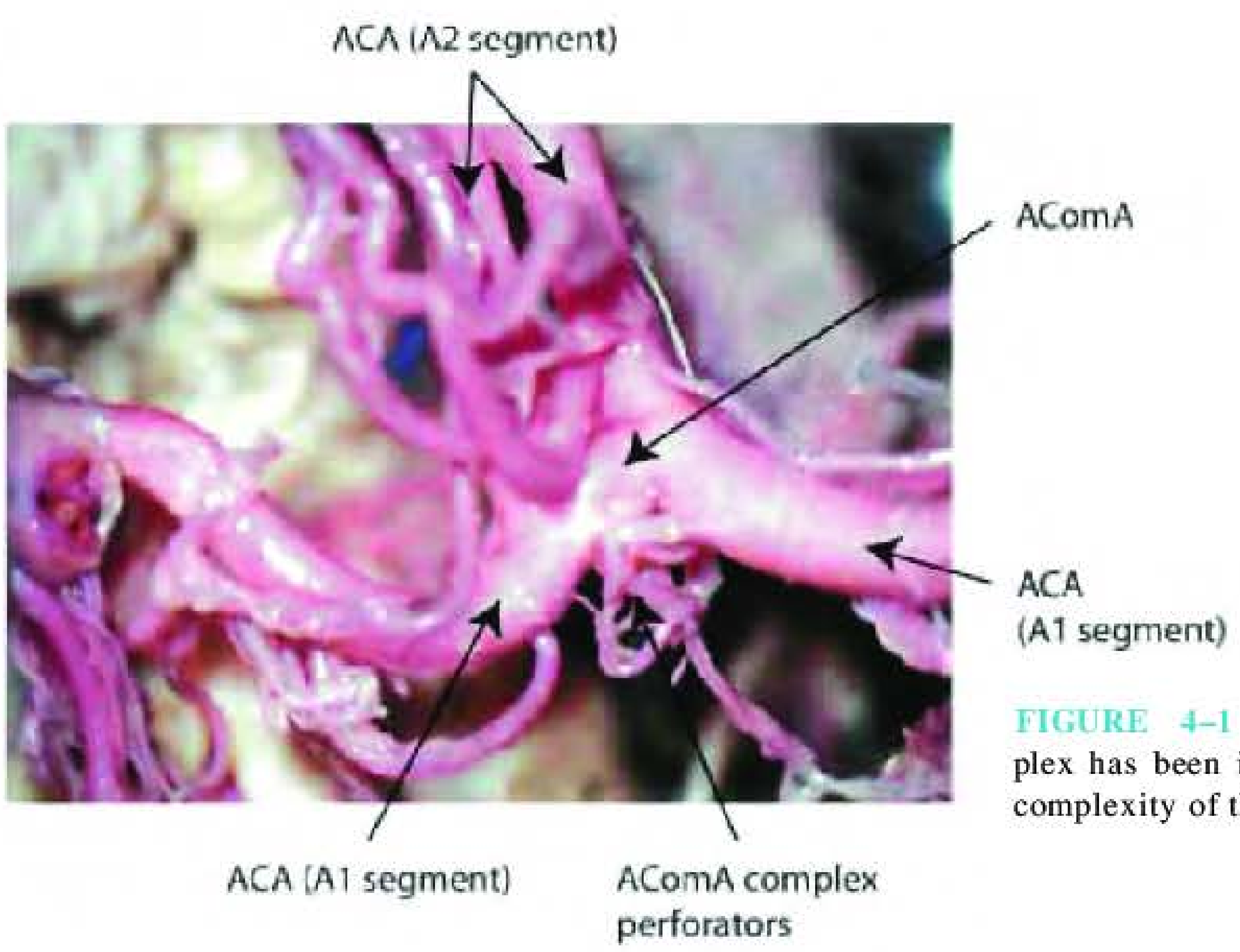


FIGURE 4–1 The complete anterior cerebral artery (ACA) complex has been isolated from the brain to demonstrate the vascular complexity of the region. AComA, anterior communicating artery.

ANATOMIC CONSIDERATIONS

ACOMA COMPLEX

A normal AComA is defined as a single lumen vessel that connects the right and left anterior cerebral arteries (ACA) (Fig. 4–2A, B). Its length ranges from 0.1 to 3 mm. An anomalous AComA complex is observed in up to 25 to 60% of the population. Such anomalies include duplication, triplication, and fenestration of the AComA. They also include the presence of a plexiform AComA or fusion of a

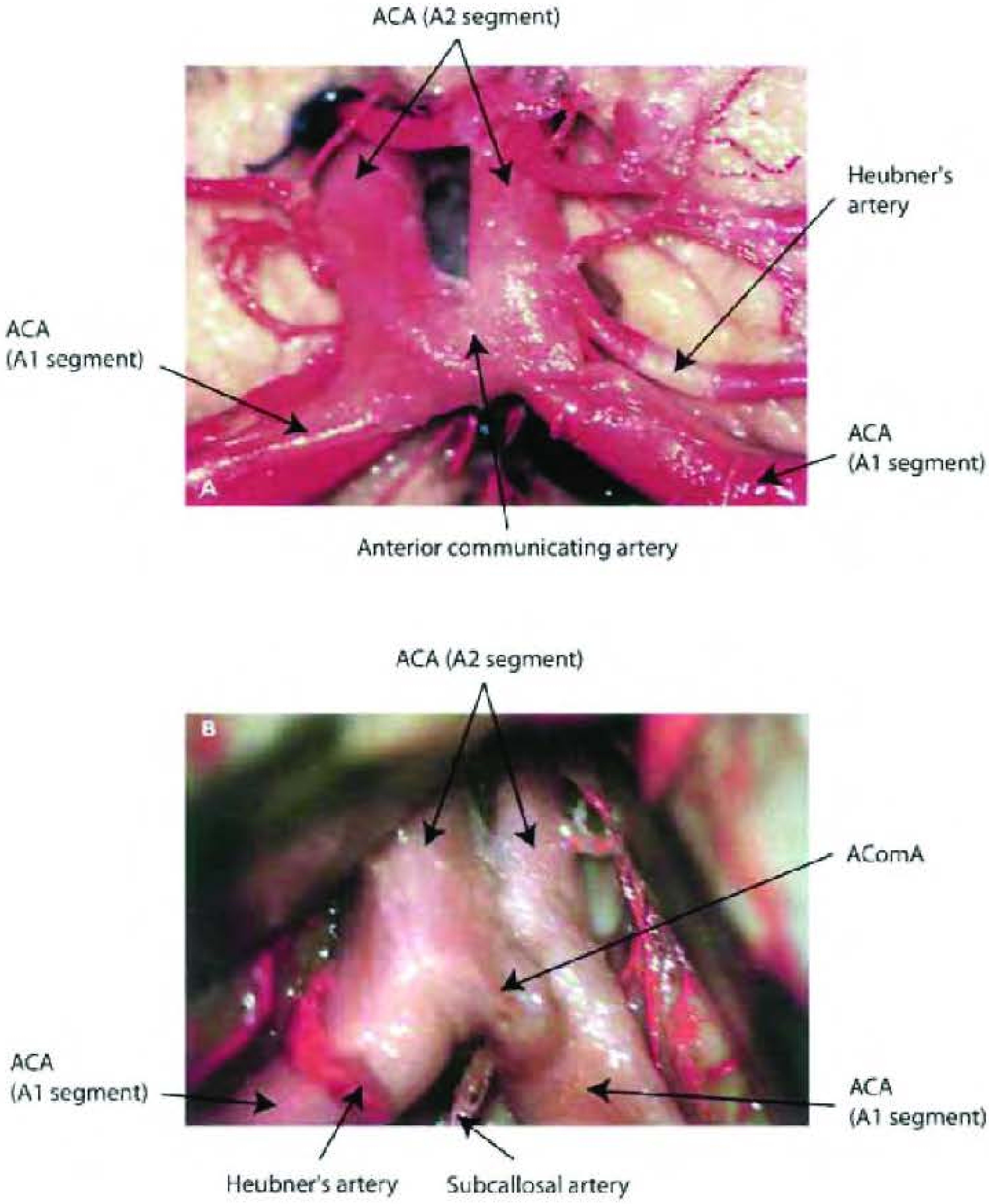
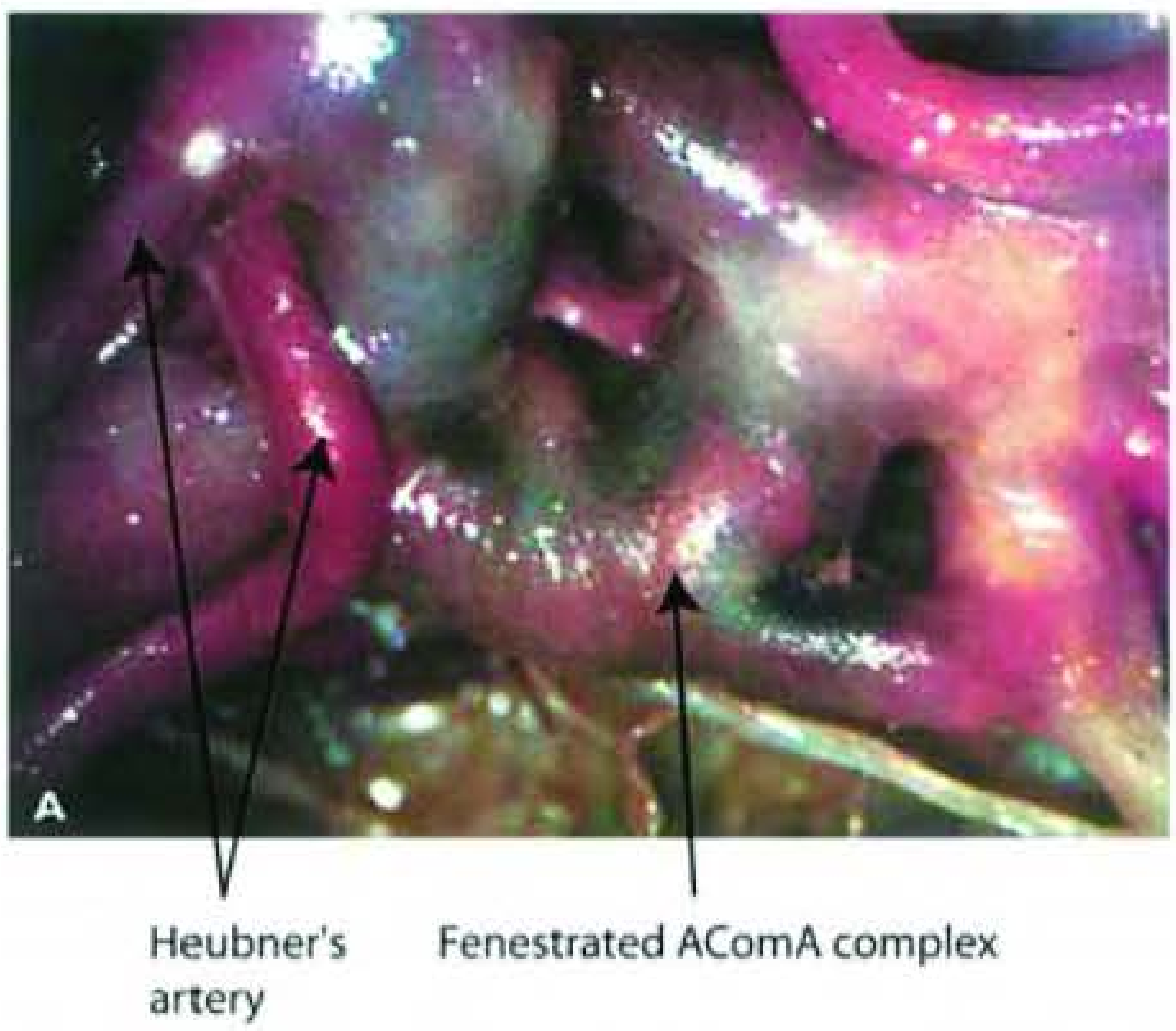
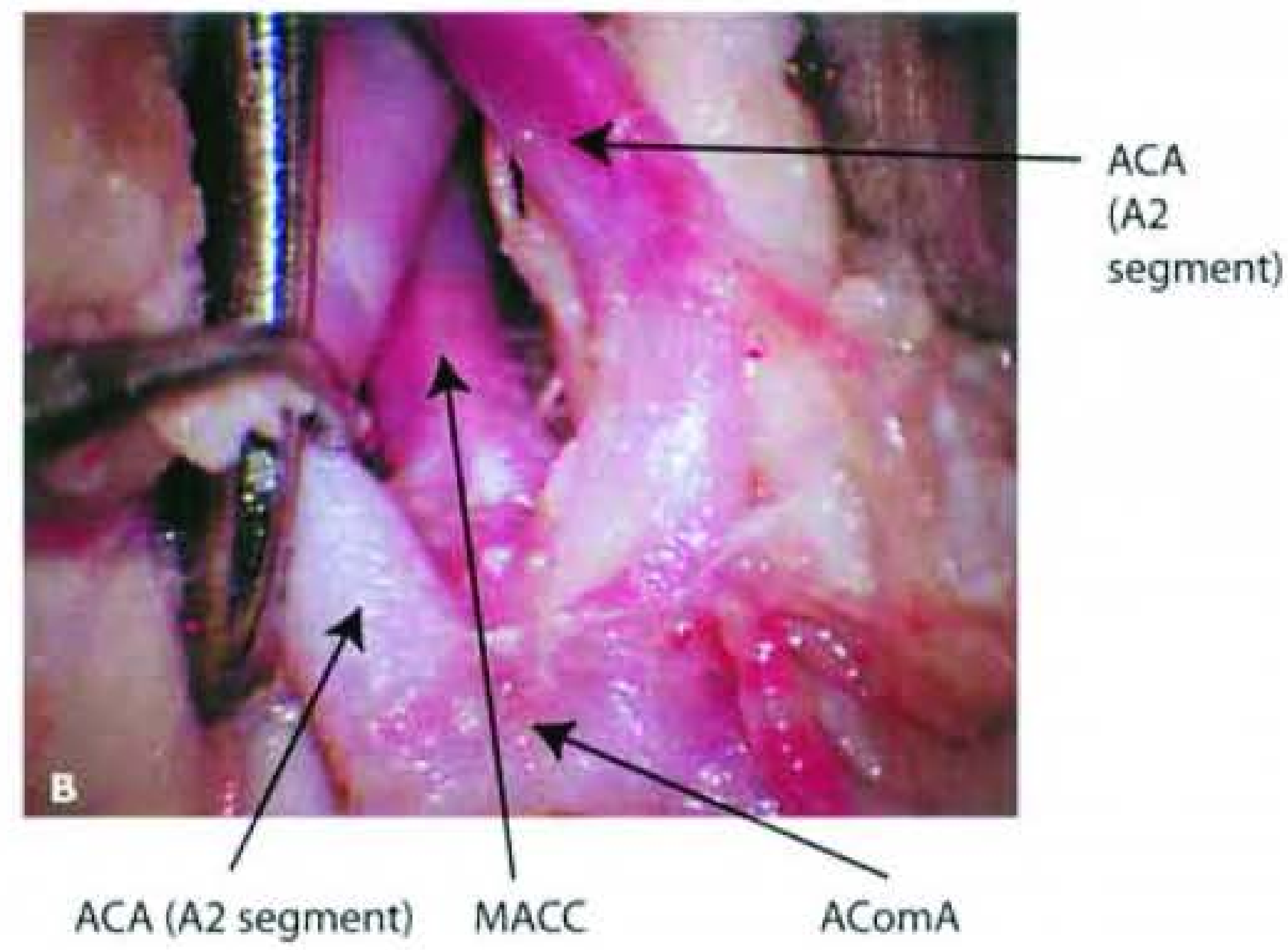


FIGURE 4–2 **A:** The normal anterior communicating artery (AComA) complex is seen. Heubner's artery is seen arising from the proximal A2. **B:** High-power view of the normal AComA, ACA, anterior cerebral artery.

multichanneled AComA with a dimple (Fig. 4–3A). A median artery of the corpus callosum (MACC) (Fig. 4–3B) or an azygous anterior cerebral artery (Fig. 4–3C) sometimes is found. Occasionally, multiple anomalies arise within the same AComA complex (Fig. 4–4). It should be kept in mind that an anomalous AComA complex is observed at a higher frequency in surgical cases. Such anomalies may be a predisposing factor in the formation of AComA region aneurysms.





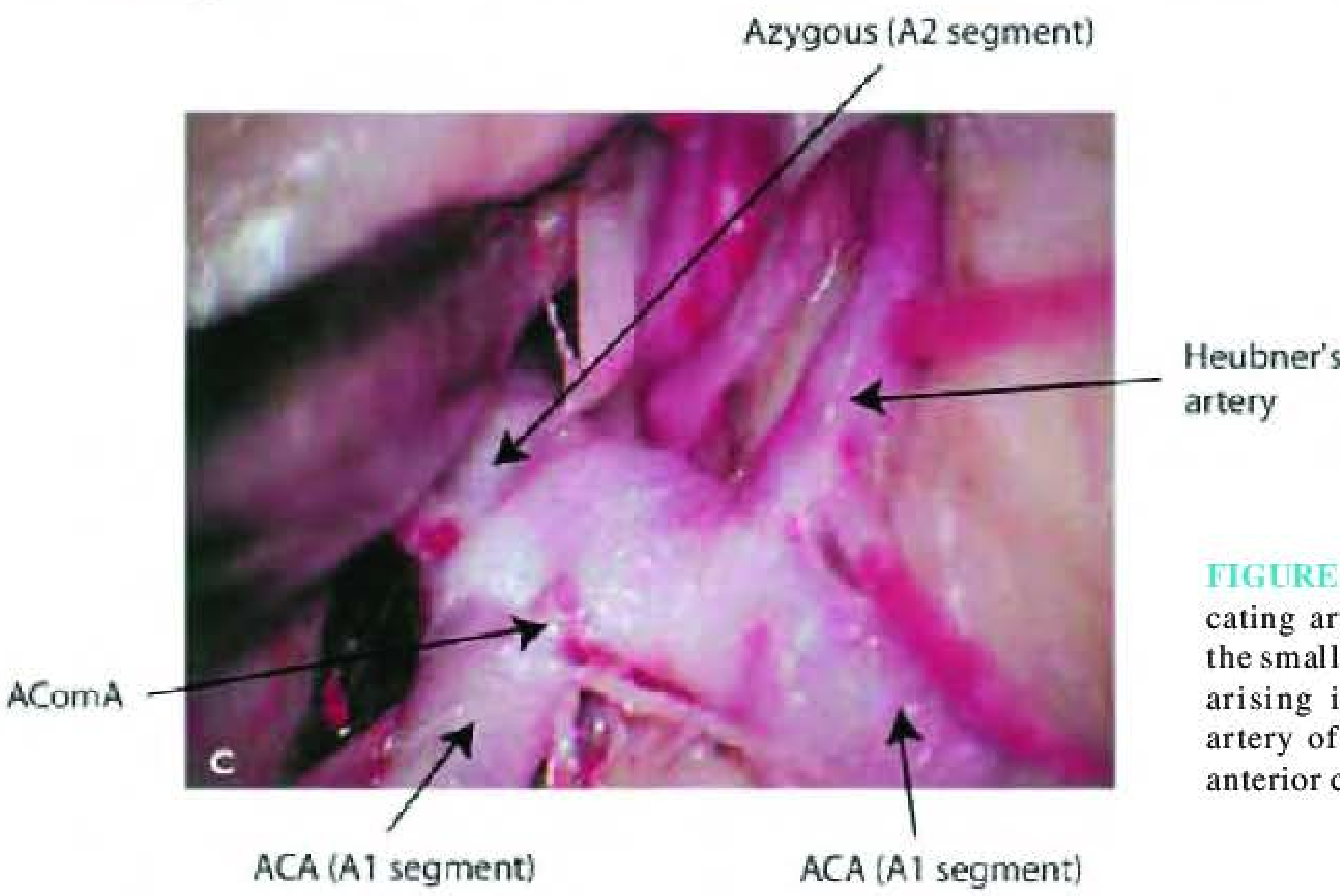


FIGURE 4–3 **A:** A fenestrated anterior communicating artery (AComA) complex. The first channel is the smaller of the two. Two Heubner arteries are seen arising ipsilaterally from the AComA. **B:** Median artery of the corpus callosum (MACC). **C:** Azygous anterior cerebral artery. ACA, anterior cerebral artery.

Perforating brandies of the AComA are always present. They range in number from one to six. The site of origin of the AComA perforators is related to variations in the anatomy of the A1 segments of the ACAs. If the A1 arteries are of equal size, the AComA perforators will originate from the midpoint of the AComA. If they are not of equal size, the perforators will arise from the AComA on the side ipsilateral to the larger A1 segment. Anomalous perforating region anatomy may coexist with an anomalous AComA complex.

Perforating branches of the AComA are classified as subcallosal, hypothalamic, or chiasmatic. These branches supply regions bearing the same names. The subcallosal region includes the rostrum and genu of the corpus callosum, the anterior commissure, the anterior cingulate gyrus, the parolfactory and paraterminal gyri, the septum pellucidum, and the columns of the fornix. The hypothalamic region consists of the anterior hypothalamus and lamina terminalis. The chiasmatic area is composed of the optic chiasm and the superior part of the optic nerve.

The subcallosal branch is typically a single vessel and is the largest perforating branch. It usually originates from the posterior or posterosuperior aspect of the AComA. It terminates bilaterally within the callosal areas by anastomosing with hypothalamic branches. Absence of a subcallosal perforating branch, a median artery of the MACC, or an azygous ACA may be seen. The MACC terminates beyond the genu of the corpus callosum and feeds the dorsal parts of the cingulate gyrus and occasionally the paracentral lobule of the right and/or left hemisphere. An azygous ACA will send feeding branches to the subcallosal area.

Hypothalamic branches originate from the posterior or posteroinferior aspect of the AComA. These branches supply the hypothalamic area and anastomose with a subcallosal branch.

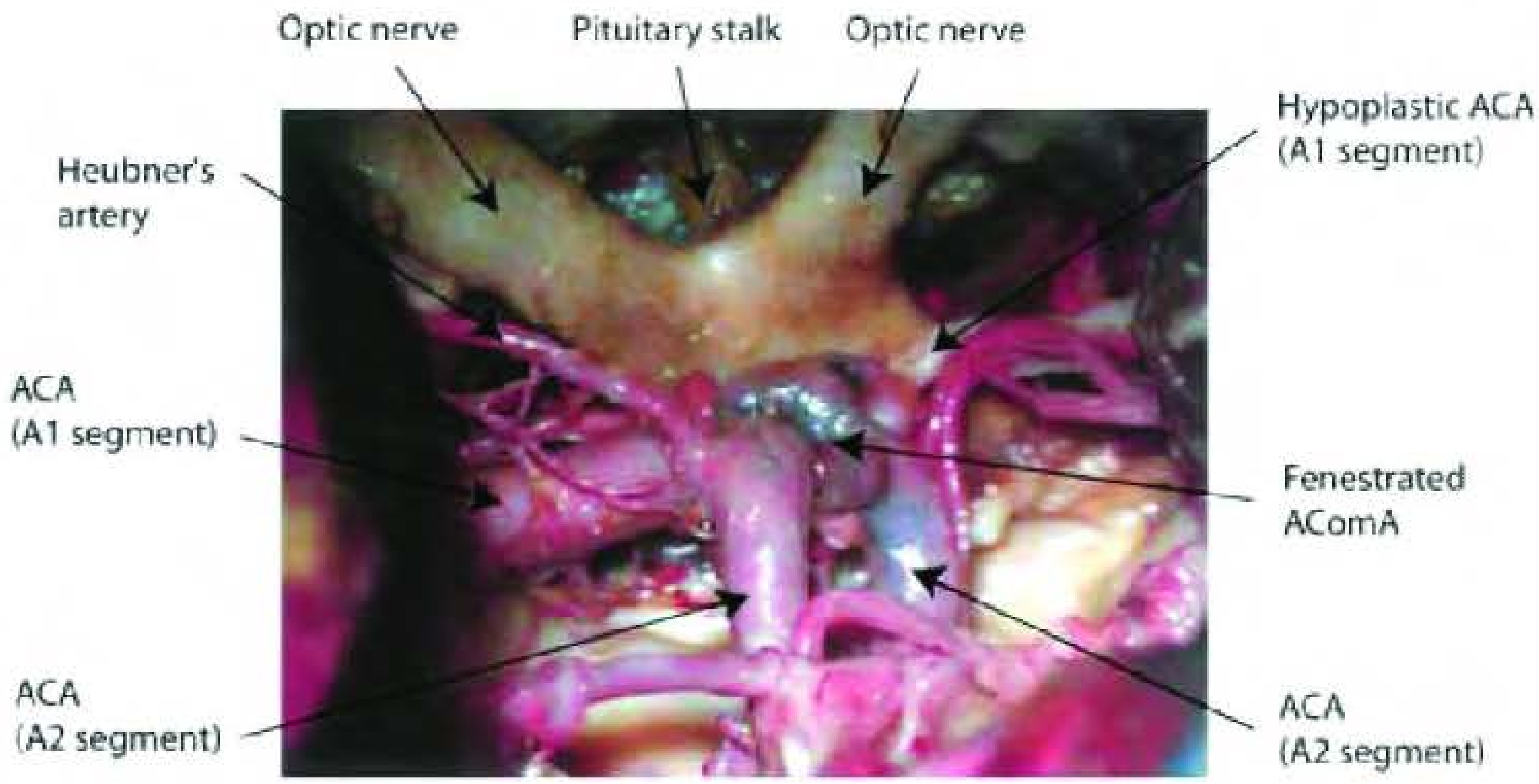


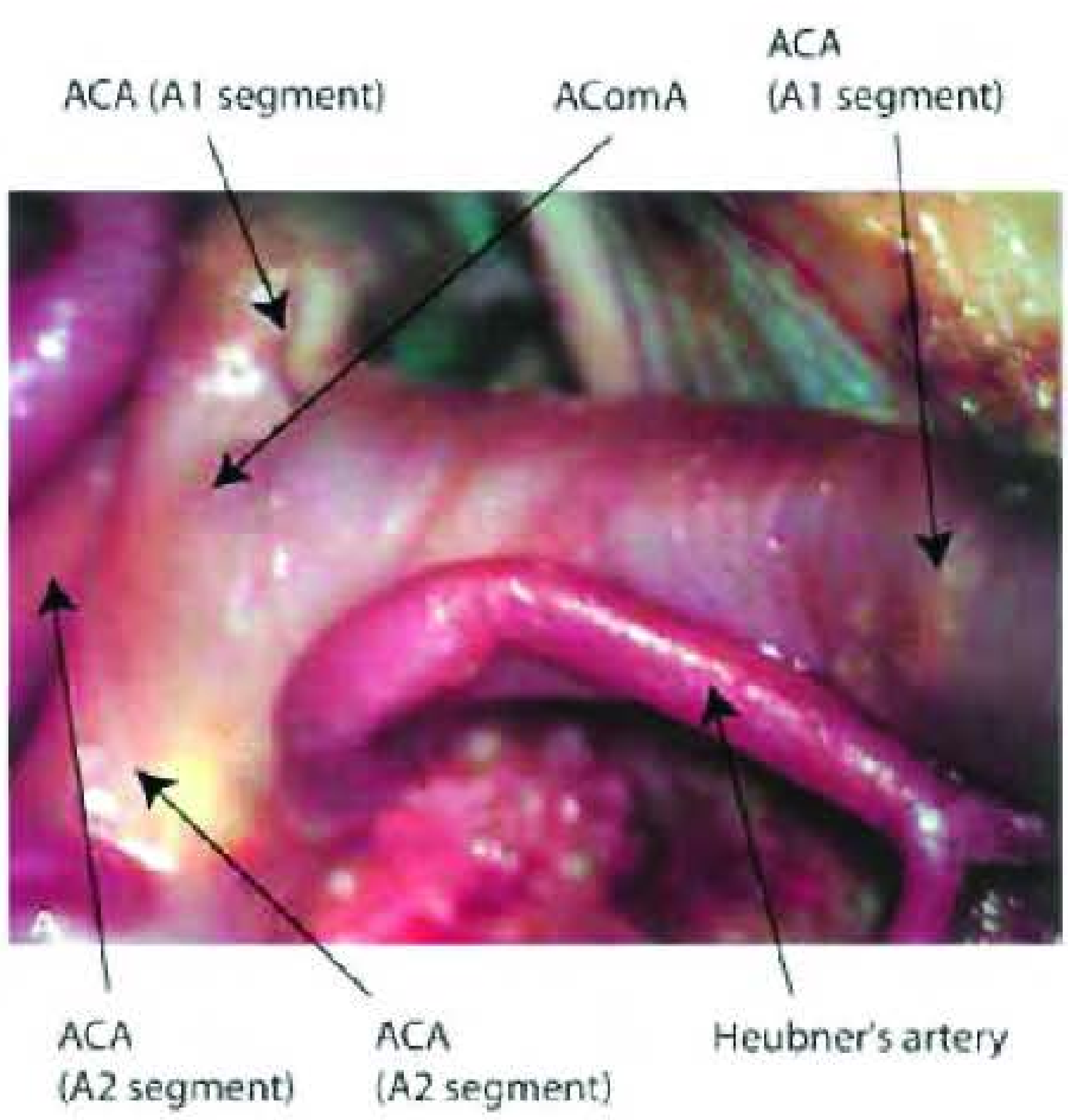
FIGURE 4–4 A fenestrated anterior communication artery (AComA). The optic chiasm is visualized as are both A2 branches. The contralateral A1 is hypoplastic, and the ipsilateral A1 is hyperplastic. ACA, anterior cerebral artery.

Chiasmatic branches have a very small diameter. They originate from the posteroinferior aspect of the AComA and terminate at the superior surface of the optic chiasm and optic nerve. The chiasmatic area is supplied mostly by branches of the ACAs.

ARTERY OF HEUBNER

During any approach to the AComA complex, the recurrent artery of Heubner should be identified and protected. Heubner's artery is of surgical significance because, to a varying degree, it supplies the anterior–inferior striatum, anterior limb of the internal capsule, olfactory region, and anterior hypothalamus. Injury to Heubner's artery, because of its inconsistent feeding pattern, can lead to varying degrees of postsurgical neurologic compromise. The recurrent artery arises most frequently from the A2 segment of the ACA, less frequently from the ACA-AComA junction, and rarely from the A1 segment of the ACA (Fig. 4–5A, B).

Three courses of this artery have been described. In type J, or the superior course, the recurrent artery follows the superior wall of the A1 segment. It then loops over the carotid bifurcation and perforates the brain lateral to the middle cerebral artery (MCA). In type II, or the anterior course, the artery maintains an anterior position in relation to the A1 segment. It loops over the carotid bifurcation and penetrates the brain lateral to the MCA. In the type III, or posterior course, the artery takes a posterior course into the anterior perforated substance (Fig. 4–6).



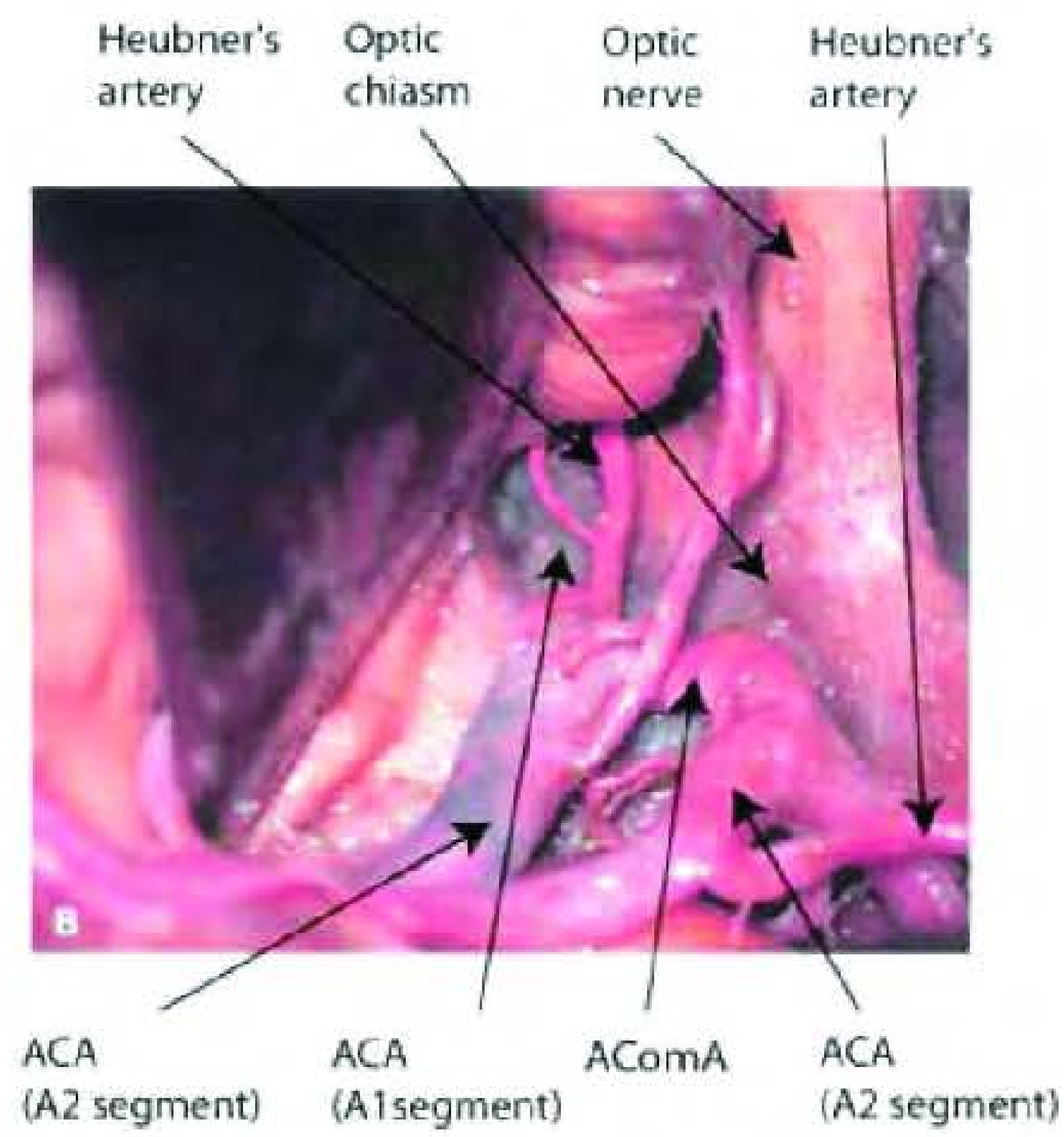


FIGURE 4–5 **A:** Heubner's artery is seen arising from the A1–2 junction. **B:** Both A2 branches are well visualized at this normal anterior communicating artery (AComA) complex. The ipsilateral Heubner is arising very distally on A2. ACA, anterior cerebral artery.

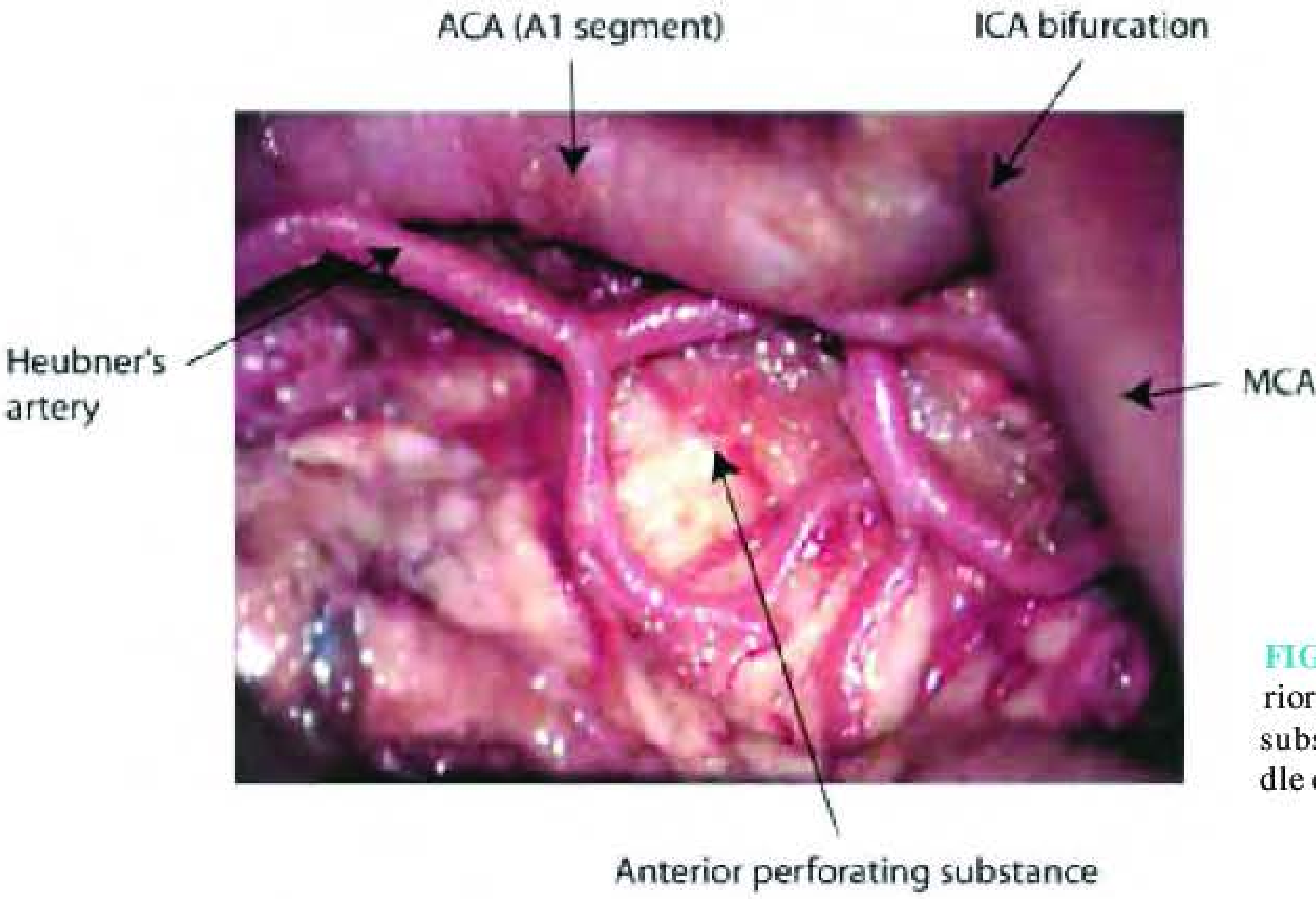


FIGURE 4–6 This Heubner's artery courses posteriorly and branches to supply the anterior perforating substance. ACA, anterior cerebral artery; MCA, middle cerebral artery; ICA, internal carotid artery.

PITFALLS, PEARLS, CONSIDERATIONS

- The AComA complex is often anomalous in nature, which may predispose to vascular pathology.
- Identification of Heubner's artery is imperative because the region it supplies is variable, and inadvertent injury may result in neurologic morbidity.

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Chapter 5

Sylvian Fissure Anatomy and the Transylvian Approach

Emel Avci, Amitabha Chanda, Damirez Fossett

Indications for Approach

- Exposure of the basal cisterns and the enclosed pathoanatomy
- Exposure of the insular cortex and upper anterior brainstem

Sylvian Fissure Anatomy

The sylvian fissure separates the frontal and temporal lobes (Fig. 5–1A). It has both a superficial and a deep component. The superficial component contains a stem and three rami. The stem runs in a medial to lateral direction between the frontal and temporal lobes. The sphenoid ridge projects against the stem of the fissure. The three rami are called the *posterior, anterior ascending,* and *anterior horizontal rami.* The posterior ramus extends posteriorly lying between the frontal and parietal lobes superiorly and the temporal lobe inferiorly. The anterior ascending and anterior horizontal rami divide the inferior frontal gyrus into three parts from anterior to posterior: the pars orbitalis, pars triangularis, and pars opercularis.

The deep component of the sylvian fissure is divided into two compartments; the anterior or sphenoidal compartment and the posterior or operculoinsular compartment. The anterior compartment is that part posterior to the sphenoid ridge between the frontal and temporal lobes. It communicates medially with the carotid and the chiasmatic cistern directly and contains the Ml segment of the middle cerebral artery (MCA). The posterior compartment is composed of two clefts that are oriented orthogonally. The vertical and deeper insular cleft lies between the insula and the operculum and has both an inferior limb adjacent to the temporal lobe and a superior limb that is adjacent to the frontal lobe. The more horizontal and superficial opercular cleft lies between the opposing parts of the frontoparietal and temporal opercula and houses the M2 and M3 segments of the MCA.

The Ml or sphenoidal segment of the MCA begins at the carotid bifurcation and runs laterally within the depths of the sylvian fissure. This segment bifurcates at its genu by turning 90 degrees upward. The branches of the Ml segment include the lenticulostriate vessels, which arise from the posteroinferior part of the Ml segment, the anterior temporal branch, and the temporopolar branch.

The M2 or insular segments lie on and are the blood supply to the insula. Anterior branches of the M2 segments have a shorter course before emerging from the insula than do posterior branches. The anterior frontal and anterior temporal branches cross only the anterior part of the insula. Posterior branches, such as the angular branch, course along the length of the insula, crossing the short gyrus, the circular sulcus, and the long gyrus, before leaving the insular surface.

The M3 or opercular segment begins at the circular sulcus and ends at the surface of the sylvian fissure. The branches that supply brain superior to the sylvian fissure undergo two 180-degree turns. The first turn is at the circular sulcus, where the vessels coursing upward over the insular surface turn 180 degrees and pass downward over the surface of the frontoparietal operculum. They turn again at the external surface of the sylvian fissure, where the branches pass around the frontoparietal operculum and run superiorly. The arteries that supply the cortex below the sylvian fissure have a less tortuous course. After reaching the circular sulcus, they turn upward and laterally on the medial surface of the temporal operculum. On reaching the external surface of the sylvian fissure, they turn downward (Fig. 5–1B).

Positioning and Skin Incision

The patient is placed supine in three-point fixation using the Mayfield system. The head is rotated 20 to 30 degrees toward the contralateral shoulder, flexed so that the chin points toward the clavicle, and gently extended such that the maxillary eminence is at the apex of the field. The skin incision is a unilateral, curvilinear incision. A standard frontotemporal or peritoneal approach as described in Chapter 2 is performed.

Surgical Technique

The dura is opened in the classic C-shaped fashion, with its base at the sphenoid ridge. It is held retracted by stay sutures. Occasionally, relaxing incisions must be made in the dura to allow access to all parts of the sylvian fissure. Once the dura is opened, the posterior limb of the superficial part of the sylvian fissure comes into view, separating the frontal and temporal lobes (Fig. 5–2).

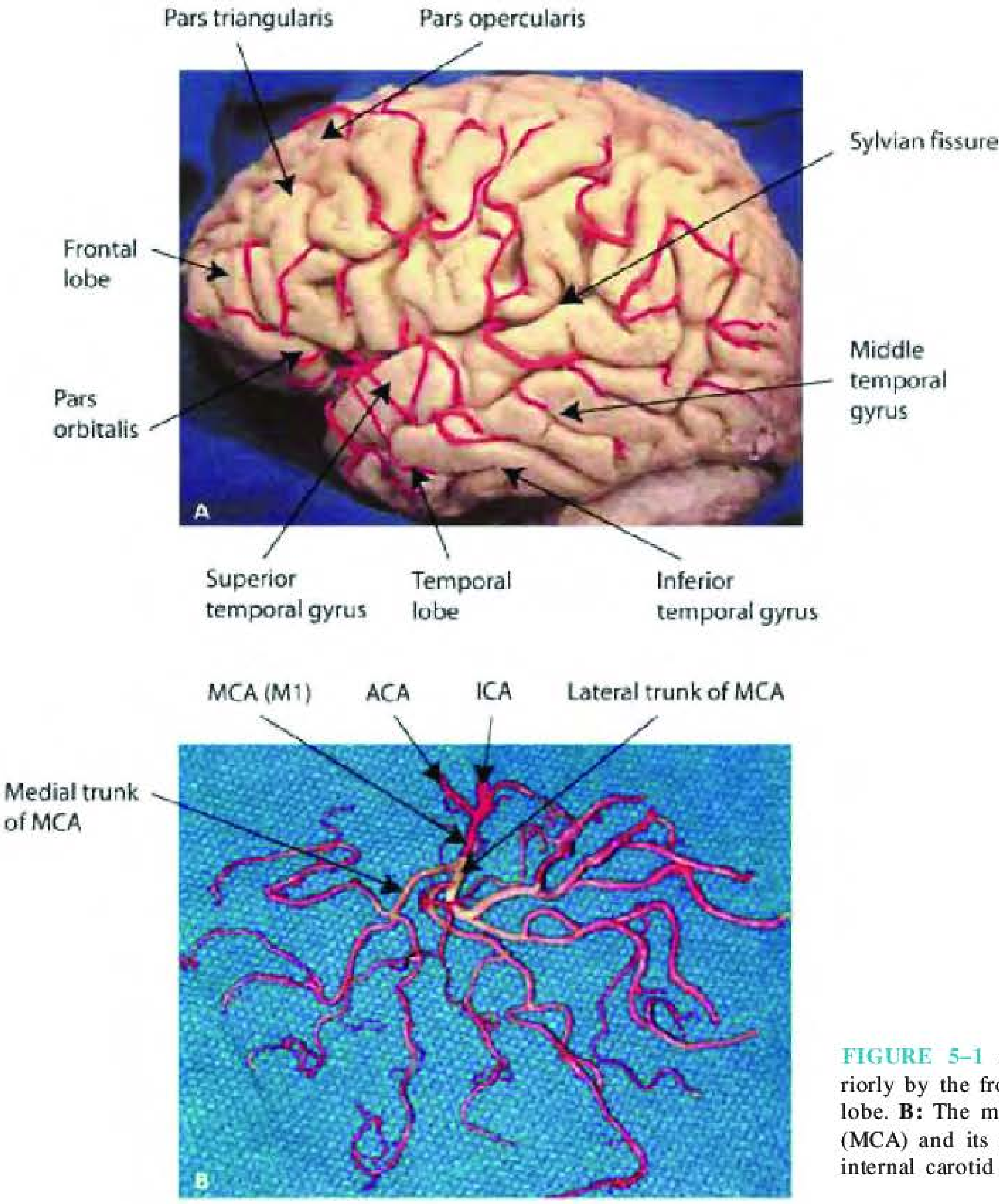

FIGURE 5–1 **A:** The sylvian fissure is bordered superiorly by the frontal lobe and inferiorly by the temporal lobe. **B:** The main trunk of the middle cerebral artery (MCA) and its major branches have been isolated. ICA, internal carotid artery; ACA, anterior cerebral artery.

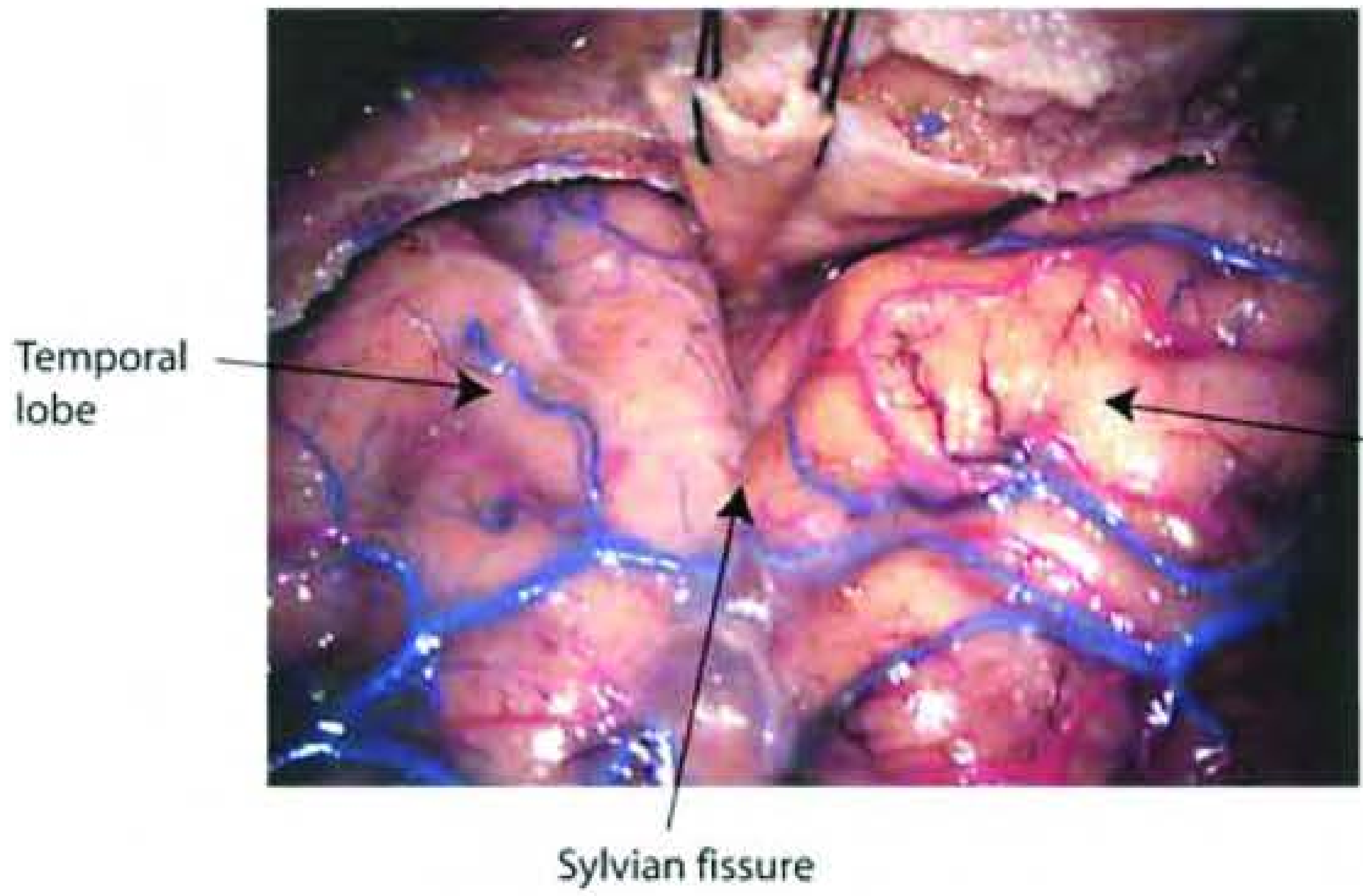

FIGURE 5–2 The frontal and temporal lobes are separated by the sylvian fissure.

For a lateral-to-medial dissection of the fissure, the frontal and temporal lobes of the brain are gently retracted using two self-retaining retractors. The arachnoid over the fissure is incised with an arachnoid knife, and the incision is extended along the posterior genu and stem of the fissure. The arachnoid incision is made superior to the sylvian vein, and the veins are reflected with the temporal lobe. The frontal and temporal lobes are gently separated either by spreading with the tips of the bipolar or by disrupting the arachnoid between two opposing tying forceps. Tethering bands are cut, and veins that cross the fissure are bipolared and sacrificed. As the fissure is gradually opened in this fashion, the branches of the MCA come into view, surrounded by arachnoidal trabeculations. The retractors are gently placed deeper into the wound, the trabeculations are divided, and the distal branches of the MCA are followed deeper into the fissure toward the MCA bifurcation (Fig. 5–3). Proximal to the bifurcation. the M1 segment is visualized. The lenticulostriate vessels arising from the M1 segment are easily visible and should be preserved (Fig. 5–4). Further dissection deeper into the fissure exposes the internal carotid artery (ICA) bifurcation (Figs. 5–5 and 5–6). Gentle but deliberate use of the retractors, combined with sharp separation of the arachnoid, allows the visualization, identification, and access to the carotid, chiasmatic, and interpeduncular cisterns and the anatomy housed within regions bordered by these cisterns.

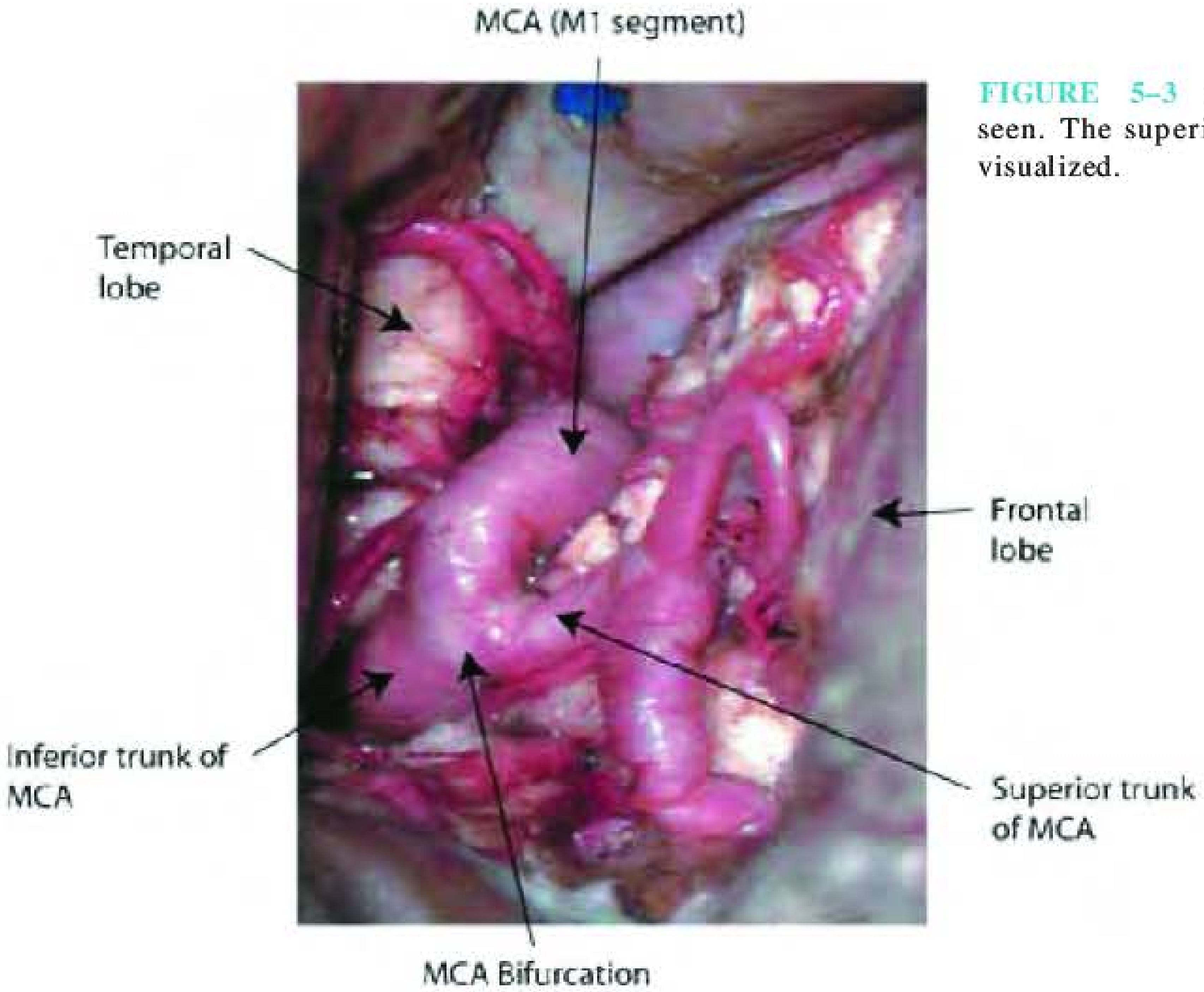

FIGURE 5–3 The middle cerebral artery (MCA) bifurcation is seen. The superior and inferior trunks (M2 branches) are well visualized.

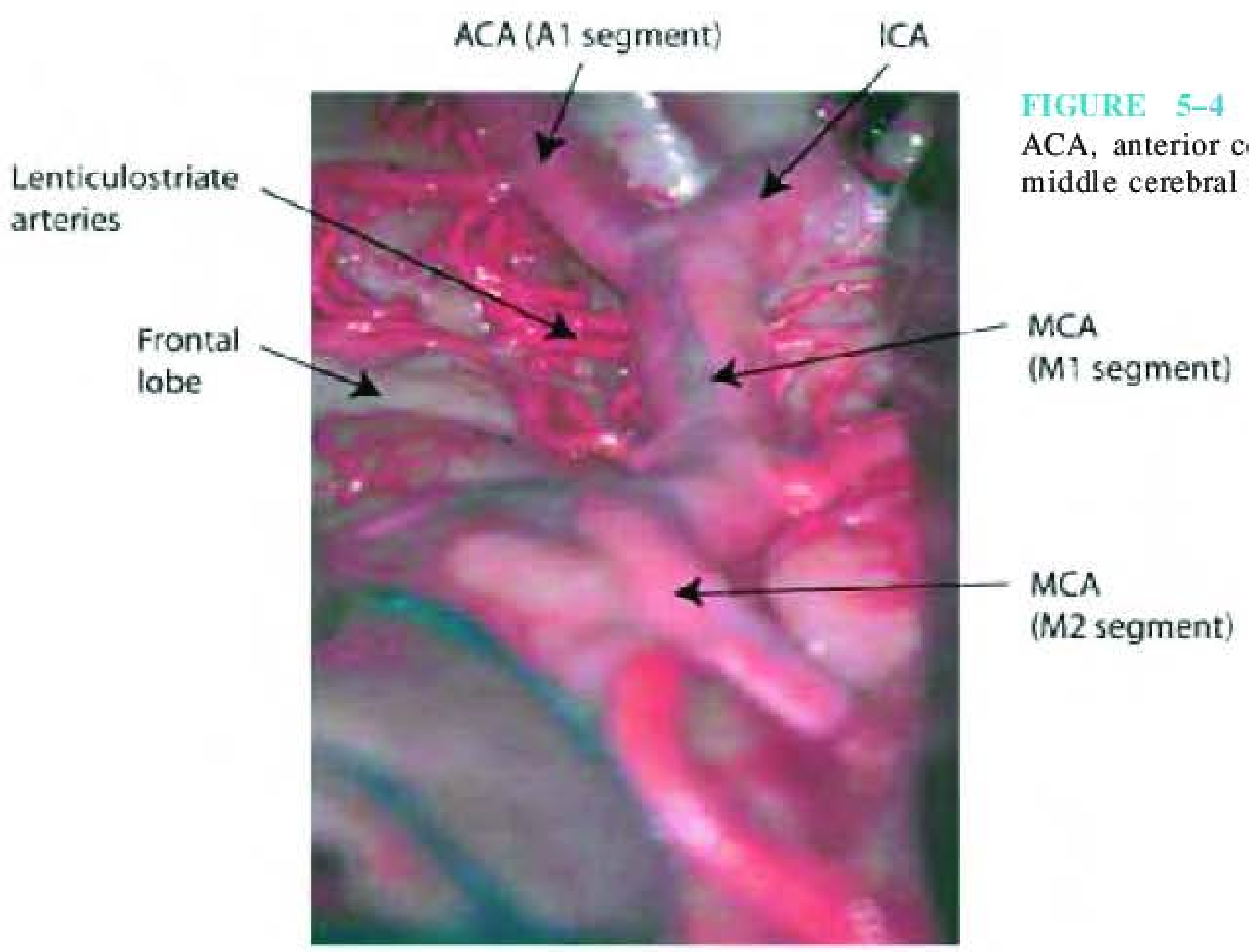

FIGURE 5–4 The lenticulostriate branches from M1 are shown. ACA, anterior cerebral artery; ICA, internal carotid artery; MCA, middle cerebral artery.

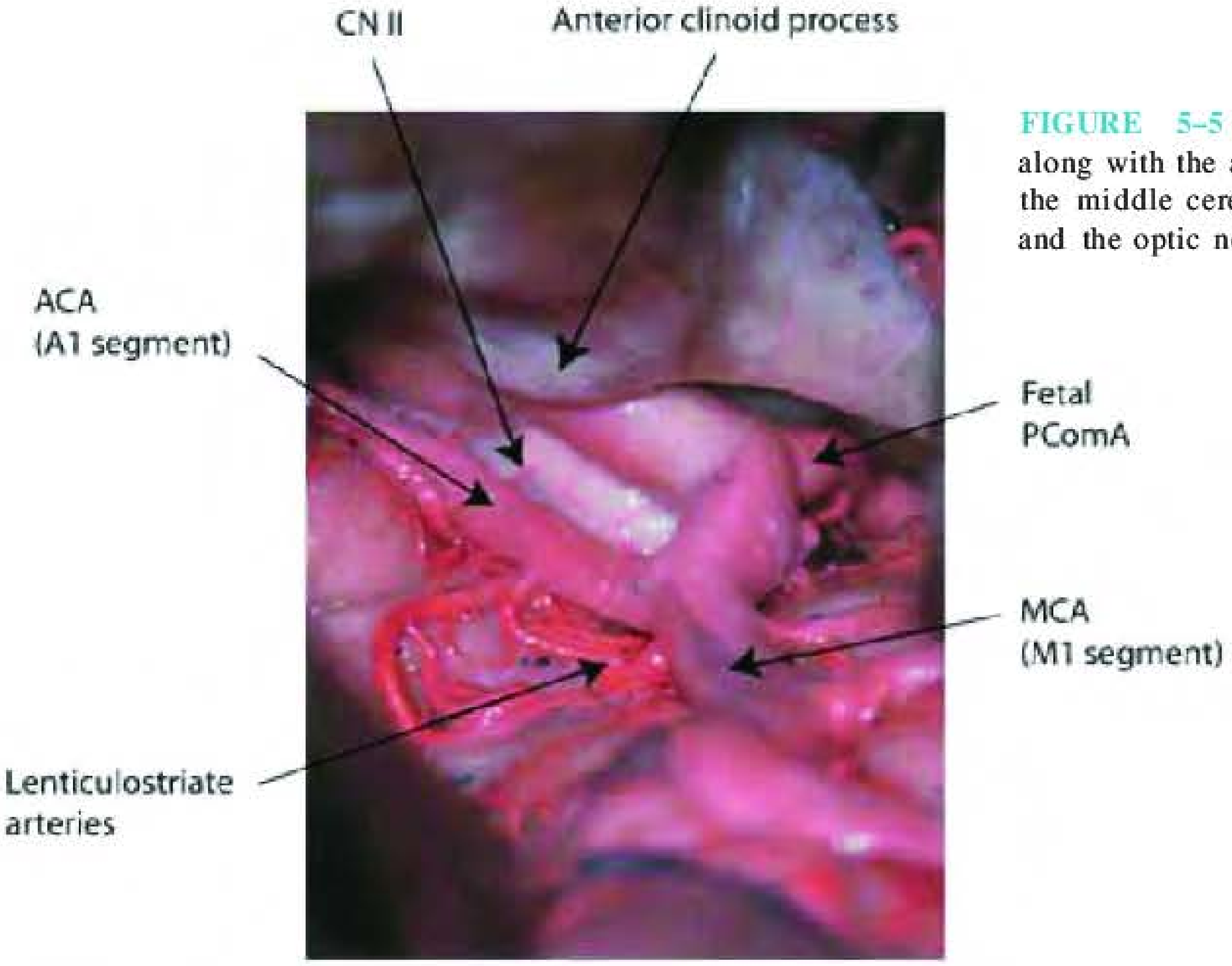

FIGURE 5–5 A fetal posterior communicating artery (PComA) along with the anterior cerebral artery (ACA), the M1 segment of the middle cerebral artery (MCA), the anterior clinoid process, and the optic nerve are well visualized, CN, cranial nerve.

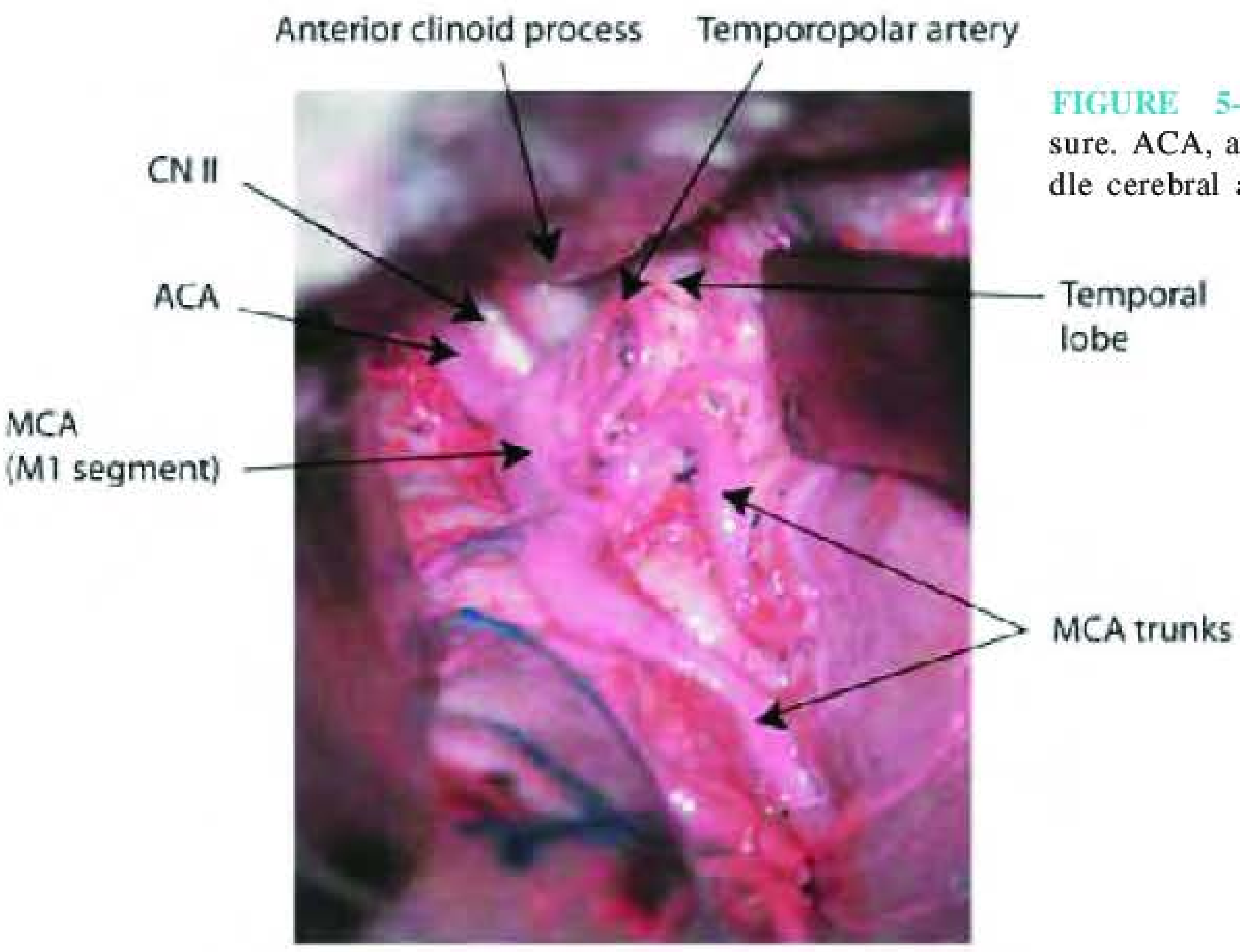

FIGURE 5–6 Panoramic view of the widely opened sylvian fissure. ACA, anterior cerebral artery; CN, cranial nerve; MCA, middle cerebral artery.

PITFALLS, PEARLS, CONSIDERATIONS

- Injury to sylvian vessels, especially veins
- Retraction injuries
- Tearing of bridging veins
- Overdrainage of cerebrospinal fluid and dehydration make a lateral-to-medial dissection more difficult
- Slow, meticulous dissection is bloodless

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Chapter 6

TRANSBASAL APPROACH

Yalcin Kocoagullar, Ali Kurtsoy, Fabio Roberti, Damirez Fossett

INDICATIONS FOR APPROACH

- Extradural midline lesions of the anterior, middle, and posterior fossa
- Paranasal sinus and nasal cavity lesions with intracranial extension

POSITIONING AND SKIN INCISION

The patient is placed in the supine position with the head secured by three-point fixation in the Mayfield headrest (Ohio Medical instrument Co., Cincinnati, OH). The vertex of the skull is extended 10 to 15 degrees toward the floor.

A bicoronal skin incision is fashioned, beginning just anterior to the tragus of the ear (Fig. 6–1). Care is taken not to go below the zygoma or too anterior to the tragus of the ear to avoid superficial branches of the facial nerve. The scalp flap is elevated anteriorly, taking care to preserve the supraorbital nerve as it exits the cranium (Fig. 6–2). A chisel or the Midas Rex (Midas Rex, Fort Worth, Texas) can be used to liberate the nerve and lift it out of the supraorbital foramen or notch. The pericranium is taken up separate from the scalp flap. The pericranium can be incised well behind the posterior edge of the incison if the scalp is dissected posteriorly away from the underlying cranium. Once the pericranium is incised, it can be elevated anteriorly toward the supraorbital rims as far as the nasofrontal suture. Generally, the temporalis muscle does not require elevation, although a small amount of dissection along the superior temporal line may be required to expose the keyhole for bur hole placement.

FIGURE 6–1 Bicoronal skin inciston.

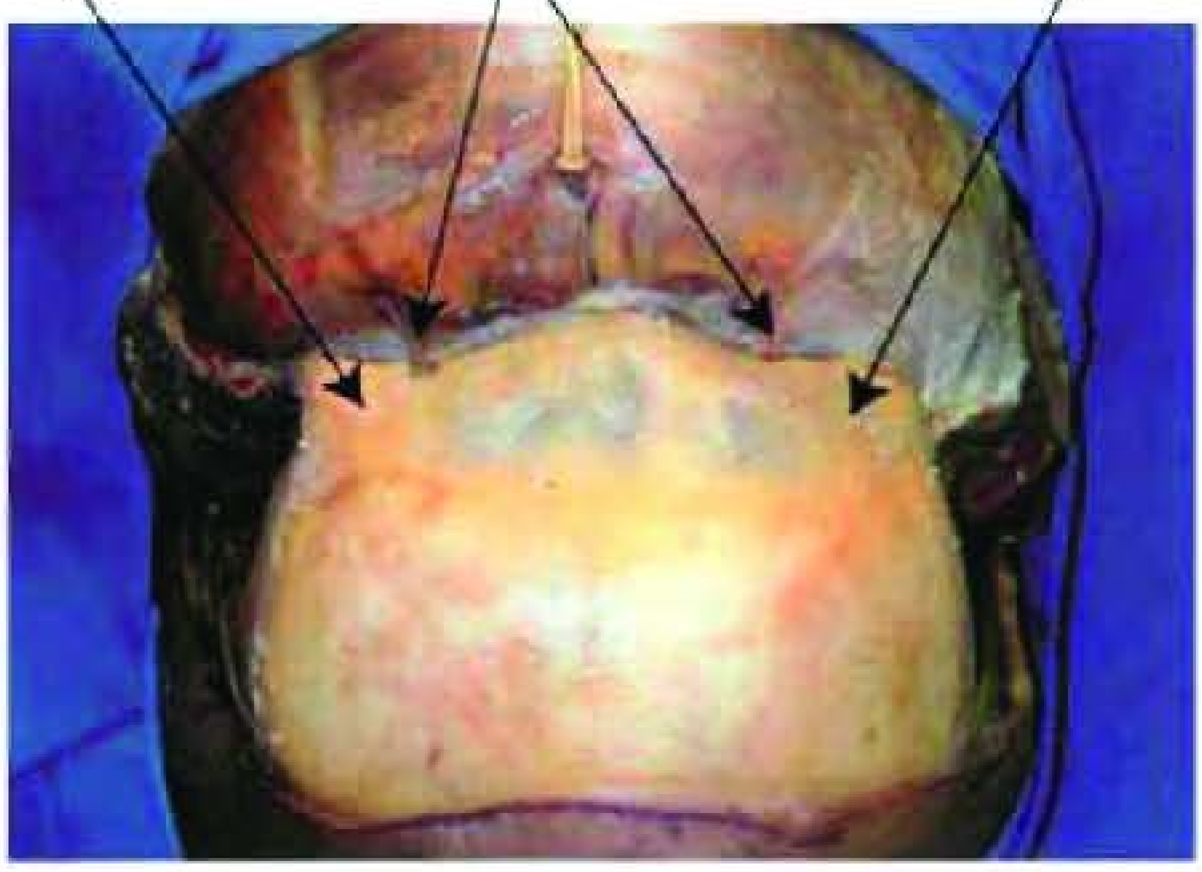

FIGURE 6–2 The supraorbital nerves are shown alter elevation of the skin flap.

SURGICAL TECHNIQUE

A bur hole is made in the region of the McCarty keyhole bilaterally, and two additional bur holes are made straddling the midline just anterior to the coronal suture. The dura is stripped away from the underlying bone using dural separators or a Pen field 3 dissector. Particular care is paid to dural separation in the midline along the sagittal sinus. A bifrontal craniotomy flap is turned as close to the floor of the frontal fossa as possible using the Midas Rex B1 foot-plated tool (Midas Rex, Fort Worth, Texas) (Fig. 6–3). The craniotomy bone flap can be elevated in one Or two segments.

The dura is elevated from the floor of the frontal fossa with a Penfield 1 dissector. The dural attachments in the region of the cribriform plate are incised bilaterally, and the olfactory nerves are transected. The dural defects are closed primarily with 4-0 neurolon sutures. The subfrontal dura is elevated posteriorly from the planum sphenoidale to the tuberculum sella and medial sphenoid ridge. The emergence of the optic nerves from their respective optic canals should be identified.

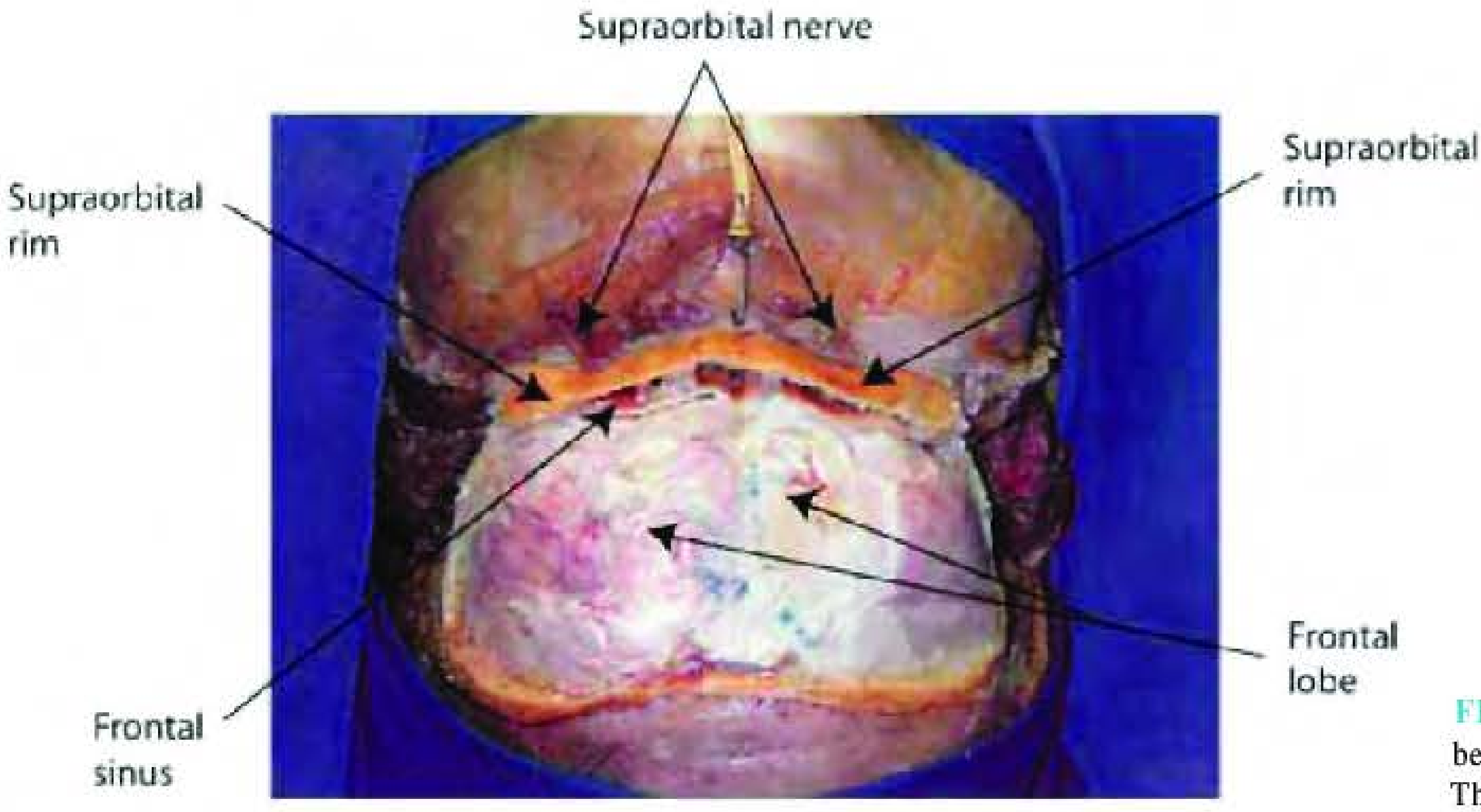

FIGURE 6–3 A bifrontal craniotomy has been performed. Both orbital rims are shown. The frontal sinus is open.

CLASSIC TRANSBASAL APPROACH

In the classic transbasal approach, the posterior wall of the frontal sinus is removed with a high-speed air drill, thereby cranializing the sinus, and the mucosa is stripped from the walls of the sinus. The ostia of the frontal sinus should be seen communicating with the ethmoid air cells (Fig. 6–4). The medial flour of the frontal fossa, including the roof of the ethmoidal air cells, is removed using a high-speed air drill. The lateral margins of the bone removal are the medial walls of the orbit. The orbits on both sides are skeletonized to smooth orbital contours, and the sphenoid sinus can be entered with the use of a high-speed air drill. In this standard approach, the lower margin of the craniotomy does not allow the floor of the pituitary fossa to be seen without an extension of the classic transbasal approach.

EXTENDED TRANSBASAL APPROACHES

To extend the classic transbasal approach, a bone cut is made through the nasofrontal suture with a reciprocating saw or high-speed air drill. Sagittal cuts are made just medial to the supraorbital notch on each side. This allows *en bloc* removal of the central portion of the supraorbital bar (Fig. 6–5). Exposure of the floor of the pituitary fossa is enhanced by this additional bone removal. A central drilling of the upper clivus can be performed; however,

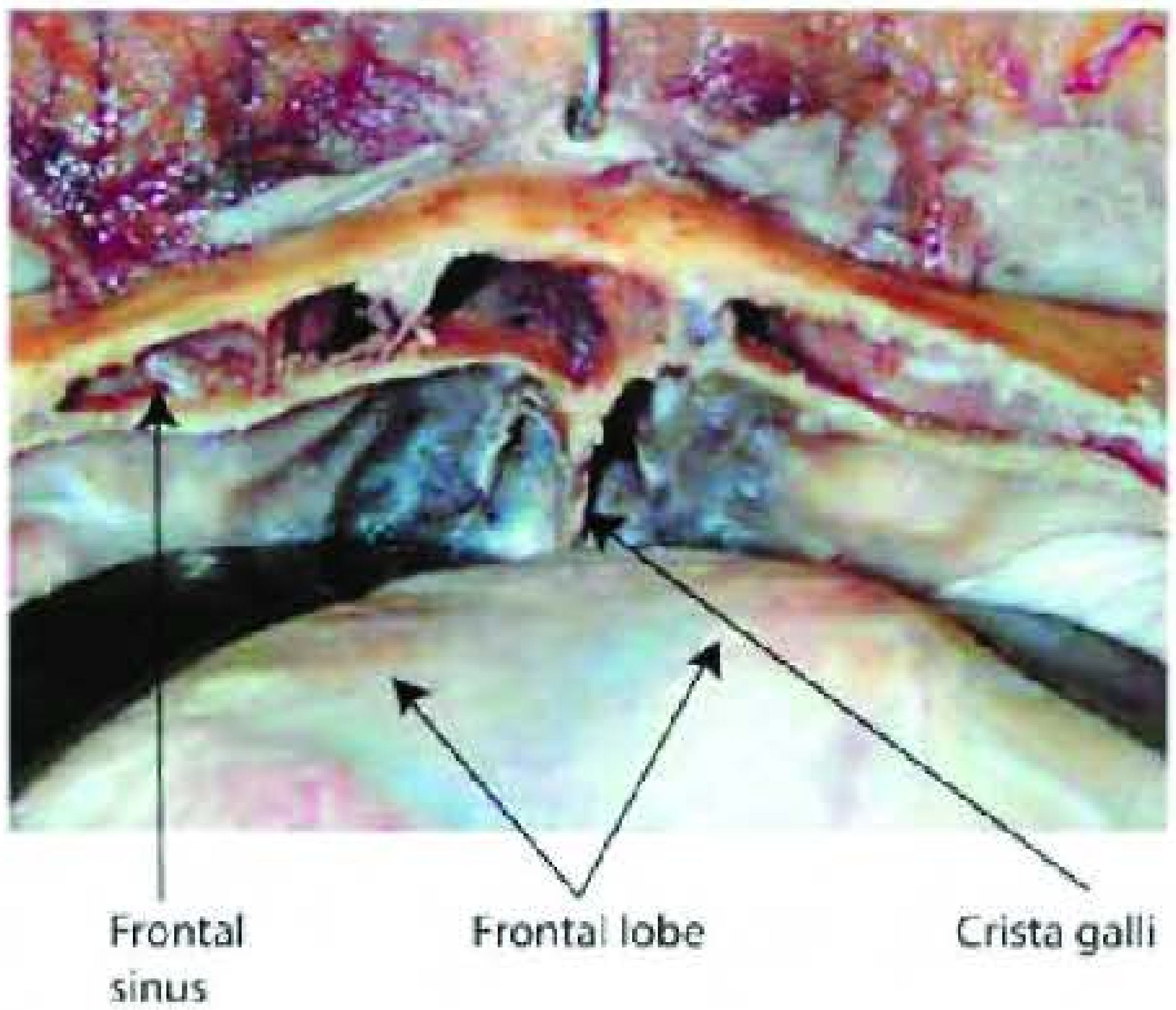

FIGURE 6–4 High-power view of the extradural dissection of the ethmoidal fovea.

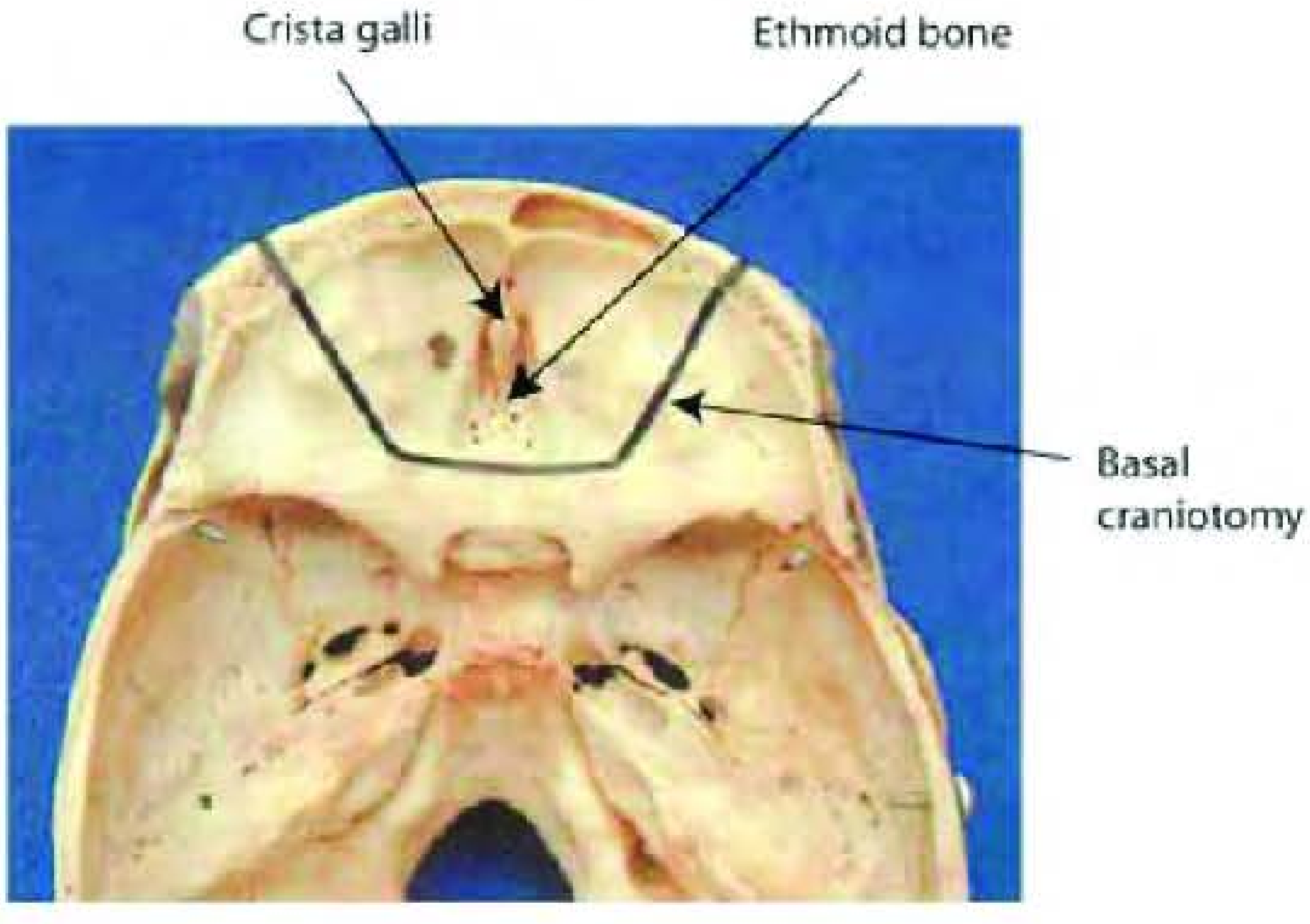

FIGURE 6–5 The inner surface of the central orbital osteotomy is depicted.

lateral visualization is limited by the supraorbital rims bilaterally.

A more extensive orbital osteotomy can be performed to permit lateral visualization of the clival region. The periorbita is stripped away from the roof of the orbits bilaterally. Using a sagittal saw or chisel and mallet, the supraorbital rims can be included in this *en bloc* resection (Figs. 6–6 A, B, and 6–7). After removal of the orbital rims, the mesial floor of the frontal fossa can be removed by a drill, and the sphenoid sinus may be entered (Fig. 6–8).

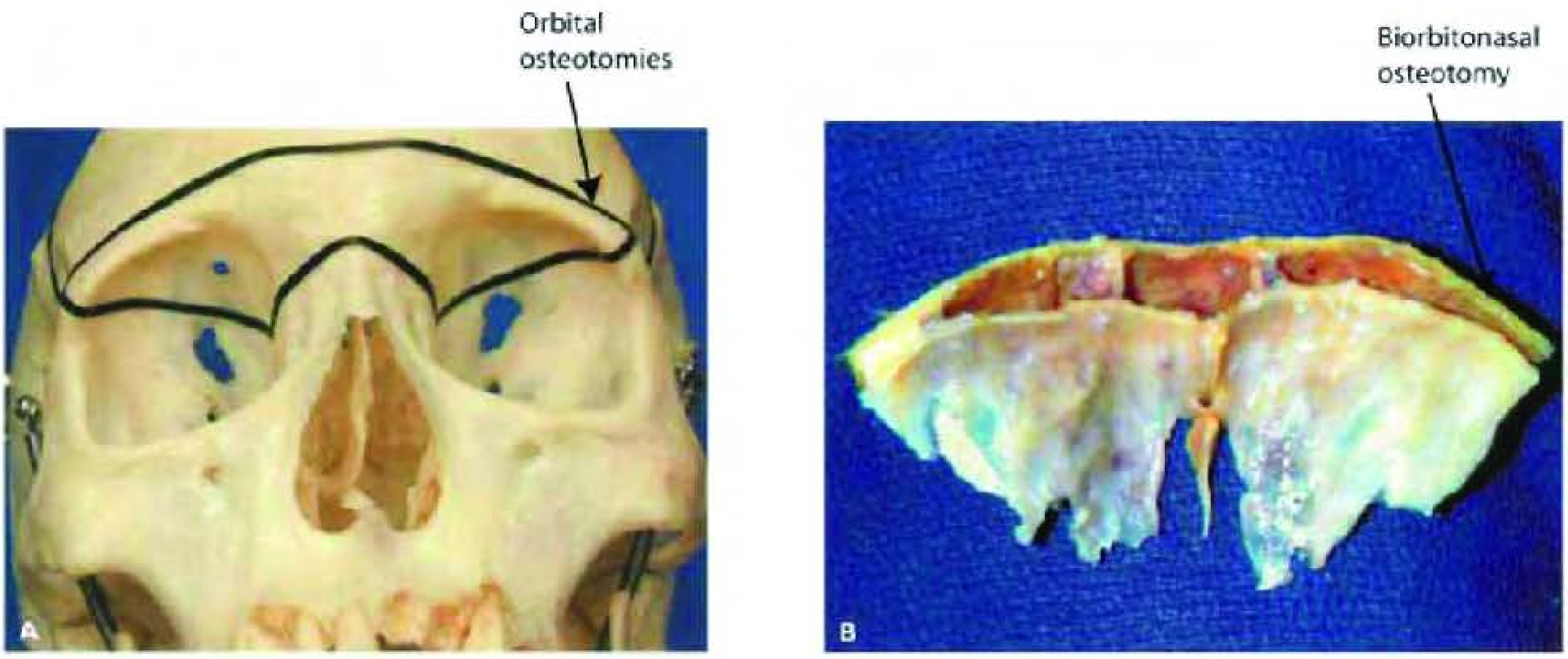

FIGURE 6–6 **A:** The supraorbital bar and orbital roof osteotomies are outlined. **B**: Biorbital osteotomy flap and the attached orbital roofs are shown.

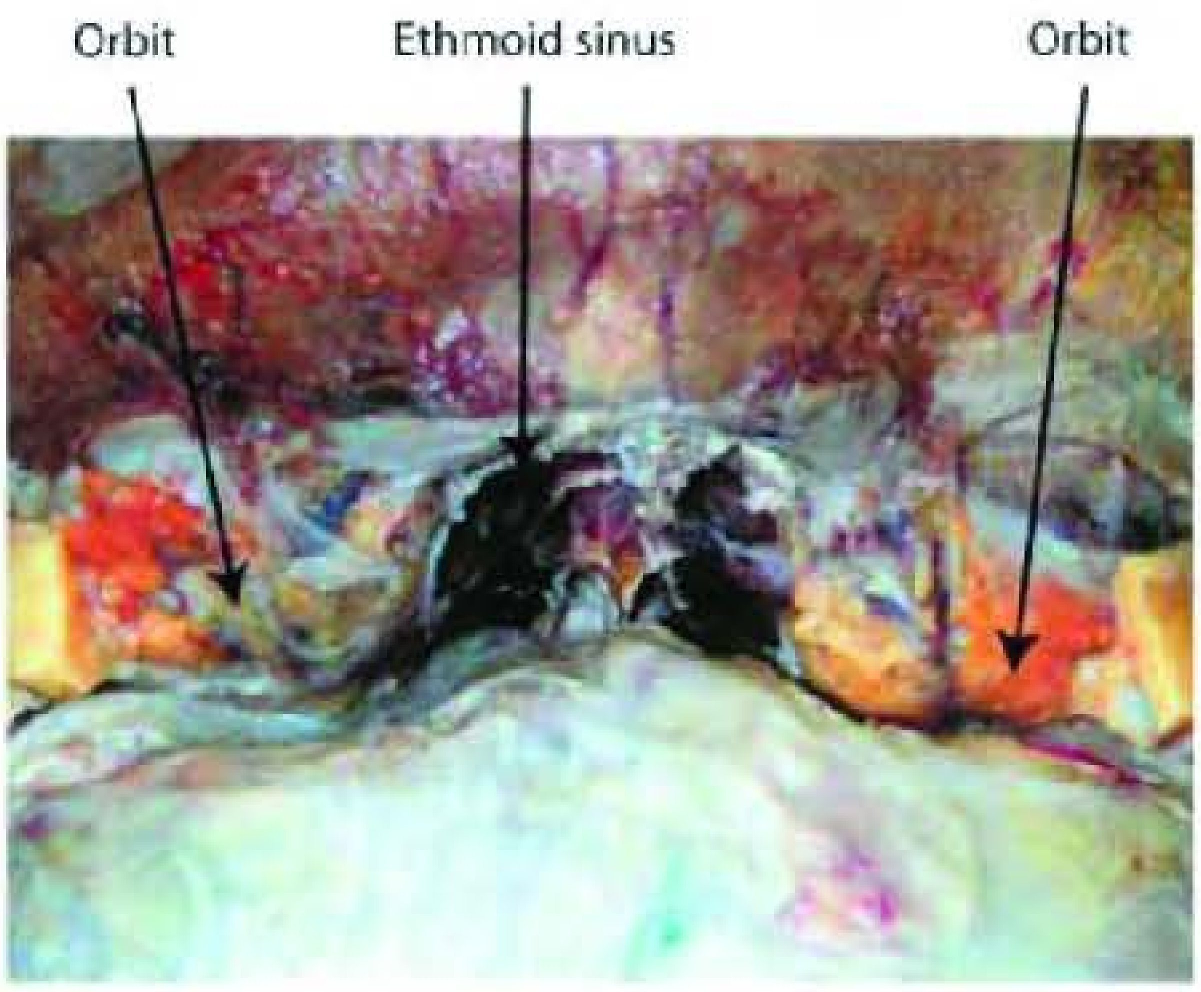

FIGURE 6–7 High-power view of the ethmoidal sinuses and both globes. Both supraorbital nerves are seen.

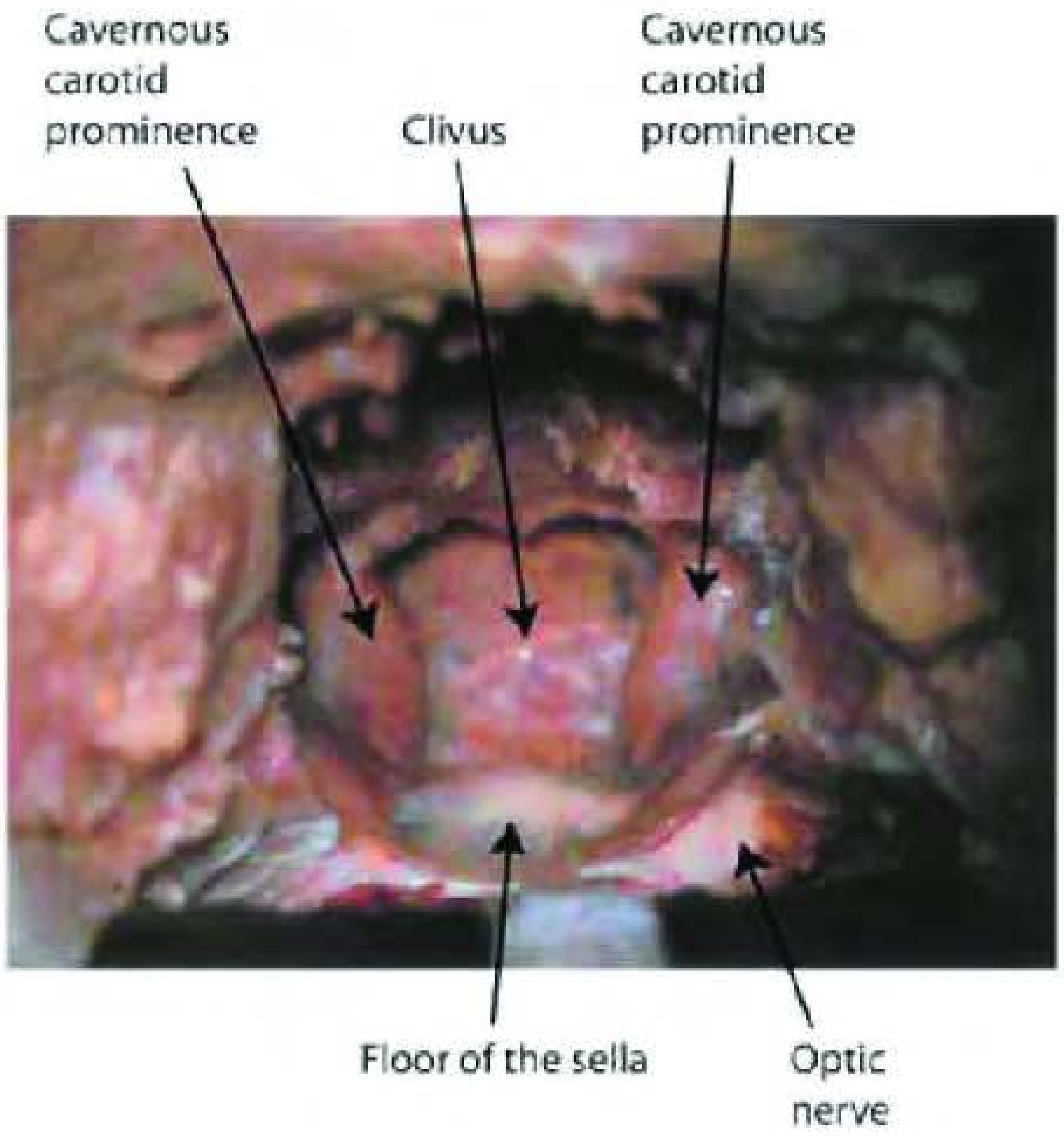

FIGURE 6–8 Panoramic view of the opened sphenoid sinus. The floor of the sella and both cavernous carotid prominences are seen. In the depth between both carotid eminences, the clivus can be visualized.

The optic nerves are then skeletonized bilaterally, and the posterior wall of the sphenoid sinus and the clivus can be resected with a high-speed air drill. The lateral margins of the bone resection are the carotid eminences in the sphenoid sinus (Figs. 6–9 and 6–10) and the hypoglossal nerves exiting through the hypoglossal canal in the lower clivus. Far lateral regions cannot be seen. because the contralateral orbital rim and roof obscure the surgical field.

Although the dura has been opened to allow inspection of the intradural contents for anatomic orientation (Fig. 6–11), transbasal procedures are generally extradural approaches. If the dura is opened, special care should be taken during wound closure because of exposure of intradural contents to the paranasal and nasal sinuses. As part of the closure, the previously isolated pericranium is reflected over the exenterated sinuses at the skull base in an extradural manner to complete the repair and isolation of the paranasal sinuses. The Orbital rim and craniotomy bone flap then are replaced with microplates.

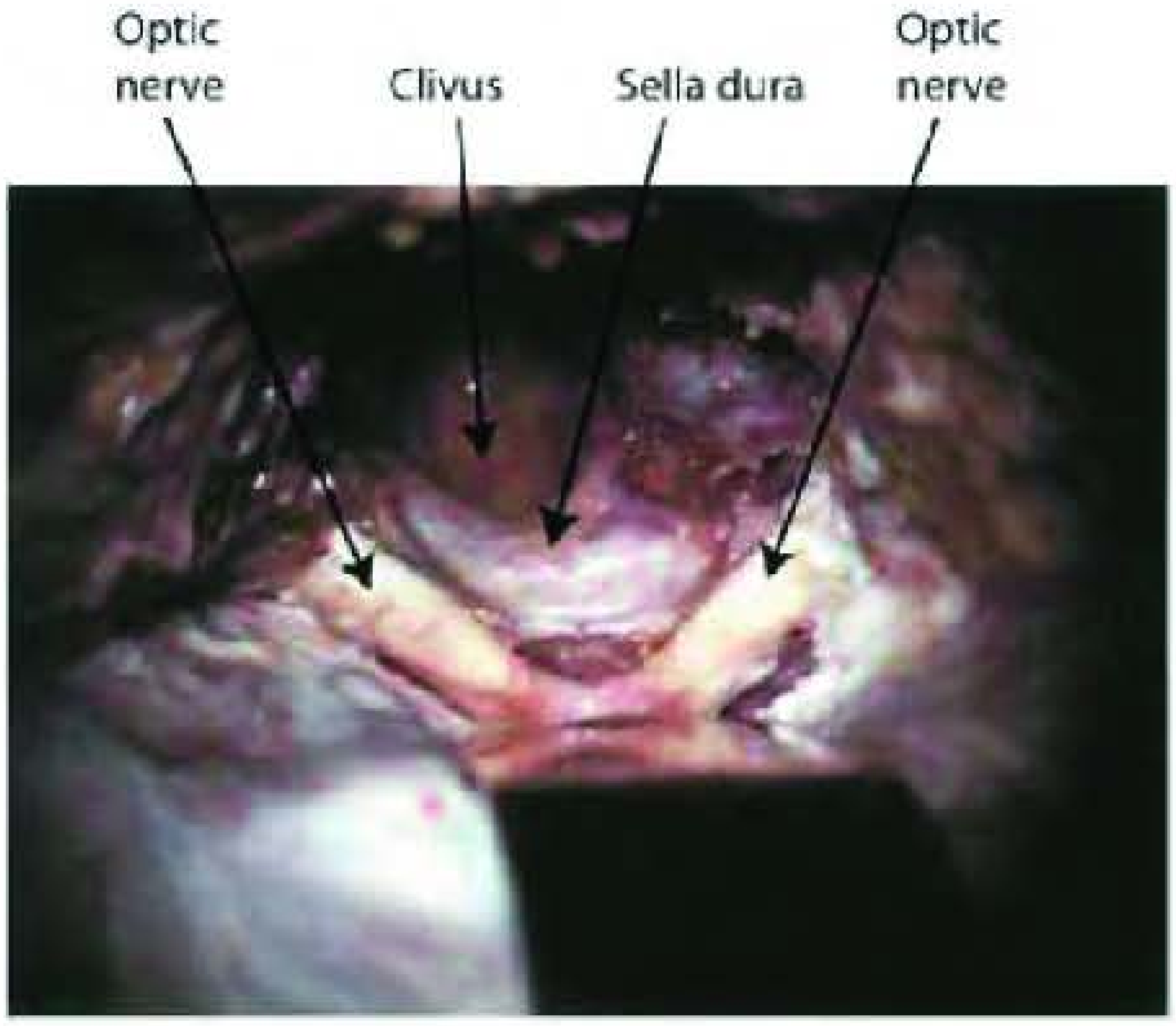

FIGURE 6–9 A dural aperture has been created in the planum region to demonstrate intradural anatomy for topographic orientation. The optic apparatus with the sella in the depths can be seen.

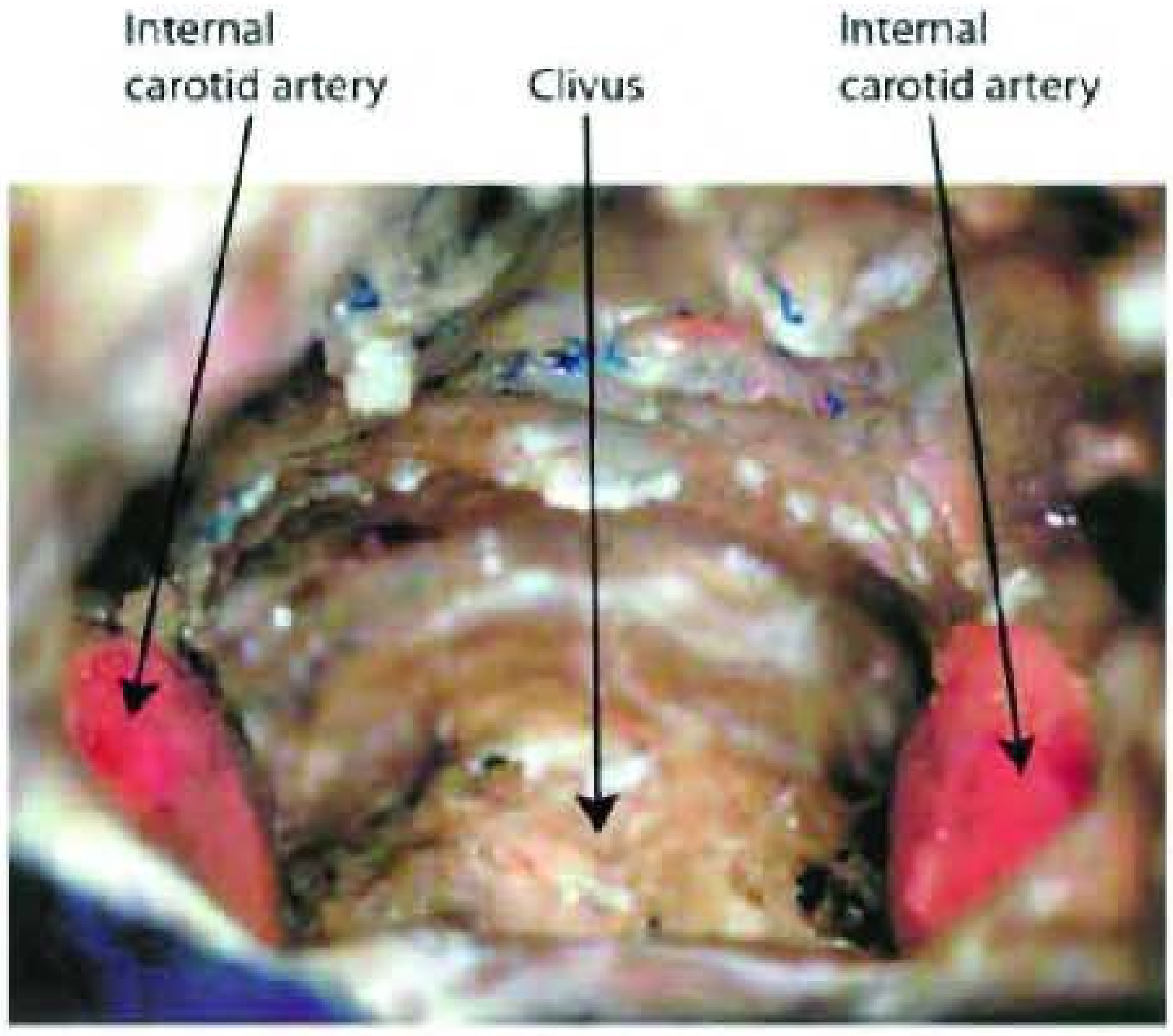

FIGURE 6–10 High-power view of a partial clival resection. The carotid prominences are the lateral margins of sphenoid drilling. The hypoglossal canals are the lateral margins of a clivectomy.

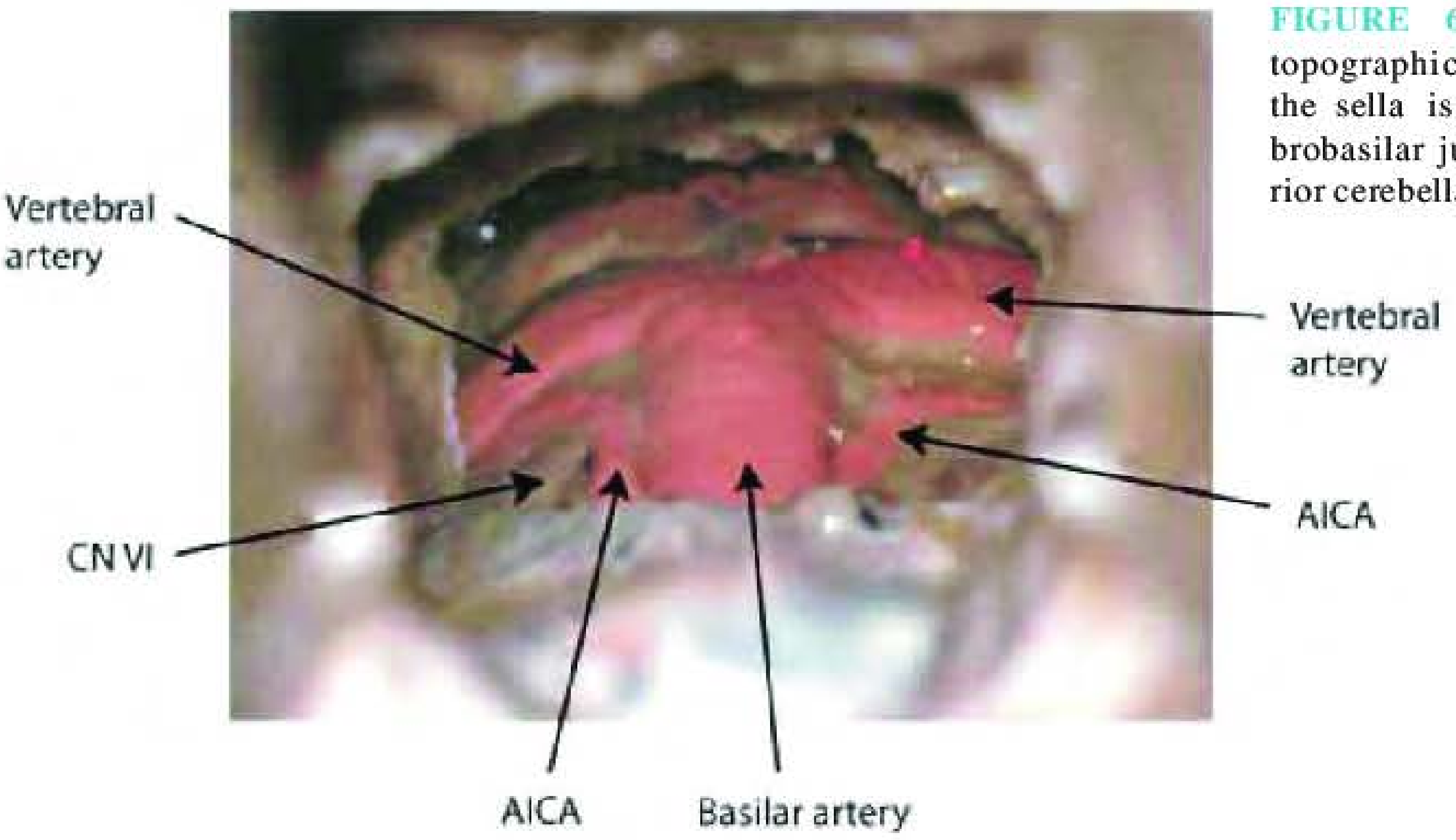

FIGURE 6–11 The clival dura has been opened for topographic orientation. The dura along the floor of the sella is demonstrated. Intradurally, the vertebrobasilar junction can be seen. AICA, anterior inferior cerebellar artery; CN, cranial nerve.

PITFALLS, PEARLS, CONSIDERATIONS

- Dural laceration with exposure to the sinuses
- Injury to frontal branches of the facial nerve and supra-orbital nerves
- Olfaction is lost
- Injuries to structures just lateral to the resection (i.e., carotid arteries, cavernous sinus, optic nerves, abducens nerves, hypoglossal canals)
- Frontal lobe contusions
- Basal reconstruction with fat and pericranium avert many potential postoperative complications

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Chapter 7

Transphenoidal Approach

M. Humayun Khalid, Carlos Acevedo, Damirez Fossett

Indications for Approach

- Sellar lesions with or without suprasellar extension
- Sphenoid sinus lesions
- Clival/retroclival lesions

Anatomy

The floor of the nasal cavity is formed by the palatine process of the maxilla and by the horizontal plate of the palatine bone. The nasal septum consists of the nasal septal cartilage, the vomer, and the perpendicular plate of the ethmoid. The lateral nasal wall is formed by the superior, middle, and inferior turbinates. The superior, middle, and inferior meatuses are situated inferior to the respective turbinates. The superior meatus provides drainage for the posterior ethmoidal and sphenoid sinuses, the middle meatus provides drainage for the anterior ethmoidal and maxillary sinuses, and the inferior meatus provides drainage for the nasal lacrimal duct. The vascular supply to the nasal cavity is through the anterior and posterior ethmoidal arteries.

The sphenoid sinus is a septated sinus with a septum that frequently deviates from the midline; accessory septa are sometimes present. The sphenoid sinus has several recesses: the posterior septal, ethmoidal, superior and inferior lateral, palatine, inferolateral, and pterygoid. The sphenoid sinus opens into the sphenoethmoidal recess above and beyond the superior nasal concha. The ostia are generally located on the posterior wall of the recess. There is significant variation in the degree of pneumatization of the sinus. The optic nerves are superior to the sinus; the carotid arteries lateral within the cavernous sinus. The maxillary nerve lies in the inferior lateral portion of the sinus anteriorly. The hypophysis lies within the posterior superior portion of the sphenoid sinus. The posterior wall of the sphenoid sinus is contiguous with the floor of the sella turcica.

Positioning and Skin Incision

The patient is placed in a supine, semi recumbent position and can either have the head resting on a donut or horseshoe or can be placed in Mayfield three-point fixation. The head should be angled toward the surgeon by 15 to 20 degrees with approximately 15 degrees of extension. A C-arm fluoroscope is usually positioned for intraoperative lateral skull imaging.

Surgical Technique

Transnasal Technique

A hemitransfixion incision is made in the right nostril along the inferior border of the nasai septum. The columella is retracted laterally to the left. The inferior border of the cartilaginous septum is dissected, and a submucosal dissection is performed to the left of the septum, thereby creating a left anterior tunnel. The nasal speculum is placed, and the remainder of the dissection is carried out as described in the section on Sublabial Technique.

Endoscopic Transnasal Technique

The endoscope is directed into the nostril, and the middle turbinate is visualized. (Fig. 7–1). Directing the scope supe-

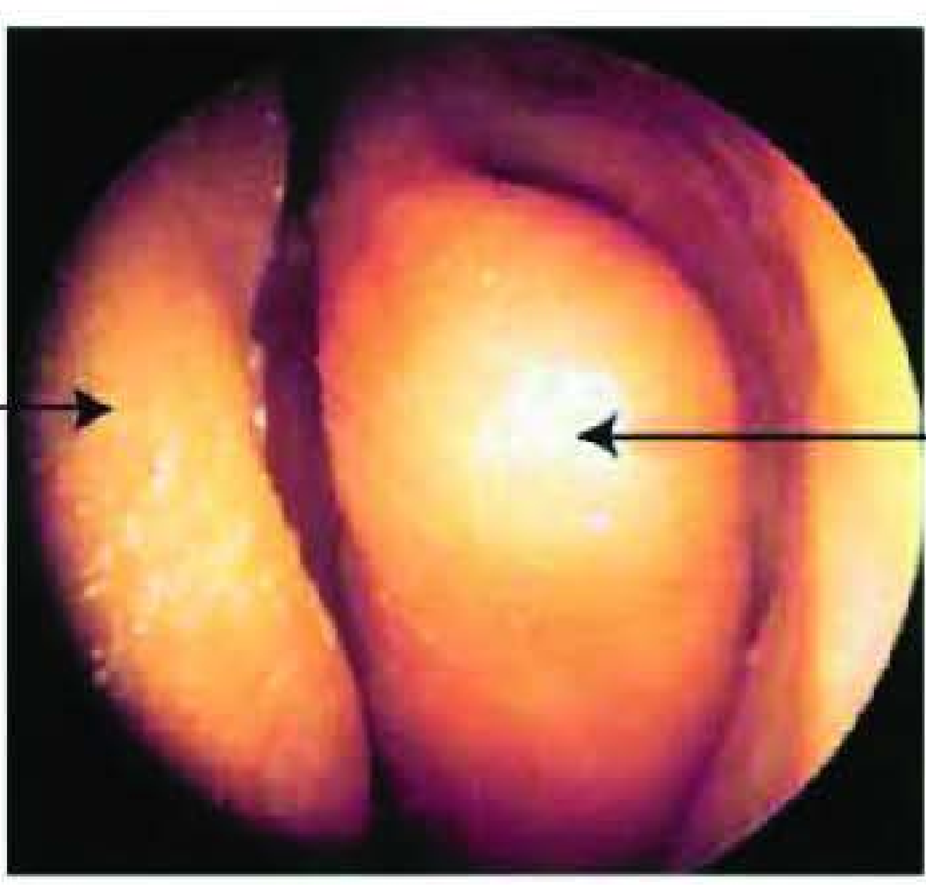

FIGURE 7–1 The middle turbinate and meatus are seen.

riorly Allows visualization of the superior turbinate and meatus (Fig. 7–2). After mobilizing the turbinate, the sphenoid ostium can be identified and enlarged (Figs. 7–3 and 7–4). The endoscope is passed into the sphenoid sinus to visualize the floor of the sella. Sphenoid sinus anatomy can be visualized prior to opening the floor of the sella (Figs. 7–5 and 7–6). The remainder of the procedure is as described with the sublabial technique.

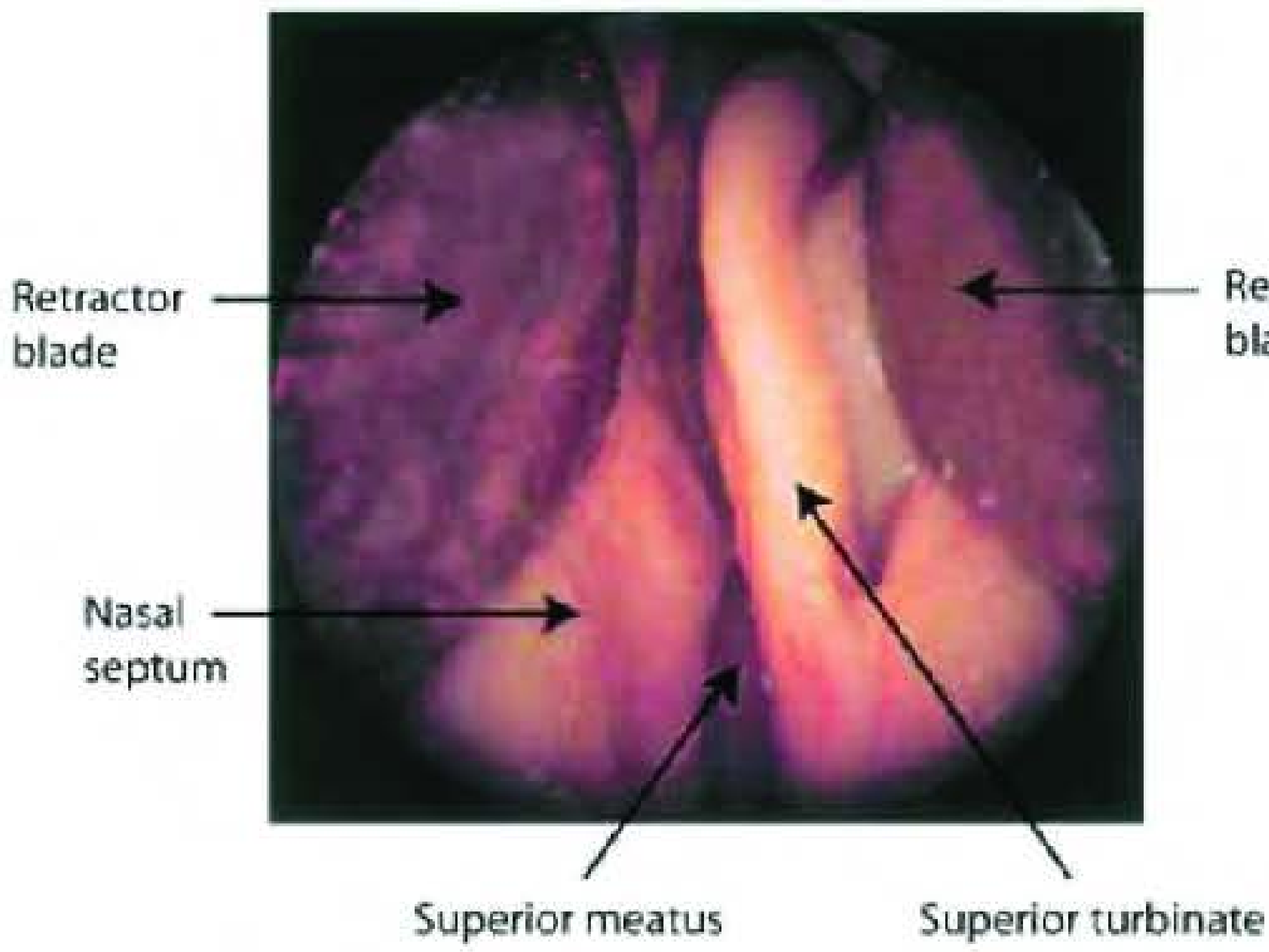

FIGURE 7–2 The superior turbinate and meatus are seen,

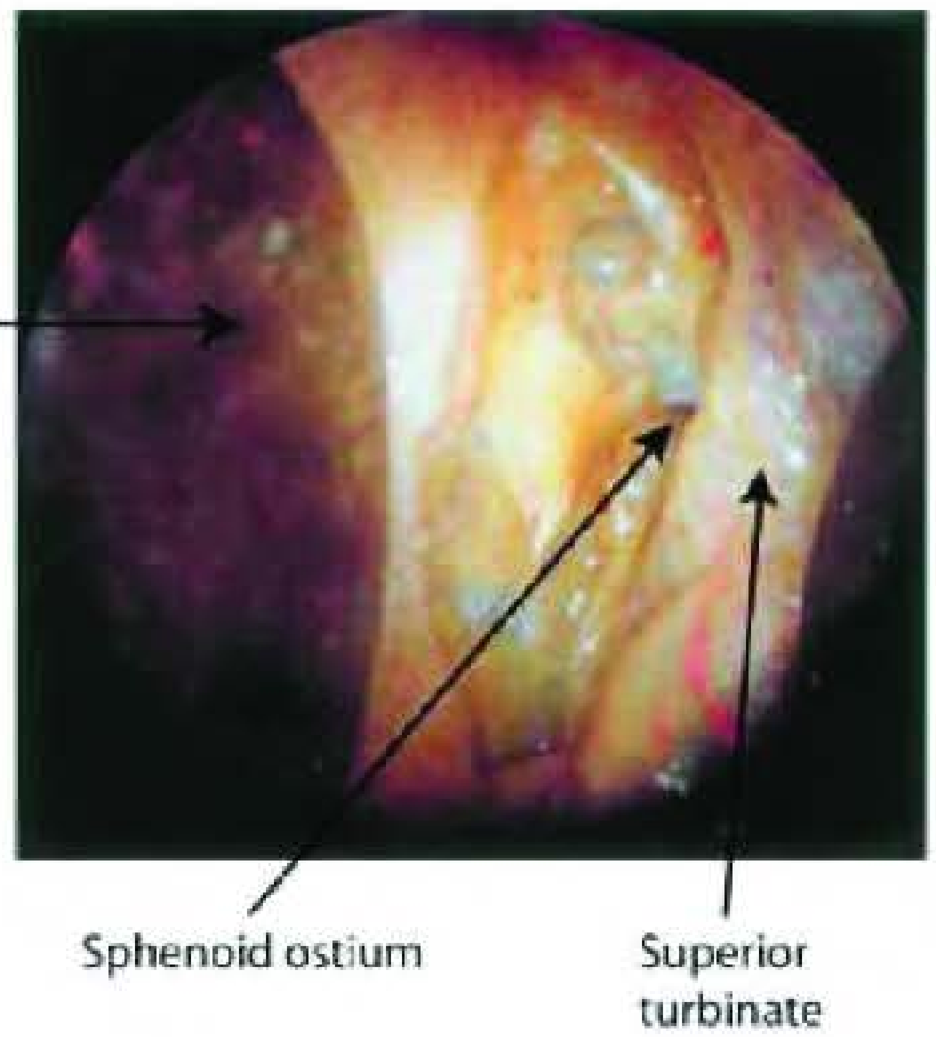

FIGURE 7–3 The superior turbinate has been mobilized laterally, exposing the sphenoid ostium within the sphenoidal ethmoid recess.

FIGURE 7–4 The sphenoid ostium has been enlarged. The mucosa of the sphenoid sinus is well visualized.

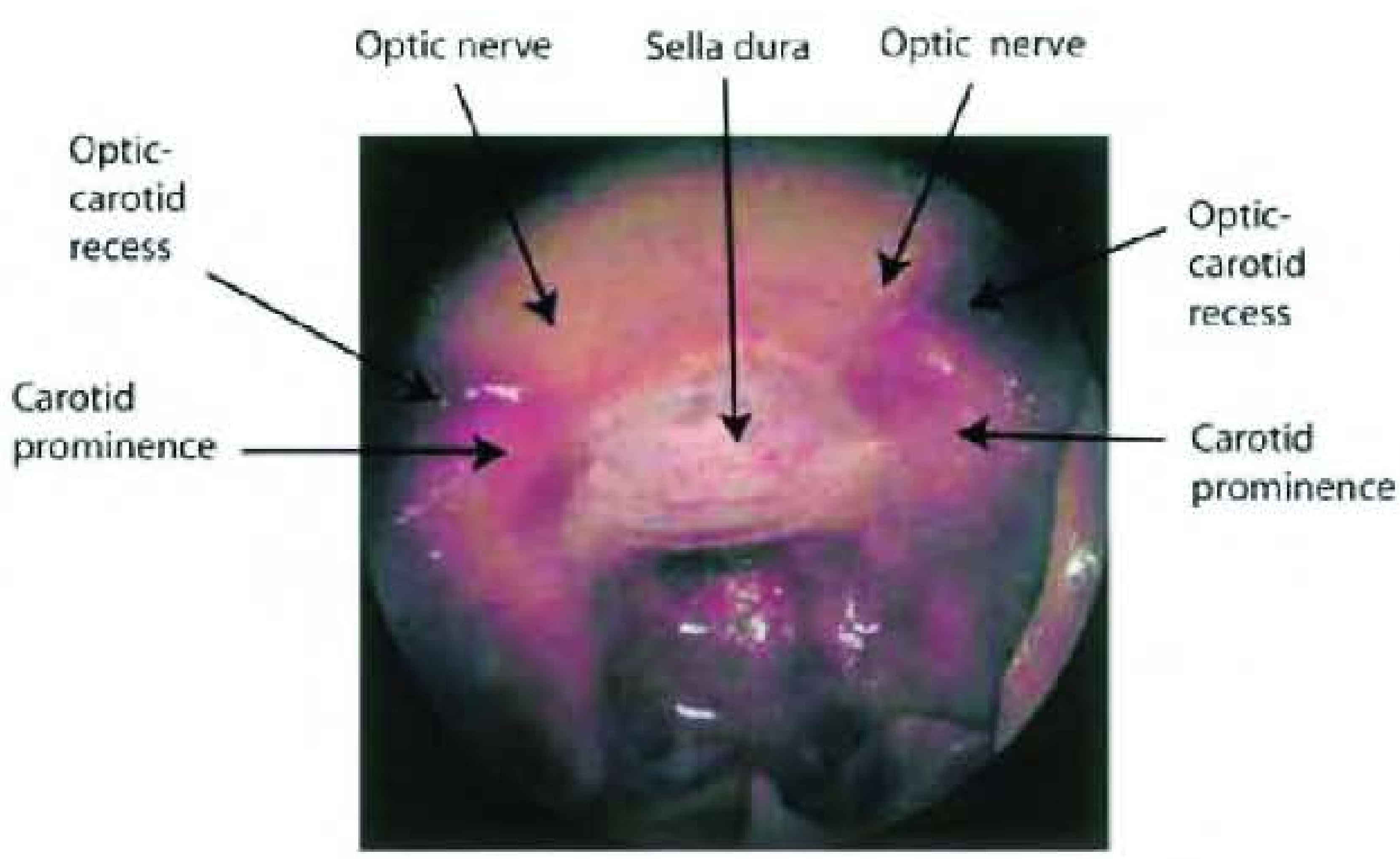

FIGURE 7–5 The sella floor has been removed, exposing the sella dura.

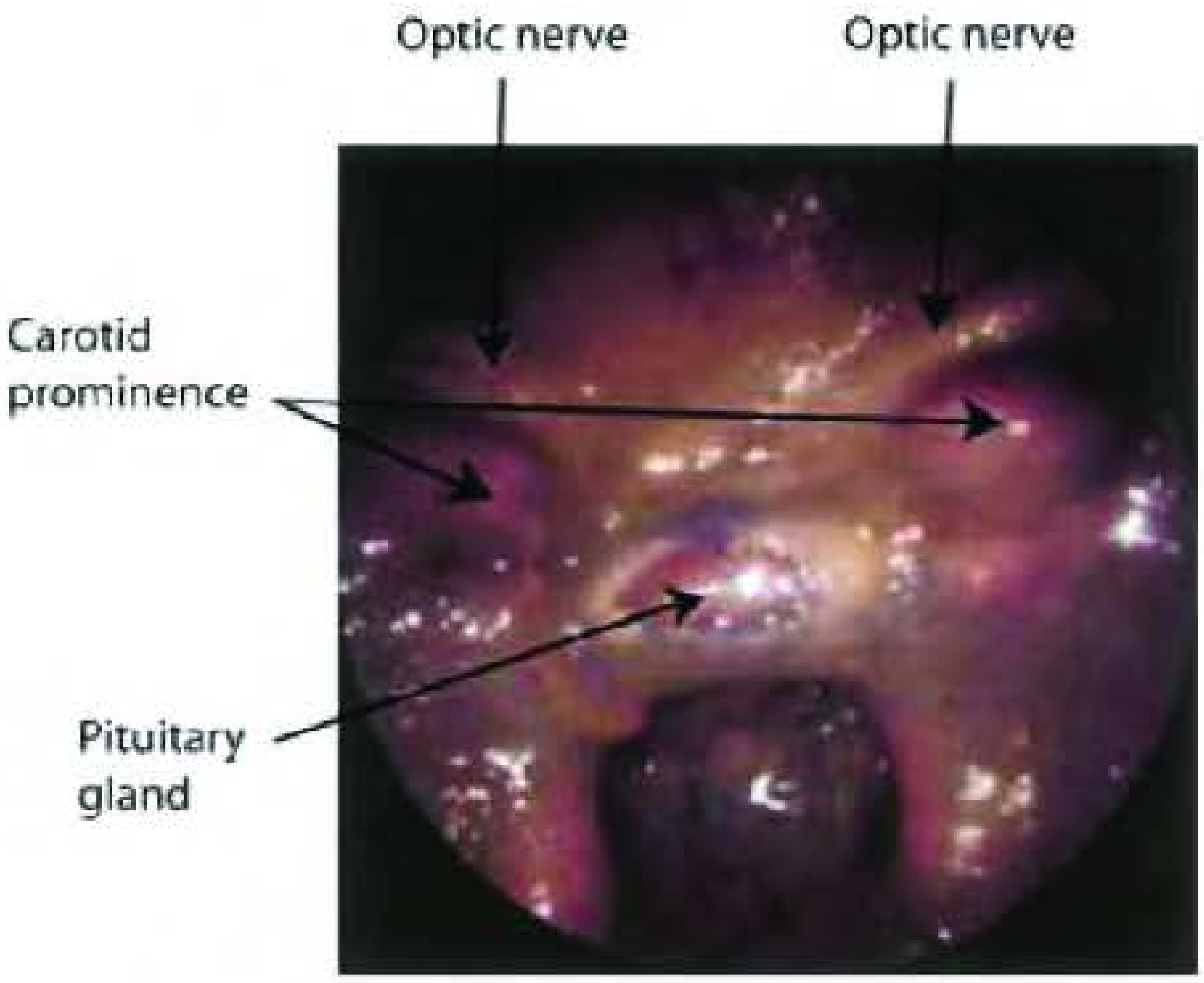

FIGURE 7–6 A panoramic view of the sphenoid sinus with a 30-degree endoscope demonstrates both carotid arteries, both optic-carotid recesses, and the optic nerves. The sella floor has been removed, revealing the sella dura.

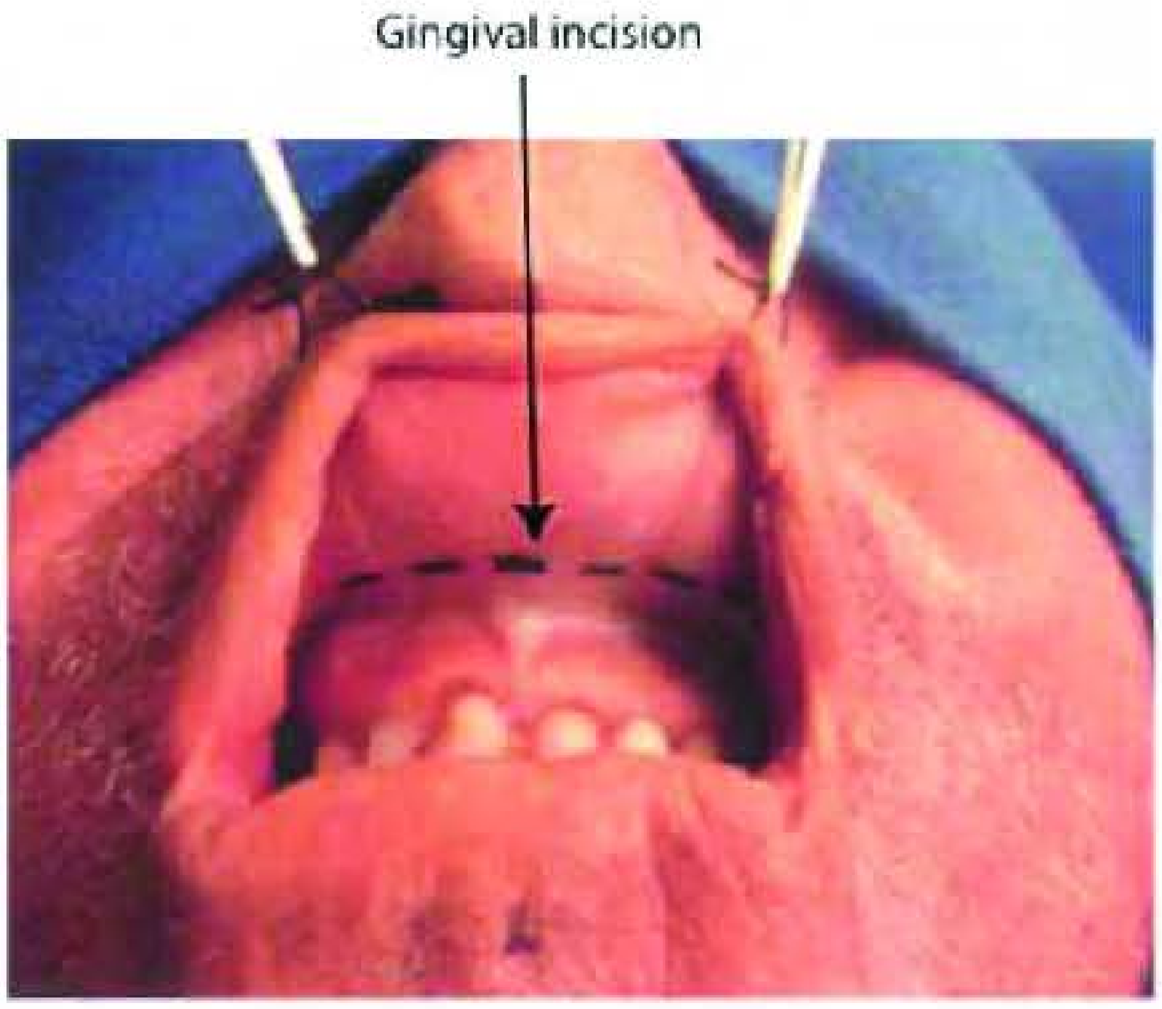

FIGURE 7–7 Sublabial incision for the transphenoidal approach.

SUBLABEAL TECHNIQUE

The upper lip is retracted superiorly and the canine fossa identified bilaterally. The gingival surface as well as the inferior nasal floor, the cartilaginous nasal septum, and the floor of the pyriform apertures are infiltrated with lidocaine with epinephrine to aid in the dissection. An incision is made into the upper gum about 1 cm above the gingival margin (Fig. 7–7). This incision is demarked laterally by insertion of the canines. The mucosa is retracted superiorly. A submucosal dissection away from the maxillary ridge and anterior nasal spine is made of the soft tissue and periosteum with a periosteal elevator to expose the inferior portion of the piriform nasal aperture (Fig. 7–8). The periosteum is elevated in a lateral-to-medial fashion to create two inferior nasal tunnels. The anterior and inferior tunnels are connected on the left, and the dissection should be carried posteriorly and medially to expose the midline bony septum and the perpendicular plate of the ethmoid. The mucosa should be separated from the perpendicular plate only on one side to elevate it from the septal cartilage. The contralateral nasal septal mucosa is left intact. The septal cartilage is then detached from the vomer and perpendicular plate (Fig. 7–9). The ligament bridging the anterior

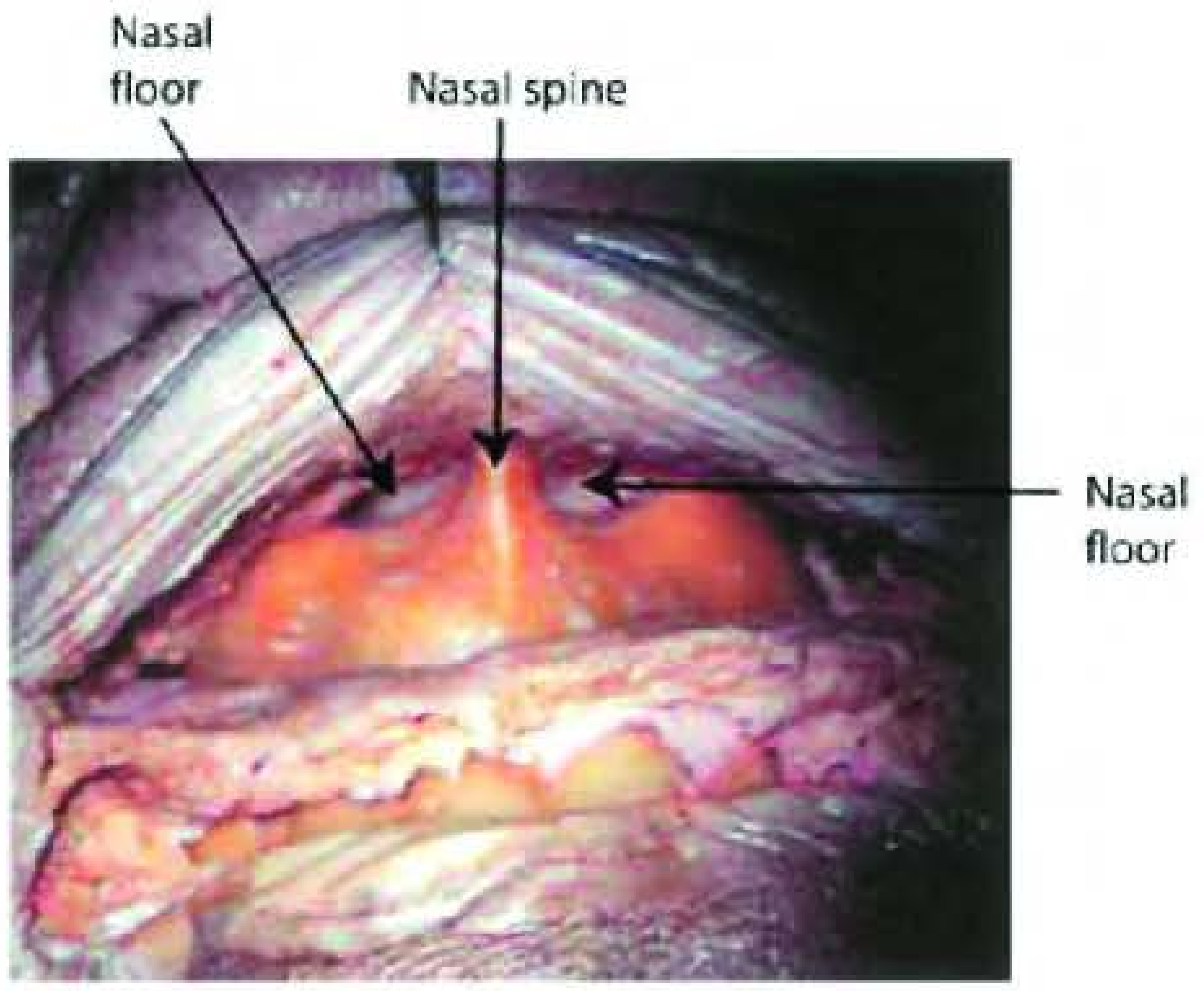

FIGURE 7–8 A submucosal dissection allows visualization of the nasal spine and floor.

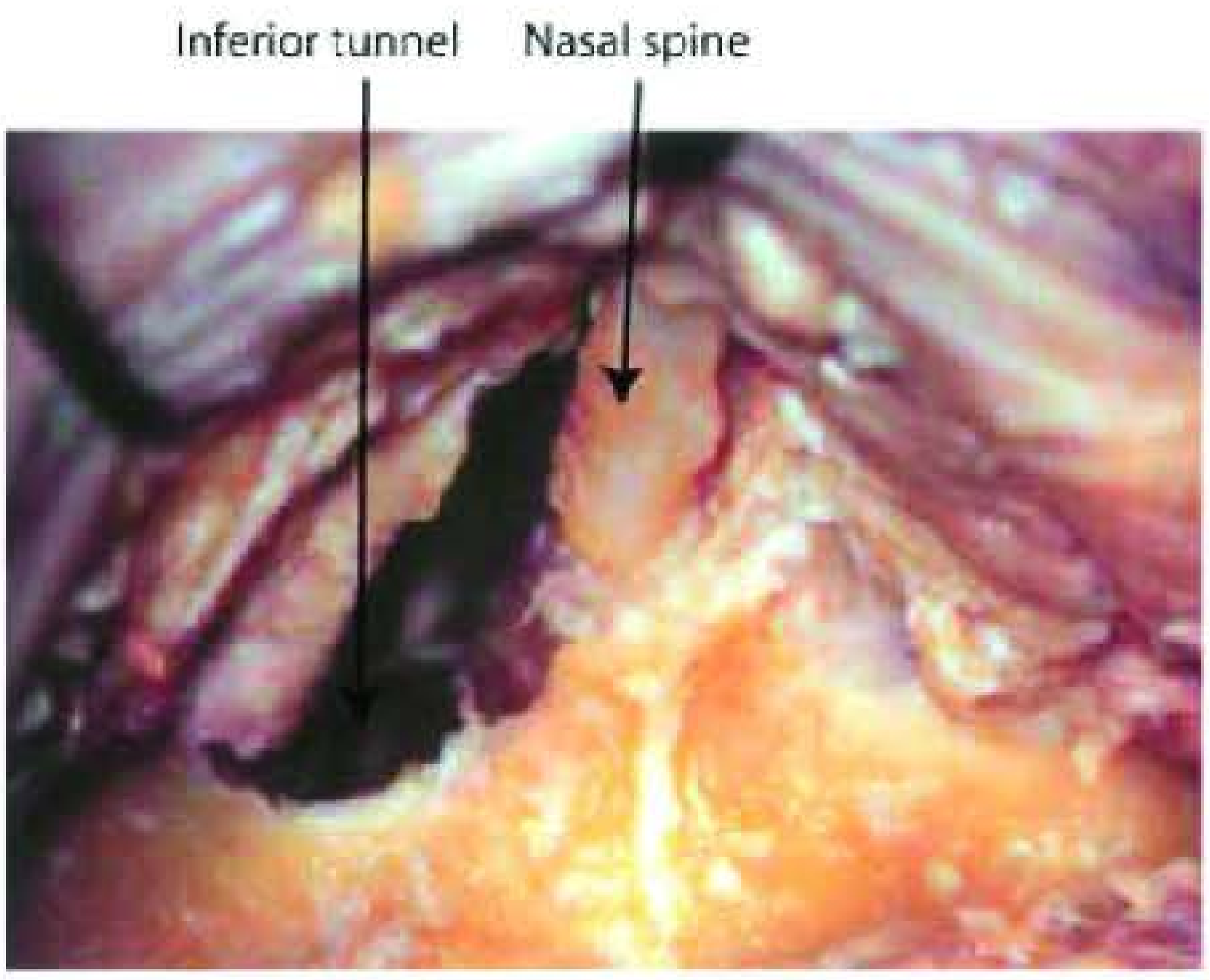

FIGURE 7–9 Elevation of the mucosa from the nasal floor to create an inferior tunnel. The septal cartilage has been separated from the nasal spine.

nasal spine to the perpendicular plate is sharply transected, and the nasal septum is dislocated to the contralateral side of the nose.

A Hardy or Hubbard nasal speculum then is inserted to straddle the perpendicular plate and widely but gently opened. The turbinates will fracture, and the vomer will be visible. Further submucosal dissection allows visualization of the rostrum of the sphenoid bone (Fig. 7–10). Using a small rongeur, the perpendicular plate of the ethmoid bone is resected. The mucosa over the sphenoid rostrum is dissected in a submucosal fashion to expose the sphenoid ostia bilaterally. The anterior wall of the sphenoid sinus then can be entered with a chisel and mallet or with a Smith-Ferris rongeur. The bone is saved to reconstruct the sella floor later. The opening into the sphenoid sinus is enlarged with a Kerrison rongeur. The sphenoid mucosa then is removed with a pituitary rongeur, and the tips of the Hardy or Hubbard retractor are placed just outside the sphenoid sinus. Positioning them within the sinus and opening them forcefully risks fracturing the optic strut or carotid prominence. A localizing radiograph or C-arm fluoroscopy should be used to confirm the floor of the sella (Fig. 7–11). Within the sphenoid sinus, one can appreciate the carotid prominences bilaterally as well as the optic-carotid recesses.

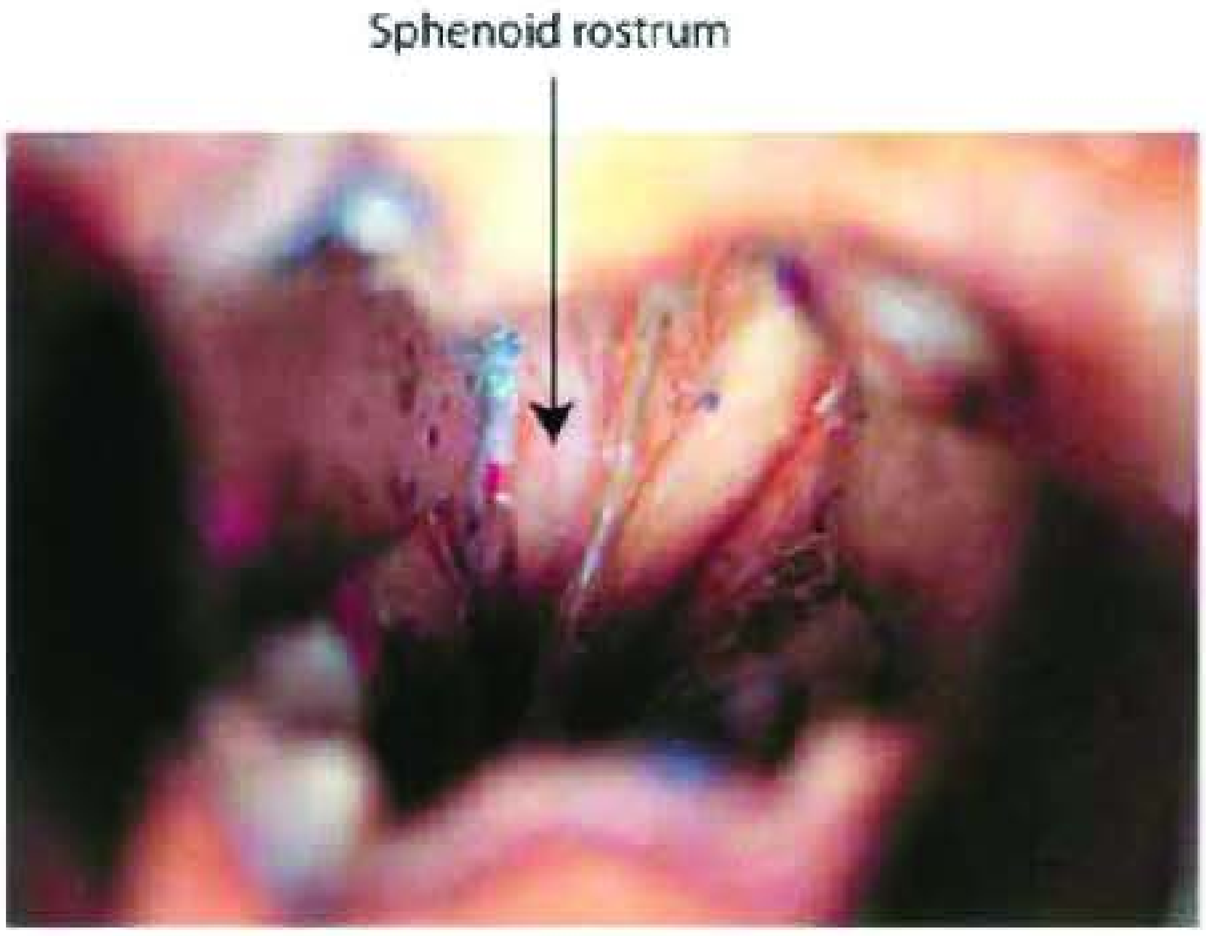

FIGURE 7–10 The sphenoid rostrum is visualized.

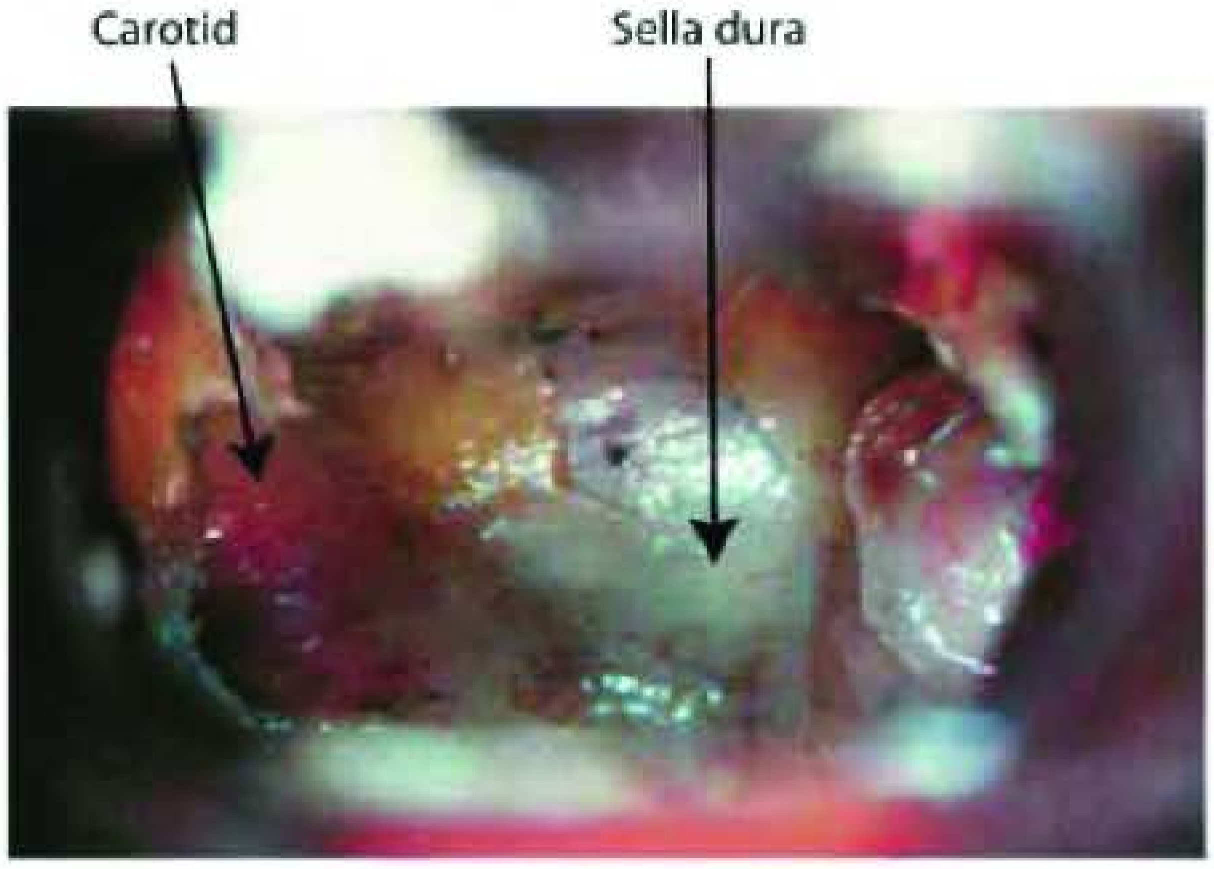

FIGURE 7–11 The floor of the sella has been opened.

The floor of the sella then is fractured using a small chisel, or it can be drilled with a small curved drill. Sometimes the floor of the sella is very thin or may already be eroded by the tumor. The limits of exposure are the intercavernous sinuses anteriorly and posteriorly and the cavernous sinus laterally.

The dura can be opened in either a rectangular fashion or with a cruciate incision. The lateral edges should be opened last in the event that the cavernous sinus is entered. Placement of a spinal needle prior to opening the dura of the sella may define an aberrant carotid artery, which would cause the transphenoidal approach to be aborted. The pituitary gland and stalk can be identified after the dural opening (Figs. 7–12 through 7–14).

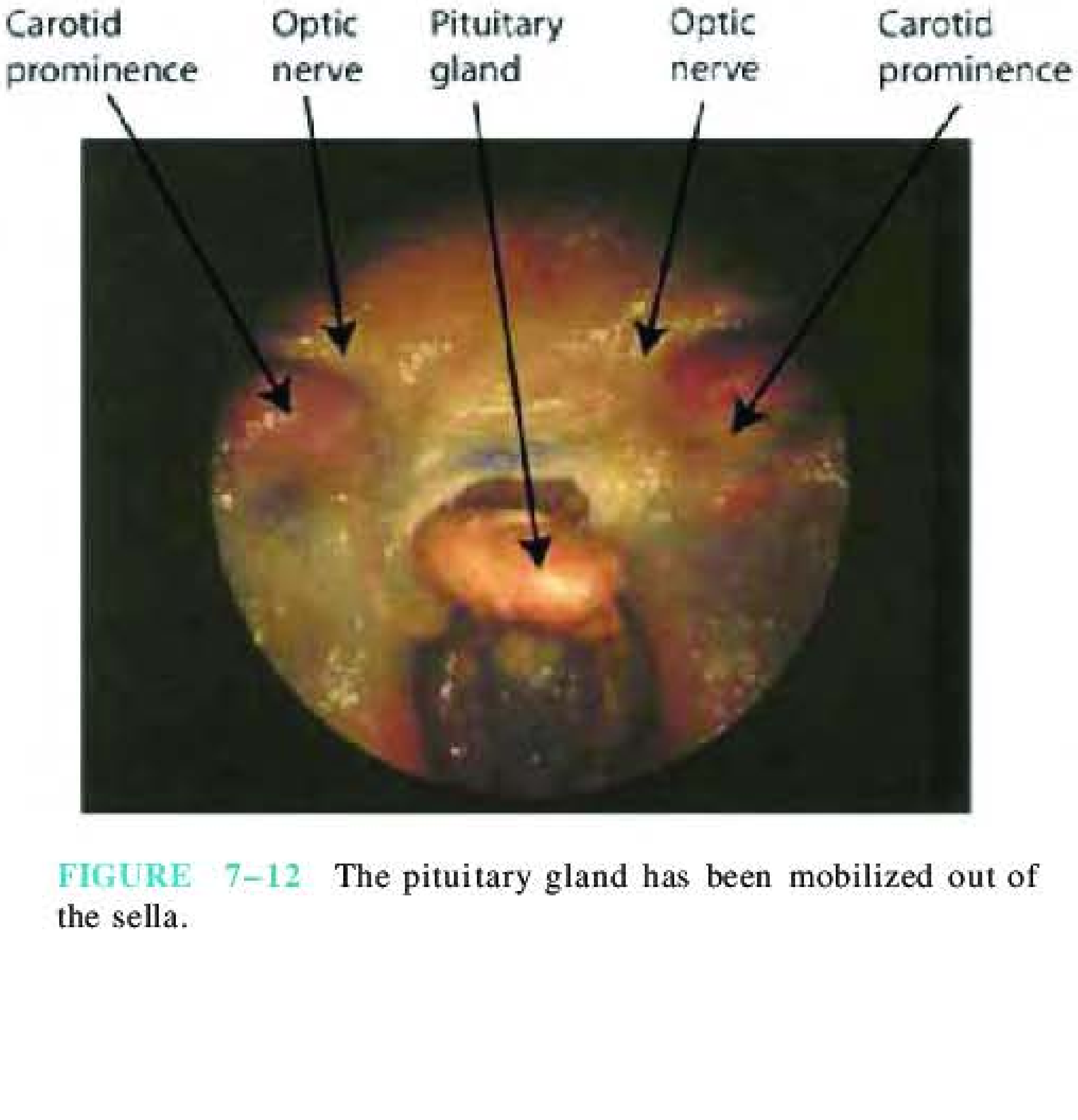

FIGURE 7–12 The pituitary gland has been mobilized out of the sella.

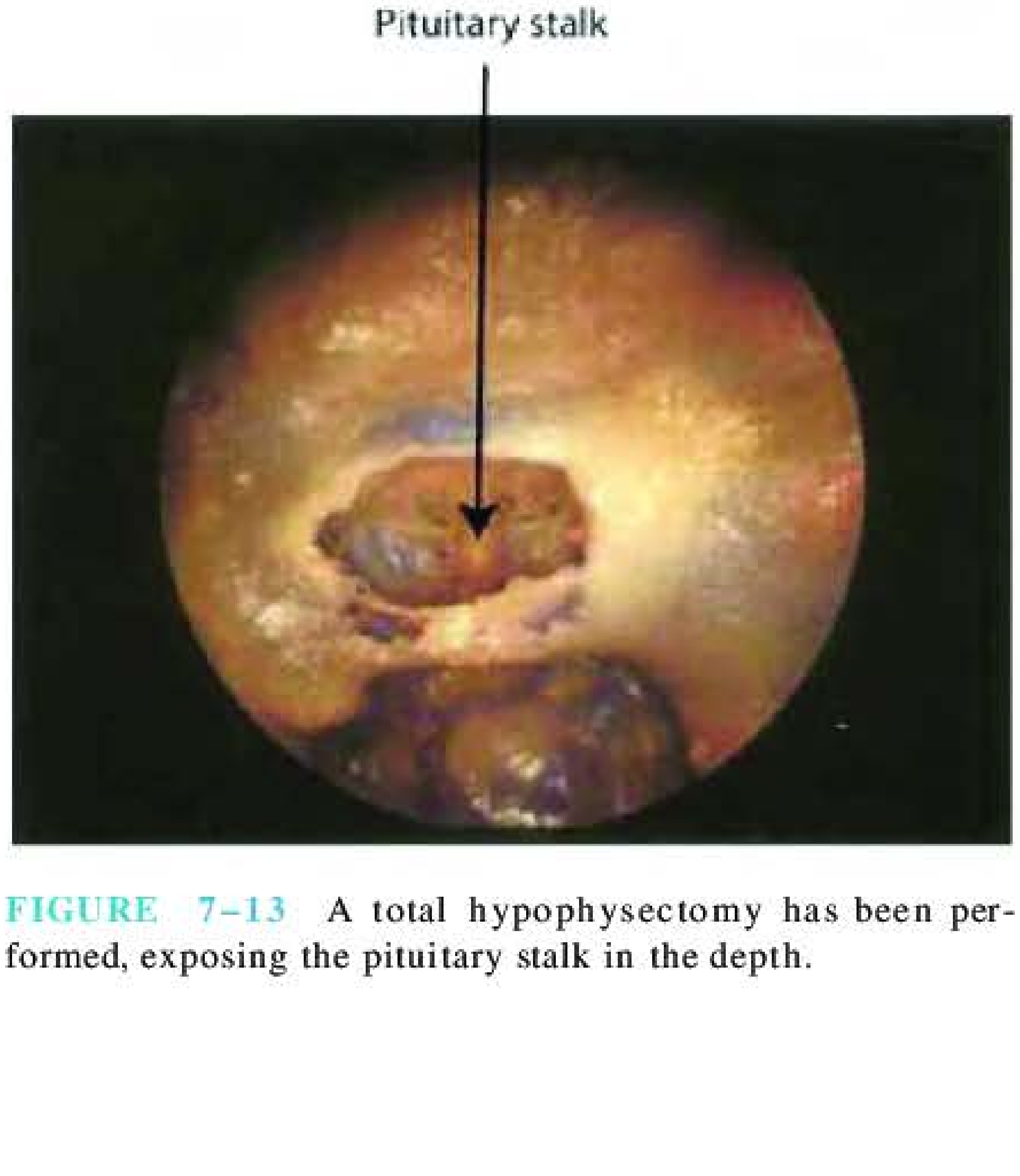

FIGURE 7–13 A total hypophysectomy has been performed, exposing the pituitary stalk in the depth.

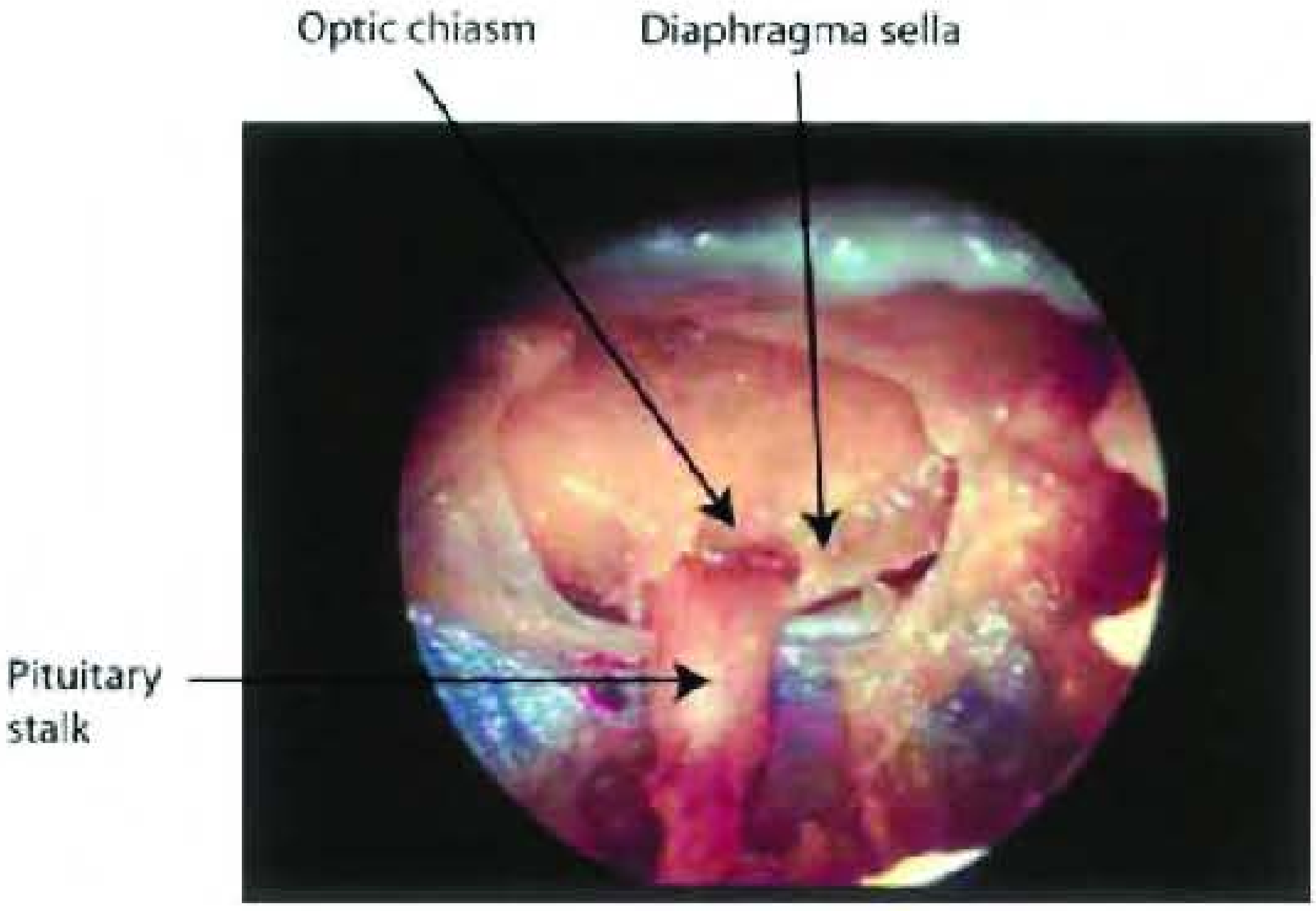

FIGURE 7–14 The pituitary stalk is visualized passing through the diaphragma sella arachnoid. The optic chiasm above the arachnoid is seen.

PITFALLS, PEARLS, CONSIDERATIONS

- Forceful opening of an improperly placed speculum risks injury to the maxillary sinus, carotid arteries, optic nerves, cavernous sinus, and hypothalamus
- Cerebrospinal fluid leak
- Injury to the nose or mouth with poor instrument placement
- Nasal septal perforations
- Vascular injury with dural opening
- Entering the floor of the frontal fossa secondary to improper trajectory: imaging avoids this problem

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CAVERNOUS SINUS ANATOMY

Carlos Acevedo, Amitabha Chanda, Mark Grant, Damirez Fossett

The cavernous sinus is composed of a heterogeneous group of vascular, neural, and mesenchymal structures. The anatomic arrangement of these elements demarcates specific anatomic regions and boundaries within the cavernous sinus. Knowledge of the anatomy of each region is imperative because these anatomic interrelationships ultimately dictate surgical approach. Without knowledge of the detailed anatomy of the floor of the middle fossa, the clinoid, tentorium, clivus, and sella, it is impossible to operate safely in the cavernous sinus (Figs. 8–1 and 8–2A, B).

Although describing the cavernous sinus region in terms of walls and triangles has created arbitrarily defined boundaries that have often been controversial, it is important to recognize these anatomic triangles to gain a sense of the relationships between the different structures contained within them. At the same time, the term *wall* or *bouudary* should not be taken to mean a limit or division but instead to mean a junction with the adjacent territory. For example, the medial wall of the cavernous sinus is the lateral wall of the pituitary fossa, and the inferior wall of the cavernous sinus is the superolateral wall of the sphenoid sinus.

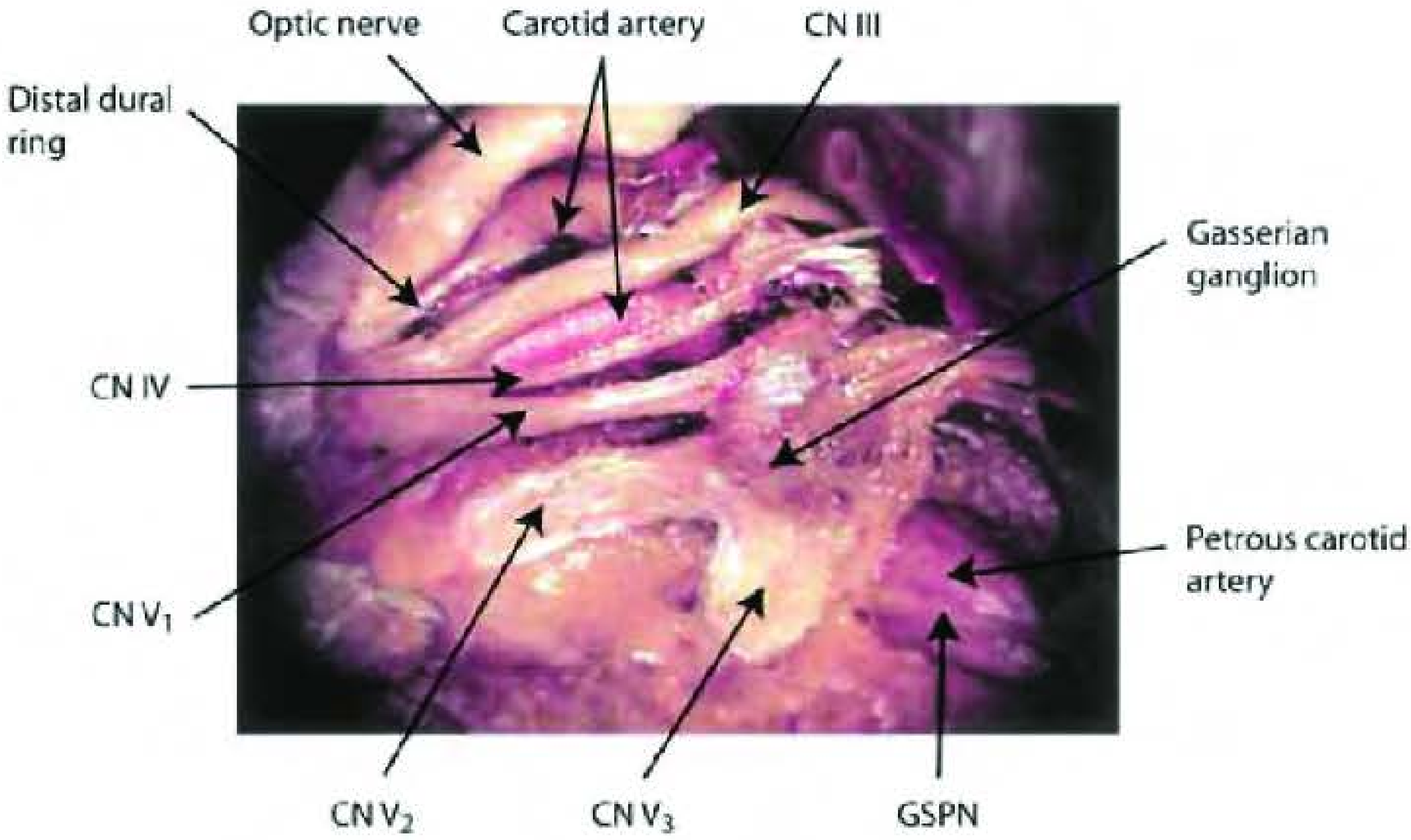

FIGURE 8–1 Panoramic view of the complete left cavernous sinus, including cranial nerve (CN) II, III, IV, V, and VI as well as the petrous, intracavernous, and supraclinoid internal carotid artery. GSPN, greater superficial petrosal nerve.

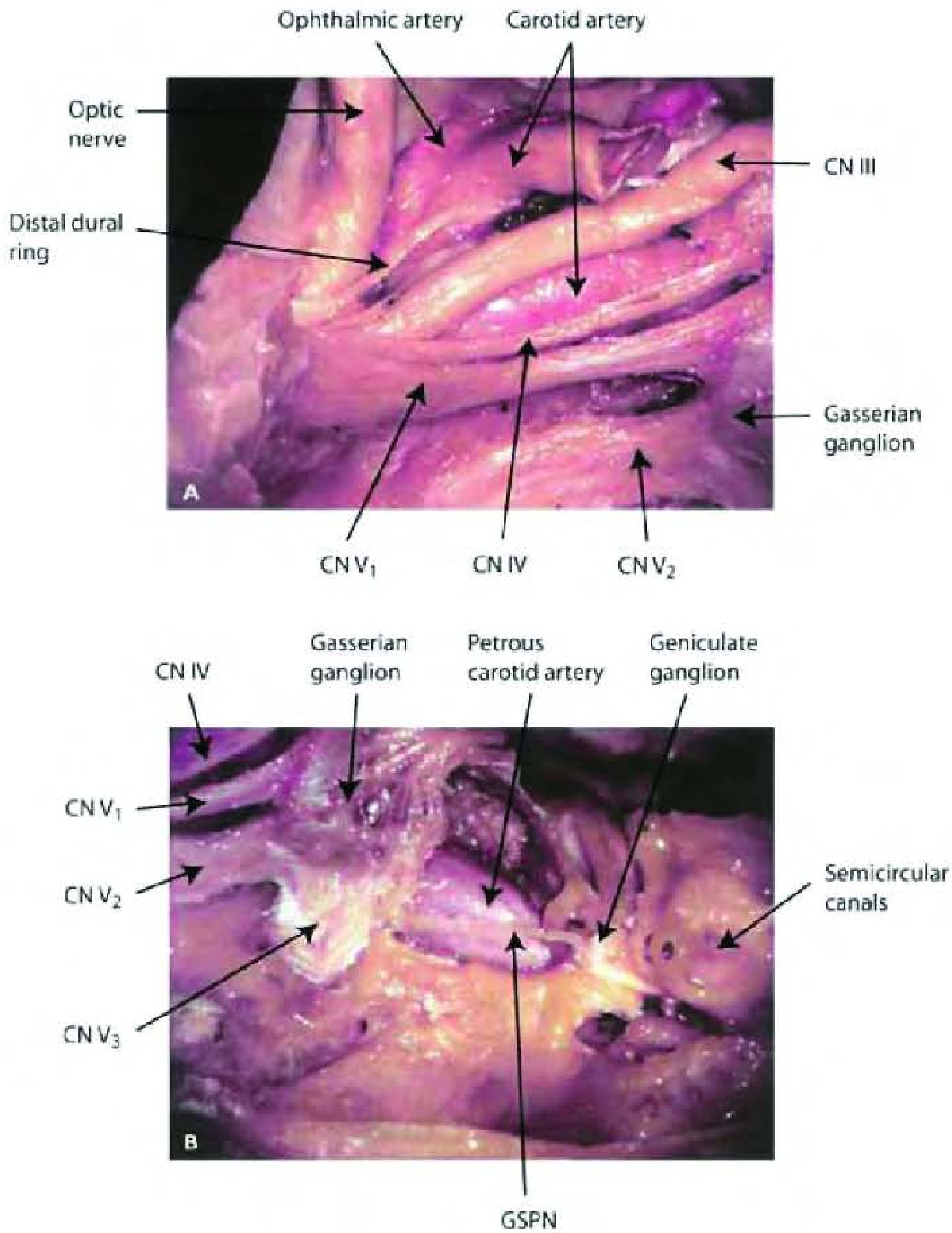

FIGURE 8–2 High-power view of the anterior and posterior Cavernous sinus. **A**: The anterior portion of the cavernous sinus showing the ophthalmic artery and distal dural ring. The clinoid has been resected. Cranial nerve (CN) II, III, IV, V_1, and V_2 are seen. **B:** The posterior portion of the cavernous sinus showing the floor of the middle fossa, gasserian ganglion, petrous segment of the internal carotid artery, cochlea, and semicircular canals. GSPN, greater superficial petrosal nerve.

ANATOMY

MIDDLE FOSSA FLOOR

Middle fossa landmarks that are the most salient during any approach to the cavernous sinus include the superior orbital fissure (SOF), the foramen ovale (FO), the foramen rotundum (FR), and the foramen spinosum (FS). The SOF is covered by the dura mater and is situated at the intersection of the lateral wall and roof of the orbit. It contains cranial nerves (CNs) III, IV, V_1, VI, and the superior ophthalmic vein. The FR is situated lateral and posterior to the SOF. The maxillary division of the trigeminal nerve (V_2) exits from the cranial cavity through this foramen. The FO is situated lateral and posterior to the FR. Its contents include the mandibular branch of the trigeminal nerve (V_3), a venous plexus that connects to the cavernous sinus via the middle meningeal vein, and occasionally an accessory branch to the middle meningeal artery. The most lateral and posterior orifice in the floor of the middle fossa is the FS, through which enters the middle meningeal artery (MMA).

DURAL WALLS

The cavernous sinus (CS) extends from the orbital apex anteriorly to the petrous apex posteriorly and is bordered by posterior, anterior, medial, lateral, superior, and inferior walls. CN III and IV enter the dural covering of the CS through its superior wall, and course in the superior aspect of its lateral wall. The ophthalmic (V_1) and maxillary (V_2) divisions of the fifth cranial nerve and the gasserian ganglion are situated in the dural sheath of the lateral wall. The abducens nerve (VI) is the only CN that runs within the CS.

The lateral wall of the CS has two well-defined, and mechanically separable, layers of dura. The internal layer, the dura propria or endosteal dura, is made up by the dura of cranial nerves III, IV, and V as they enter the CS. A reticular membrane unites the dural coverings of each of these nerves, forming a continuous sheath. The outer layer of the lateral wall of the cavernous sinus, the cerebral dura, is thick and can be separated from the inner layer by sharp dissection. Through careful sharp dissection between the outer and inner dural layers covering cranial nerves III, IV, and V, a bloodless surgical plane is revealed.

The dura of the medial wall of the cavernous sinus is very thin and closely adherent to the sphenoid bone. The sphenoid bone, which is also quite thin, separates the pituitary gland from the cavernous sinus. This explains the frequent spread of pituitary tumors into the cavernous sinus as well as the iatrogenic injuries to the cavernous carotid that may occur during transphenoidal approaches. On the other hand, the lateral wall of the cavernous sinus is both thick and resilient and prevents further spread of pituitary tumors. The dura of the medial wall travels with the nerves and the carotid artery at the foramina located in this area. It becomes thicker and makes up a firm ring at the entrance of the carotid artery into the CS above the foramen lacerum.

The outer thicker layer of dura, which makes up the lateral wall of the cavernous sinus, continues laterally as the inner layer of the middle fossa dura and medially as the superior wall of the CS. The superior wall dura continues anteromedially as the dura of the planum sphenoidale. It wraps around the anterior clinoid process, covers the tuberculum sella, and continues over the pituitary fossa as the diaphragma sella. The dura of the superior wall also makes up the roof of the proximal part of the optic canal as a thick dural fold called the *falciform ligament.* This same layer of the dura is continuous posteriorly with the dura of the tentorium and clivus.

NERVES

Cranial nerve III enters the superior dural wail of the CS through me lateral portion of the oculomotor trigone. After entering the sinus, the nerve is accompanied for a few millimeters by the dura of the superior wall. CN III and the anterior clinoid process represent the most important surgical landmarks in the anterior cavernous sinus. The inferolateral surface of the anterior clinoid process is in direct contact with the third nerve. Thus, special care should be taken when drilling the anterior clinoid process as it can result in damage to the nerve. The fourth CN enters the superior dural wall of the CS lateral to the position of CN III in the oculomotor trigone. Just before entering the SOF, CN IV turns superiorly and crosses the third nerve. The fourth nerve is therefore the most superior nerve of the SOF.

The fifth CN is located between the two dural layers of the lateral wall of the CS. These dural layers also enclose the gasserian ganglion and its three main divisions, which may be easily dissected and separated from each other. The ophthalmic division (V_1) runs along the middle portion of the lateral wall and exits the CS through the SOF. The maxillary division (V_2) runs slightly oblique along the lateral wall and exits the CS through the foramen rotundum. The mandibular division (V_3) does not enter the cavernous sinus; instead, it exits the cranium through the foramen ovale. The superior ophthalmic vein drains into the CS through the angle between V_1 and V_2.

The sixth CN enters the CS through Dorello's canal, which is located between the two layers of the dura of the petroclival region. It is situated between the petroclinoid ligament and the superior third of the medial surface of the clivus. The entry point of the nerve into the clival dura is located approximately 15 mm below the tip of the posterior clinoid process. After entering, it courses superiorly within the basilar venous plexus along the clivus and then takes a smooth bend over the petrous apex. At the petrous apex, it traverses under the medial part of the posterior petroclinoid ligament (Gruber's ligament); a bow-tie–shaped ligament extending from the petrous apex to the posterior clinoid process. The sixth nerve may have multiple rootlets that join into a single bundle on entry into the clival dura. After passing under the petroclinoid ligament, the sixth nerve turns superolaterally and travels lateral to the carotid artery at its posterior ascending segment. It may be followed along its course medial to Meckel's cave as well as along the inferior aspect of the first division of the trigeminal nerve. The nerve travels lateral to the carotid artery at its posterior ascending segment to become located at the inferolateral aspect of the artery (Fig. 8–3).

ARTERIES

The carotid artery traverses the apex of the petrous region underneath the gasserian ganglion. A dural ting under the mandibular division of the trigeminal nerve marks the entrance of the artery into the CS, at which point it is relatively fixed (note that in a small percentage of patients, this segment of the carotid will lack a bony covering). The intracavernous portion of the carotid artery has been divided into five anatomic segments: posterior ascending, posterior genu, horizontal, anterior genu, and anterior ascending. The distal part of the anterior ascending segment of the carotid artery is located medial to the anterior clinoid process. Resection of this bone permits an additional exposure of 4 to 7 mm of the internal carotid artery without entering the cavernous sinus. The carotid artery is separated from the anterior clinoid process by a dural sheath. Two prominent dural folds can be identified on the carotid artery after the anterior clinoid process is removed. These folds represent the proximal and distal dural rings. The dural sheath covering the artery is continuous with the dura encasing the nerves of the SOF, the dura over the planum sphenoidale and tuberculum sella, and the dura of the lateral wall of the CS.

The intracavernous carotid artery has two main branches. The posterior caroticocavernous or meningohypophyseal trunk originates from the posterior aspect of the ascending segment of the cavernous carotid artery approximately 4 to 6 mm below the dome of the posterior genu of the artery. The artery divides into multiple branches. Of these, the tentorial artery (Bernasconi and Casinari) enters into the tentorial dural folds, the dorsal meningeal artery courses in a posteromedial direction over the clival dural surface, and the inferior hypophyseal artery traverses medially to the posterior lobe of the pituitary gland. The other branch of the intracavernous carotid artery is the lateral caroticocavernous trunk or the inferior cavernous sinus artery. This artery originates from the horizontal segment of the carotid artery and courses over the sixth CN. It supplies the dura of the inferior wall of the CS and the intracavernous cranial nerves. McConnell's capsular artery arises from the medial surface of the horizontal segment of the carotid artery and supplies the dural sheath around the pituitary gland.

VEINS

Anteriorly, the CS communicates with the superior and inferior ophthalmic veins as well as with the sphenoparietal sinus, which receives blood flow from the sylvian veins. Laterally, the CS communicates with the venous sinus accompanying the middle meningeal artery. Posteriorly, the superior petrosal sinus, the inferior petrosal sinus, and the basilar sinus communicate with the CS. These posterior communications are located in or around Meckel's *cave* so that surgical maneuvers in this area usually are accompanied by copious bleeding. The anterior and posterior intercavernous sinuses connect the two cavernous sinuses. These interconnections are situated between two layers of the dura mater.

GEOMETRIC CONSTRUCT

The numerous elements that make up the cavernous sinus are arranged in a specific way, coming together to form several triangles that act as surgical windows. Despite the deformation caused by pathology, this anatomic arrangement typically remains identifiable and helps to orient the surgeon during the procedure.

The cavernous sinus may be divided into a parasellar subregion, a middle cranial subregion, and a paraclival subregion. Each of these subregions contains windows that allow access to different portions of the CS or that can be

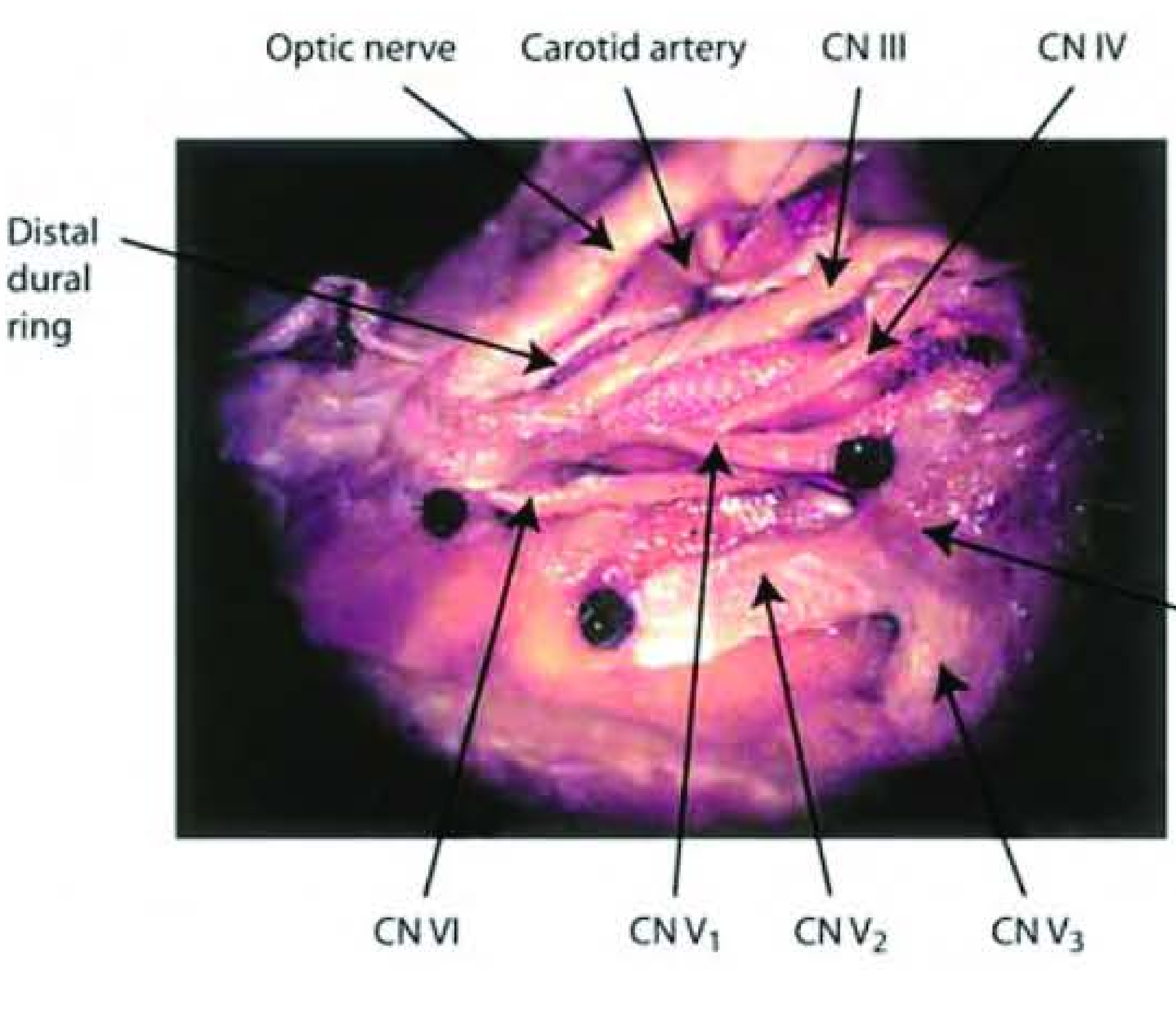

FIGURE 8–3 With upward retraction of CN V, the intracavernous portion of cranial nerve (CN) VI is well visualized.

passed through to reach adjacent targets such as the sella turcica or basilar artery.

PARASELLAR SUBREGION

Anteromedial Triangle

This area is bordered by the optic nerve covered by its dura propria medially, by the third nerve covered with the fibrous tissue of the proximal ring laterally, and by the dura extending from the entry point of CN III (porus oculomotorius) to the optic nerve (Fig. 8–4). Although the limits of this window are generally clear, it is necessary to resect the anterior clinoid process to reach the anterior loop of the internal carotid artery (clinoidal segment) and its dural rings as well as the mucous membrane of the sphenoid sinus. The anteromedial triangle is the key to accessing the anterior portion of the CS and therefore must be completely exposed.

Paramedial Triangle

This area is bordered medially by the lateral aspect of the third nerve, laterally by the medial aspect of the fourth nerve, and posteriorly by the dura extending between the dural entry points of the CNs III and IV. In dissecting this triangle, special attention should be paid to the arterial inferolateral trunk, which is the blood supply to the oculomotor and trochlear nerves (Fig. 8–5).

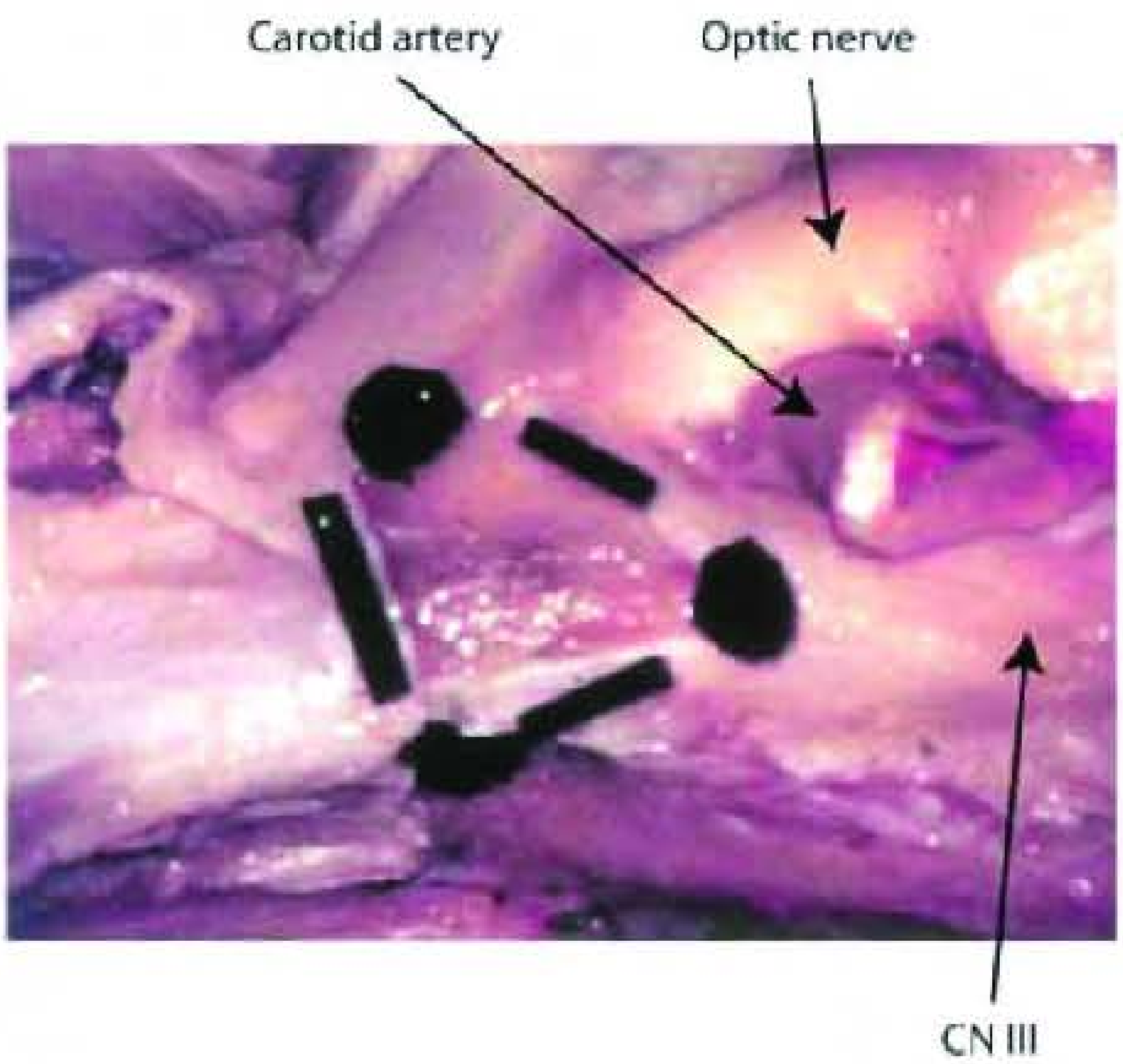

FIGURE 8–4 Anteromedial triangle. The limits are the lateral aspect of the optic nerve, medial aspect of cranial nerve (CN) III, and the dura extending between the two.

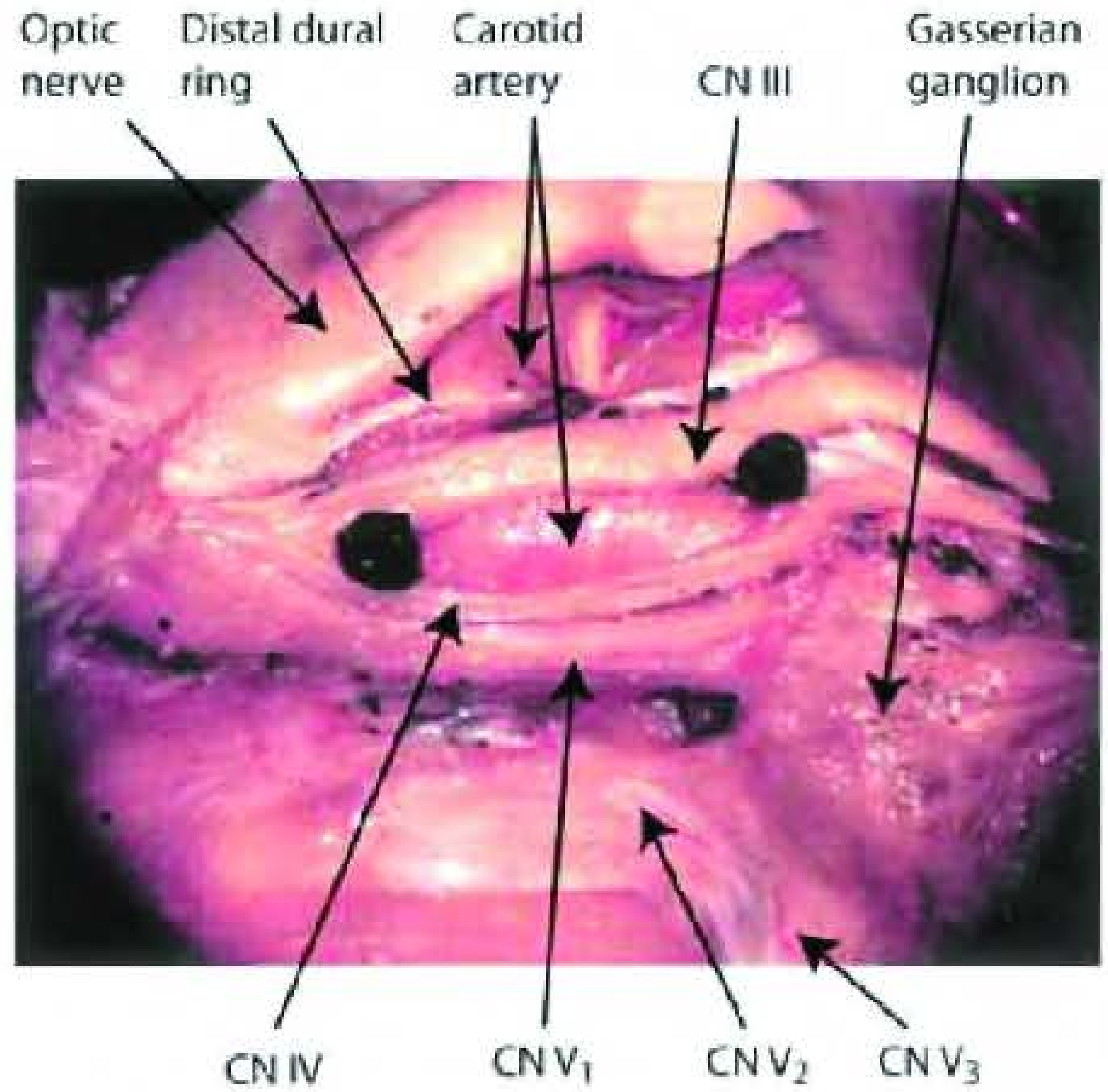

FIGURE 8–5 Paramedian triangle. The limits are the lateral aspect of cranial nerve (CN) III, the medial aspect of CN IV, and the dura ex lending between the dural entry points of each nerve.

Parkinson's Triangle

This area is bordered by the lateral aspect of the fourth nerve medially, by the medial aspect of V_1 laterally, and by the dura between CN IV and V_1 posteriorly. This window is usually small and needs to be enlarged to gain access to the sinus. This can be achieved by retracting the nerves. CN IV is a tiny structure, and so it is advisable to apply the retraction to V_1. This maneuver will expose the sixth nerve running parallel and lateral to the carotid artery as well as its relationships with the meningohypophyseal trunk (Fig. 8–6).

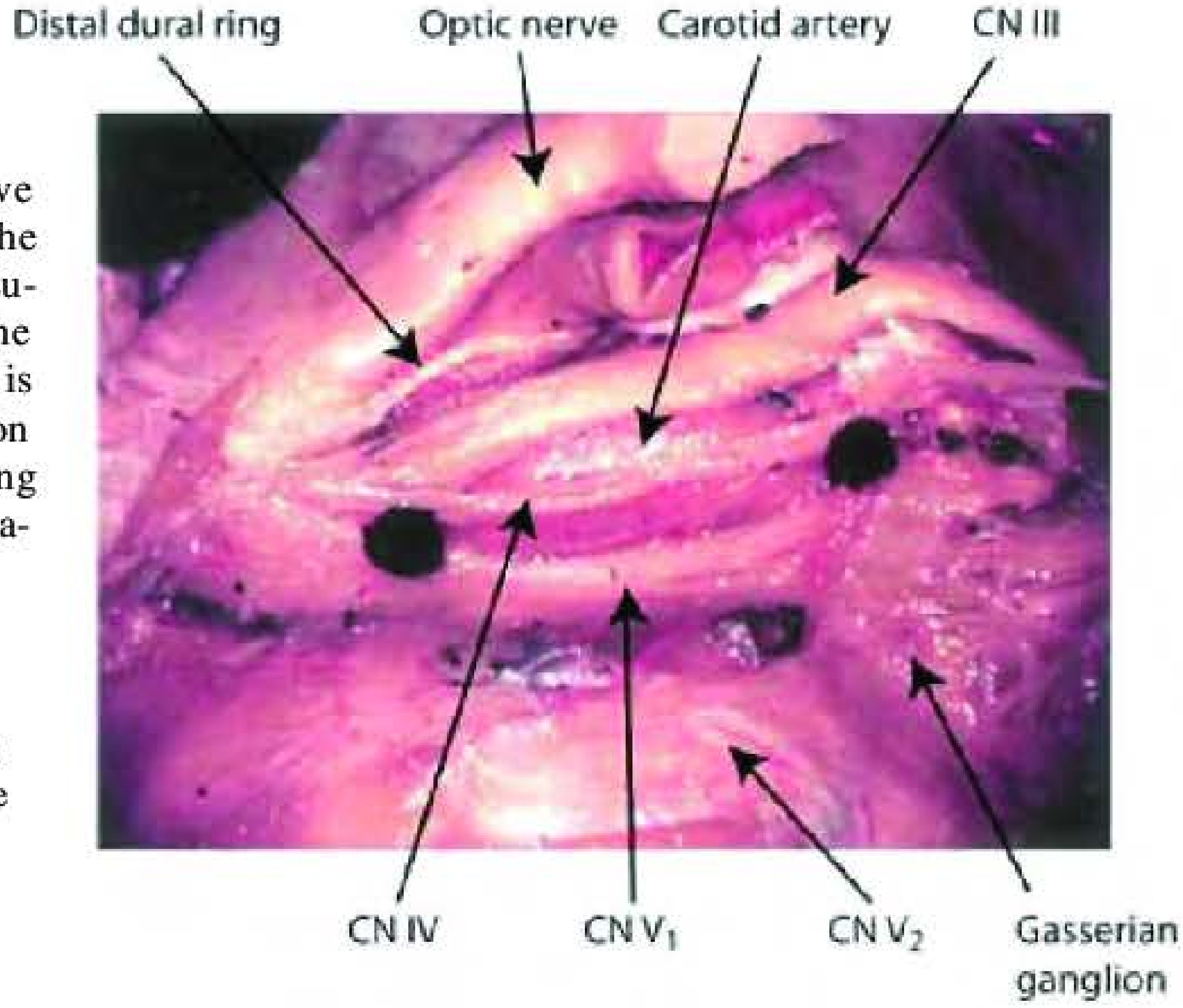

FIGURE 8–6 Parkinson's triangle. The limits are the lateral aspect of cranial nerve (CN) IV, medial aspect of CN V_1, and the dura extending between both nerves.

Oculomotor Trigone

This area is bordered by the anterior petroclinoid fold extending from the petrous apex to the anterior clinoid process anterolaterally, by the posterior petroclinoid fold extending from the petrous apex to the posterior clinoid process posteriorly, and by the interclinoid fold extending between the anterior and the posterior clinoid processes medially. This trigone makes up the superior wall of the CS, and it is adjacent to the posterior borders of the anteromedial and paramedial triangles. The lateral border of the trigone is perforated by CNs III and IV as they enter the CS. The superior wall of the CS continues medially as the sellar diaphragm (Fig. 8–7).

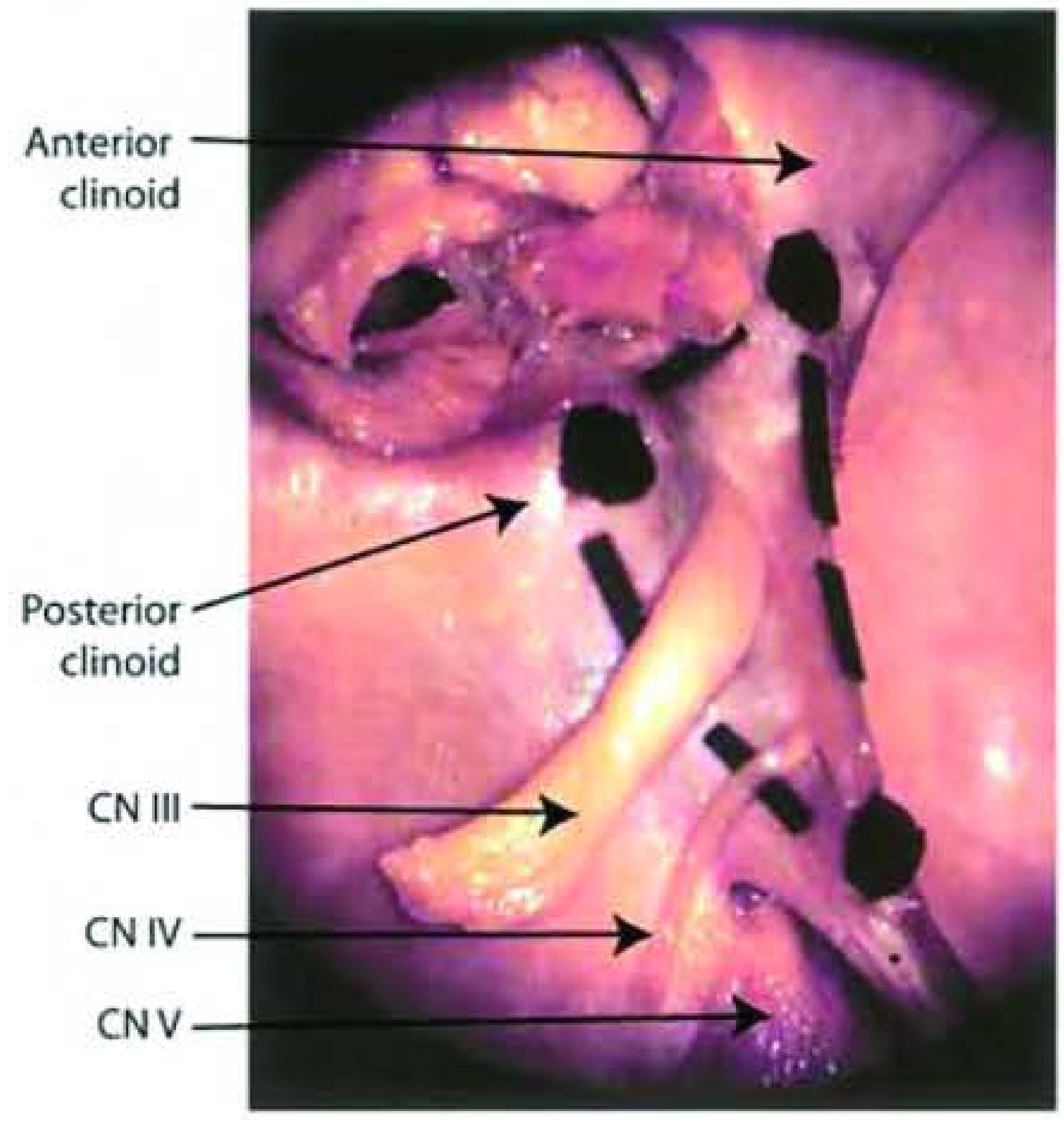

FIGURE 8–7 Oculomotor trigone. The limits are the anterior, posterior, and interclinoid dural folds. CN, cranial nerve.

MIDDLE CRANIAL FOSSA SUBREGION

Anterolateral Triangle

This area is bordered by the lateral aspect of V_1 medially, by the medial aspect of V_2 laterally, and by the middle fossa bone between the SOF and the FR anteriorly. This triangle usually is occupied by venous structures that may be coagulated or packed with Surgicel to gain access to the anterior portion of the sixth nerve. If necessary, V_1, may be retracted superiorly to enlarge the window. By drilling the anterior border of the anterolateral triangle, between the SOF and the FR, the sphenoid sinus can be reached (Fig. 8–8).

Lateral Triangle

This area is bordered by the lateral edge of V_2 anteromedially, by the anterior aspect of V_3 posteriorly, and by the middle fossa bone between the FO and FR laterally. Because this triangle is the smallest in the middle cranial fossa subregion, it may be enlarged by drilling into the bone of the middle fossa, retracting V_3 posteriorly and V_2 anteromedially in such a way that the lateral loop of the internal carotid artery (ICA) can be reached (Fig. 8–9).

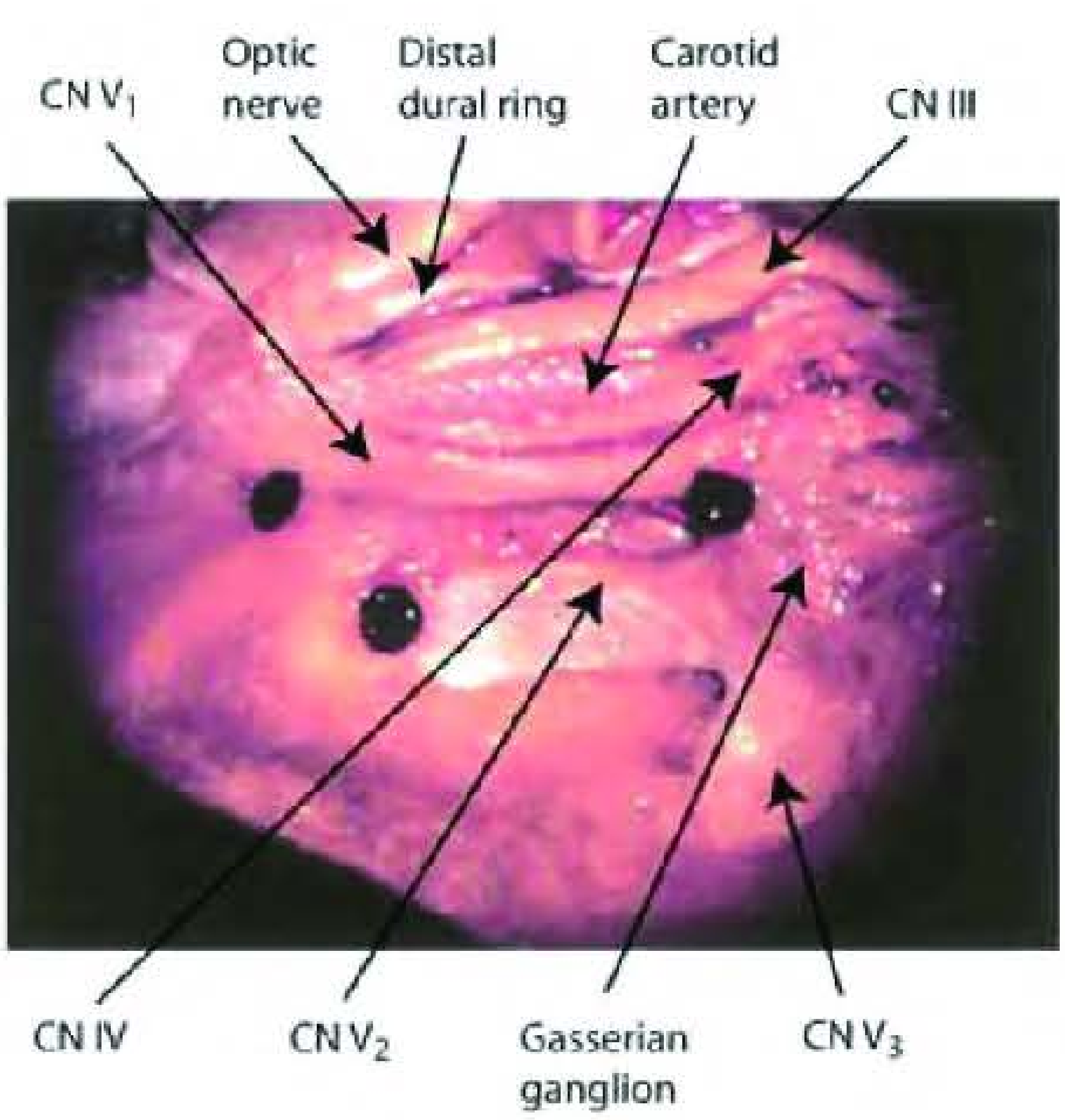

FIGURE 8–8 Anterolateral triangle. The limits are the lateral border of V_1, medial border of V_2, and the bone of the middle fossa between the superior orbital fissure and the foramen rotundum. CN, cranial nerve.

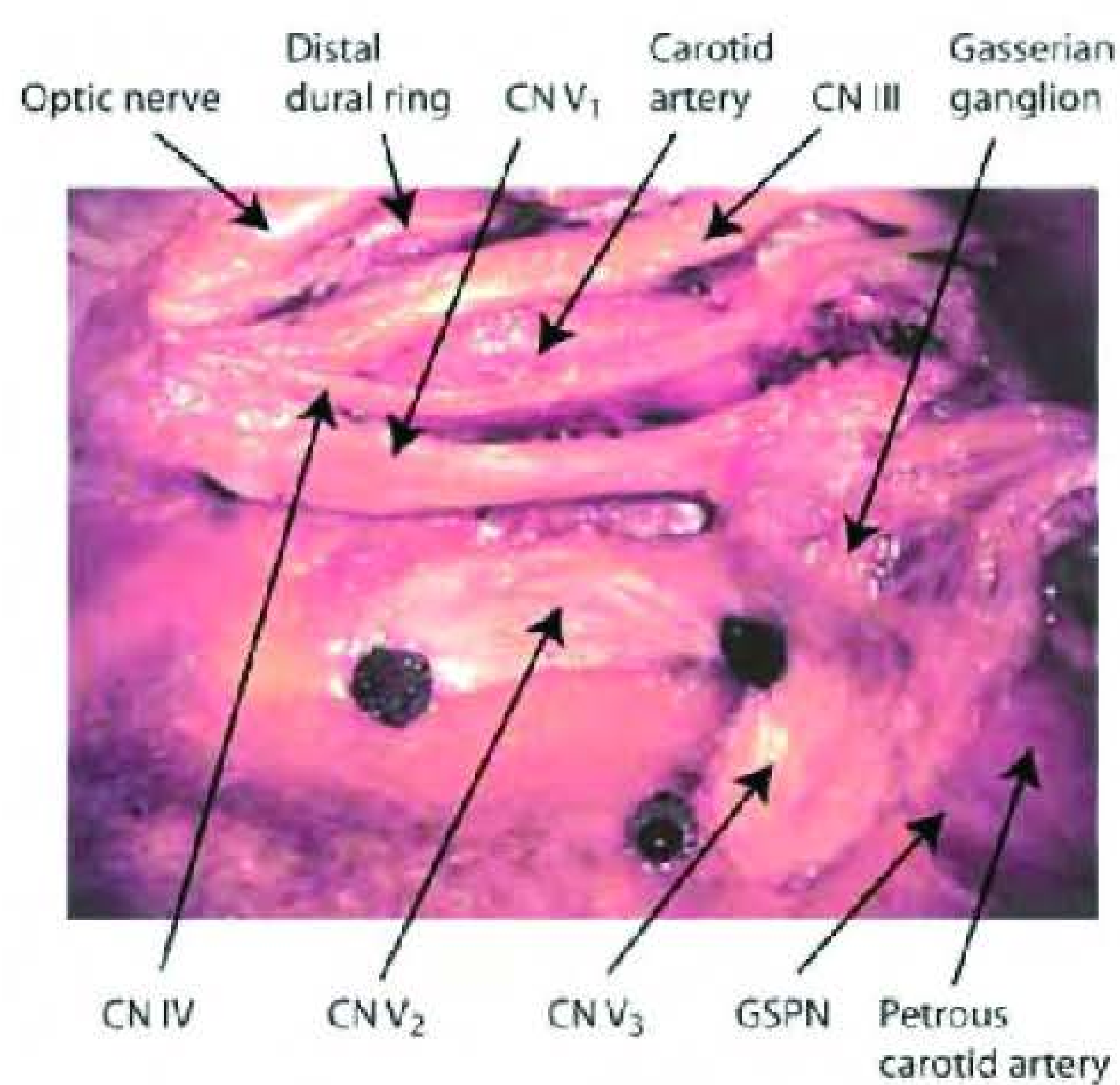

FIGURE 8–9 Lateral triangle. The limits are the lateral edge of V_2, anterior edge of V_3, and the bone of the middle fossa between the foramen rotundum and the foramen ovale, GSFN, greater superficial petrosal nerve; CN, cranial nerve.

Posterolateral Triangle (Glasscock's)

This area is bordered by the posterior aspect of V_3 anteriorly, by the greater superficial petrosal nerve (GSPN) medially, and by a line drawn between the FS and the geniculate ganglion laterally. Within this triangle, the lesser superficial petrosal nerve (LSPN), the tensor tympani muscle, the eustachian tube, and the labyrinthine branch of the middle meningeal artery can be identified. It is by drilling the posterolateral triangle that the posterior loop of the ICA (petrous carotid) is reached (Fig. 8–10).

Posteromedial Triangle (Kawase's)

This area is bordered by the posterior aspect of the gasserian ganglion anteriorly, by the GSPN in the sphenopetrosal groove laterally, and by a line drawn between the porus trigeminus and the geniculate ganglion medially. By drilling this triangle, the posterior fossa is reached, as is the posterior loop of the ICA. The bone resection may be extended posteromedially beyond the limits of Kawase's triangle to reach the internal auditory canal, but special care must be taken to protect the vestibulocochlear apparatus (Fig. 8–11).

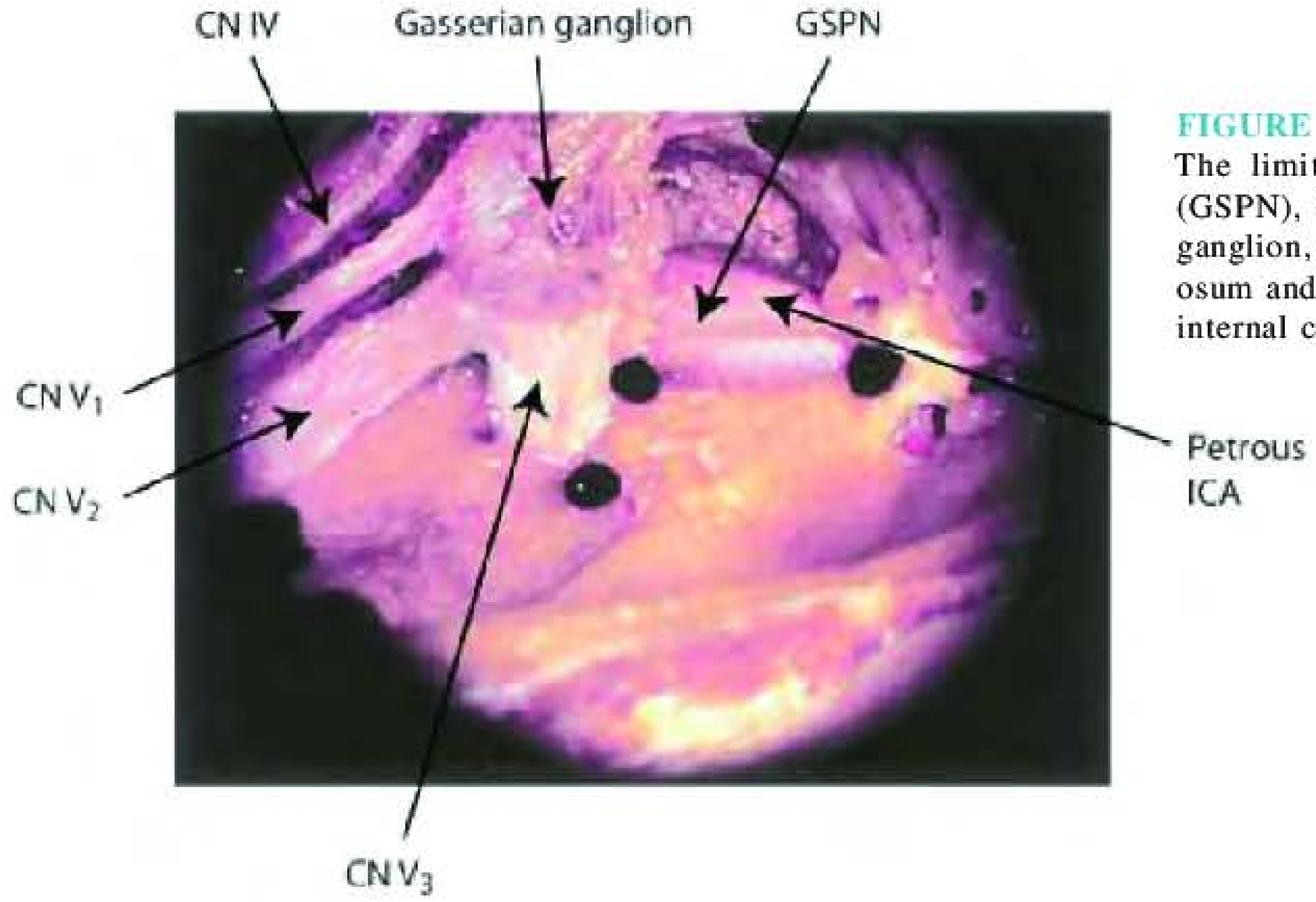

FIGURE 8–10 Posterolateral (Glasscock's) triangle. The limits are the greater superficial petrosal nerve (GSPN), the posterolateral aspect of V_3, the gasserian ganglion, and a line extending between the foramen spinosum and the arcuate eminence. CN, cranial nerve; ICA, internal carotid artery.

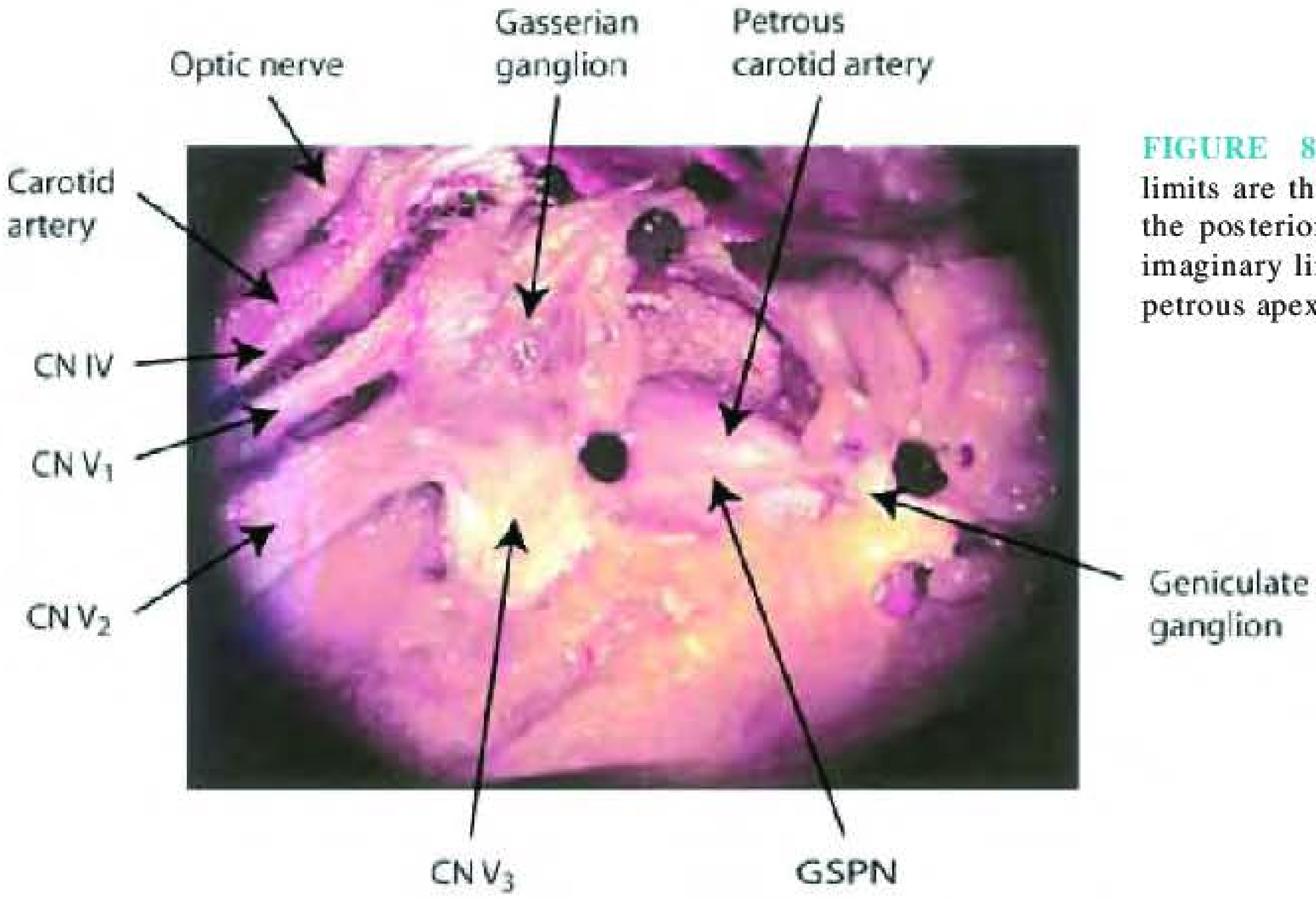

FIGURE 8–11 Posterolateral (Kawase's) triangle. The limits are the greater superficial petrosal nerve (GSPN), the posterior border of the gasserian ganglion, and an imaginary line between the geniculate ganglion and the petrous apex. CN, cranial nerve.

PARACLIVAL SUBREGION

Inferolateral Triangle (Trigeminal)

This area is bordered by a line connecting the tentorial entry point of the fourth nerve with the entrance of the petrosal vein into the superior petrosal sinus superolaterally, by a line drawn between V1 and the petrosal vein inferolaterally, and by a line connecting the fourth with the sixth nerves medially. The inferolateral triangle has a tentorial portion located above a line between the fifth nerve and the petrosal vein. This tentorial portion contains the superior petrosal sinus. Below the line between the fifth nerve and the petrosal vein is the osseous portion, which represents the medial extension of the posteromedial triangle (Fig. 8–12).

Inferomedial Triangle

This area is bordered by a short line between the CN IV entrance point into the tentorium and the posterior clinoid process superiorly, by a line between the posterior clinoid process and CN VI entering the dura mater medially, and by a line between the fourth and sixth cranial nerves entering the dura mater laterally. Because of the presence of the basilar venous plexus, the inferomedial triangle is an extremely vascular area. It is an important pathway through which the petroclinoid ligament, Dorello's canal, and origin of the meningohypophyseal artery can be accessed (Fig. 8–13).

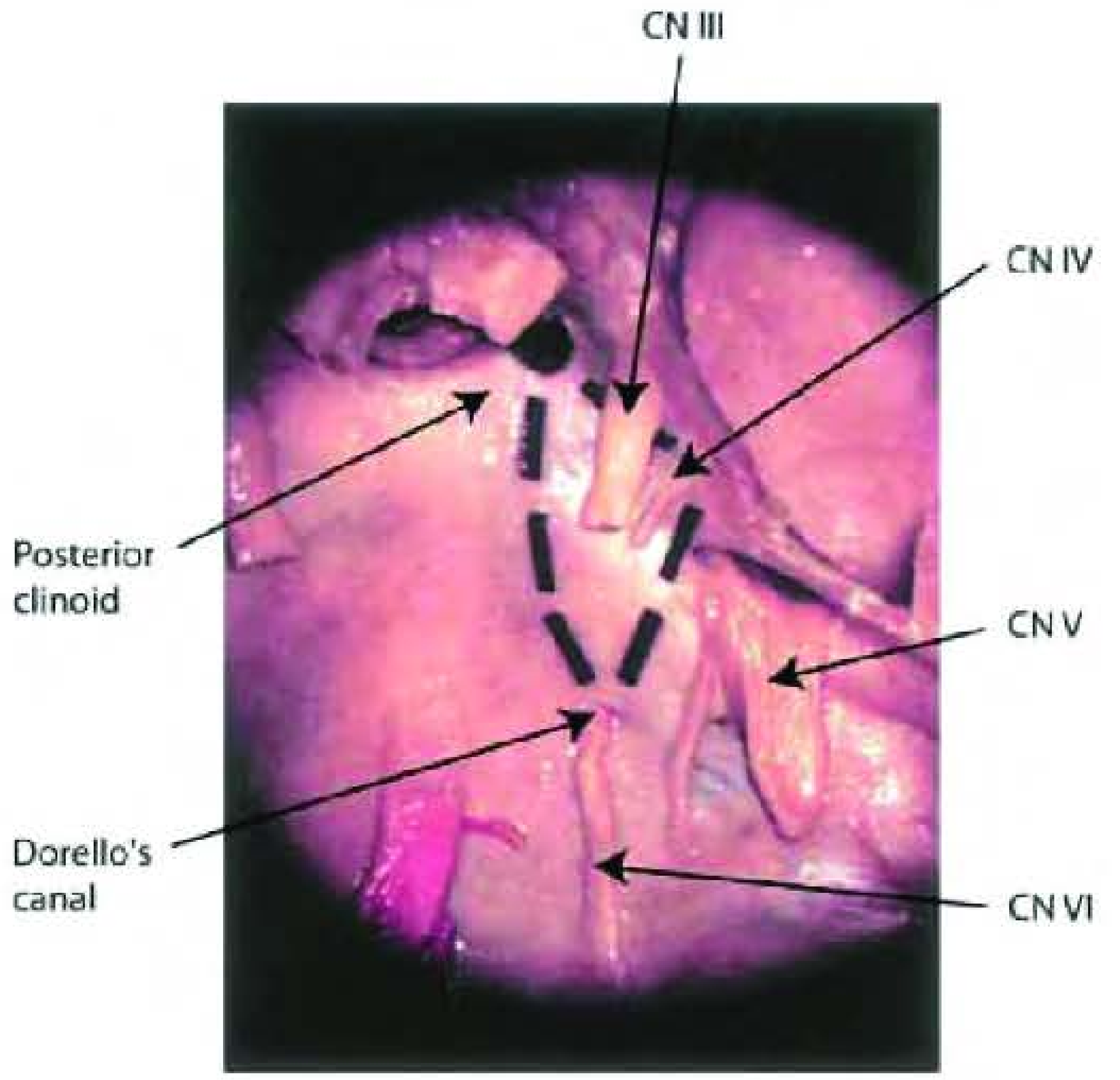

FIGURE 8–12 Inferomedial and inferolateral triangles. The limits of the inferomedial triangle are the posterior diploid process and the dural entry points of cranial nerves (CN) IV and VI. The limits of the inferolateral triangle are the dural entry points of CN IV and VI and the dural entry point of the petrosal vein into the superior petrosal sinus.

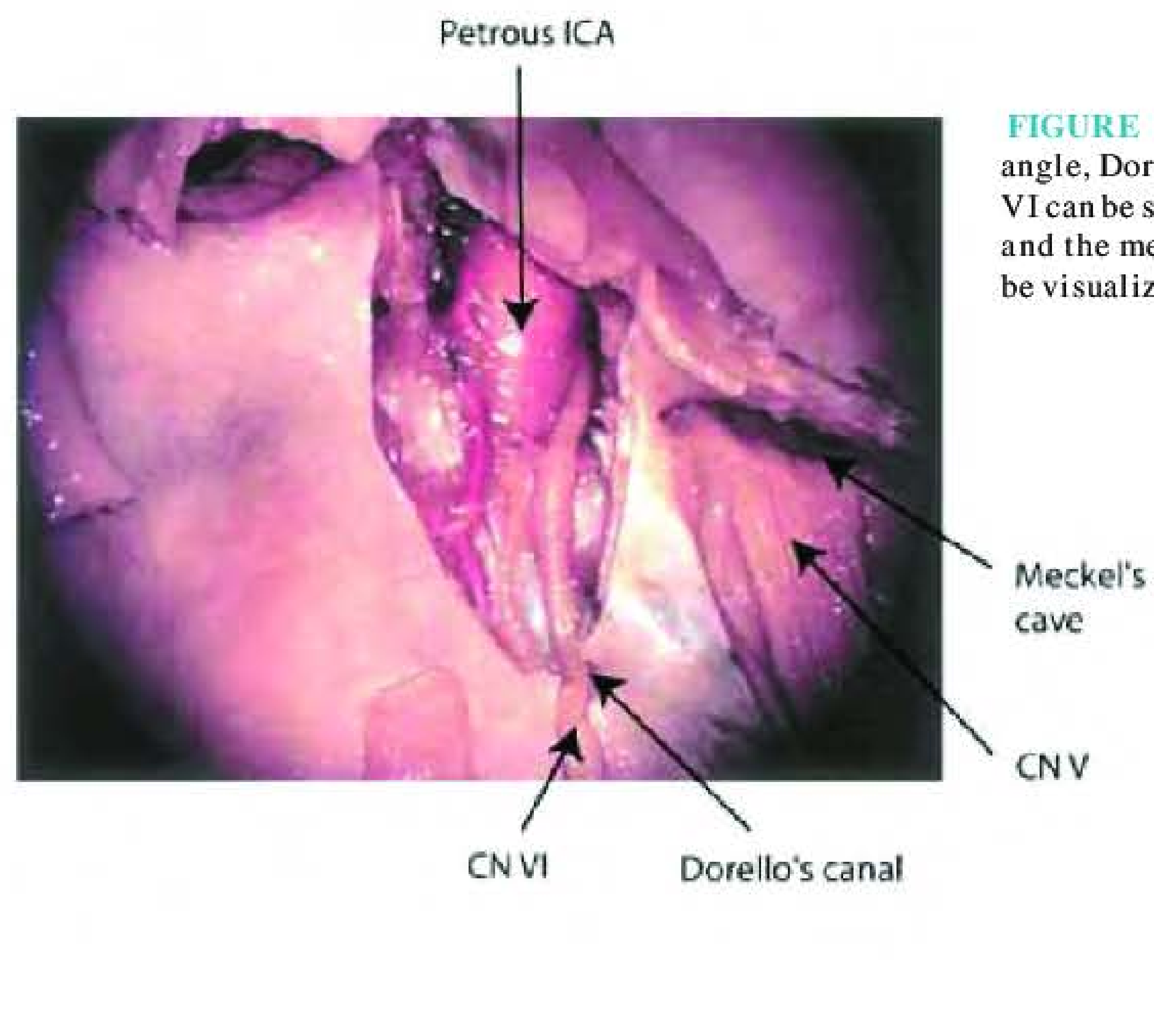

FIGURE 8–13 Opening the right inferomedial triangle, Dorello's canal is exposed. Cranial nerve (CN) VI can be seen entering the posterior cavernous sinus, and the medial loop of the internal carotid artery can be visualized.

TABLE 8–1 CAVERNOUS SINUS TRIANGLES

Triangle	*Boundaries*			*Contents*
	Medial	*Lateral*	*Base*	
Anteromedial	CN II	CN III	Anterior petroclinoid fold	Anterior clinoid process, carotid rings, anterior loop, distal horizontal ICA
Paramedial	CN III	CN IV	Posterior petroclinoid fold	Horizontal ICA, lateral trunk
Parkinson	CN IV	CN V_1	Posterior petroclinoid fold	Medial loop, horizontal ICA, CN VI
Oculomotor trigone	Interclinoid fold	Anterior petroclinoid fold	Posterior petroclinoid fold	Medial trunk of ICA
Anterolateral	CN V_1	CN V_2	Bone in between the SOF and the foramen rorundum	Lateral wall of the sphenoid sinus, horizontal ICA, CN VI
Lateral	CN V_2	CN V_3	Bone in between the foramen rotundum and the foramen ovale	Lateral loop of ICA
Posterolateral	GSPN	Geniculate ganglion to foramen spinosum	Posterior margin of V_3	Posterior and lateral loop of ICA tensor tympani, lateral loop of eustachian tube
Posteromedial	Petrous ridge	GSPN	Posterior margin of V_3 and ganglion gasserian	Posterior surface of medial loop, petrous apex with Meckel's cave, posterior fossa dura
Inferolateral	Line connecting the TV and VI nerves	Line connecting the VI nerve and the petrosal vein	Line connecting the IV nerve and the petrosal vein	Trigeminal root and porus trigeminus
Inferomedial	Line between the PCP and VI nerve	Line between VI and IV nerves	Line between IV nerve and PCP	CN VI, posterior genu of ICA

CN, cranial nerve; GSPN, greater superficial petrosal nerve; ICA, infernal carotid artery; PCP, posterior clinoid process; SOF, superior orbital fissure.

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Chapter 9

Surgical Approaches to the Cavernous Sinus

Emel Avci, Carlos Acevedo, Damirez Fossett

Indications for Approach

- Neoplastic lesions within the cavernous sinus or its walls
- Cavernous–carotid aneurysms
- Extracavernous lesions with intracavernous extensions

Positioning and Skin Incision

Because the cavernous sinus (CS) region cannot be completely exposed through a single approach, positioning the patient depends on the area that requires exposure; however, the most commonly used position is the supine position with the head held in three-point Mayfield fixation. The head is generally rotated about 30 degrees to the contralateral side with the chin flexed toward the clavicle. The maxillary eminence is brought to the apex of the field by gentle extension.

The initial position is easily changed intraoperatively, depending on which subregion of the CS the surgeon is working. Elevation of the head facilitates visualization of more anterior structures, whereas the Trendelenburg position improves posterior and superior access. Ipsilateral rotation facilitates access to structures located medially, whereas contralateral rotation improves visualization of structures located laterally within the middle fossa. The patient should be adequately fixed to the operating table to avoid any untoward events during intraoperative position changes.

A curvilinear incision is made similar to that described in Chapter 3 in preparation for a cranio-orbitozygomatic approach.

Surgical Technique

The cavernous sinus is generally reached using the frontotemporal orbitozygomatic technique as described in Chapter 3. The frontotemporal orbitozygomatic osteotomy also can be turned in one piece (Figs. 9–1 and 9–2). Three bur holes are made. The first is at the McCarty keyhole and

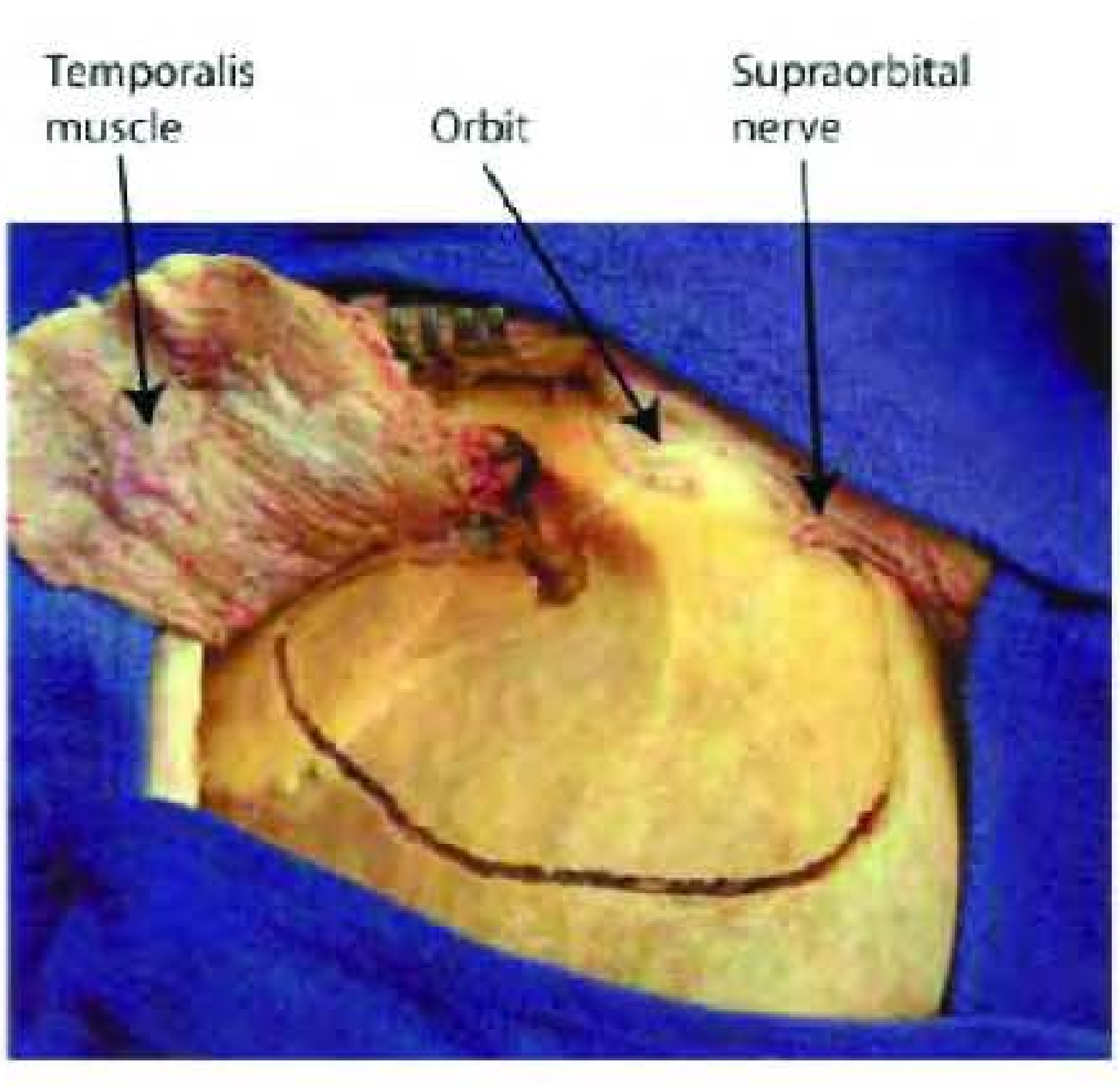

FIGURE 9–1 The frontotemporal orbitozyygomatic one-piece bone flap.

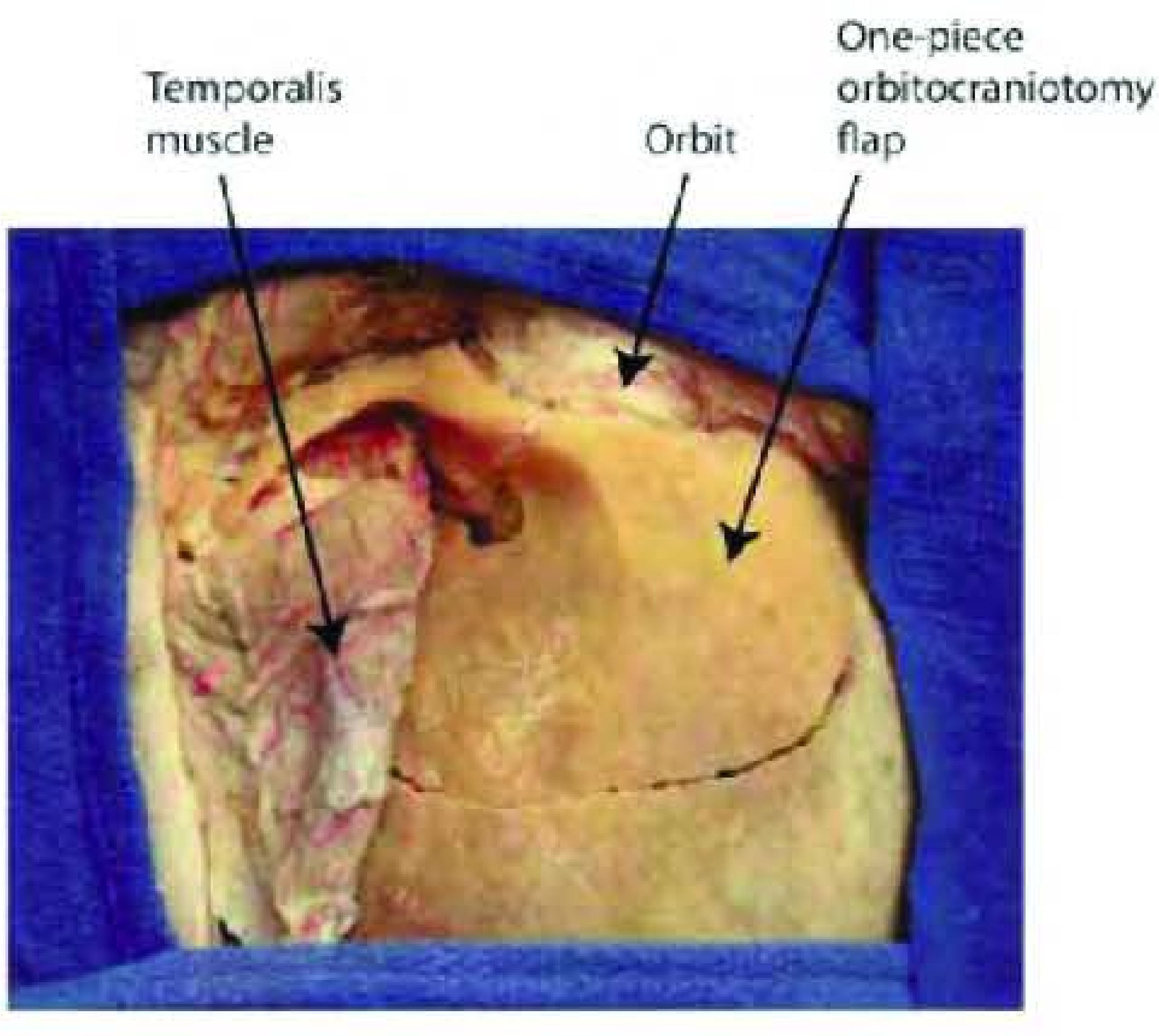

FIGURE 9–2 The temporalis muscle is reflected forward to allow visualization of the osteotomy of the posterior zygomatic arch.

should show in its upper half the dura of the frontal lobe and in its lower half the periorbita. The orbital roof separating these structures should be visible. The second bur hole is in the squamosal portion of the temporal bone, and the third is a small bur hole in the frontal bone just lateral to midline and just above the supraorbital rim. Because the sinus may be entered, the anterior and posterior walls must be perforated. Using a Midas Rex foot-plated tool, the squamous temporal bur hole and the keyhole are connected. The squamous bur hole also is connected to the frontal bur hole, making sure to go through both walls of the frontal sinus. A cut then is carried inferiorly and medially from the frontal bur hole into the orbital roof. Using an osteotome, the anterior roof of the orbit is cut, beginning at the keyhole and ending at the medial orbital cut made above. A lateral orbital wall cut extending to the keyhole at the level of the inferior orbital fissure allows a one-piece cranioorbital flap. A diagonal cut, including the anterior zygoma, associated with an oblique posterior zygomatic cut allows elevation of a one-piece cranio-orbitozygomatic flap. If a one-piece flap is turned, the sphenoid wing must be drilled to make it flat with the floor of the frontal fossa.

SPECIFIC APPROACHES

ANTEROLATERAL EXTRADURAL/INTRADURAL APPROACH

After performing a cranio-orbitozygomatic osteotomy as described in Chapter 3, the optic canal is unroofed and its medial wall drilled, taking care not to enter the ethmoid or sphenoid sinuses. The superior orbital fissure (SOF) should be unroofed and the anterior clinoid process (ACP) resected either purely extradurally (Figs. 9–3 and 9–4A, B), or with the extradural/intradural combined

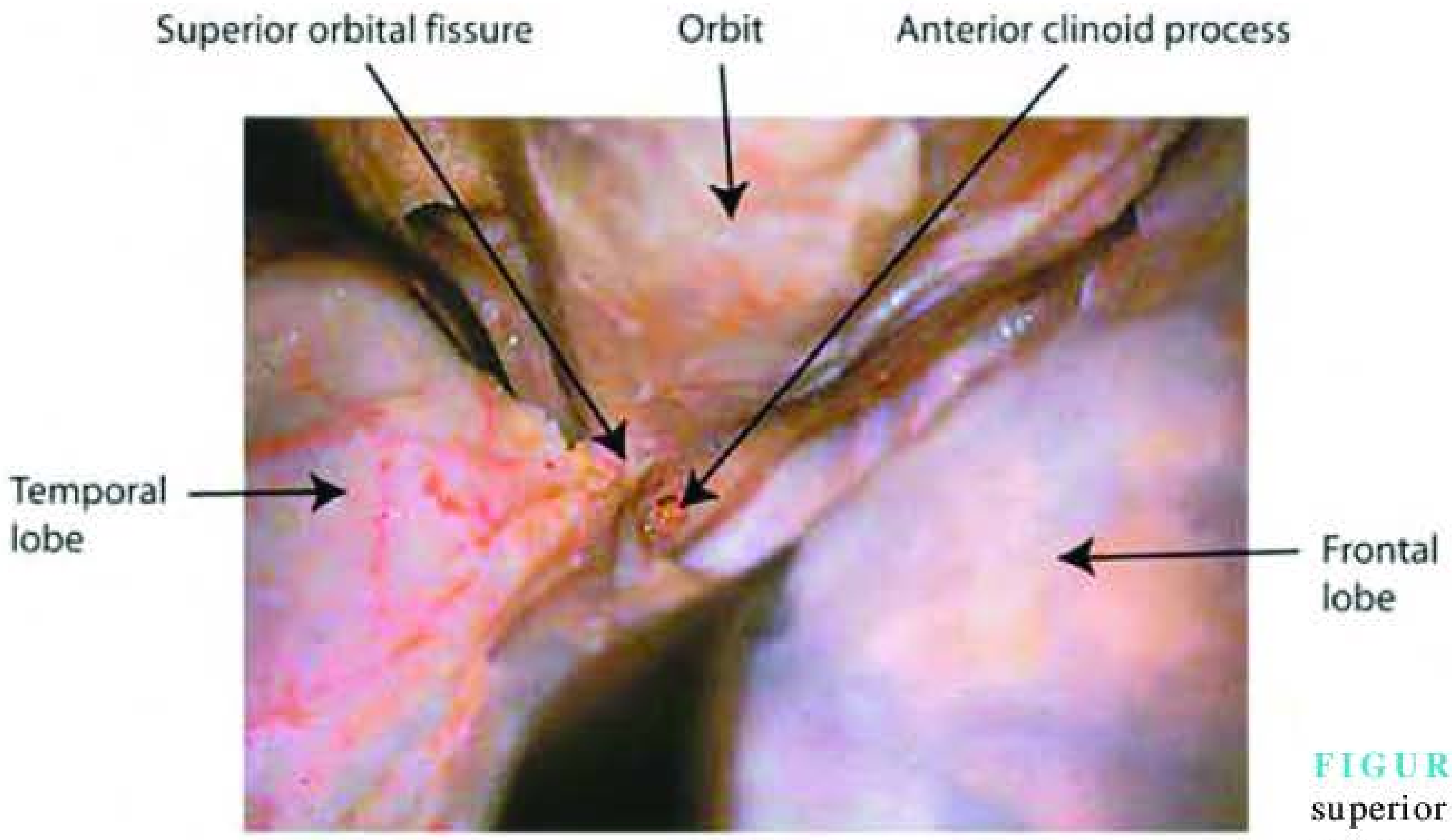

FIGURE 9–3 After removal of the bone flap, the superior orbital fissure, globe, and anterior clinoid process are identified.

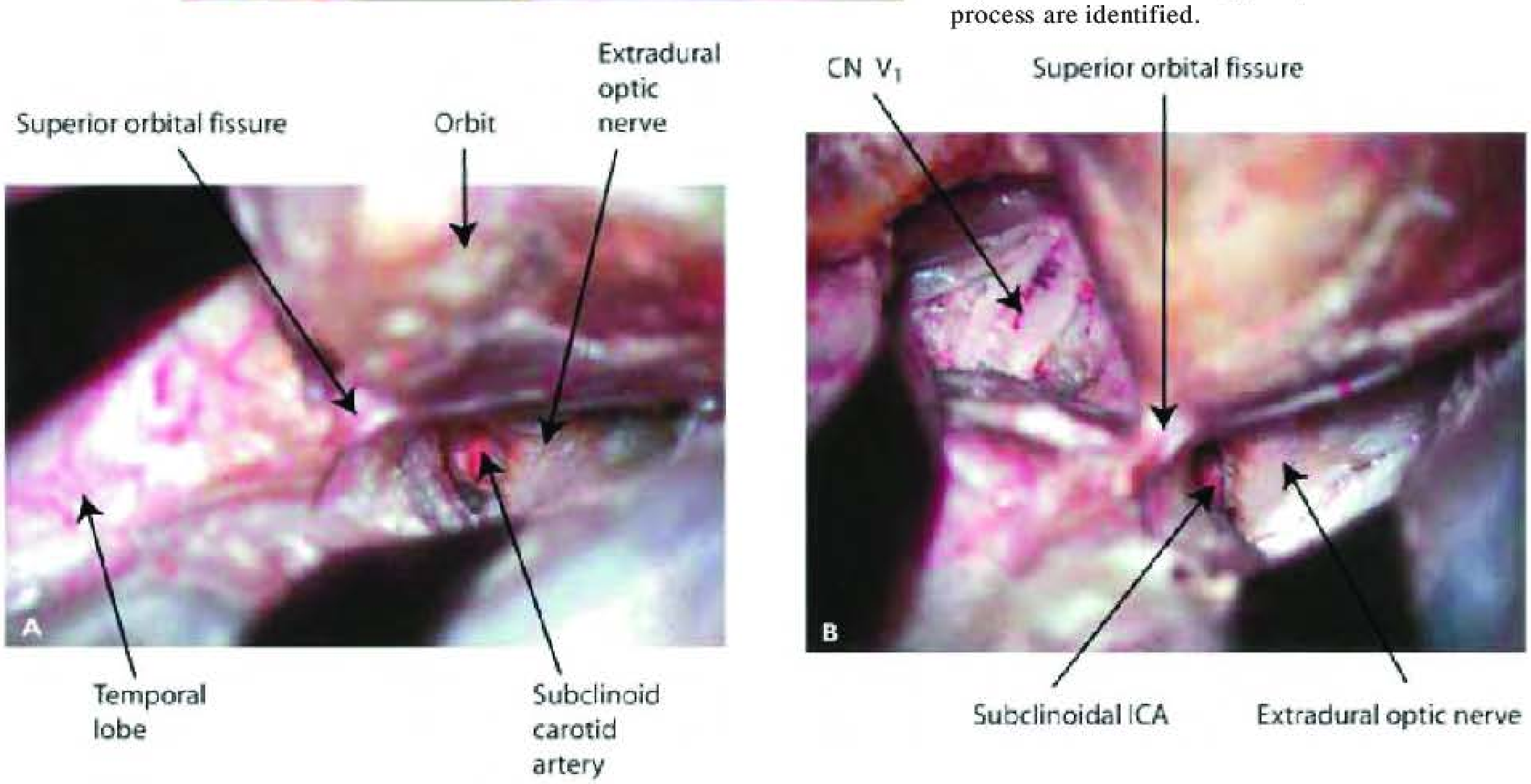

FIGURE 9–4 A: The clinoid is cored out extradurally. The extradural optic nerve is seen. B: After resection of the clinoid, the extracavernous, extradural, subclinoid carotid segment, as well as the extradural optic nerve can be visualized. CN, cranial nerve; ICA, internal carotid artery.

technique described in Chapter 3 (Fig. 9–5A, B). The floor of the middle fossa then is dissected from anterior to posterior (see Chapter 11). The floor of the middle fossa between the SOF and the foramen rotundum (FR) is drilled, and the foramen is enlarged. The middle meningeal artery is identified and followed to the foramen spinosum (FS). It is coagulated and divided, thus allowing the dura to be elevated from the floor of the middle fossa. The dura is dissected in a lateral-to-medial fashion until the greater superficial petrosal nerve (GSPN) is encountered. To avoid the risk of injury to the facial nerve, the GSPN is transected and the bone of the Glassock's triangle is drilled away (Fig. 9–10), exposing the posterior loop of the internal carotid artery (ICA) and freeing it from its bony canal to obtain proximal control (see Chapter 10). The dura is now ready for opening.

If a purely extradural resection of the anterior clinoid process was performed, the dura must now be opened. A large C-shaped curvilinear incision is made in the frontotemporal dura just over the sylvian fissure. Then the dura over the sylvian fissure is bisected with the cut carried toward the optic nerve sheath dura, which is incised to liberate the nerve. Tack-up sutures reflect the dural flap toward the globe. The sylvian fissure is split widely from lateral to medial. The distal fibrous dural ring tethering the carotid is sharply opened to reveal the ophthalmic artery. Completing this opening allows the anteromedial cavernous triangle to communicate with the intradural compartment.

The dural leaves composing the tentorial edge are split in lateral and posterior directions to expose the area of the porus oculomotorius and open the superior cavernous triangle (Figs. 9–6 and 9–7). Arachnoidal dissection in the region

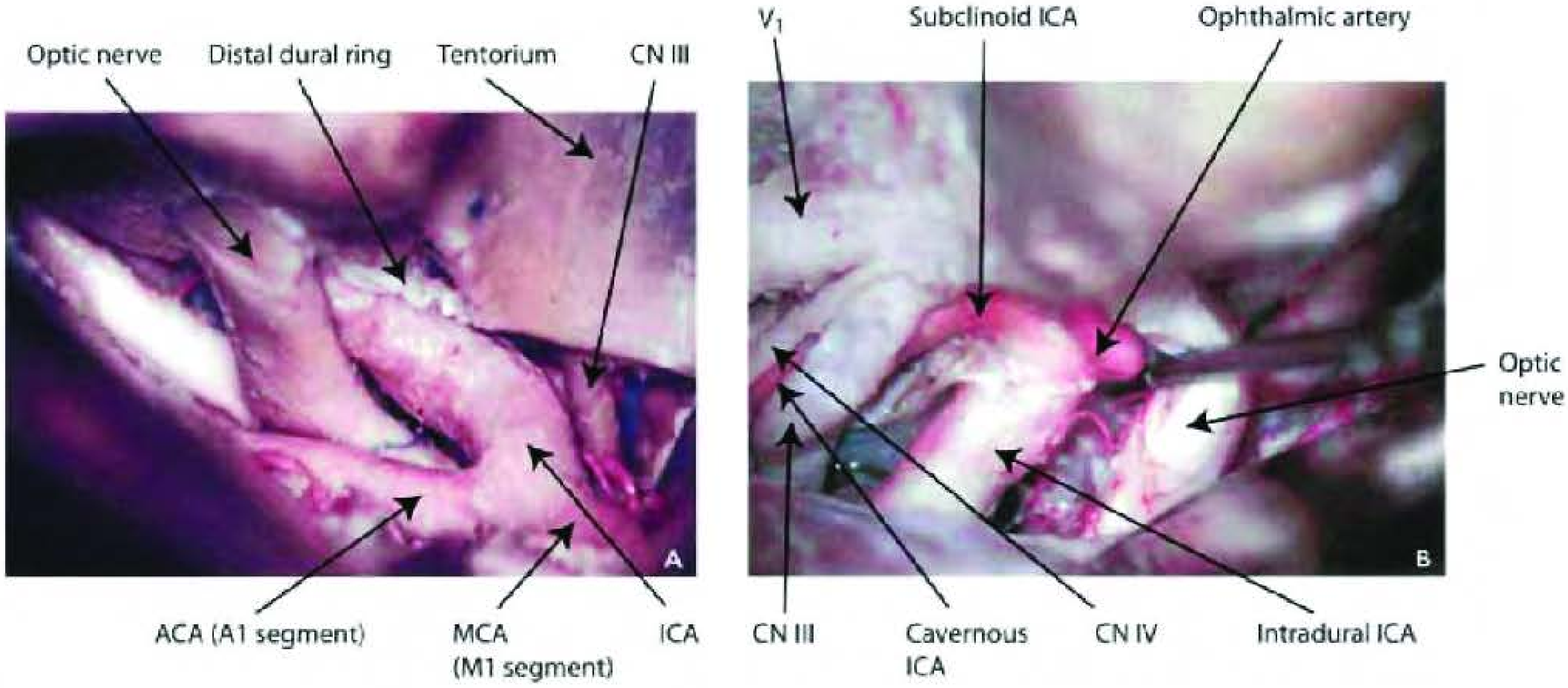

FIGURE 9–5 A: The anterior clinoid process is removed intradurally. ACA, anterior cerebral artery; CN, cranial nerve; ICA, internal carotid artery; MCA, middle cerebral artery. B: Resection of the anterior clinoid process allows visualization of the ophthalmic artery origin from the ICA.

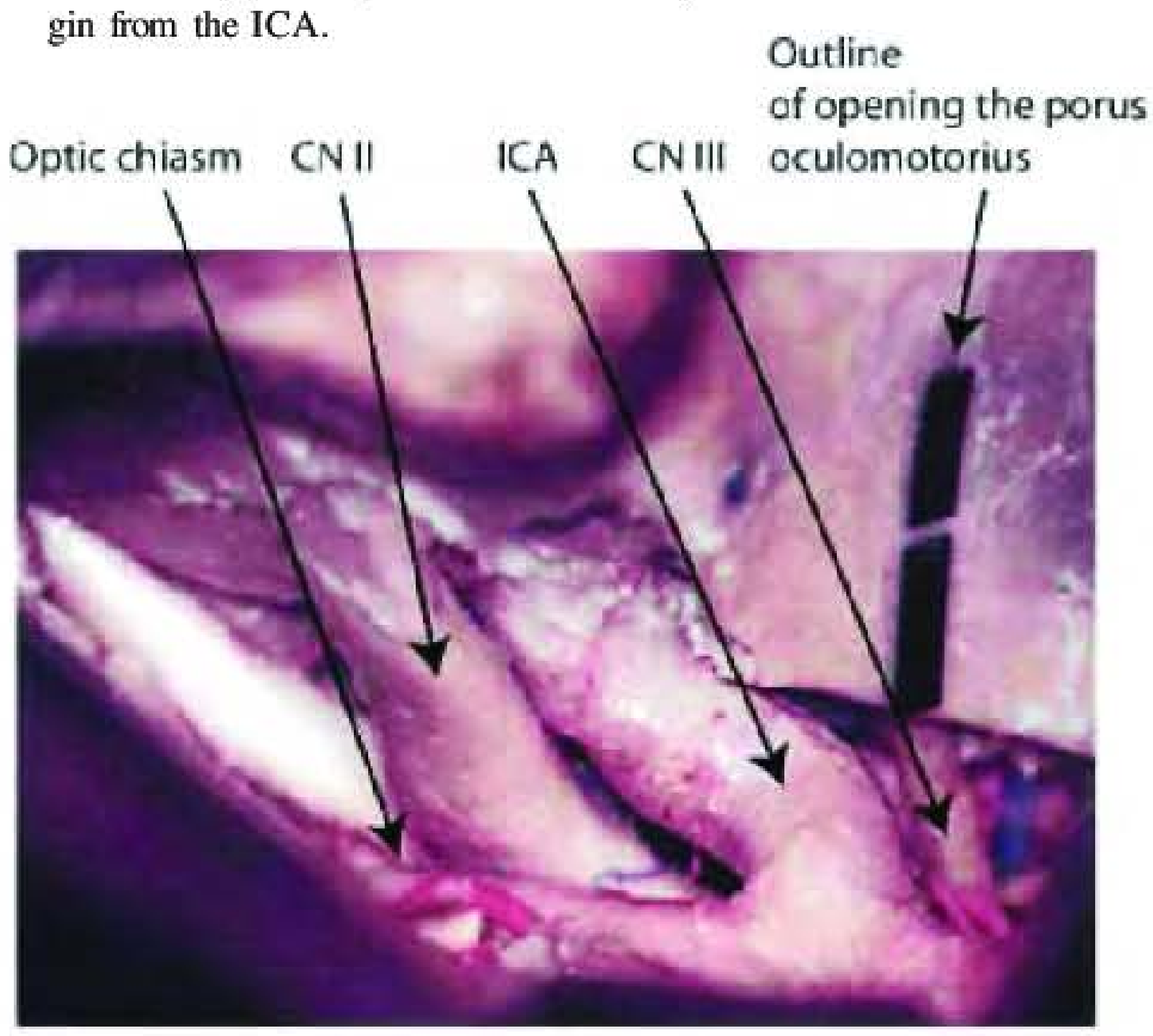

FIGURE 9–6 Dural incision to open the superior cavernous sinus and porus oculomotorius. CN, cranial nerve; ICA, internal carotid artery.

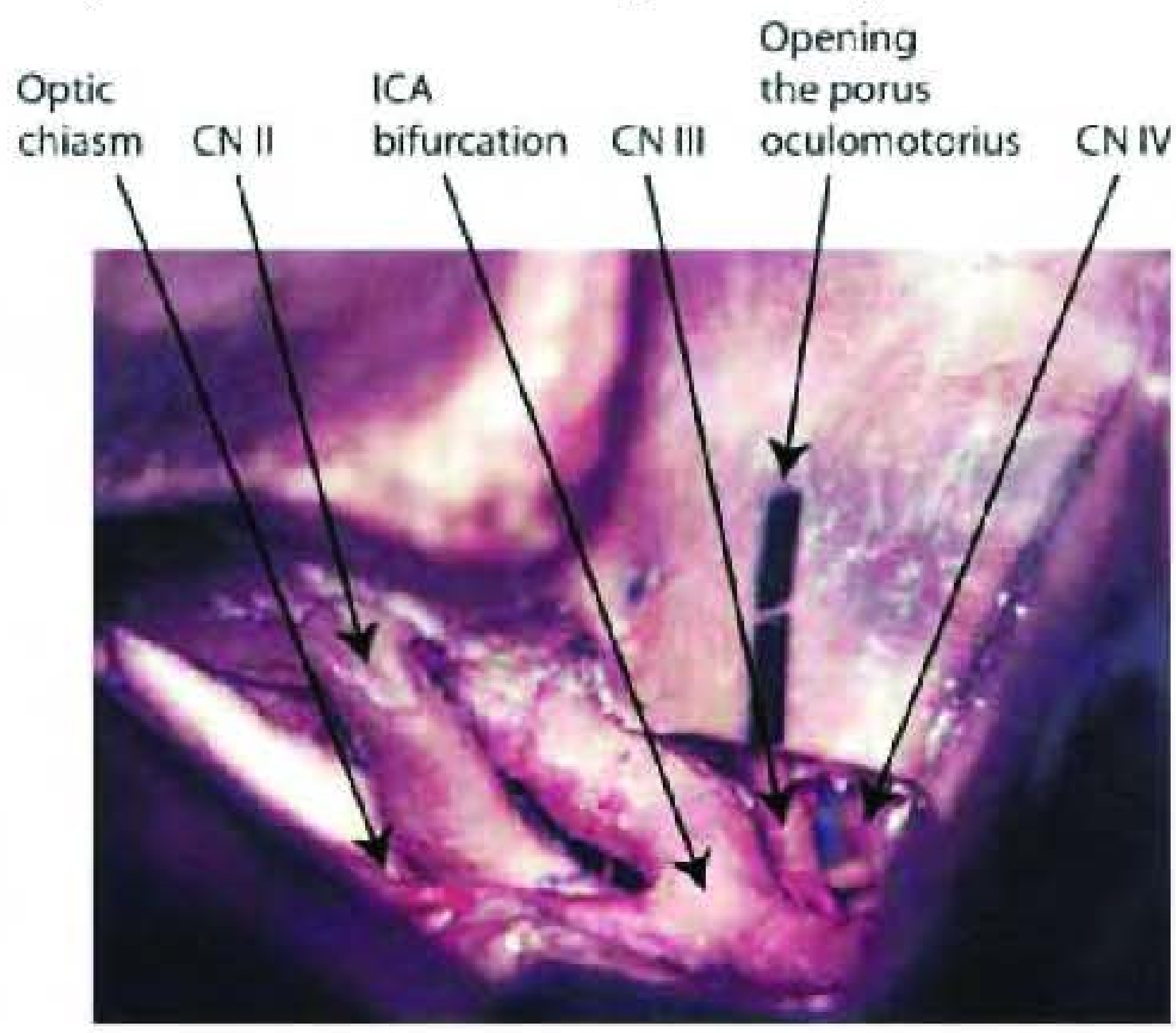

FIGURE 9–7 Panoramic view before dural opening. The fourth cranial nerve (CN) can be seen along the tentorial edge. ICA, internal carotid artery.

exposes the third cranial nerve (CN). Incising the dura along the third cranial nerve toward the superior orbital fissure will allow visualization of the fourth nerve (Figs. 9–8 and 9–9). Opening the membrane between the third and fourth CN opens the paramedial triangle and allows the intracavernous carotid to come into view (Fig. 9–10). Continued dural opening in this manner opens Parkinson's triangle (Fig. 9–11). Elevation of V_1 allows the sixth nerve to be visualized. Further opening of this outer dural membrane allows exposure of the other cavernous sinus triangles.

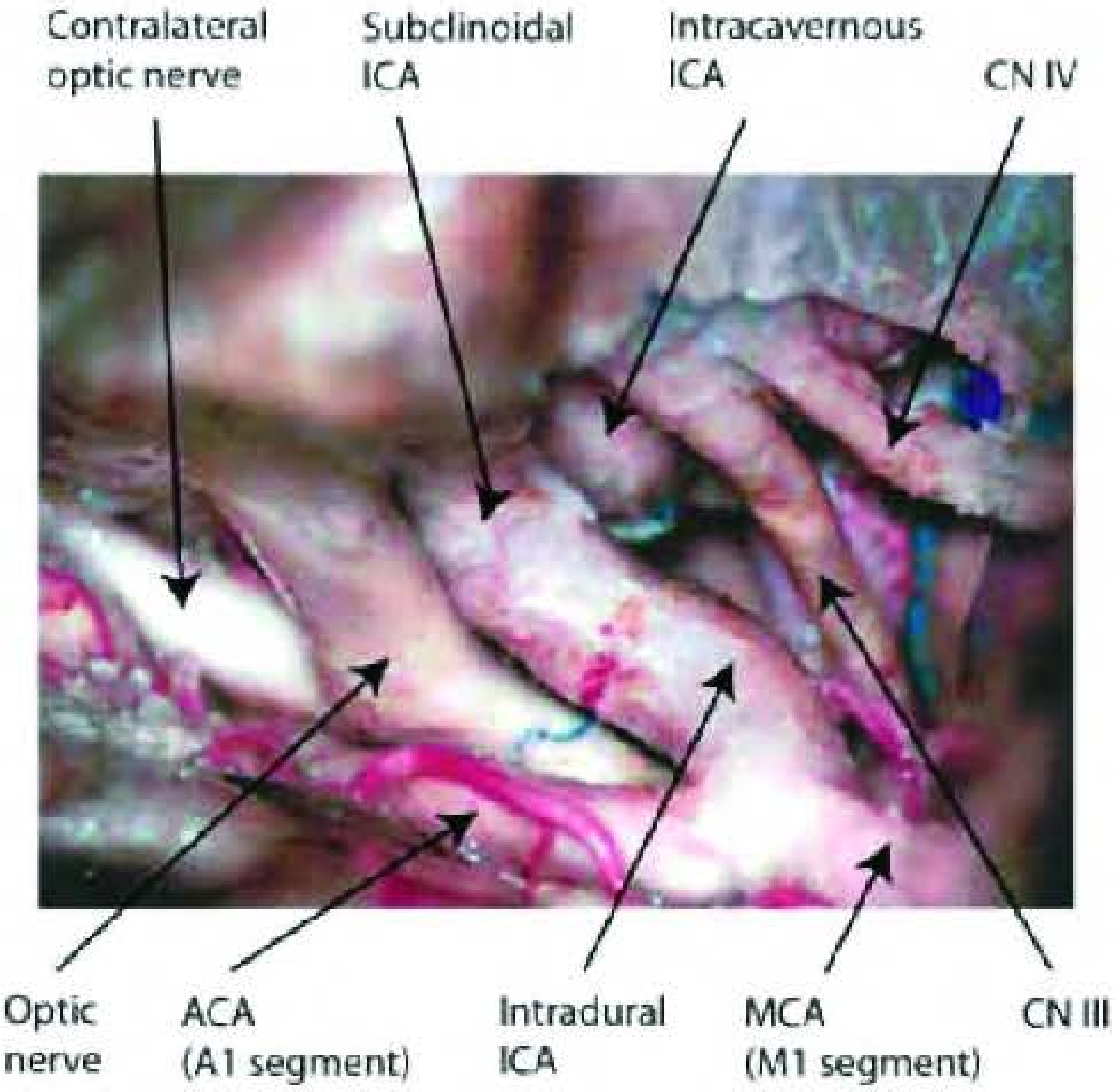

FIGURE 9–8 Superior opening into the cavernous sinus allows visualization of the carotid artery and the third and fourth cranial nerval (CN). Note the proximity of the third and fourth cranial nerves at the anterior tentorial edge. ACA, anterior cerebral artery; ICA, internal carotid artery; MCA, middle cerebral artery.

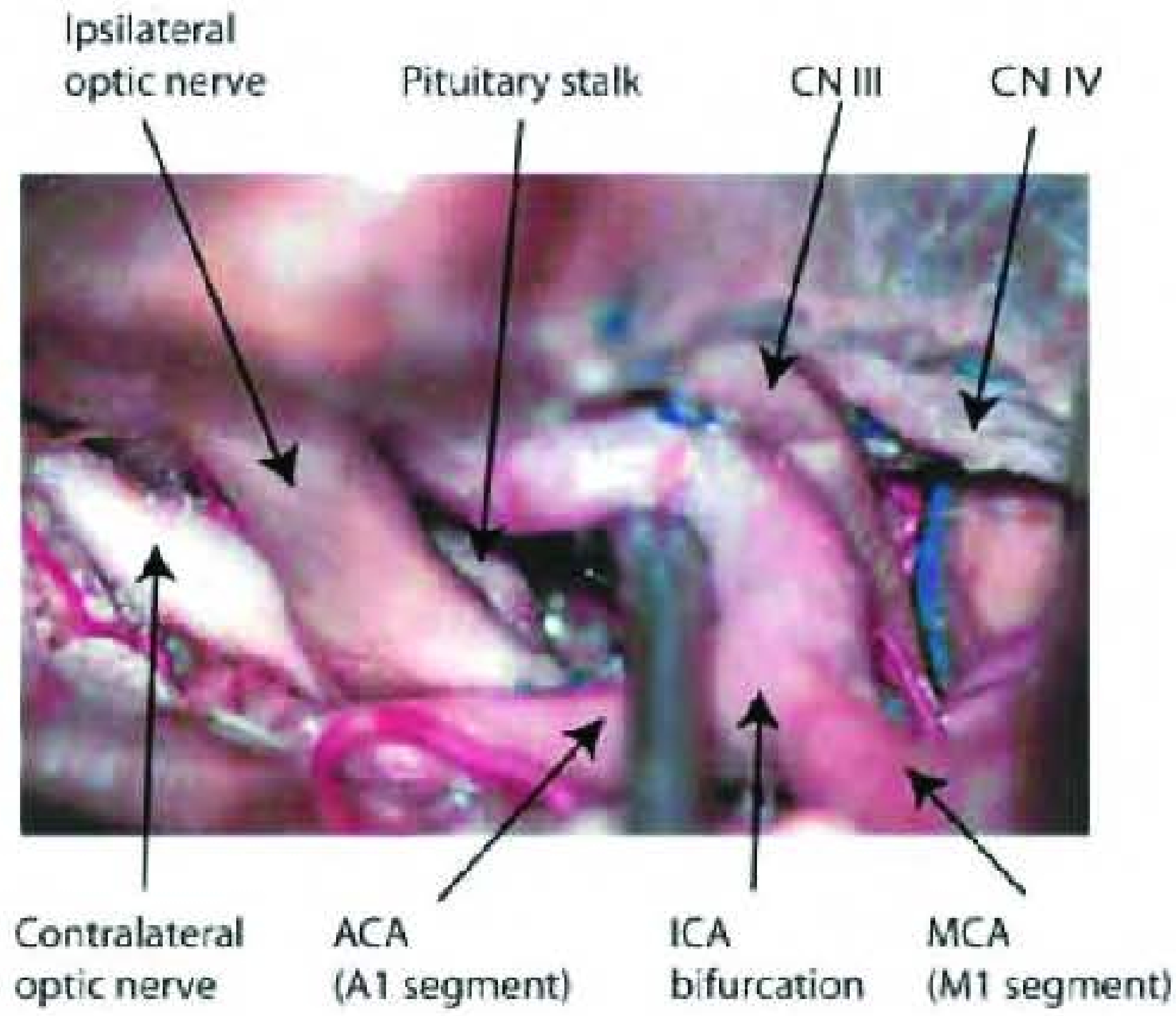

FIGURE 9–9 The carotid has been mobilized, and the pituitary stalk is seen between the optic nerves. ACA, anterior cerebral artery; CN, cranial nerve; ICA, internal carotid artery; MCA, middle cerebral artery.

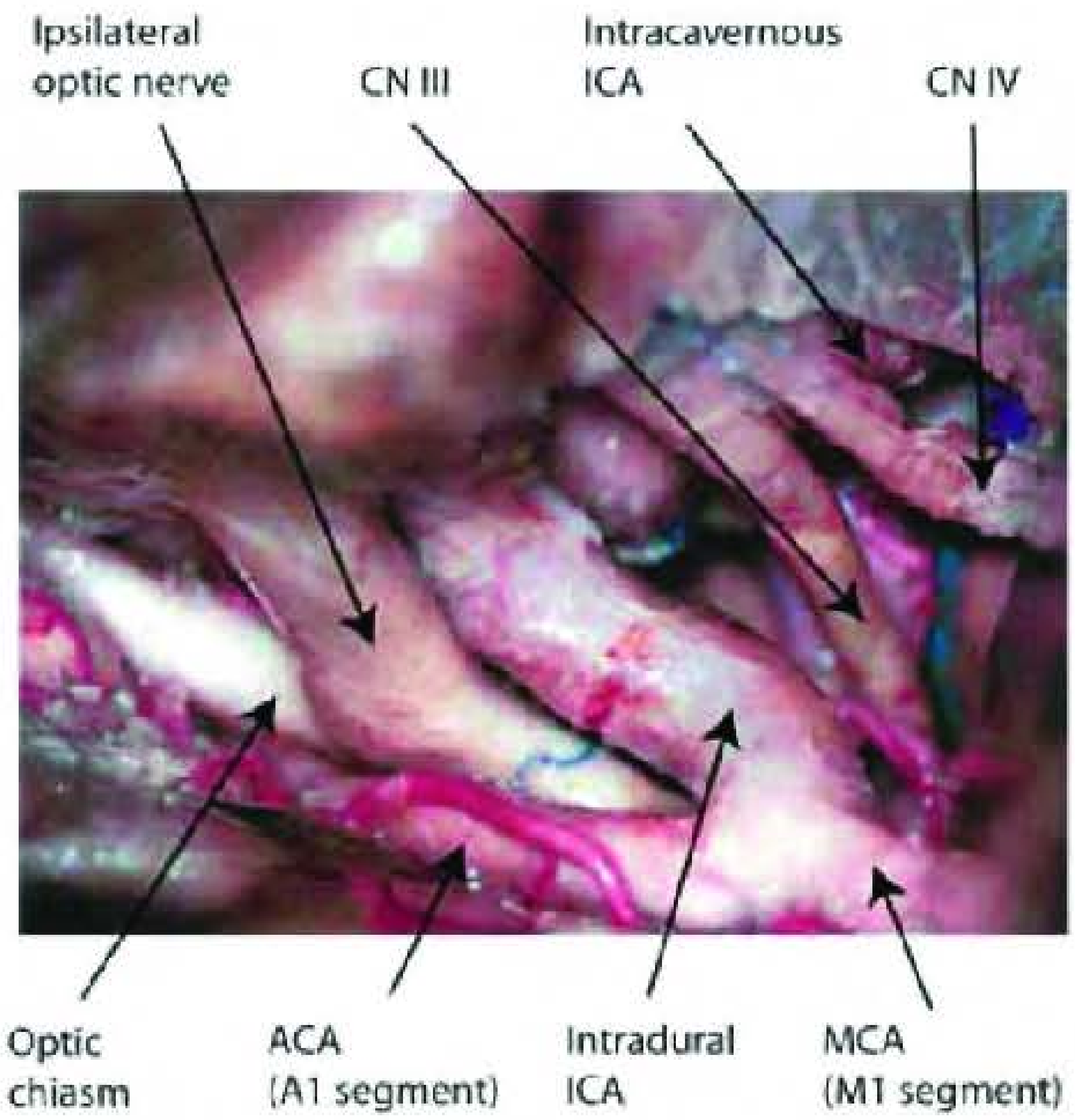

FIGURE 9–10 The intradural intracavernous carotid artery is visualized. ACA, anterior cerebral artery; CN, cranial nerve; ICA, internal carotid artery; MCA, middle cerebral artery.

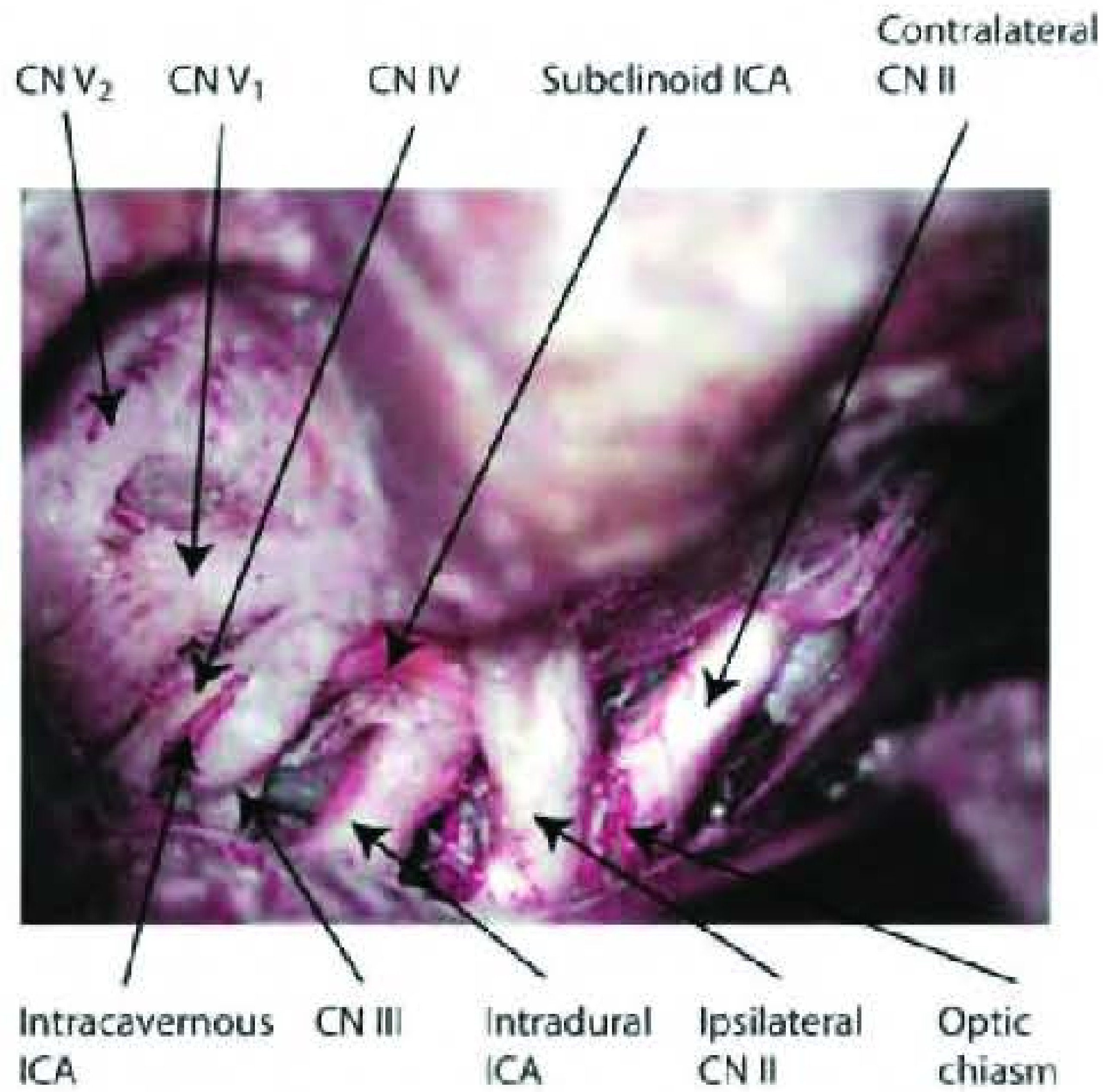

FIGURE 9–11 Panoramic view of the anterior cavernous sinus after intradural clinoidectomy. CN, cranial nerve; ICA, internal carotid artery.

TRANSCAVERNOUS TO THE BASILAR ARTERY

Certain types of basilar tip and superior cerebellar artery aneurysms require the posterior clinoid process (PCP) to be resected during the clipping process. The two PCPs are the highest projections of the dorsum sellae and may be pneumatized by the sphenoid sinus. These PCPs become a barrier when the upper basilar artery is approached from anterolateral approaches (i.e., frontotemporal, pretemporal, and transsylvian); in such cases, they must be resected.

The transcavernous route to the upper third of the basilar artery is performed through a cranio-orbitozygomatic approach. Liberation of the optic nerve (ON) from its canal and removal of the anterior clinoid process are especially useful when the intracranial segment of the ICA is short. The frontotemporal dura then is opened, and the sylvian fissure, the chiasmatic cistern, and the carotid cisterns are widely opened. As is the case with most patients, the carotid artery is oriented along the bisection of the angle made by the ON and the tentorial edge. If this is the case, the surgeon may find enough space to work through the carotid-tentorial corridor. Sometimes the posterior communicating artery (PComA) becomes an obstacle. After careful review of the preoperative angiogram, the PComA may be sectioned, taking care to preserve its perforating branches (Fig. 9–12). After the PComA is divided, it is easier intermittently to retract the ICA medially using a suction cannula.

The PCP and the dorsum sellae now make up the center of the field. The dural covering of the PCP is cut, and the PCP is reduced with the use of a drill. As drilling proceeds between the ICA and CN III, the surgeon must pay special attention to preserving their integrity. Typically, only a small amount of bone resection is required; when necessary, the superior third of the clivus may be drilled away. If the anterior incisural space is small, the tentorium may be divided posterior to the entrance of CN IV, which allows visualization of the prepontine cistern and its contents (Figs. 9–13 and 9–14).

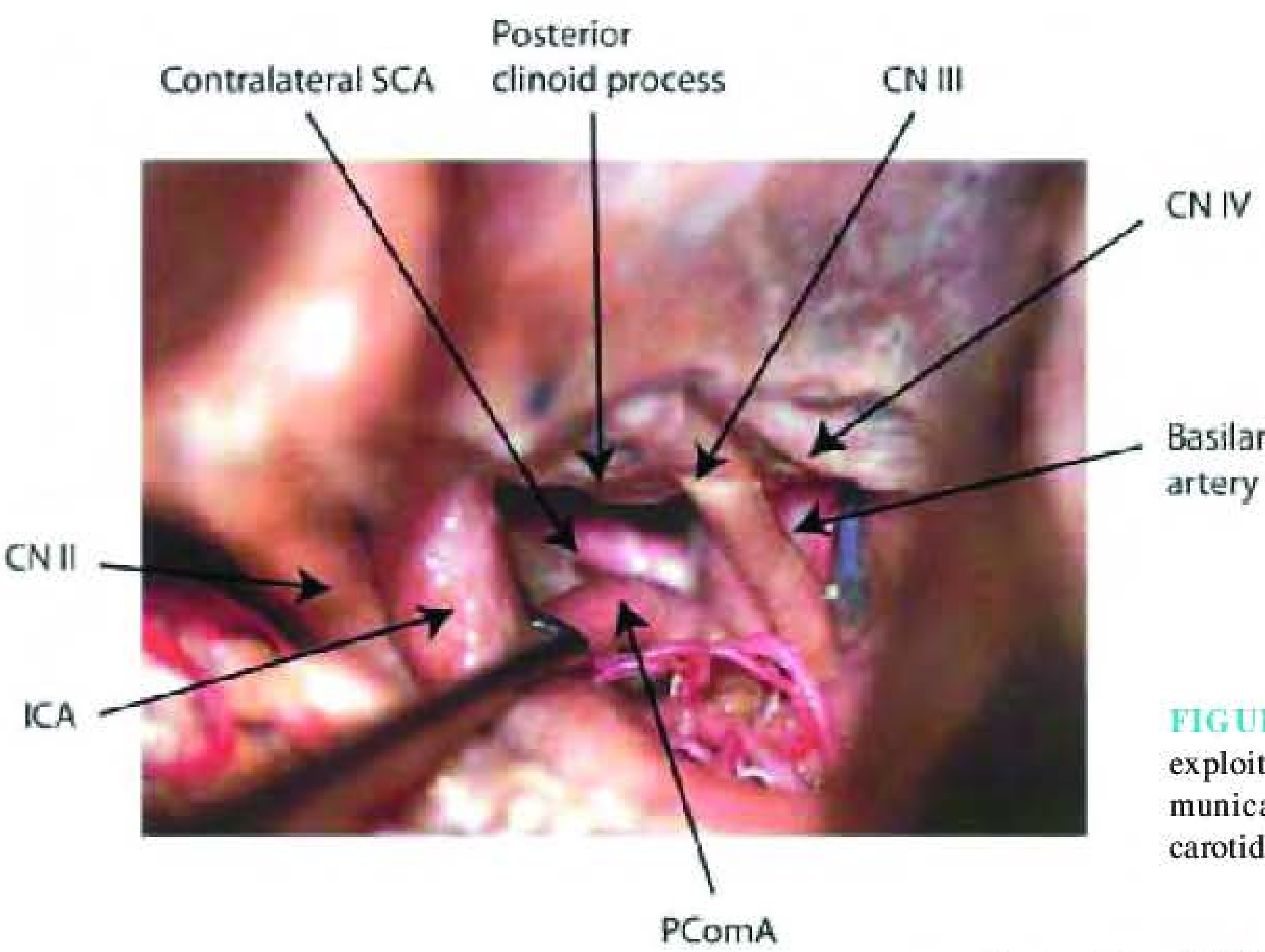

FIGURE 9–12 The carotid–oculomotor triangle is exploited to reach the basilar artery. Mote the posterior communicating artery (PComA) and its perforators. ICA, internal carotid artery; SCA, superior cerebellar artery.

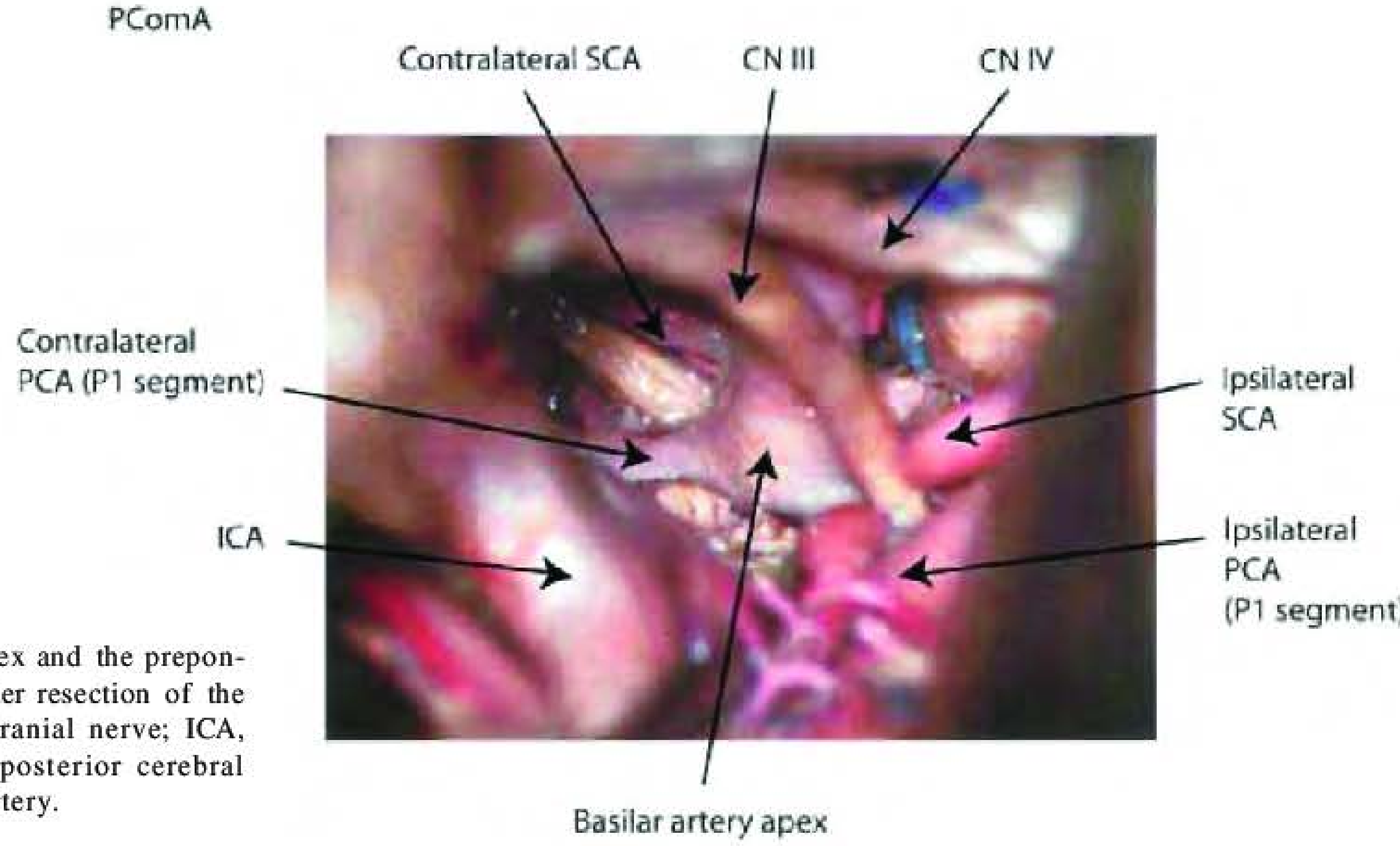

FIGURE 9–13 The basilar apex and the prepontine structures are visualized after resection of the posterior clinoid process. CN, cranial nerve; ICA, internal carotid artery; PCA, posterior cerebral artery; SCA, superior cerebral artery.

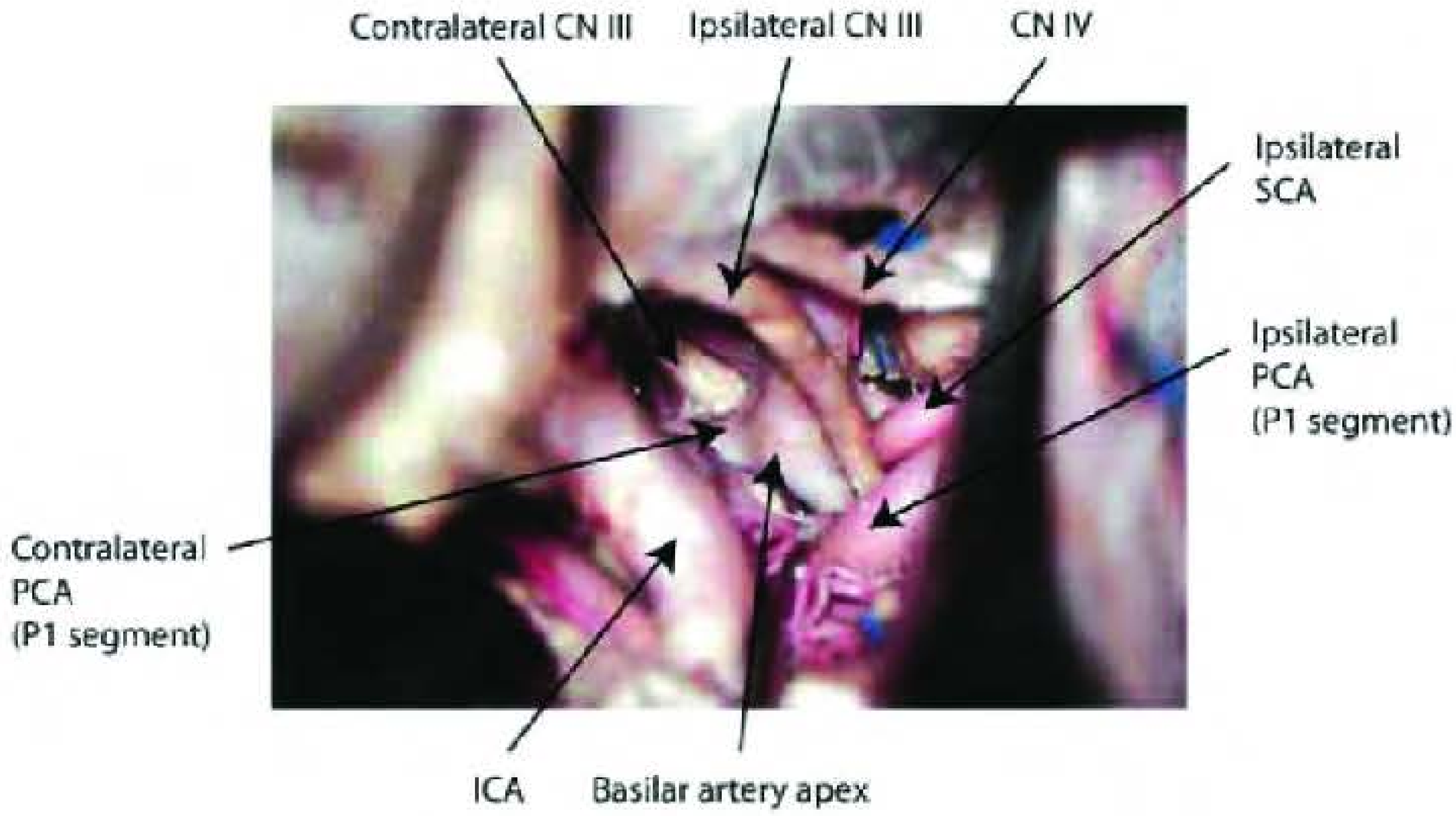

FIGURE 9–14 Panoramic transsylvian view of the basilar and prepontine regions. ICA, internal carotid artery; PCA, posterior cerebral artery; SCA, superior cerebral artery.

PITFALLS, PEARLS, CONSIDERATIONS

- Vascular injury
- CN paresis
- CN sectioning
- Cerebrospinal fluid fistula
- Cochlear injury
- Facial nerve palsy
- Brain retraction injury

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Chapter 10

Preauricular Subtemporal-Infratemporal Approach

Emel Avci, Amithaba Chanda, Damirez Fossett

Indications for Approach

- Extradural petroclival lesions
- Midclivus region extradural lesions
- Posterior cavernous sinus lesions
- Lesions in the region of Meckel's cave

Anatomy

Extradural Anatomy

The middle cranial fossa (MCF) is a butterfly-shaped structure, with the two petrous ridges forming an angle of approximately 100 degrees. It is bounded anteriorly by the free margin of the lesser wing of the sphenoid, posteromedially by the petrous ridge, and laterally by the squamous portion of the temporal bone.

There are several important surgical landmarks of the MCF. Dissection of the MCF usually starts at the arcuate eminence (AE), which is oriented at right angles to the petrous ridge. The most anterior point of the bony external auditory meatus (EAM) is located at the level of the most lateral part of the AE. The central part of the AE is situated above the loop of the superior semicircular canal (SSC), which lies at a depth of 1 to 3.5 mm from the bony surface. Just anterior to the lateral end of the AE is the tegmen tympani (TT), which is the roof of the middle ear cavity. The TT is in continuity with the intracranial surface of the squamosal segment of the temporal bone. It is very thin and often exhibits small zones of dehiscence connecting the cranial and tympanic cavities. The TT is crossed by the petrotympanic fissure, the intracranial boundary between the squamous part of the temporal bone and the petrous pyramid.

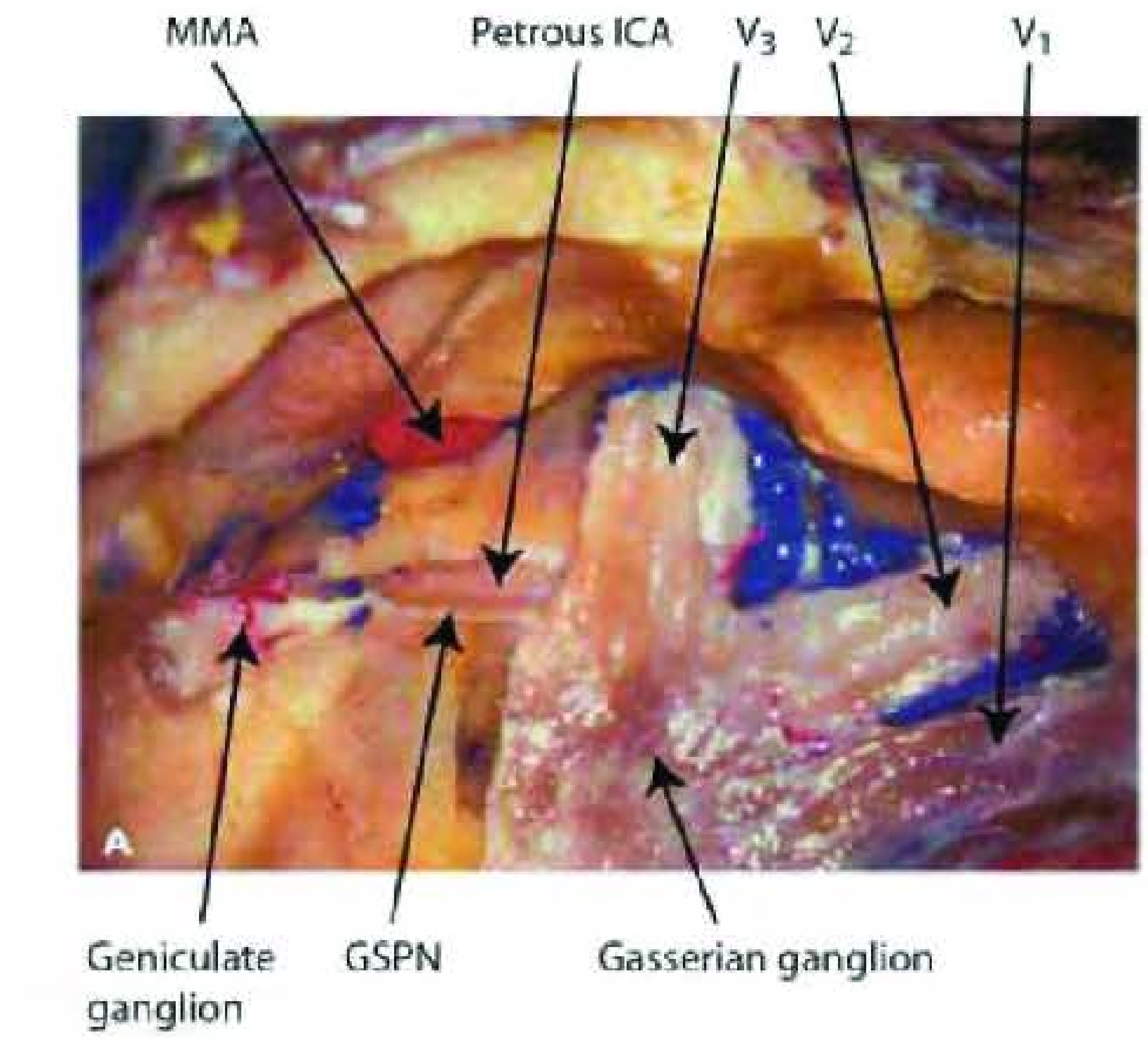
Immediately anterior to the TT, adjacent to the zygomatic root, the floor of the MCF separates the intracranial cavity from the glenoid fossa. Medial to TT, anterior to the AE, extending toward the petrous apex lies the orifice of the canal for the greater superficial petrosal nerve (GSPN). The position of the orifice is variable and depends on the length of the canal. Slightly anterior but parallel to the GSPN runs the lesser superficial petrosal nerve (LSPN). It exits the cranial cavity at the foramen ovale to join the otic ganglion.

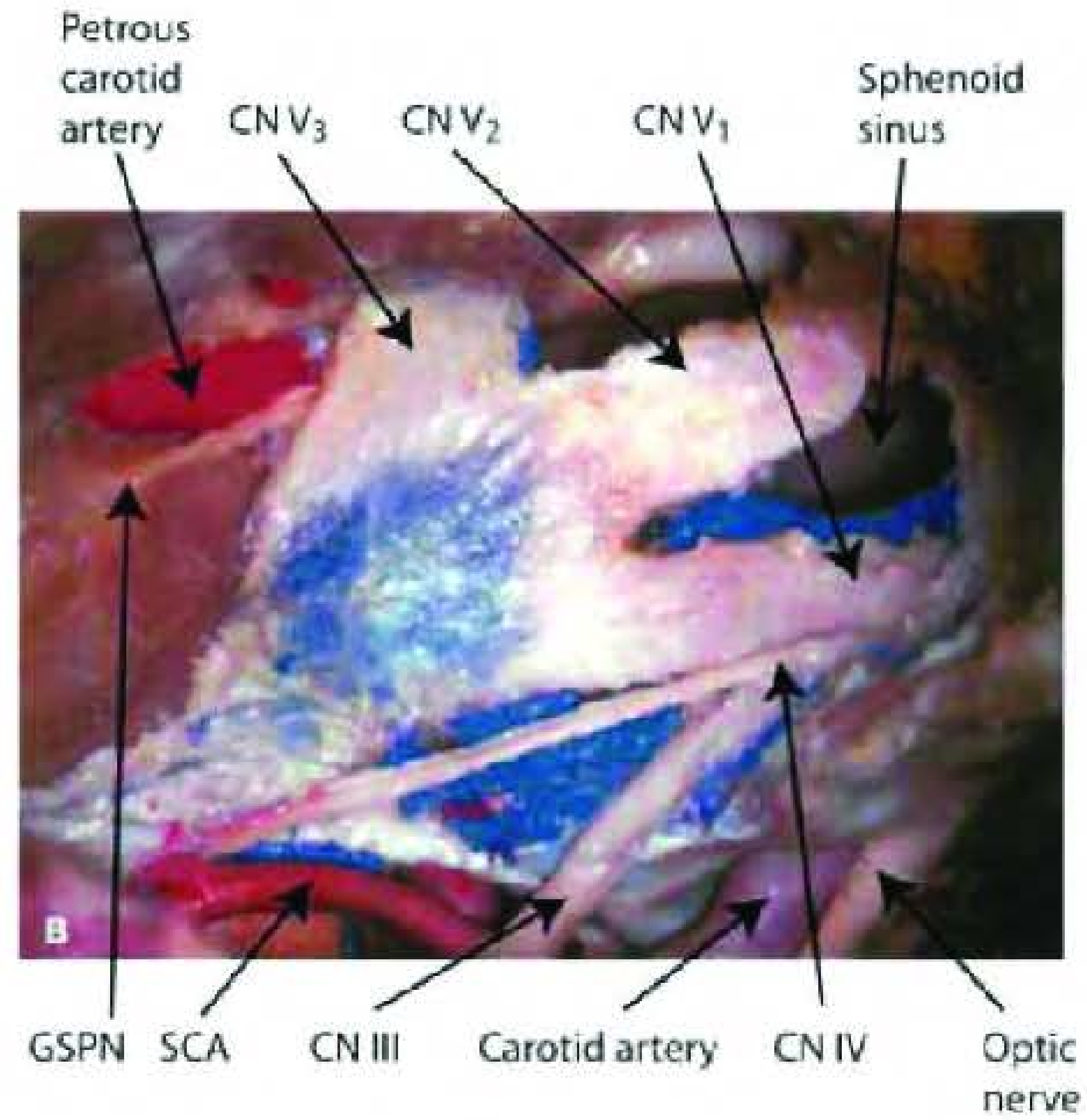
Lateral to the canal for the GSPN lies the foramen spinosum (FS), through which the middle meningeal artery (MMA) enters the cranial cavity. Just anteromedial to the FS lies the foramen ovale (FO), through which passes the mandibular division of the trigeminal nerve (V3). FO and FS are the deepest portions of the MCF floor. A venous plexus here surrounds the V3. The foramen rotundum (FR) and superior orbital fissure (SOF) lay further anteriorly and medially (Fig. 10–1A).

Medial to the FO and canal of GSPN, the MCF floor in the region of the petrous apex may be variably dehiscent. There may be no bone covering the carotid canal. Very close to the anterior aspect of the petrous ridge, there is a small prominence, the tubercle of Princeteau, which overshadows Meckel's cave in which sits the gasserian ganglion. A venous plexus surrounds the gasserian ganglion.

The floor of the MCF is the roof of the inner ear (Fig. 10–1B, C). Under the floor of the MCF are the cochlea, the semicircular canals, and the internal auditory canal (IAC). The cochlea lies anterior to the fundus of the IAC, 3.0 to 4.5 mm deep to the floor of the MCF. It is encased in very dense compact bone. The superior aspect of the basal turn lies in close proximity posterior or posterosuperior to the genu of the internal carotid artery (ICA).

The facial nerve has a complex course in the temporal bone. The parts of the facial nerve in temporal bone are the IAC segment, the labyrinthine segment, the tympanic segment, and the mastoid segment. The canal of Fallopius or the facial canal through the base of the skull is quite long; its course is Z-shaped, threading its way between the labyrinth and the tympanic cavity. The anatomic course of the facial nerve is further complicated by the fact that the segments do not exist in a single plane. The labyrinthine segment begins at the fundus of the IAC, bending forward by about 50 degrees, the general direction of the IAC. The direction of the fallopian canal here is at right angles to the long axis of the petrous pyramid. It curves forward and inward skirting the superolateral flank of the basal turn of the cochlea and moves in the direction of the GSPN. It has a slightly ascending course. Posterolaterally, it comes in close relationship to the SCC, where it is sandwiched between the superior SCC and the cochlea. Here it is susceptible to being damaged during drilling of the bone. The facial nerve then makes a sharp bend posterolaterally, creating the first genu. Here lies the geniculate ganglion, from which arises the GSPN.





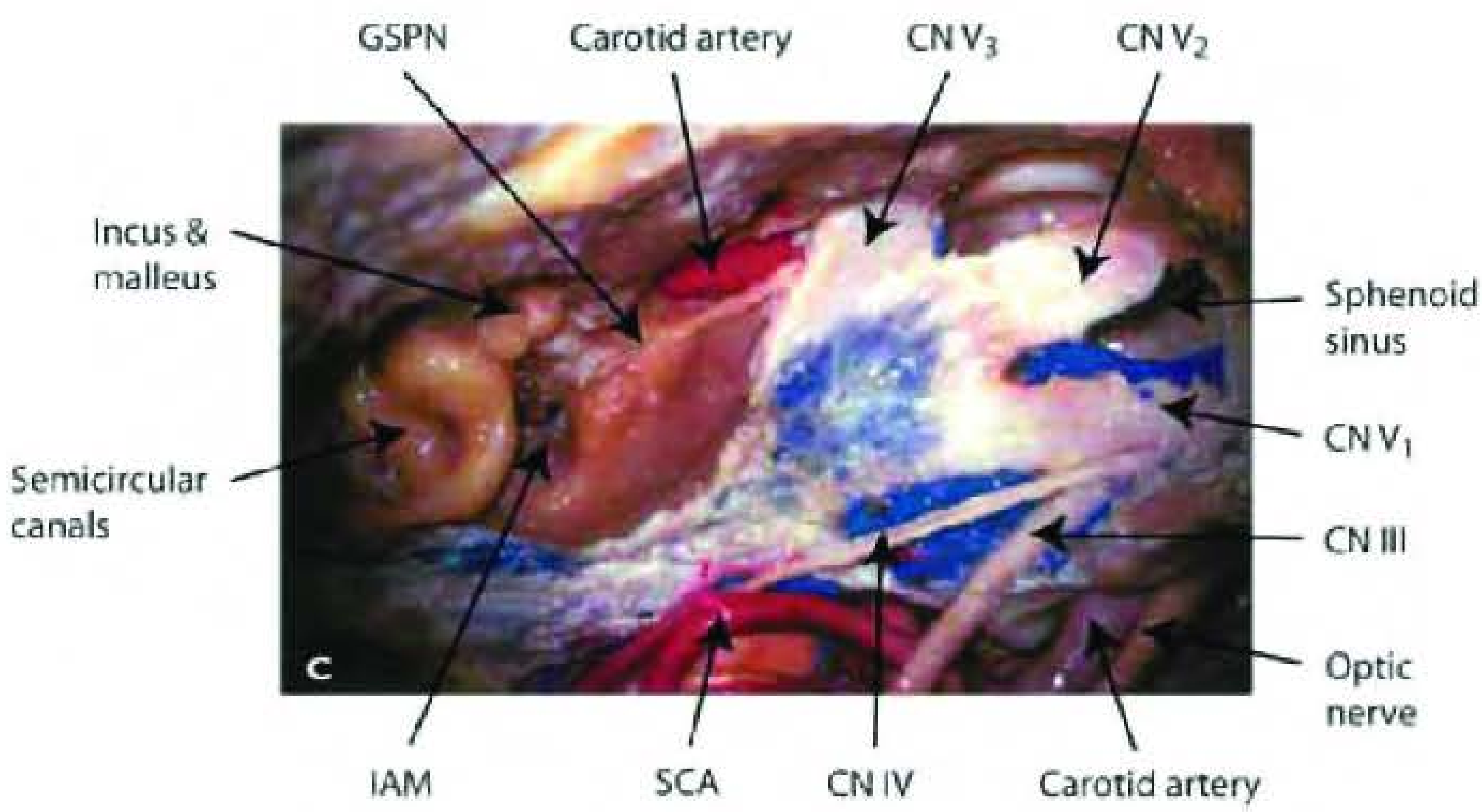
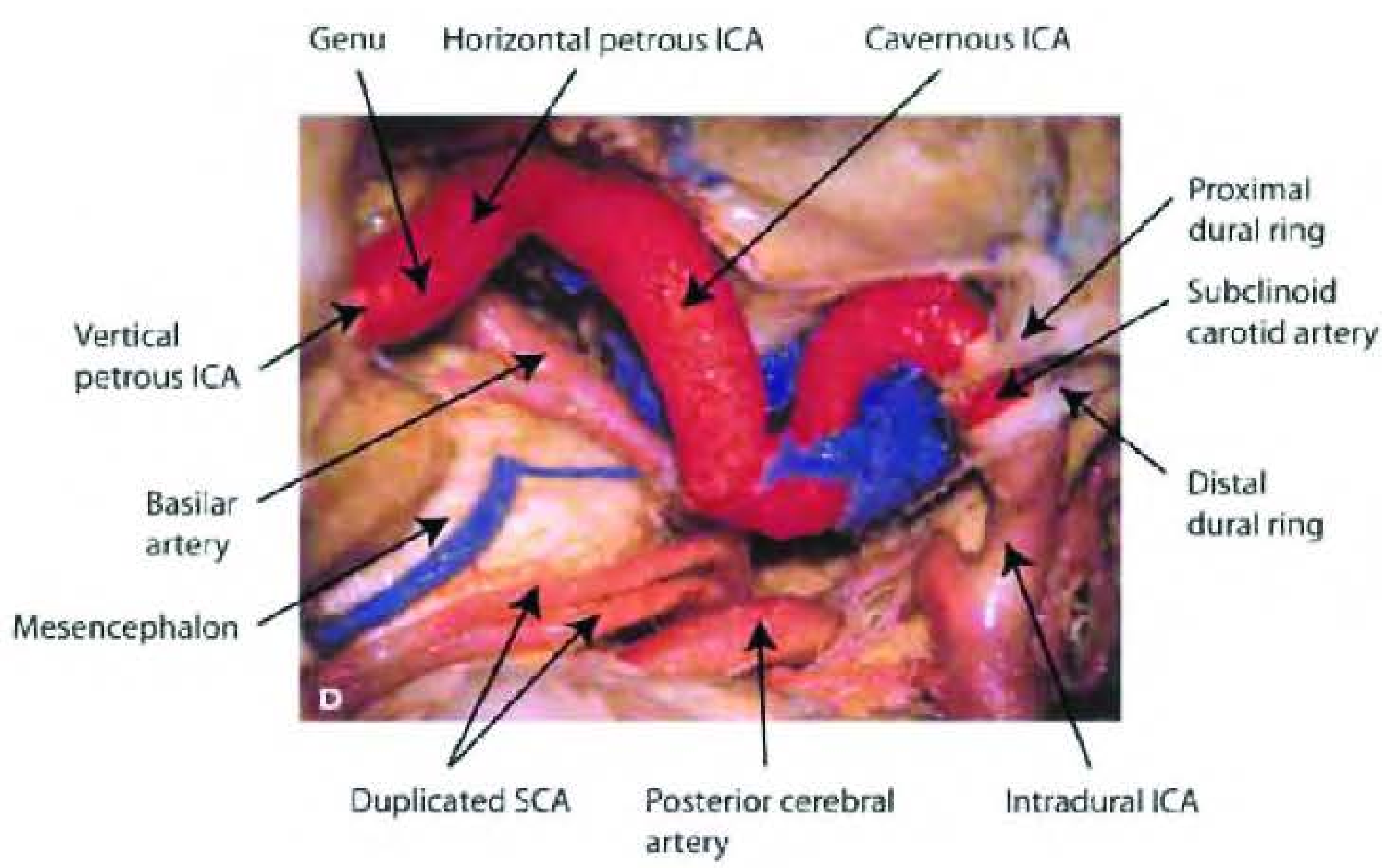


FIGURE 10–1 **A**: Anatomy of the floor of the middle fossa. The foramen spinosum with the entering middle meningeal artery (MMA) is seen along with the foramen ovale and rotundum. The exiting branches of the fifth cranial nerve can be visualized. **B**: The anatomic complexity of the floor of the middle fossa is appreciated. **C**: The inner ear structures have been unroofed to demonstrate the proximity of structures in the floor of (he middle fossa to middle ear structures. **D**: The cavernous sinus neural structures have been removed to allow visualization of all the intracranial segments of the internal carotid artery (ICA). CN, cranial nerve; GSPN, greater superficial petrosal nerve; IAM, internal auditory meatus; SCA, superior cerebellar artery.



Petrous Internal Carotid Artery and Adjoining Structures

The petrous carotid artery begins at the point of entry of the ICA through the periosteal-lined carotid canal in the petrous bone. The external orifice of the carotid canal is directly anterior to the jugular foramen, and its internal orifice is located at the petrous apex. Except at the entrance of the artery to the vertical canal, where it is anchored to the bone by dense bands, the artery can be easily separated from its connective tissue adhesions.

The petrous ICA has a vertical segment and a horizontal segment that join at the genu (Fig. 10–1D). The vertical segment, as the name implies, passes vertically upward in the carotid canal. It is surrounded by the jugular fossa posteriorly, the eustachian tube (ET) anteriorly, and the tympanic bone anterolaterally. The vertical segment turns anteromedially at the genu to form the horizontal segment, which continues anteromedially and runs anterior to the cochlea, from which it is separated by a thin plate of bone. The anteromedial part of the roof of the horizontal part is formed by the dura, or by a thin plate of bone, which separates the ICA from the trigeminal/gasserian ganglion. There are generally one or two branches of the ICA in the carotid canal.

A periarterial venous plexus, which is an extension of the cavernous sinus, extends around the petrous ICA for a variable distance. In most cases, it runs along the anterior and inferior side of the artery, and its extension is limited to the horizontal segment in most cases. This venous plexus lies within the periosteal covering of the canal (Fig. 10–2). The petrous segment of the ICA is also accompanied by the sympathetic fibers.

The eustachian tube (ET) and tensor tympani muscle lie anterior and parallel to the horizontal segment of the petrous ICA, below the floor of the MCF (Fig. 10–3). Usually, the tensor tympani lies superior to the ET; during dissection, exposure of the tensor tympani heralds the imminent exposure of the ET. In most patients, a thin plate of bone separates them, but in many others, they may be separated only by fibrous tissue. The tensor tympani muscle and the ET are separated from the carotid canal by a plate of bone, which varies in thickness. Sometimes the superior surface of the muscle is exposed through a bony dehiscence between the carotid canal and FS. The ET crosses the anterolateral aspect of the genu as it exits the middle ear cavity.

Cavernous Sinus

Refer to Chapter 8 for a detailed description of the anatomy of the cavernous sinus.

Intradural Anatomy

The following subarachnoid cisterns can be reached through these approaches:

1. Prepontine cistern
2. Cerebellopontine cistern
3. Premedullary cistern
4. Literal cerebellomedullary cistern
5. Lower part of the interpeduncular cistern

This section discusses only the prepontine and the premedullary cisterns. The other cisterns are discussed in detail in other sections.

Premedullary Cistern

This cistern extends from the pontomedullary sulcus over the ventral aspect of the medulla to the upper spinal

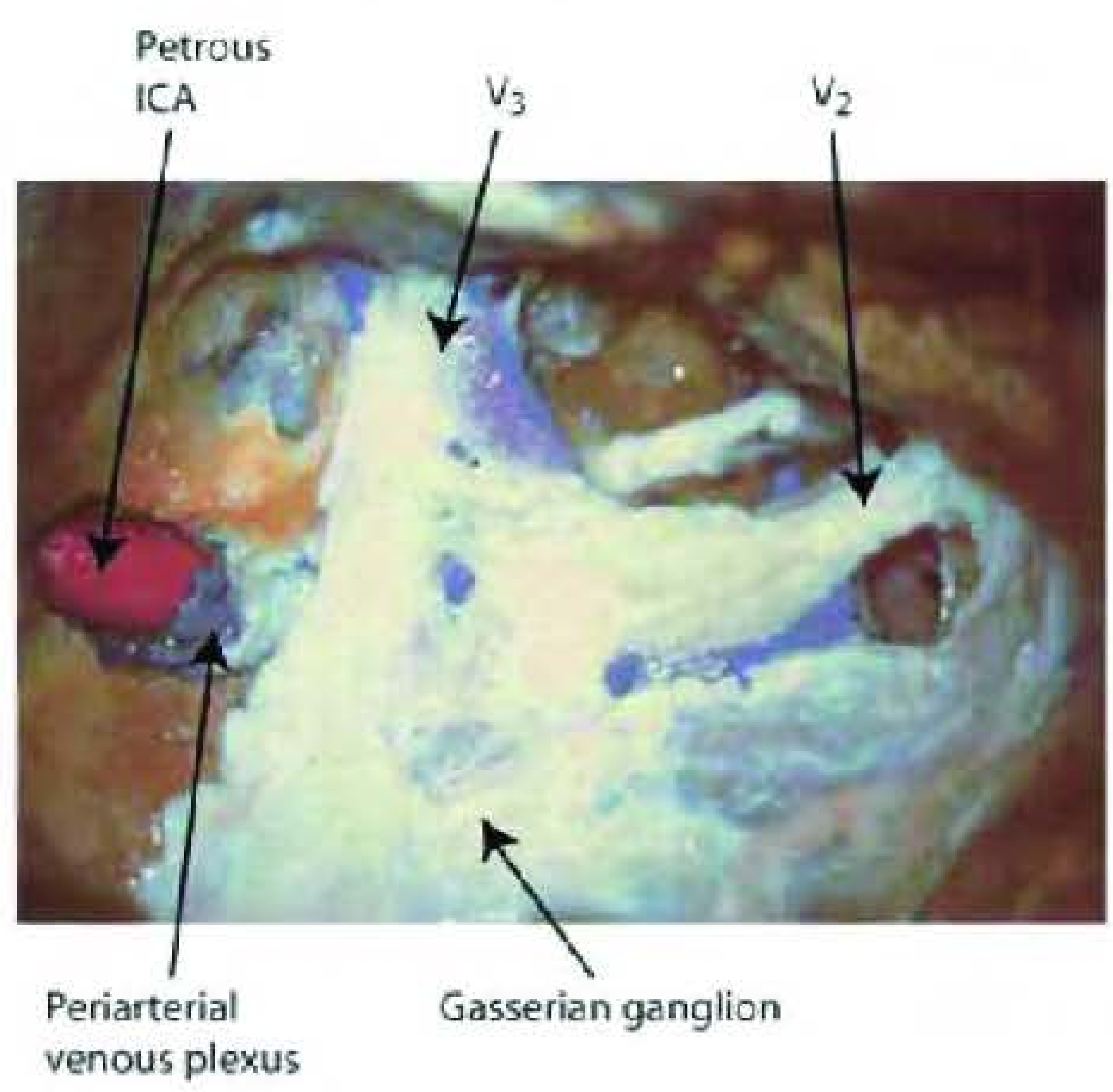


FIGURE 10–2 The venous plexus overlying the petrous carotid artery can be seen. ICA, internal carotid artery.

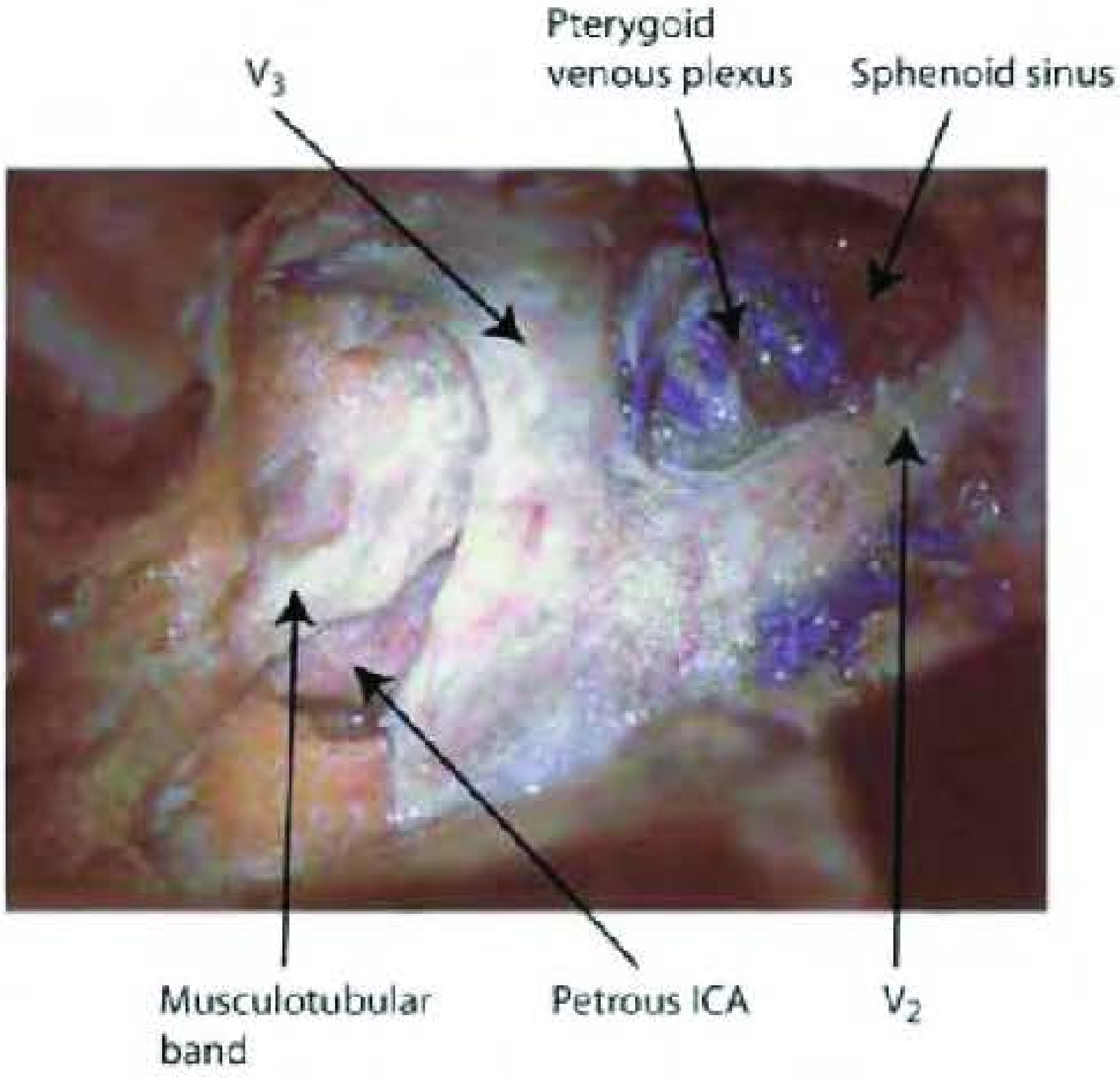


FIGURE 10–3 The eustachian tube can be seen crossing parallel to the carotid artery. ICA, internal carotid artery.

subarachnoid space. It is bounded laterally by the arachnoid membrane separating it from both cerebellomedullary cisterns, anteriorly by the clivus and posteriorly by the anterior surface of the medulla. The major contents of this Cistern are the terminal part of the vertebral artery, the anterior spinal artery, and the anterior medullary vein.

Prepontine Cistern

This cistern lies between the anterior surface of the pons and the midclivus. Laterally, it is bounded by an arachnoid membrane that separates it from the cerebellopontine cistern. Superiorly, it is limited by the interpeduncular cistern. Inferiorly, the limiting arachnoid membrane is thickened around the junction of the two vertebral arteries to form the basilar artery. The major contents are the basilar artery, the origin of the anterior inferior cerebellar artery (AICA), the whole cisternal course of the sixth cranial nerve, and the prepontine vein. The site where the AICA leaves the prepontine cistern and enters the cerebellopontine cistern is again reinforced by thickened arachnoid membrane.

POSITIONING AND SKIN INCISION

The patient is placed in the supine position in Mayfield three-point fixation with a roll under the ipsilateral shoulder. The head is rotated 60 to 90 degrees to the side contralateral to the lesion. The vertex is tilted 10 to 15 degrees toward the floor. A question mark or coronal incision typically is made (Fig. 10–4). In general, the lower end of the incision should reach the lower end of the pinna of the ear to expose the zygomatic arch completely and to dissect the parotidomasseteric fascia from the parotid gland. If a neck dissection is required, the incision should extend below the ear, skirt the ear lobule, and then make a gentle curve along the skin crease of the upper cervical region. The coronal incision is cosmetically better and is particularly useful if an orbitozygomatic approach is combined with this approach. Making a V-shaped notch in the incision anterior to the tragus also produces a better cosmetic result.

SURGICAL TECHNIQUE

The upper part of the incision is dissected down to the bone and temporalis fascia. The portion of the incision beneath the zygomatic arch should be deepened to expose the parotid gland by incising the parotidomasseteric fascia. If a cervical dissection is required, the incision should be taken to the deep cervical fascia. The reflection of the skin should stop just before the frontozygomatic process and zygomatic arch are reached. The temporalis fascia is incised along the arch to expose the deep temporal fat. The skin and temporalis fascia then are completely mobilized with elevation of me fat pad to expose the zygomatic arch and frontozygomatic recess. This preserves the frontotemporal branches of the facial nerve.

After the skin and subcutaneous tissue are mobilized in the temporal region, the parotidomasseteric fascia is dissected and separated from the parotid gland. This maneuver becomes important in a later phase of the procedure if the mandibular condyle is to be retracted downward. The facial nerve branches could be stretched without this dissection. The zygomatic arch and the frontozygomatic process are completely denuded of periosteum and exposed.

The temporalis fascia is incised along the upper part of its attachment in the frontoparietal region. A cuff is left for reapproximation at the end of the procedure. The muscle is dissected in a subperiosteal fashion away from the parietal and temporal bone up to the infratemporal crest. The anterior insertion of the temporalis muscle then can be easily detached from the frontozygomatic arch. Further downward retraction of the muscle is not possible unless a zygomatic osteotomy is performed.

A temporal or frontotemporal craniotomy is performed with a bur hole placed in the keyhole and a

FIGURE 10–4 The curvilinear incision is demonstrated.

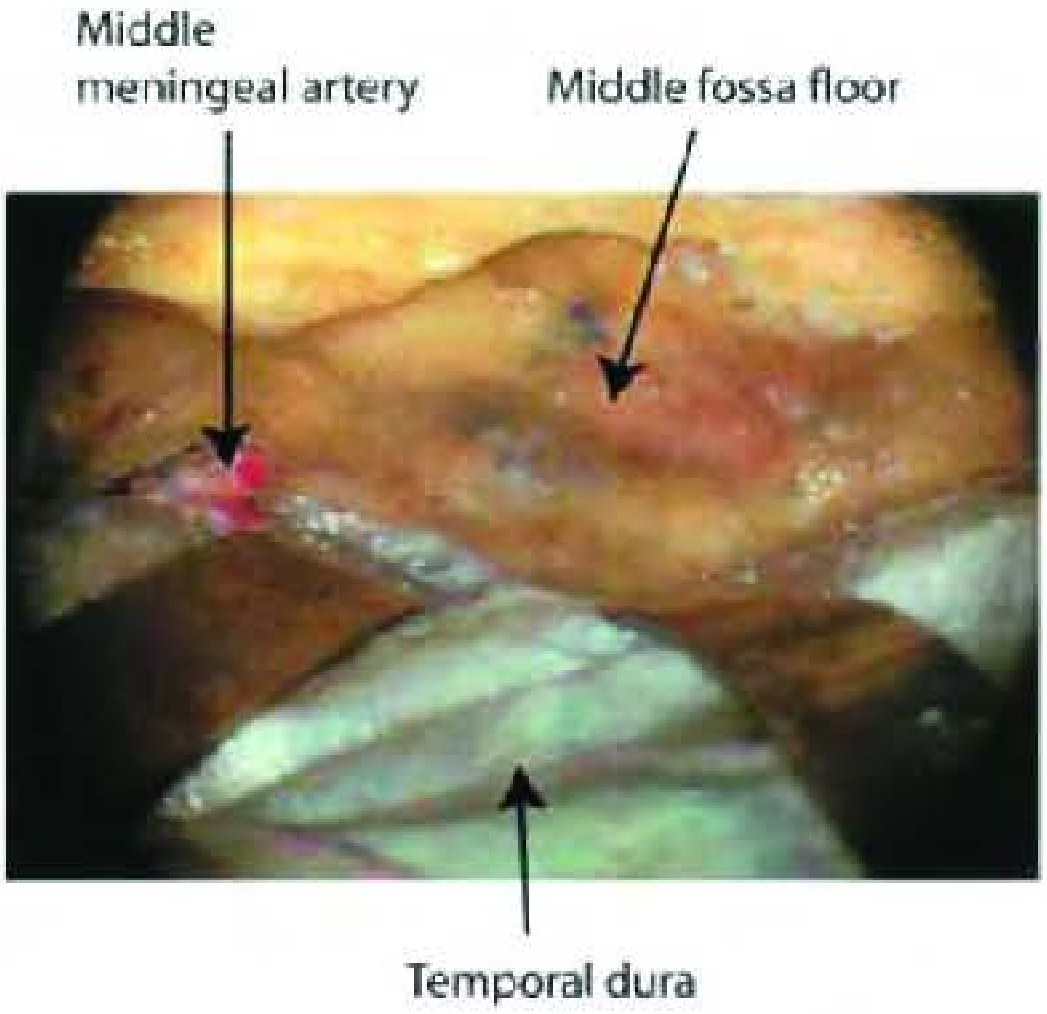


FIGURE 10–5 The dura is peeled from the floor of the middle fossa revealing the middle meningeal artery entering through the foramen spinosum.

second one in the squamosal portion of the temporal bone (sec Chapter 2). The dura should be stripped free of the bone to keep the approach purely extradural. The operating microscope can be brought into the field after the craniotomy is performed. The temporal dura then is gently stripped from the floor of the middle fossa. While separating, the arcuate eminence is identified. This is generally the posterior extent of the dissection. The dural separation is then continued anteriorly to reach the foramen spinosum, where the MMA can be seen as it enters the cranial cavity (Fig. 10–5).

At this stage, attention is focused on performing the zygomatic osteotomy with or without resection of the mandibular condyle. Anteriorly, a V-shaped cut is made at the level of the frontozygomatic and the zygomaticomaxillary suture. The anterior cut can be made in such a fashion to include the lateral wall of the orbit, depending on the nature and location of the pathology. The posterior cut is made to include the condylar fossa. This cut is also V-shaped, with the apex of the V falling just short of the foramen spinosum and the limbs spanning the anterior and posterior extent of the zygomatic root (Fig. 10–6A-C). Before making the osteotomy, the capsule of the temporomandibular joint is exposed (this can be facilitated by slight anteroinferior retraction of the masseter muscle) and cut sharply. The meniscus of the joint is separated from the condylar fossa. While making the osteotomy, one must be careful not to enter the middle ear cavity. The zygomatic arch then is removed (Fig. 10–7A, B). This will expose the mandibular condyle covered by the meniscus.

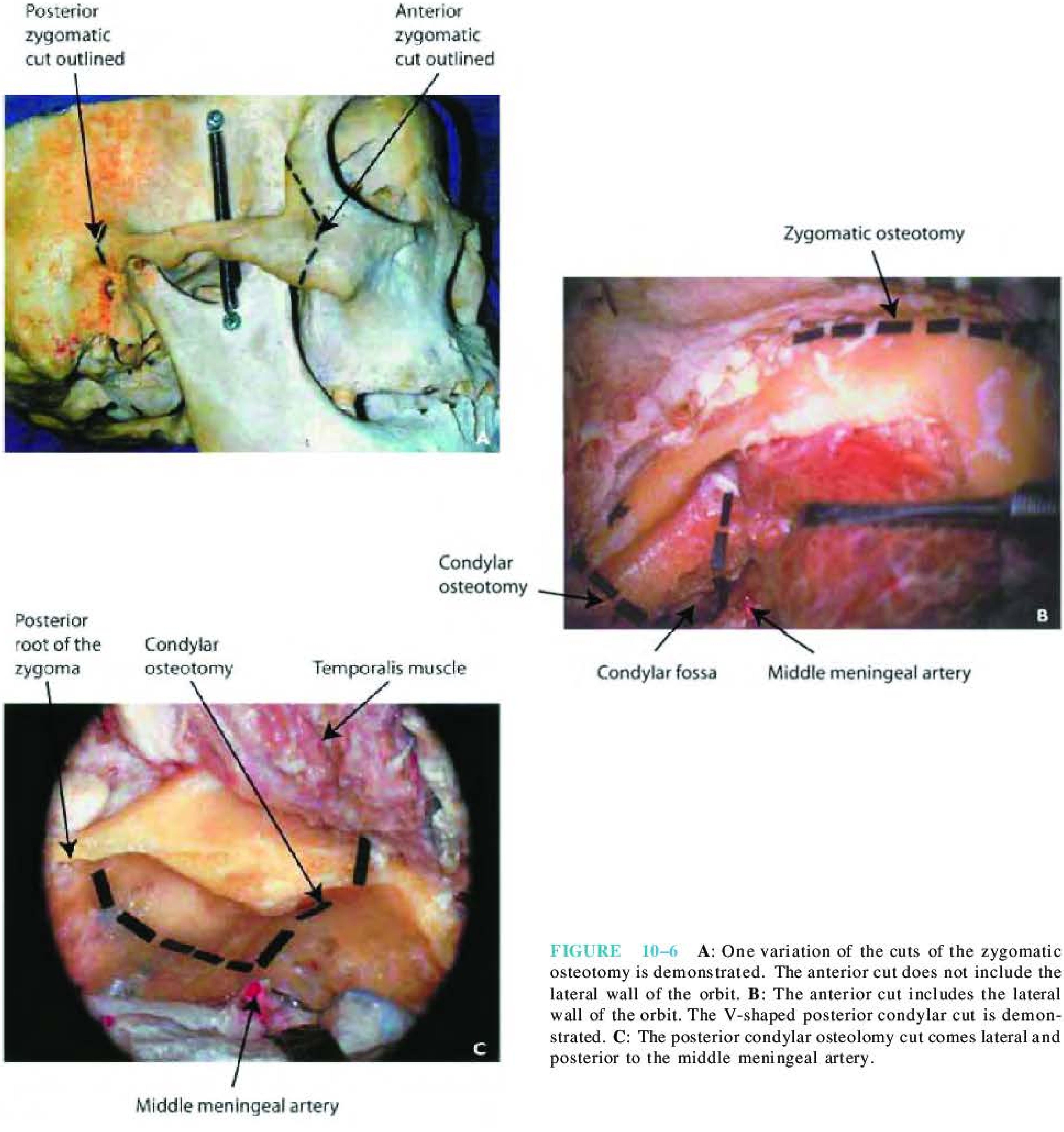


FIGURE 10–6 **A**: One variation of the cuts of the zygomatic osteotomy is demonstrated. The anterior cut does not include the lateral wall of the orbit. **B**: The anterior cut includes the lateral wall of the orbit. The V-shaped posterior condylar cut is demonstrated. **C**: The posterior condylar osteolomy cut comes lateral and posterior to the middle meningeal artery.

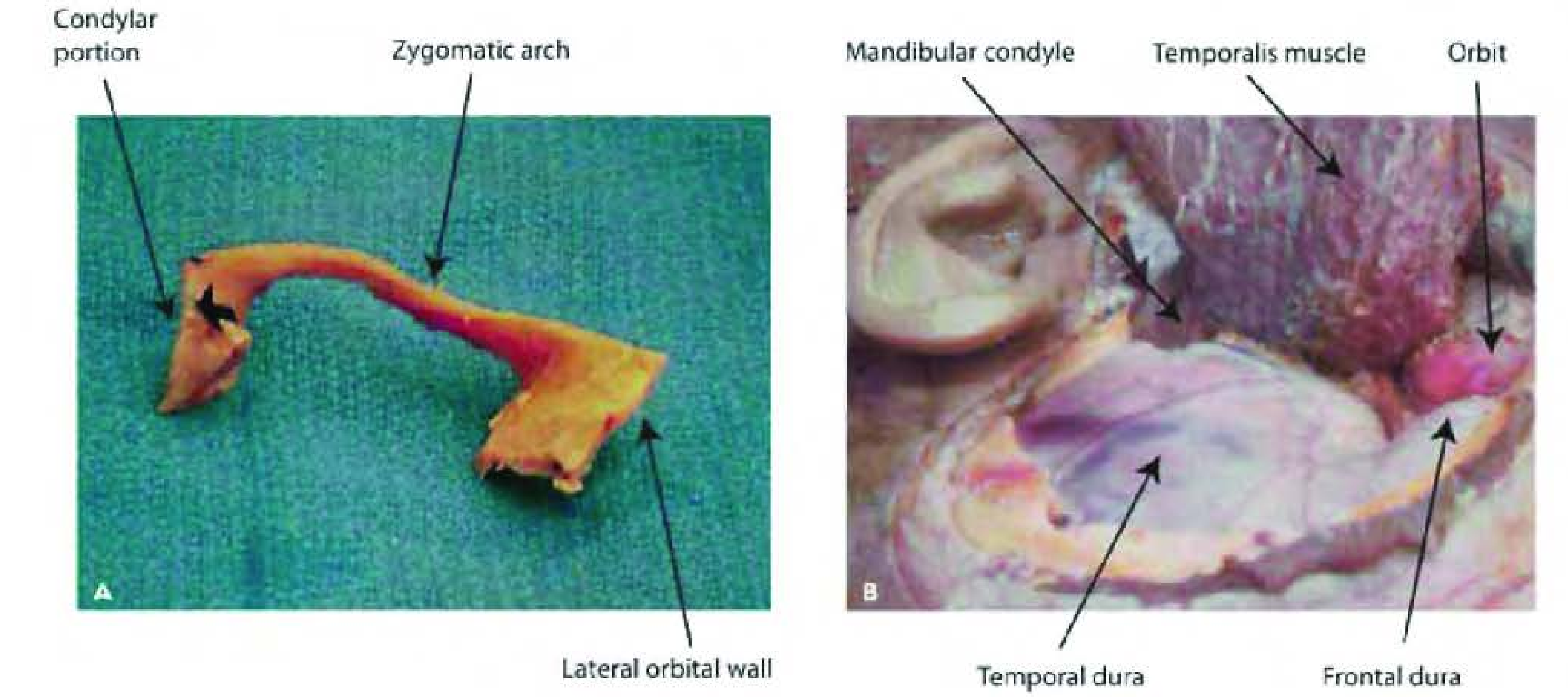


FIGURE 10–7 **A:** The condylar zygomatic ostetomy has been performed. The lateral wall of the orbit is included. **B**: The dura can be visualized after a frontotemporal craniotomy and condylar orbitozygomatic osteotomy.

The mandibular (V_3) and the maxillary (V_2) divisions of the fifth nerve then are exposed at the foramen ovale and rotundum, respectively. The dura at the terminal intracranial segments of V_2 and V_3 is adherent, and these dural attachments must be sharply cut and separated from the V_3. This will expose the venous plexus covering V_3 and ultimately the V_3 exiting through the foramen ovale. The dissection is continued anteriorly to reach V_2 exiting the foramen rotundum. The GSPN is well visualized and may be cut at this stage close to the facial hiatus. Further dissection of the dura medially will expose part of the horizontal portion of the petrous ICA close to V_3. The petrous portion of the ICA is variably roofed by bone. The bone of the middle cranial fossa floor lateral to the GSFN, V_3, and V_2 is drilled. This will skeletonize the middle meningeal artery. The lateral margins of the foramen rotundum and ovale are completely removed, which exposes the pterygoid venous plexus. Drilling bone of the middle cranial fossa between V_2 and V_3 may expose the sphenoid sinus (Fig. 10–8A, B).

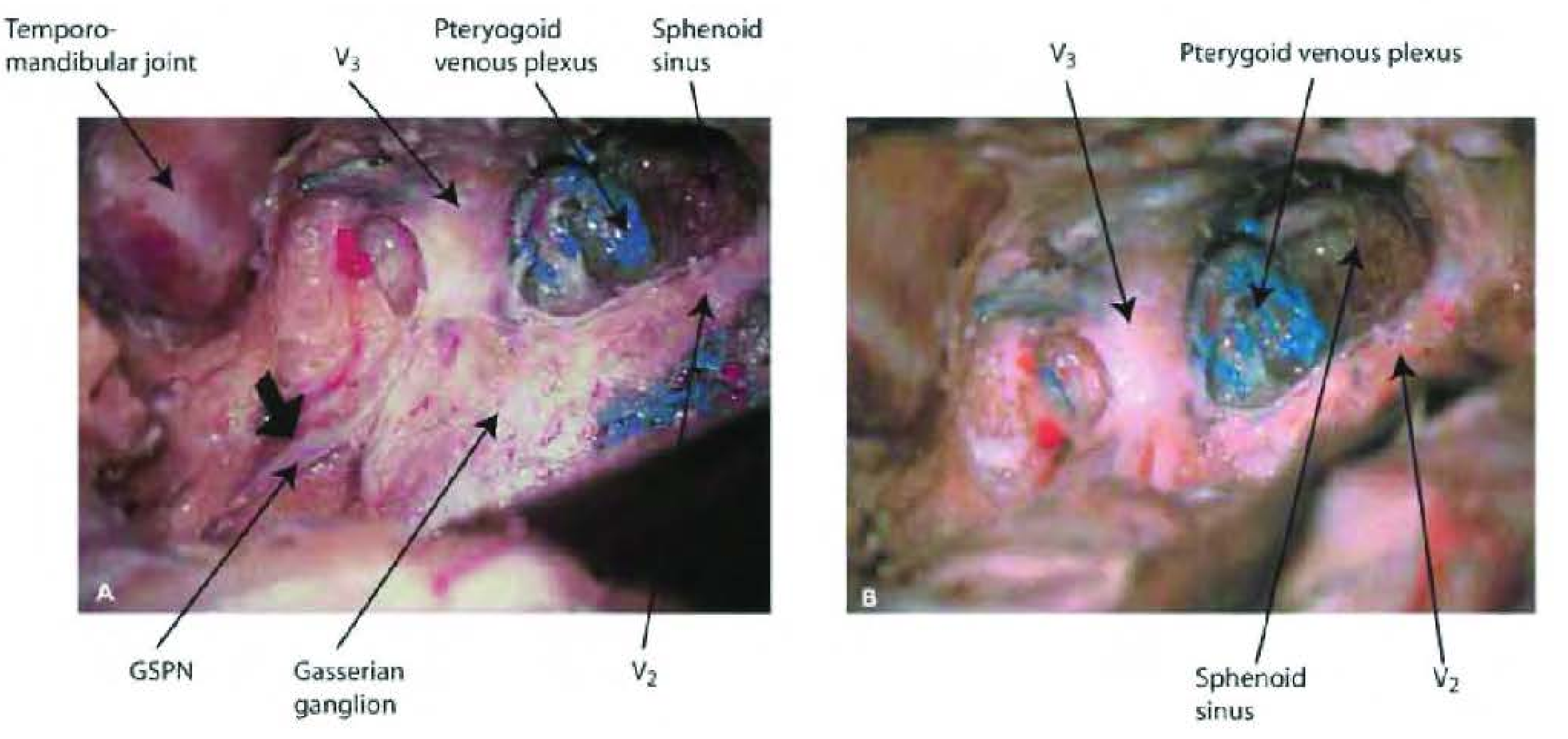


FIGURE 10–8 **A**: The middle meningeal artery and cranial nerve (CN) V_2 and V_3 have been unroofed. **B:** The bone between V_2 and V_3 has been drilled to allow visualization of the sphenoid sinus and pterygoid venous plexus. GSPN, greater superficial petrosal nerve.

Once all the bone of the middle cranial fossa floor lateral to GSPN, V_3, and V_2 has been removed, attention is turned toward exposure and mobilization of the petrous ICA. Initially, the posterior inferomedial region is inspected to determine whether the vessel can be visualized because it may not be covered by bone. If not visible, the ICA is covered by bone that must be drilled to expose the vessel. Drilling lateral to the horizontal segment of the petrous ICA with a diamond bur is relatively safe. The ICA sometimes is covered by a venous plexus. If the periosteal sheath surrounding the vessel is kept intact the venous plexus is not encountered. During lateral drilling, the muscle and tendon of the tensor tympani muscle can be seen. The muscle is cut and reflected away. Just inferior to the tensor tympani, the cartilaginous part of the ET is found. The ET may be separated from the petrous ICA by a small plate of bone. Dissection is made around the ET to free it from the ICA, and then it is cut to expose the lateral wall of the horizontal part of the petrous ICA completely (Fig. 10–9 A, B). The ET should be packed and closed with transfixion stitches. Bone drilling is continued to expose the superior, lateral, and inferior walls of the horizontal part of the petrous ICA.

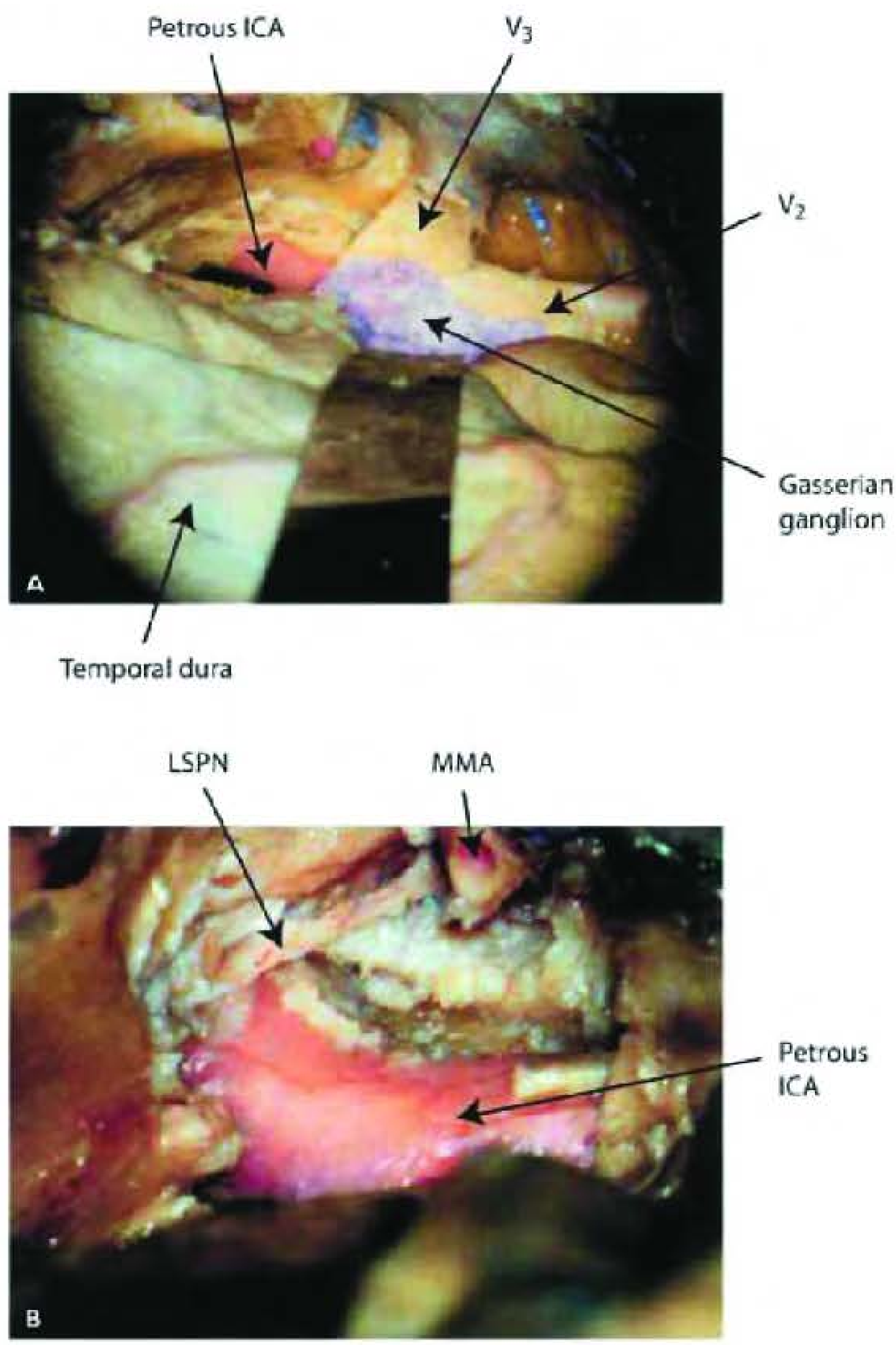


FIGURE 10–9 **A**: The greater superficial petrosal nerve (GSPN) and eustachian tube have been transected to allow visualization of the petrous internal carotid artery (ICA) **B**: High-power view. LSPN, lower superficial petrosal nerve; MMA, middle meningeal artery.

The genu and vertical segments of the petrous ICA then are exposed. During exposure of the genu, care must be taken to avoid injury to the cochlea. If drilling is done lateral to the ICA, the chance of injuring the cochlea is minimal. In this approach, it may not be necessary to drill the bone superior to the genu completely. The cochlea lies posteromedial to the genu; identification of the cochlea is described fully in Chapter 11. The petrous bone and the tympanic plate lateral and anterior to the vertical limb of the petrous ICA are completely drilled. During this part of the procedure, the condyle of the mandible has to be retracted inferiorly and the downward tilt of the vertex reduced. This enhances the view of the lower part of the petrous ICA. A thick fibrocartilaginous band is identified, and it is continuous with the periosteum covering the ICA. This fibrocartilaginous ring is cut and gently dissected away from the wall of the ICA. This frees the ICA to be retracted laterally and anteriorly. A thin bone plate forming the medial rim of foramen ovale lies between V_3 and the ICA, hindering complete mobilization. A drill can be used to remove this bone. The carotid then is free to be mobilized and retracted anteriorly and laterally (Fig. 10–10A, B).

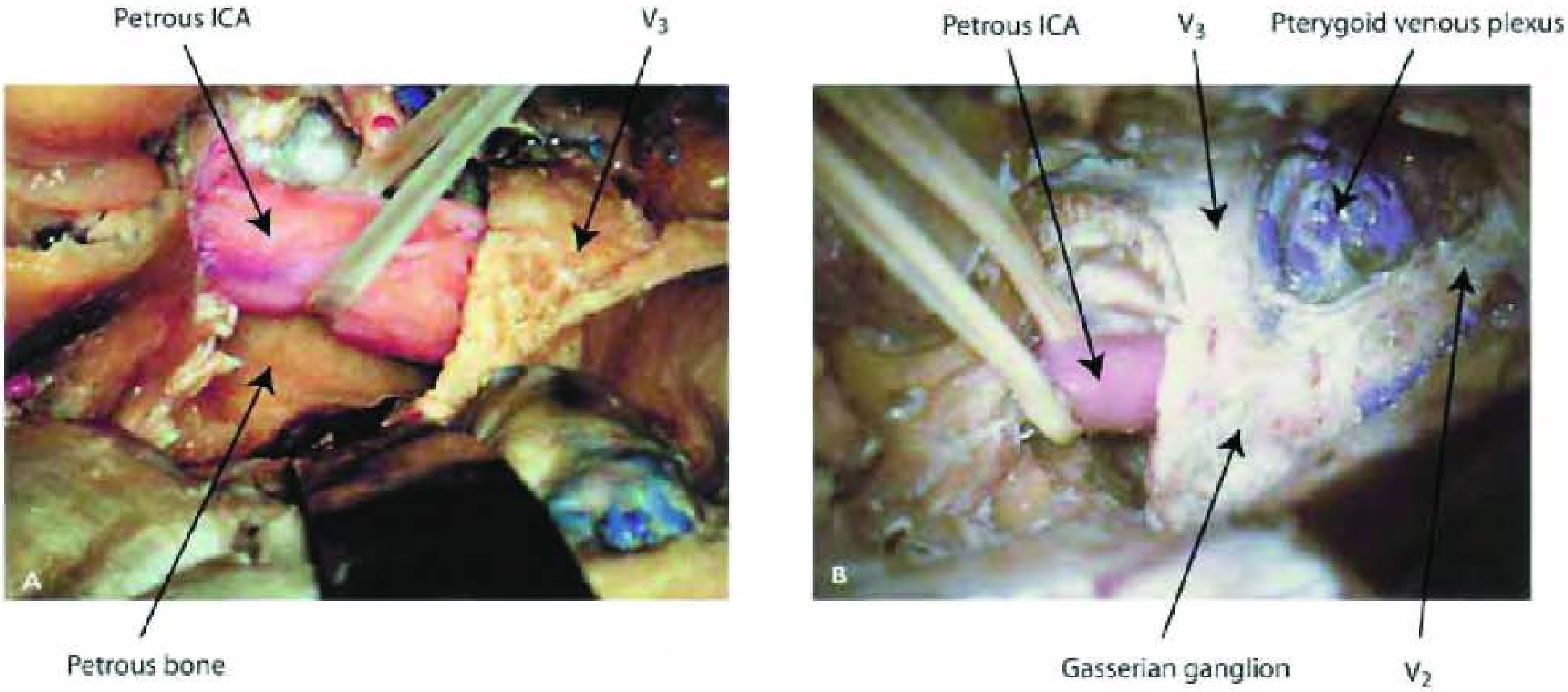


FIGURE 10–10 **A:** High-power view of mobilization of the carotid artery. **B**: A partial petrous apicectomy has been performed. ICA, internal carotid artery.

At this point, the petrous apex can be resected freely. During drilling posteriorly, care must be taken to respect the location of the cochlea. Further medially and posteriorly, the anterior wall of the IAC will be encountered. The petrous pyramid is drilled completely to expose the posterior fossa dura bounded above by the superior petrosal sinus and below by the inferior petrosal sinus (Fig. 10–11). Just below the inferior petrosal sinus, the clivus will become visible.

The dura can be opened along the region of Meckel's cave. Usually, the dura is opened in the posterior fossa first. The drilling will have created a triangular region of the posterior fossa dura bounded inferioriy by the inferior petrosal sinus and the clivus; superiorly by the trigeminal root and the superior petrosal sinus; and posteriorly by the superior semicircular canal, IAC, and the jugular bulb. This is opened in a triangular fashion with its base posterior. If necessary, the triangle can be bisected by incising the dura along the posterior aspect of the IAC, which will expose the sixth cranial nerve exiting the pontomedullary junction on the ventral surface. The contralateral sixth nerve also can be visualized, but its origin may not be seen.

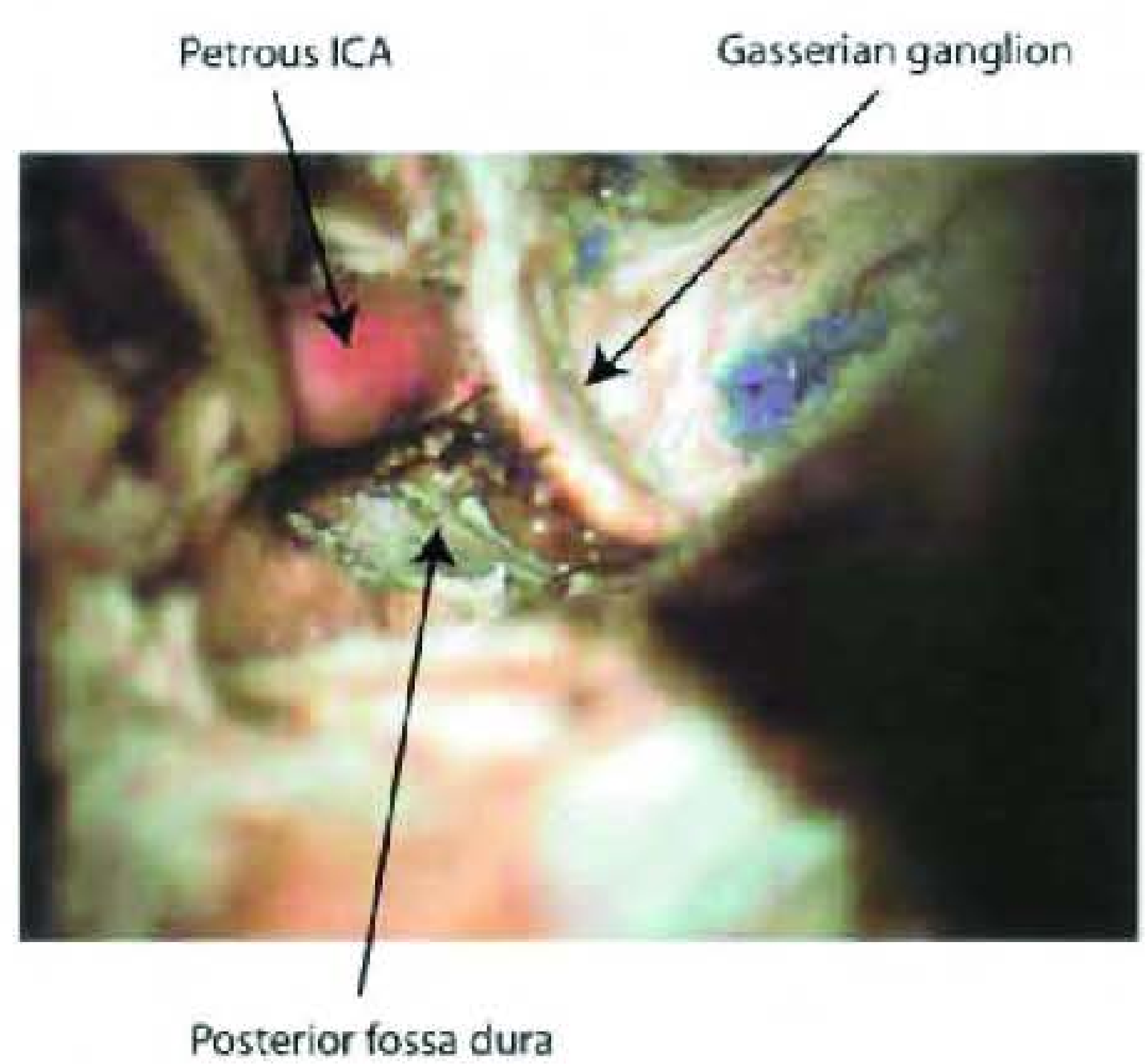


FIGURE 10–11 The petrous apex has been completely drilled bo expose the posterior fossa dura. ICA, internal carotid artery.

The midbasilar artery, the origin of AICA (Fig. 10–12), the ipsilateral VII/VIII cranial nerve complex, the IX/X/XI nerve complex, and both XII nerves can be seen.

Pathology located more superiorly can be visualized by Sectioning the tentorium. The dura along the inferior surface of the temporal lobe is incised in an anterior-posterior direction. A second incision is made at right angles to the first incision, making a T. The superior petrosal sinus will be encountered. It must be ligated, coagulated, and sectioned.The temporal lobe is now gently elevated to expose the tentorial notch. The fourth cranial nerve will be seen diving below the tentorium. The tentorium is incised posterior to the entrance point of the fourth nerve. This incision extends to the region where the superior petrosal sinus was litgated. Sutures are placed in the tentorium, and the tentorium is retracted. All the cranial nerves from CN III through CN XII are now exposed. The fifth cranial nerve can be seen exiting the brainstem and heading toward Meckel's cave.

At the end of the procedure, the dura must be closed in a watertight fashion. A dural graft may be required. Fat is used to fill in dead space. The craniotomy flap is replaced, the temporalis reattached, and the osteotomy replaced. The subcutaneous tissue and skin are closed in multiple layers.

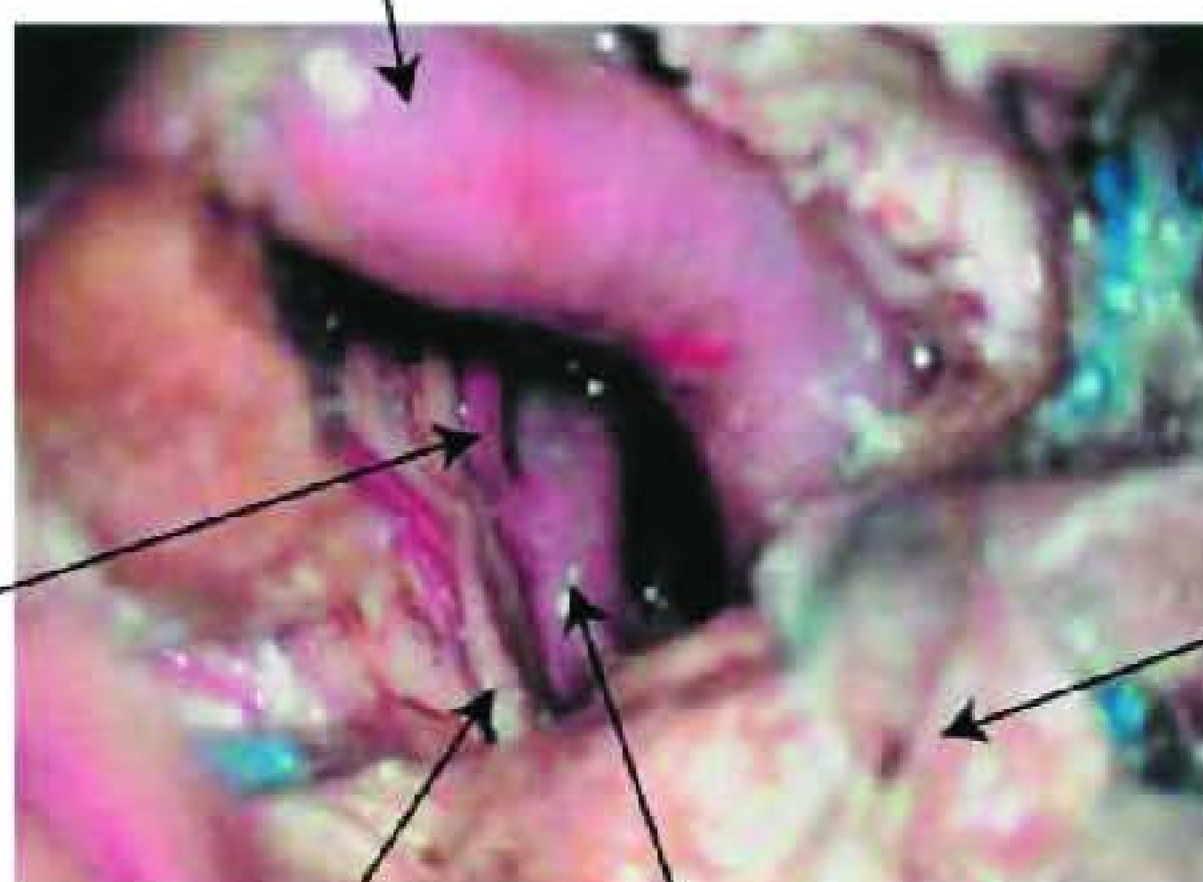


FIGURE 10–12 The dura has been opened to expose the basilar artery, anterior inferior cerebellar artery (AICA), and the sixth cranial nerve (CN). ICA, internal carotid artery.

PITFALLS, PEARLS, CONSIDERATIONS

- Risk of vascular injury to the ICA
- Facial nerve stretch injury
- Extradurally, the limit of the approach is the fifth nerve
- Lesions of the mid and anterior cavernous sinus cannot be resected

SUGGESTED READINGS

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Chapter 11

MIDDLE FOSSA APPROACH

Amithaba Chanda, Emel Avci, Damirez Fossett

INDICATIONS FOR APPROACH

- Extradural petrous apex lesions
- Internal auditory canal lesions
- Intradural lesions of the ventral pons, midbasilar artery, proximal anterior inferior cerebellar artery (AICA)
- Facial-nerve decompression

ANATOMY

Please refer to the anatomy section of Chapter 10 for a review of the pertinent anatomy.

POSITIONING AND SKIN INCISION

The patient is placed in the supine position in Mayfield three-point fixation with a shoulder roll under the ipsilateral shoulder. The head is rotated 90 degrees toward the contralateral shoulder with the vertex pointed 10 degrees toward the floor. A question mark incision, a horseshoe-shaped incision, or a coronal incision can be used (Fig. 11–1). The lower end of the incision should reach at least the lower margin of the zygomatic arch and remain as close as possible to the tragus of the ear to preserve the frontotemporal branch of the facial nerve and the superficial temporal artery. A V-shaped notch is made just anterior to the tragus to give a belter cosmetic result.

The skin and subcutaneous dissections are carried down to the bone in the upper part of the incision and to the temporalis fascia in the lower part of the incision. The skin flap is mobilized anteriorly and inferiorly. The fascial splitting technique is used to spare the frontotemporal branches of the facial nerve. The temporalis muscle is detached as described in previous chapters. A zygomatic osteotomy, although not mandatory, may enhance exposure. It is not necessary to include the condyle with the zygomatic osteotomy.

A temporal craniotomy is made with two thirds of it anterior to the external auditory meatus and one third posterior to the meatus. The anterior limit should be as close as possible to the anterior wall of the middle cranial fossa. After turning the bone flap, any remaining squamosal portion of the temporal bone is drilled flush with the floor of the temporal fossa. The operating microscope is then brought into the field. The temporal dura is gently separated from the floor of the middle cranial fossa to expose the tegmen tympani and the arcuate eminence. Continued dural dissection anteriorly exposes the middle meningeal artery entering the cranial cavity through the foramen spinosum (Fig. 11–2). More anterior dissection will expose the lateral margin of the foramen ovale with the mandibular nerve (V_3) exiting through it.

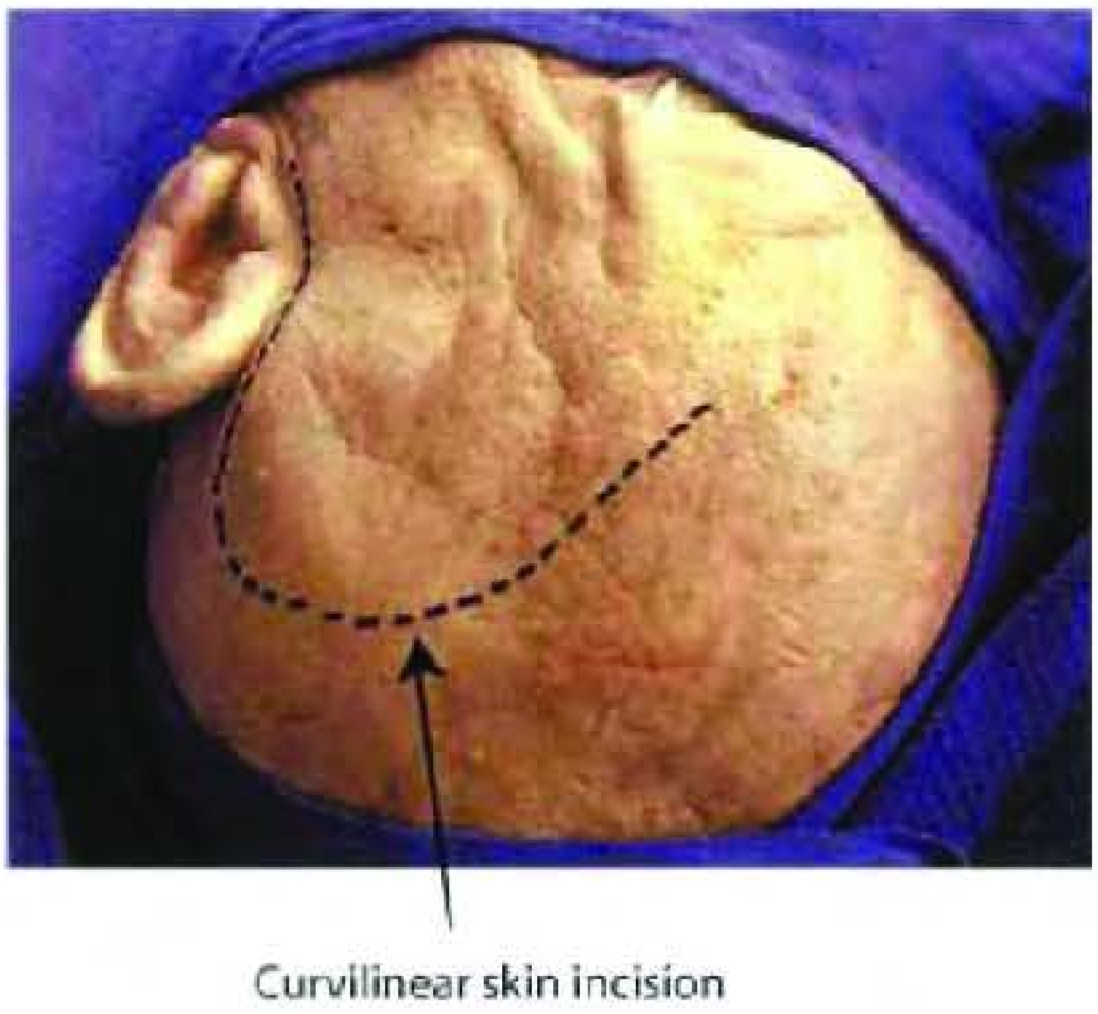


FIGURE 11–1 Curvilinear preauricular incision for the middle fossa approach.

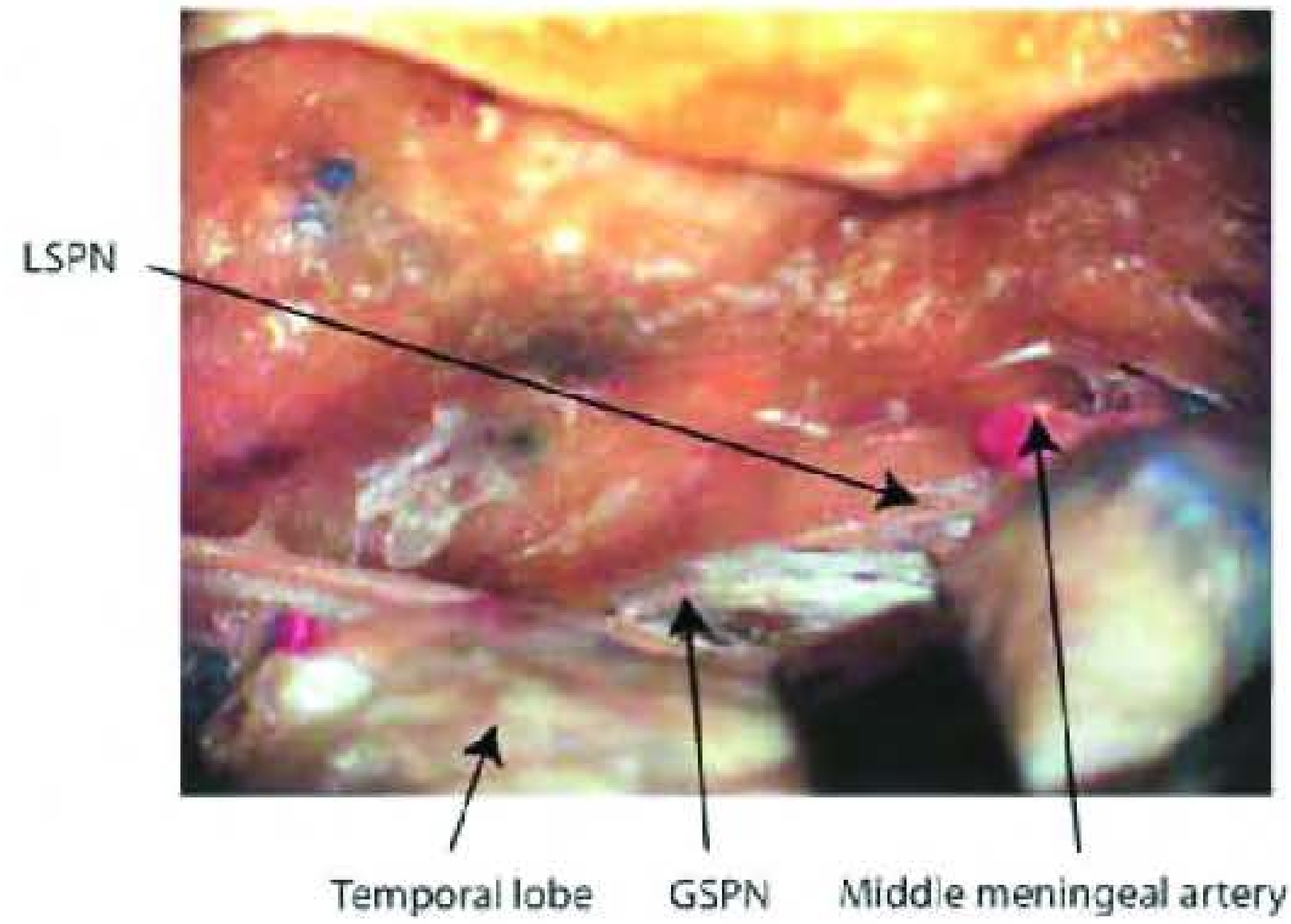


FIGURE 11–2 The cut end of the middle meningeal artery is seen. From lateral to medial, the LSPN, GSPN, and tensor tympani muscles are visualized. LSPN, lesser superficial petrosal nerve; GSPN, greater superficial petrosal nerve.

The middle meningeal artery is sectioned to free the dura so that dural separation can proceed medially. Medial separation will expose the greater superficial petrosal nerve (GSPN) emerging from the facial hiatus. Care is taken to separate the GSPN from the dura so that the facial nerve will not suffer a stretch injury. The dural adhesion to the superolateral surface of the V_3 is cut transversely. Just posteromedial to V_3 and under the GSPN one can visualize the petrous internal carotid artery (ICA) (Fig. 11–3).

Dura is separated from the middle cranial fossa up to the petrous ridge. Two tapered, malleable self-retaining retractors are used to retract the temporal dura covering the inferior surface of the temporal lobe. This will expose the middle fossa rhomboid construct which is formed by the joining of the following four points; (1) porus trigeminus, (2) intersection of the petrous ridge with the arcuate eminence, (3) intersection point of the axis of the arcuate eminence and that of the GSPN, (4) intersection of the lateral border of the gasserian ganglion and V_3 with the GSPN. This rhomboid construct overlies several important anatomic structures. If the rhomboid is divided by bisecting the angle defined by the axis of the GSPN and the axis defined by the arcuate eminence, premeatal and postmeatal triangles can be defined. The postmeatal triangle overlies the block of bone separating the superior semicircular canal and the internal auditory canal (IAC) and can be drilled safely. While drilling proceeds laterally, care must be exercised as the superior semicircular canal and the IAC come dose and there is a danger of facial nerve injury. Below the premeatal triangle lie the cochlea and the ICA (Fig. 11–4A-C). Preservation of the cochlea is the goal

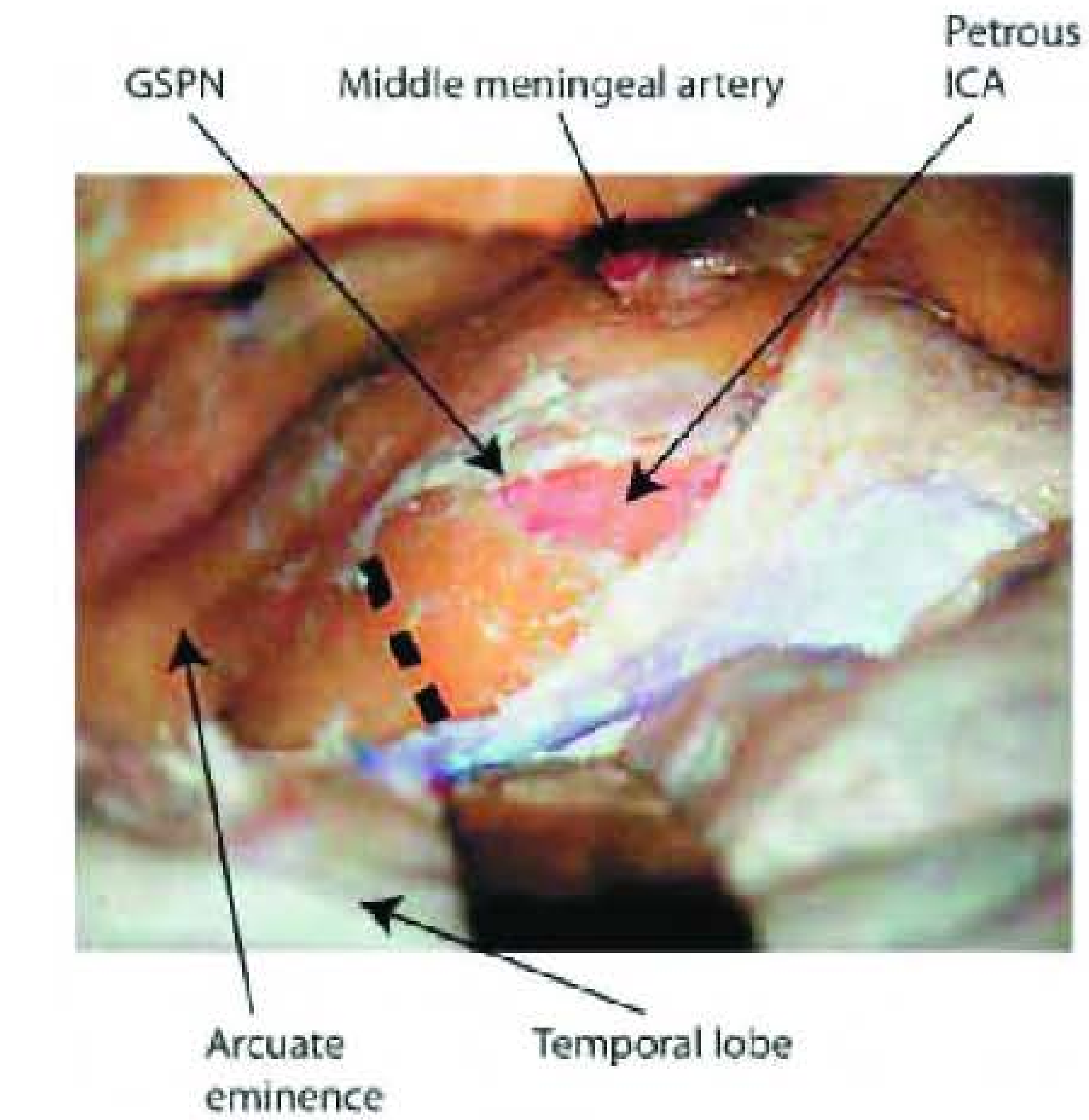


FIGURE 11–3 The middle fossa rhomboid construct is visible. The middle meningeal artery, greater superficial petrosal nerve (GSPN), V_3, internal carotid artery (ICA), and arcuate eminence are identified. A portion of the cavernous sinus can be seen.

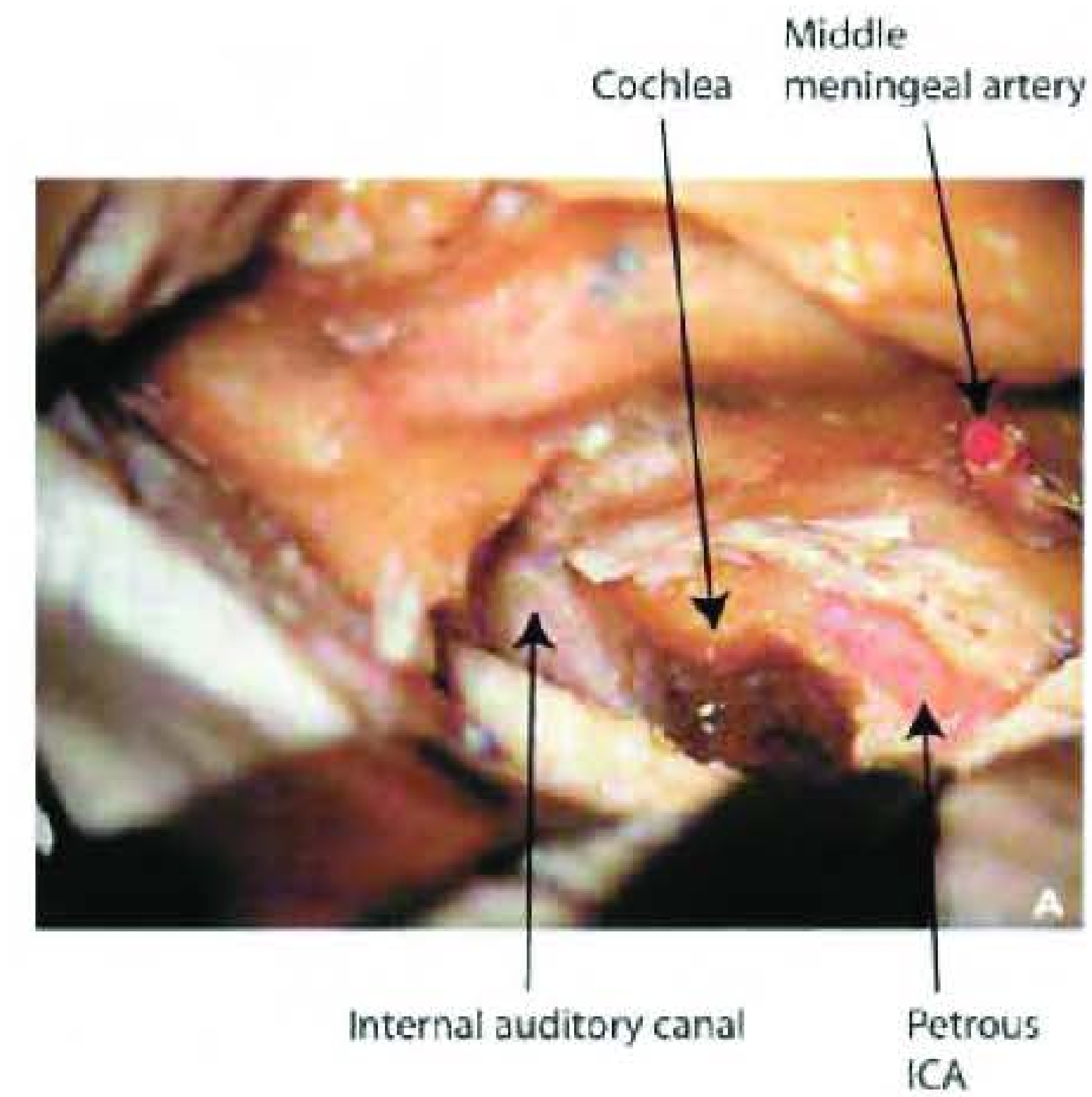
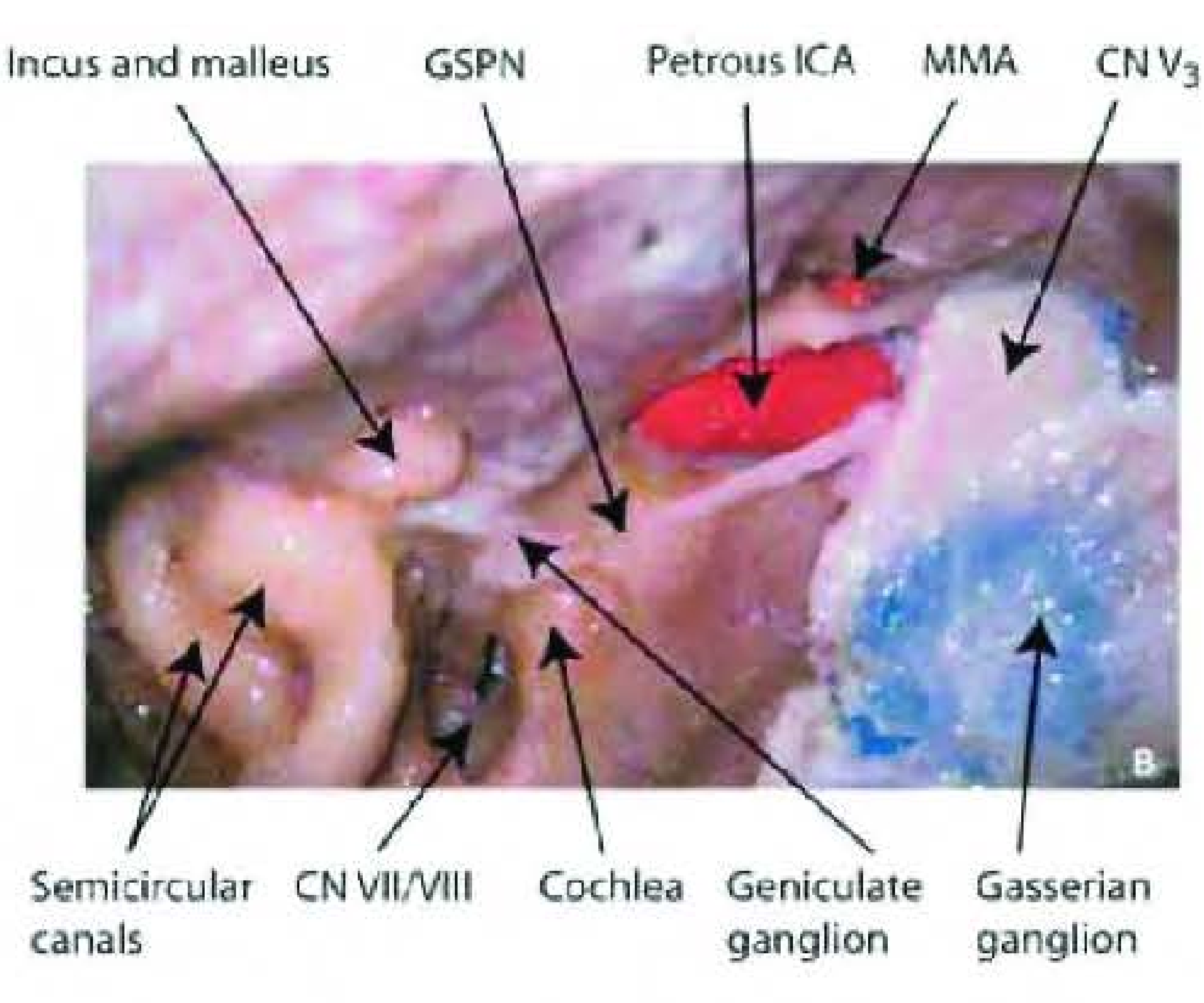
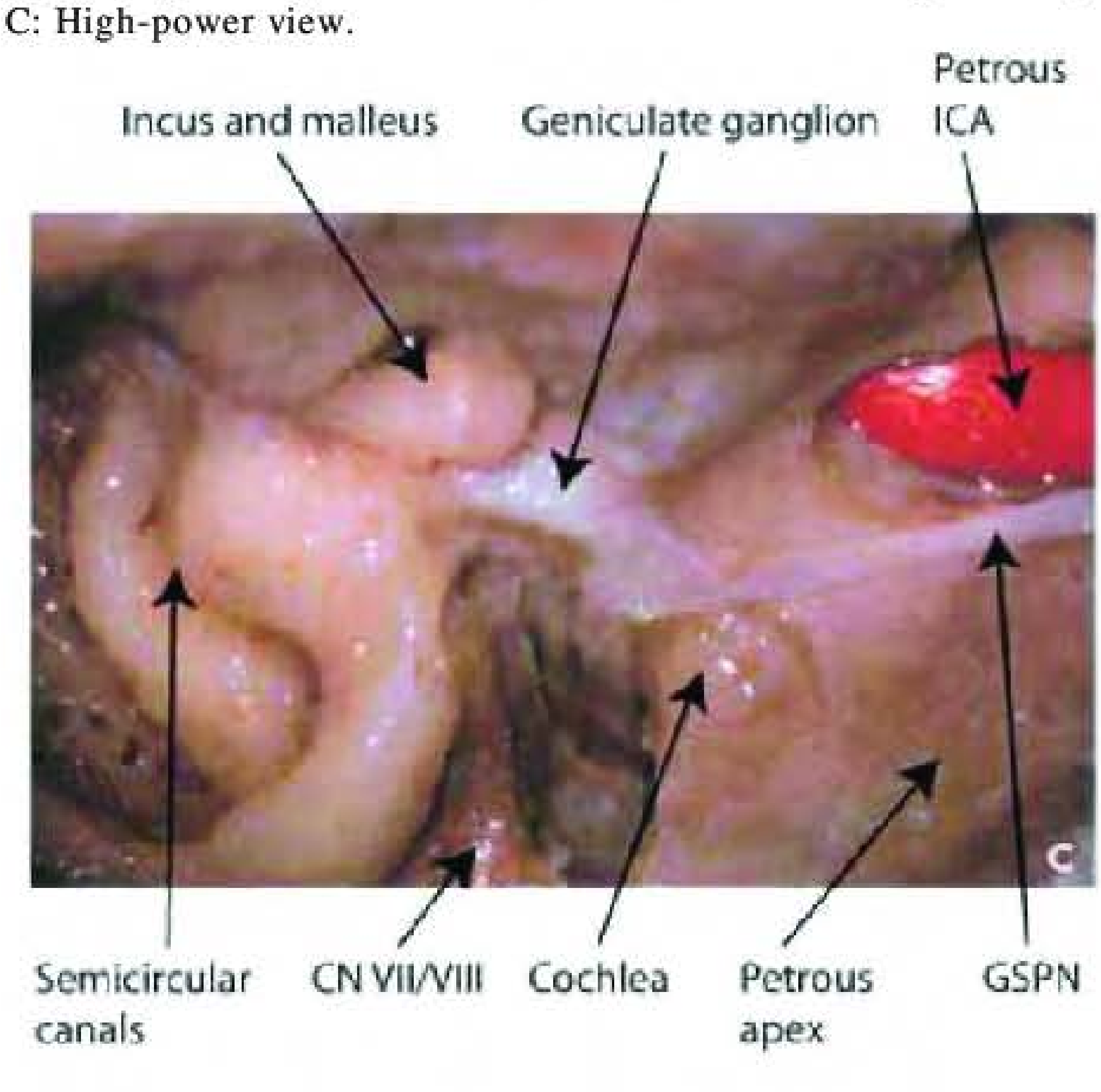


FIGURE 11–4 **A**: The internal auditory canal (IAC) has been opened. Note its proximity to the petrous internal carotid artery (ICA). **B**: The IAC has been opened and the middle ear structures uncovered. The proximity of the geniculate ganglion, GSPN, and the petrous ICA to the middle car structures is appreciated. GSPN, greater superficial petrosal nerve; MMA, middle meningeal artery. C: High-power view.





The drilling is started where the bisecting line joins the petrous ridge. The angle of drilling should be along the petrous ridge. As the bone is drilled, the superior petrosal sinus will come into view. It is advisable to use a diamond burr and to keep a thin plate of bone over the vital structures during bone removal. The thin plate then can be gently separated from the underlying structures, broken, and removed. After a trough is drilled a little anterior to the expected location of the porus acousticus, a diamond burr is used to identify the anterior canal dura and the porus acousticus. The bone then is removed from medial to lateral to expose the full length of the IAC all the way to the fundus. Care must be taken to remain directly above the IAC so as not to injure the cochlea or superior semicircular canals.

There are other methods of identification and exposure of the IAC. The IAC can be identified by following the GSPN back to the hiatus. Drilling over the hiatus exposes the geniculate ganglion. Subsequently, the labyrinthine portion of the facial nerve, which is parallel to the superior semicircular canal (SSCC), is followed to the fundus of the IAC. It must be remembered that the facial nerve lies directly against the dura; therefore, the bone must be removed carefully.

After the IAC is exposed, the postmeatal triangle is drilled until the SSCC is blue-lined. Attention then is turned toward the premeatal triangle. Here the cochlea lies at the IAC–ICA angle and is blue-lined and preserved. The bone of Kawase's triangle can be drilled away completely to the depth of the inferior petrosal sinus to expose the posterior fossa (Fig. 11–5). If necessary, the lateral part of the clivus can be drilled to gain more extradural exposure.

The dural opening is essentially the same as that described in Chapter 10 (Fig. 11–6). The temporal dura is Opened along the undersurface of the temporal lobe, and a second incision is made perpendicular to the first along the floor of the middle fossa toward the posterior fossa dura (Fig. 11–7). At the level of Kawase's triangle the superior petrosal sinus is sectioned as previously described. The tentorium then is sectioned into the incisura, and the posterior fossa dura is sectioned to the depth of Kawase's triangle (Fig. 11–8). This

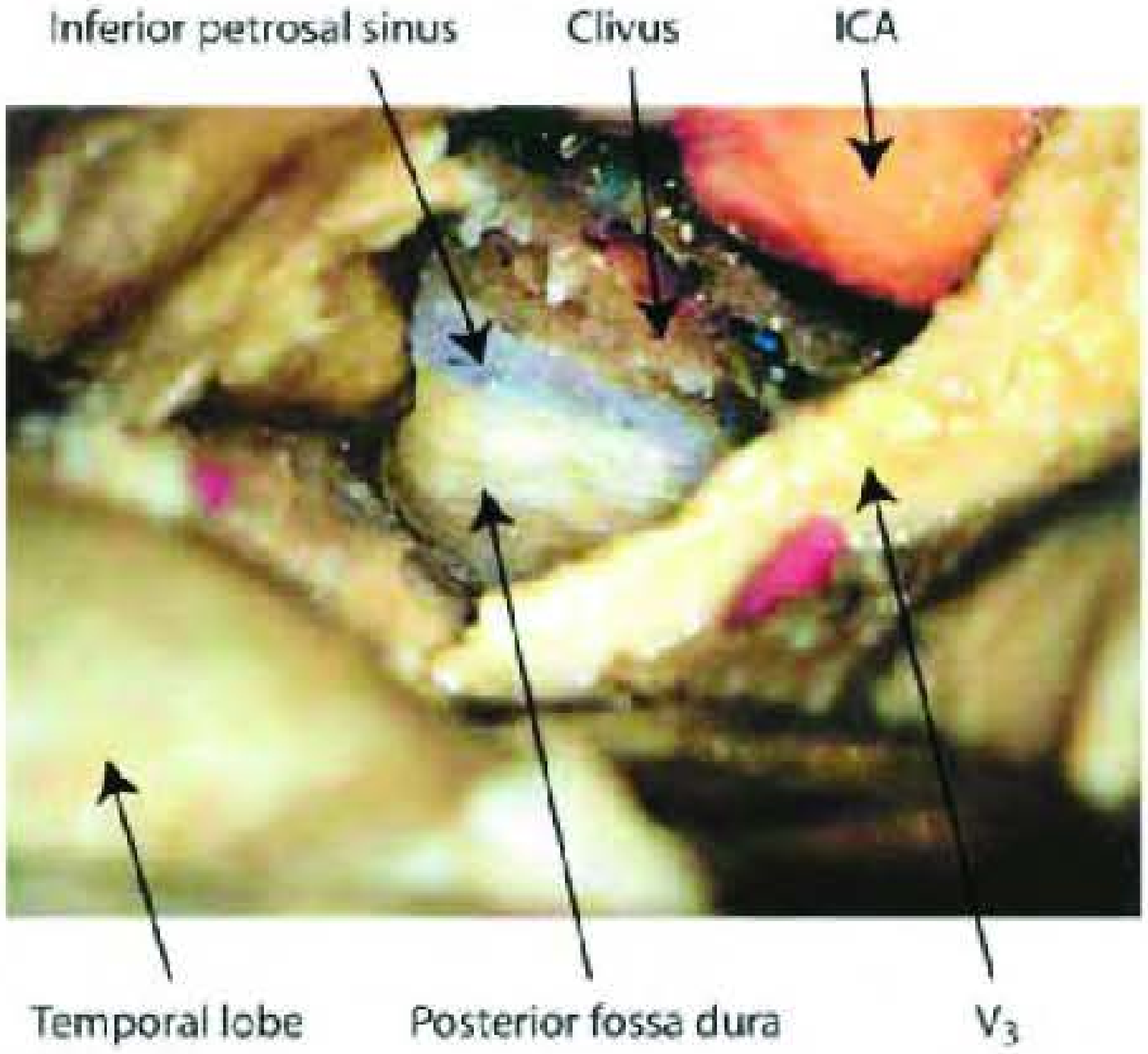


FIGURE 11–5 After complete drilling of the petrous apex, the posterior fossa dura, inferior petrosal sinus, and clivus can be seen. ICA, internal carotid artery.

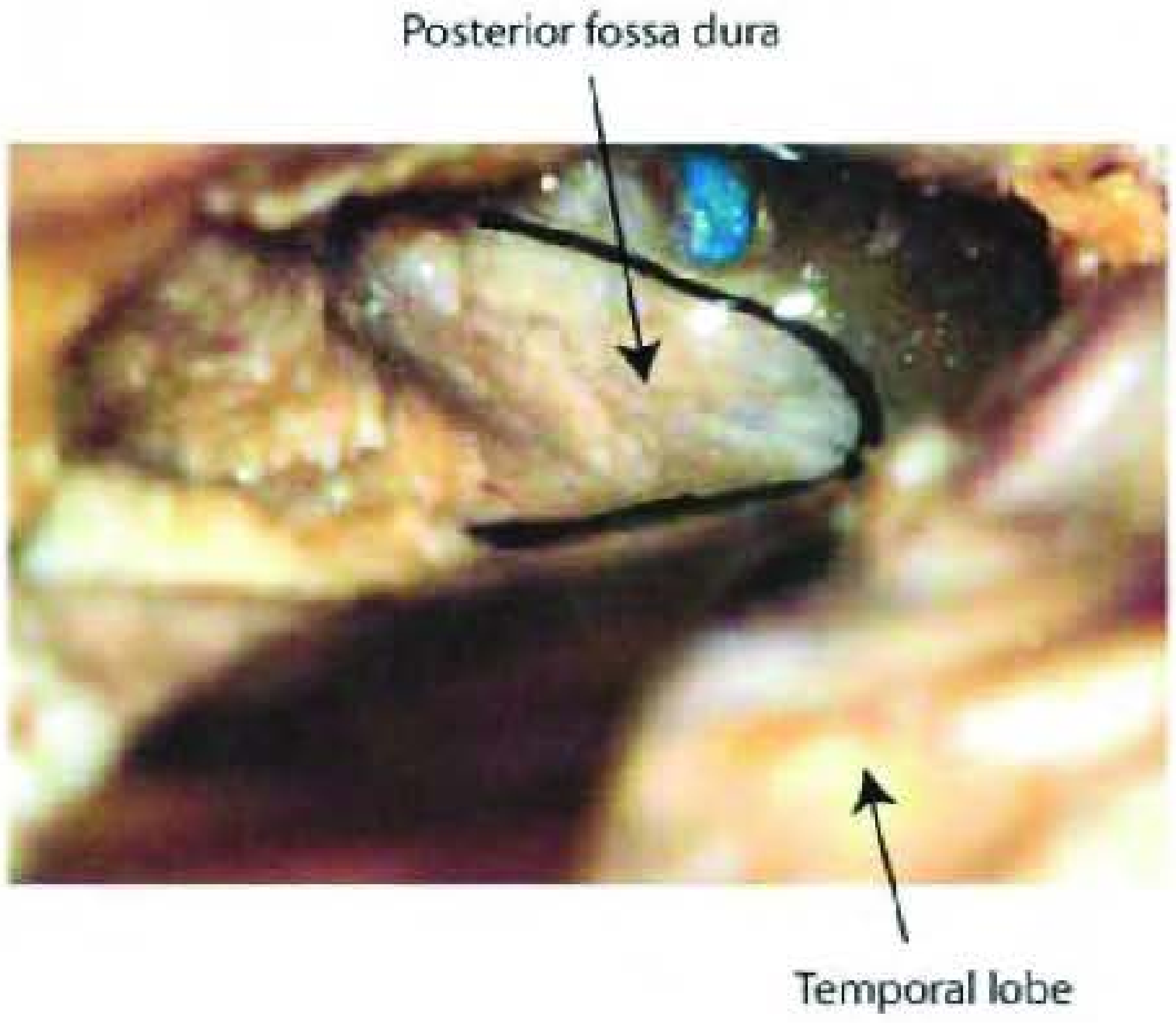


FIGURE 11–6 The dural incision is outlined of the posterior fossa.

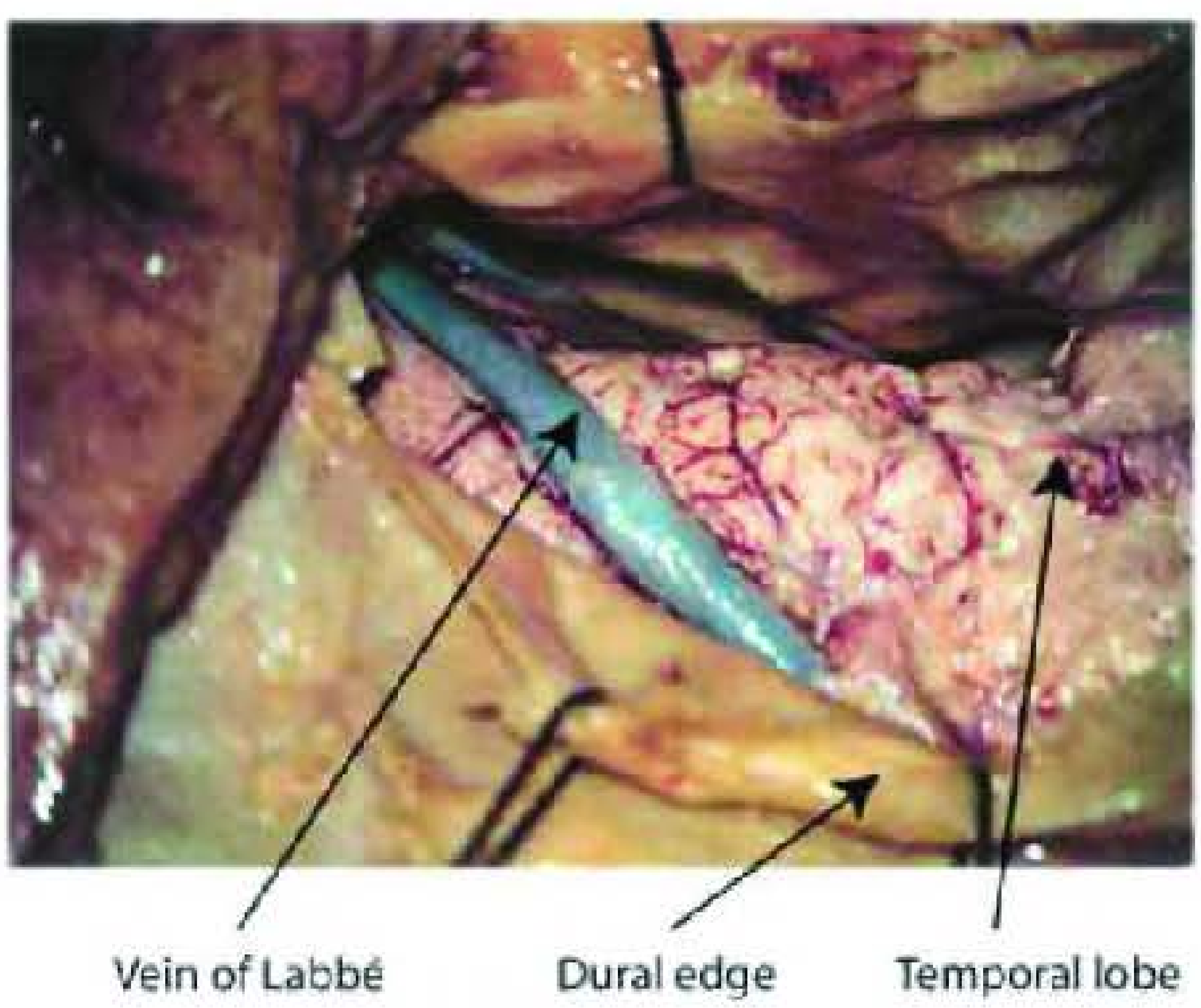


FIGURE 11–7 After incision of the inferior temporal dura, the vein of Labbé can be identified.

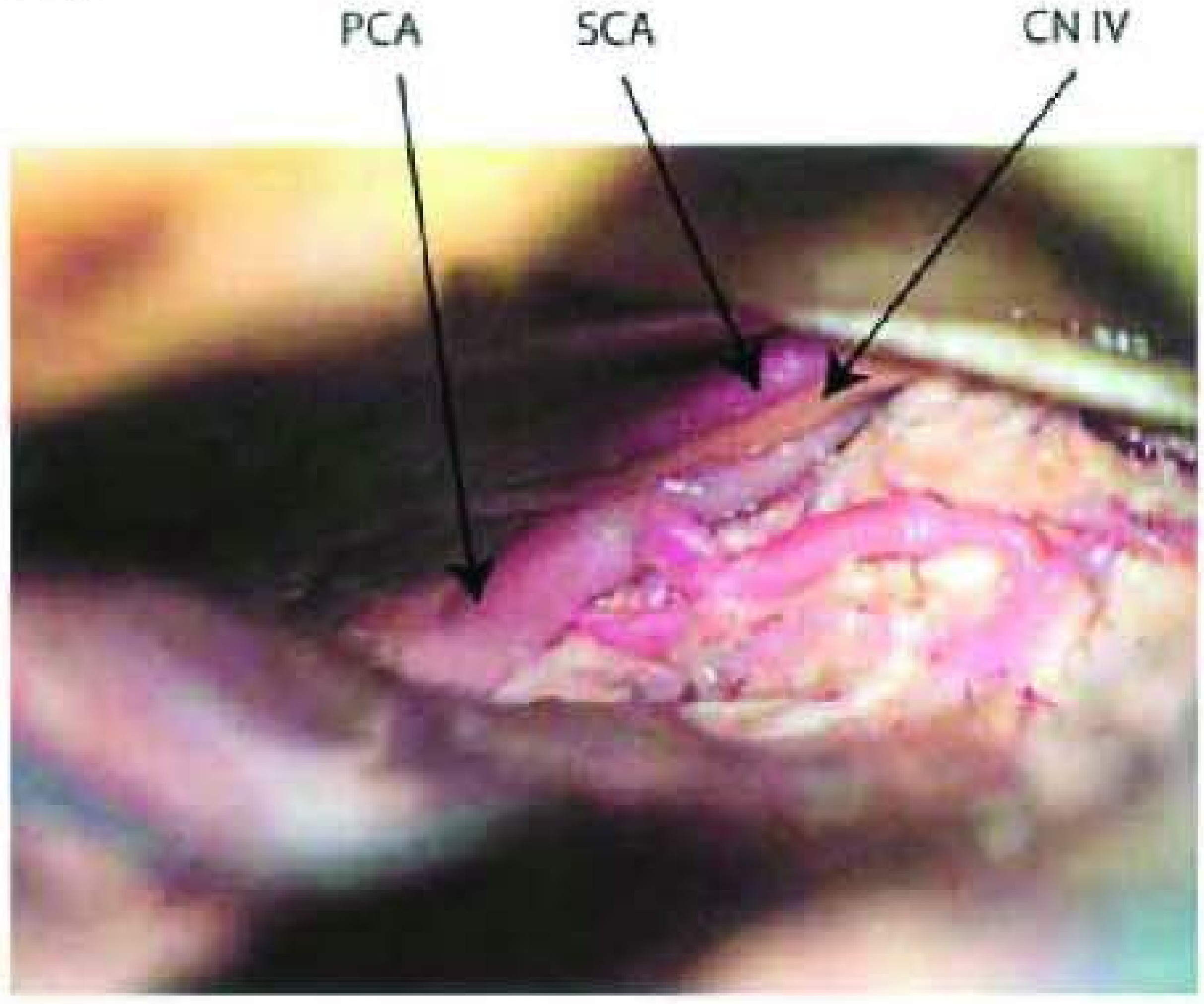


FIGURE 11–8 The tentorium has been incised to show the fourth nerve, posterior cerebral artery (PCA), and superior cerebellar artery (SCA).

will expose the basilar artery from the posterior clinoid process to the vertebrobasilar junction, cranial nerves (CN) III, IV, V, VI, and the VII/VIII complex, the anterior inferior cerebellar artery (AICA), and sometimes the superior cerebellar artery (SCA) (Figs. 11–9 through 11–18).

The dura must be closed in a watertight fashion. This usually requires a dural graft. Fat is used to fill in dead space. The craniotomy flap is replaced, and the temporalis is reattached. The subcutaneous tissue and skin are closed in multiple layers.

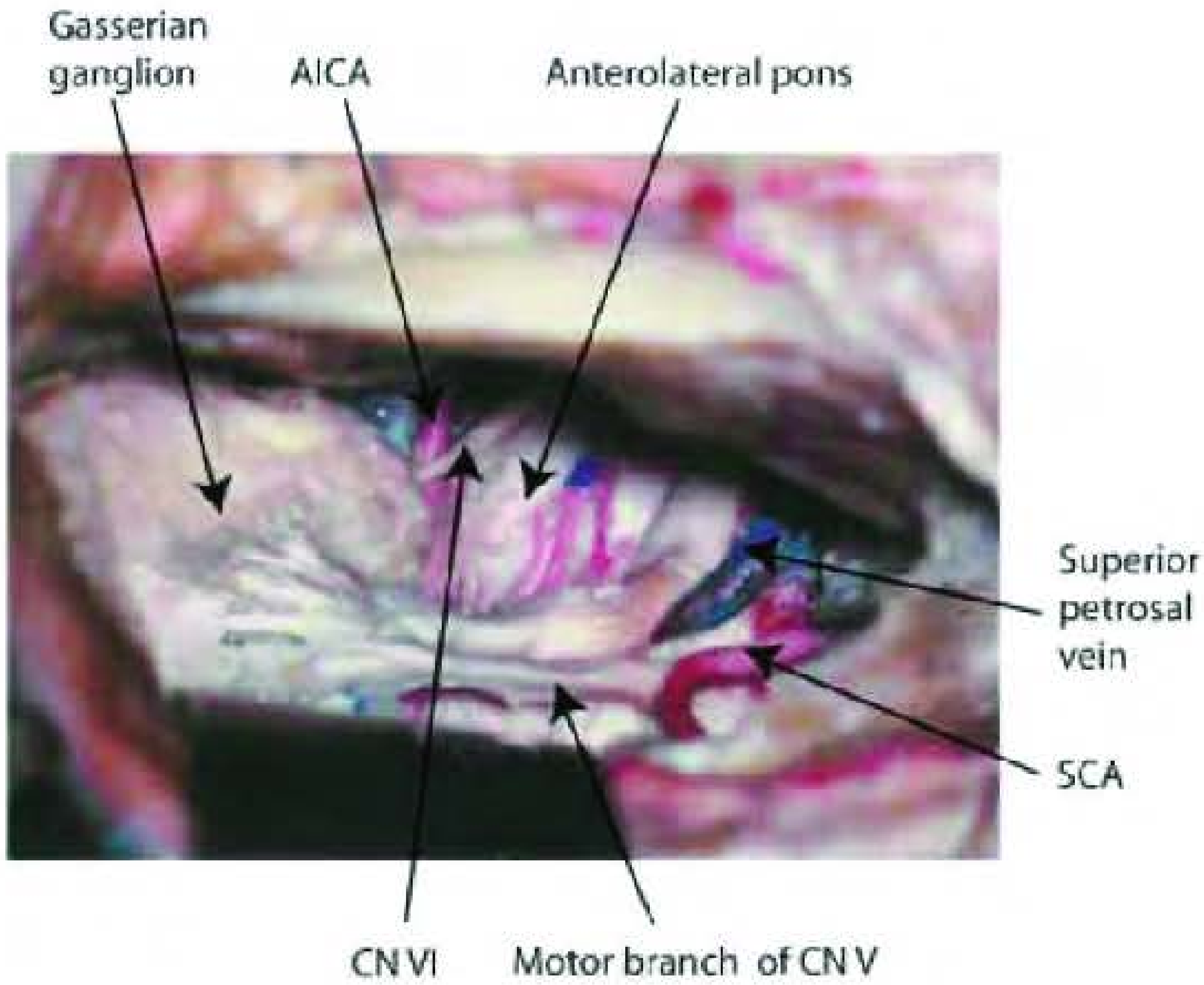


FIGURE 11–9 The porus trigeminus is opened and the course of the fifth nerve is exposed. The superior petrosal vein and the superior cerebellar artery (SCA) are seen in the region of the fifth nerve. AICA, anterior inferior cerebellar artery; CN, cranial nerve.

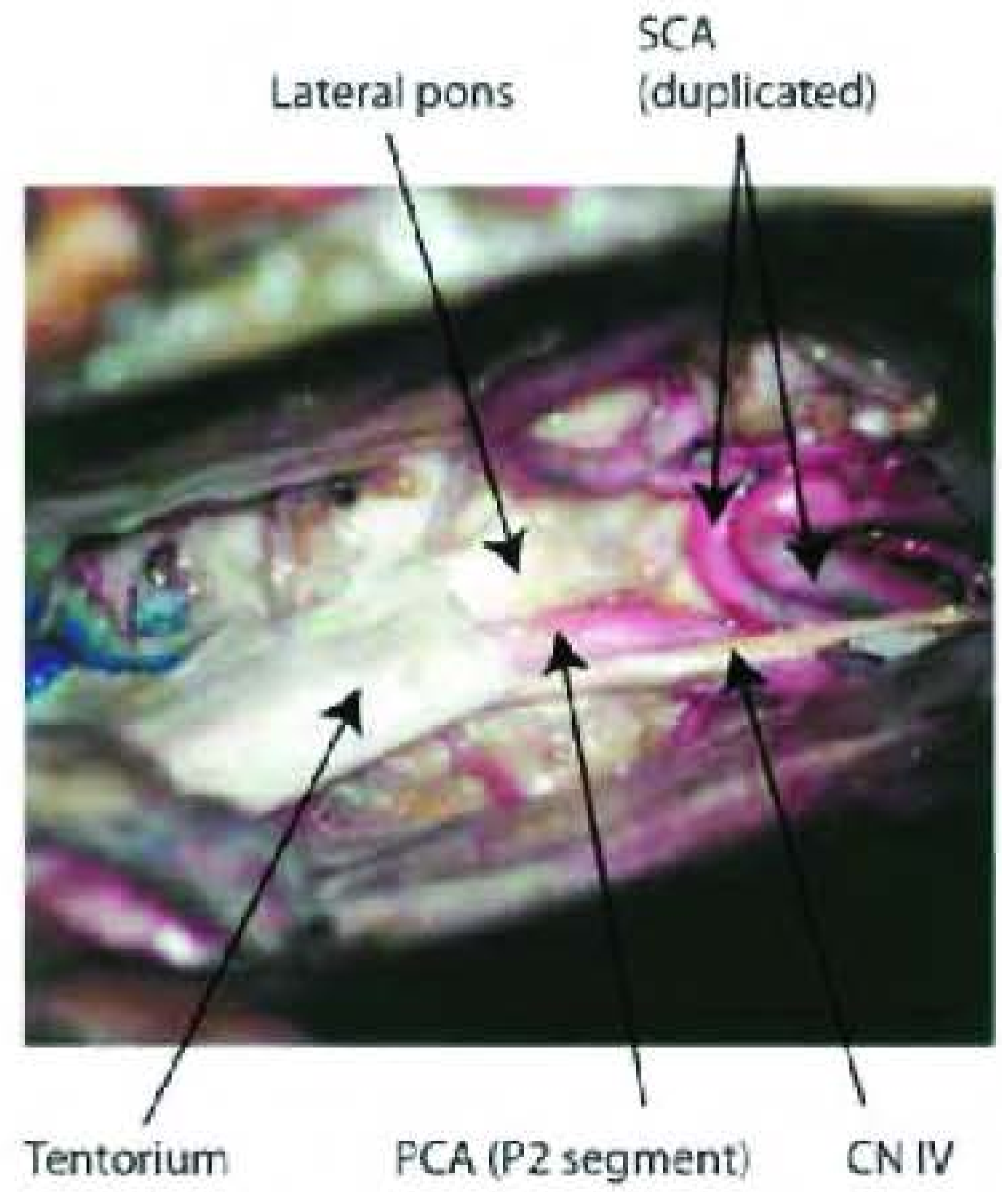


FIGURE 11–10 The tentorium is partially incised, and the fourth nerve is visualized. The duplicated superior cerebellar artery (SCA), posferior cerebral artery (PCA), and superolateral puns are visible, CN, cranial nerve.

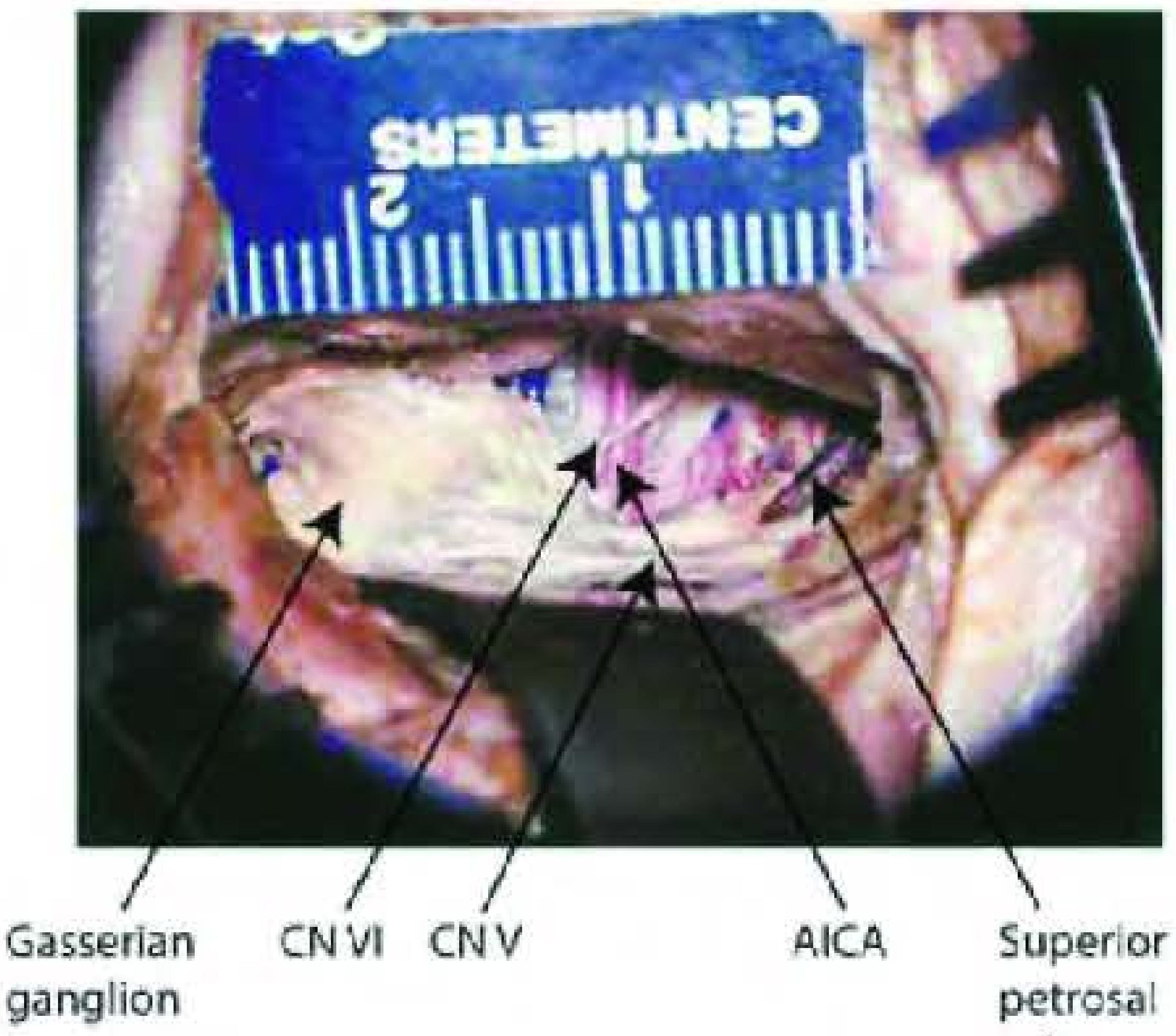


FIGURE 11–11 Panoramic view of the approach through a 2.5-cm keyhole. AICA, anterior inferior cerebellar artery.

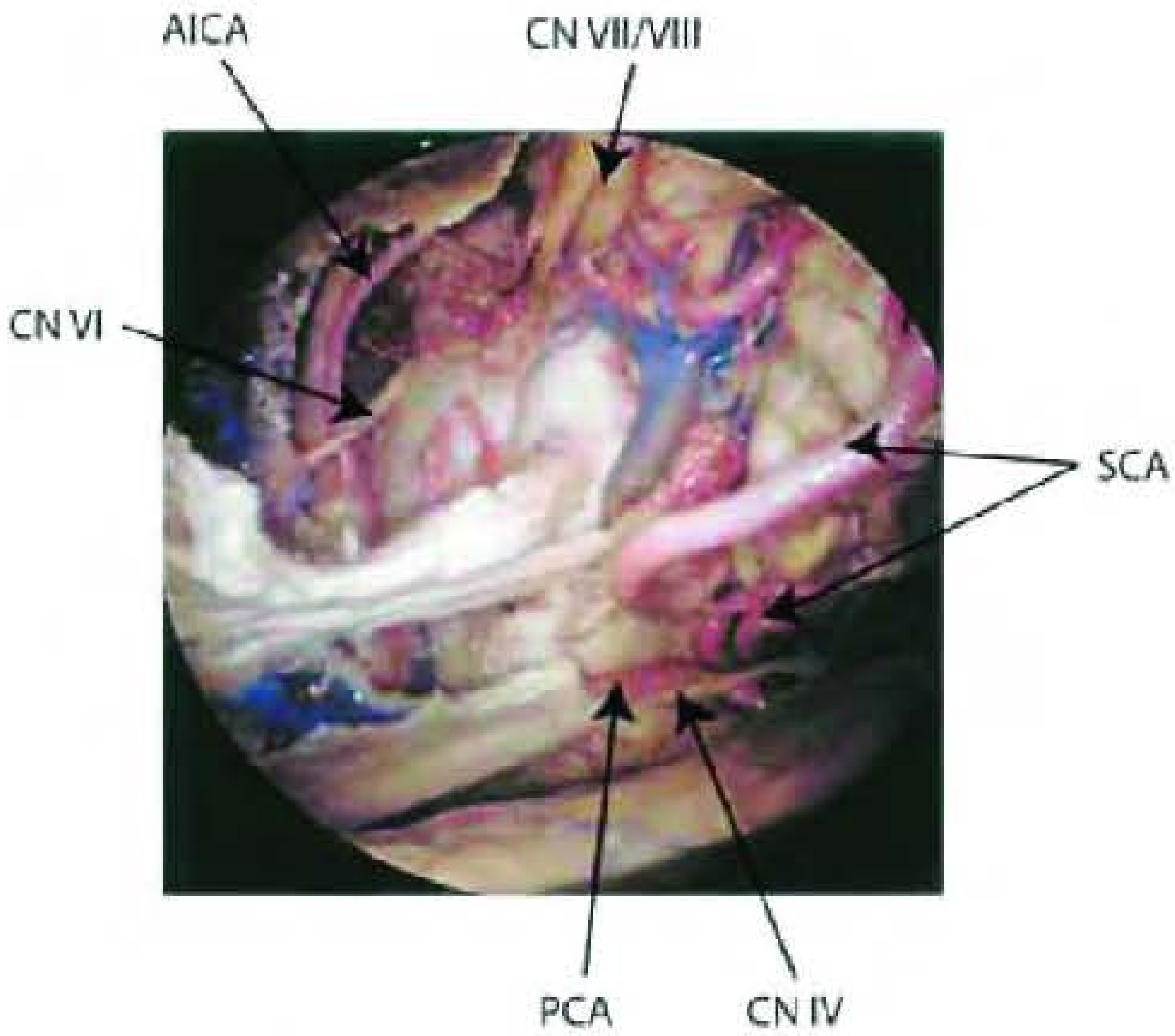


FIGURE 11–12 Panoramic view with a 30-degree endoscope of cranial nerves (CNs) IV, V, VI, VII, and VIII. The tentorium has been partially incised. The basilar artery, anterior inferior cerebellar artery (AICA), posterior cerebral artery (PCA), and petrosal vein are all seen. SCA, superior cerebellar artery.

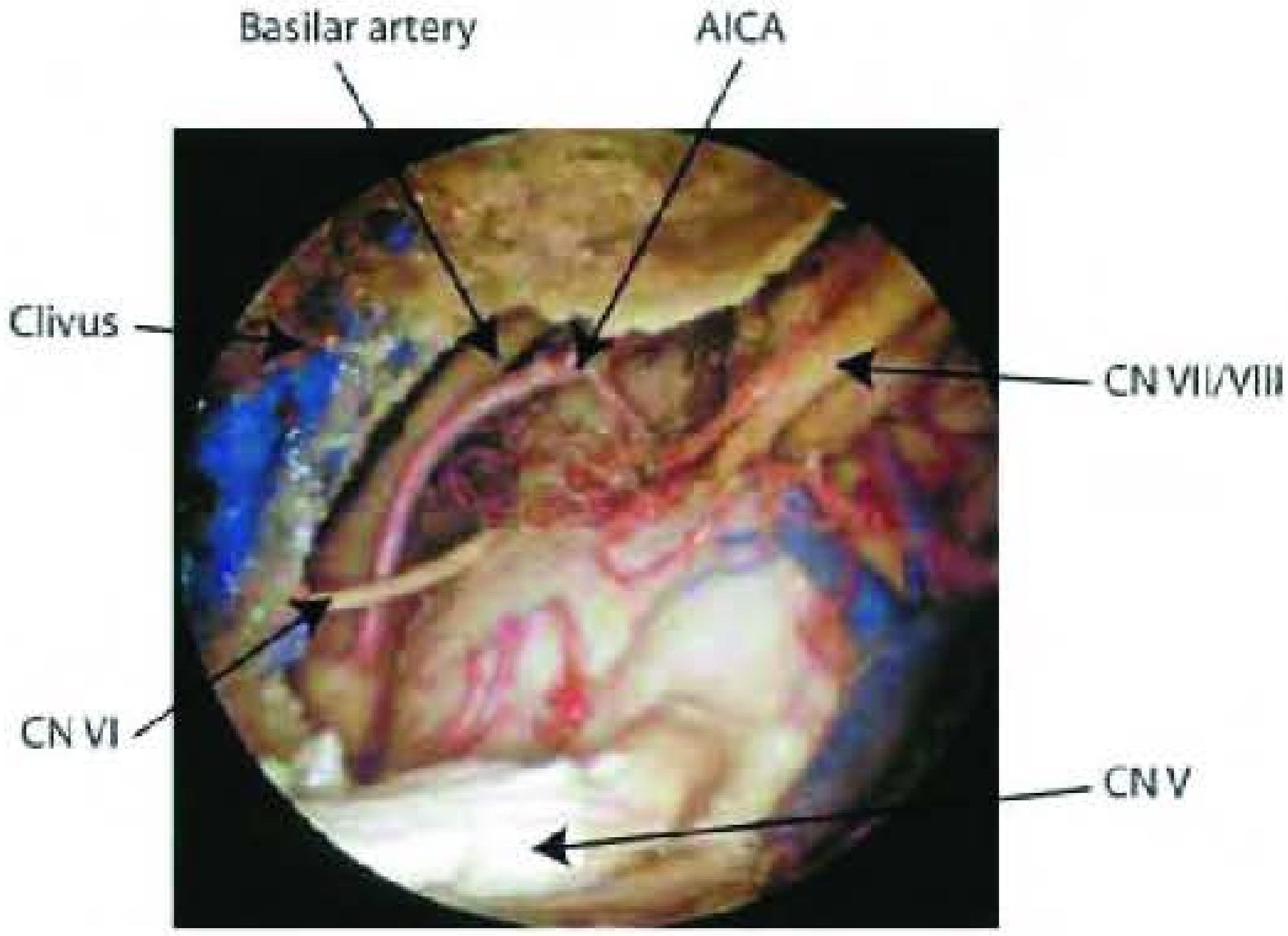


FIGURE 11–13 High-power view of cranial nerve (CN) V, VI, VII, and VIII. The anterolateral pons is also visualized, AICA, anterior inferior cerebellar artery.

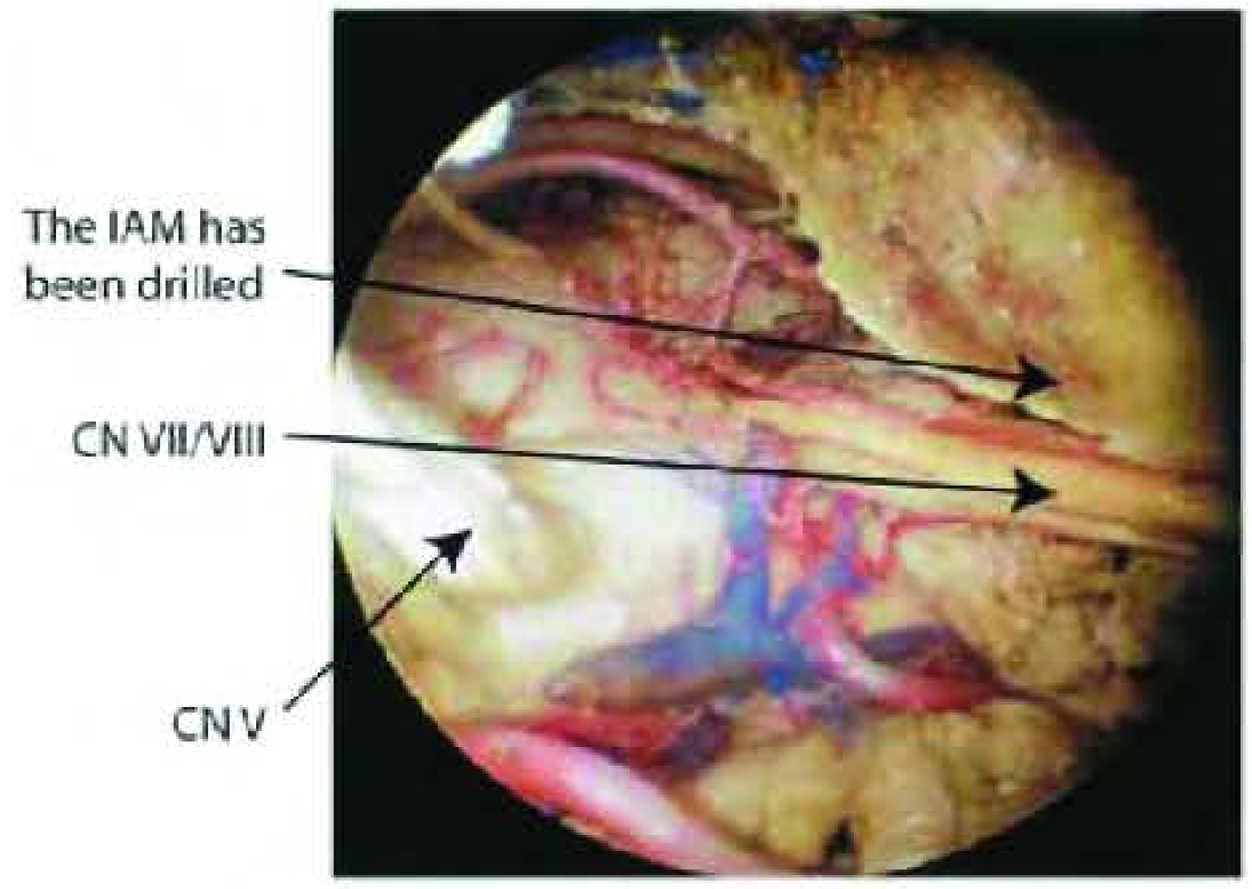


FIGURE 11–14 High-power view of the VII–VIII complex. The internal auditory canal has been drilled. The internal auditory artery is seen following the nerve. CN, cranial nerve; IAM, internal auditory meatus.

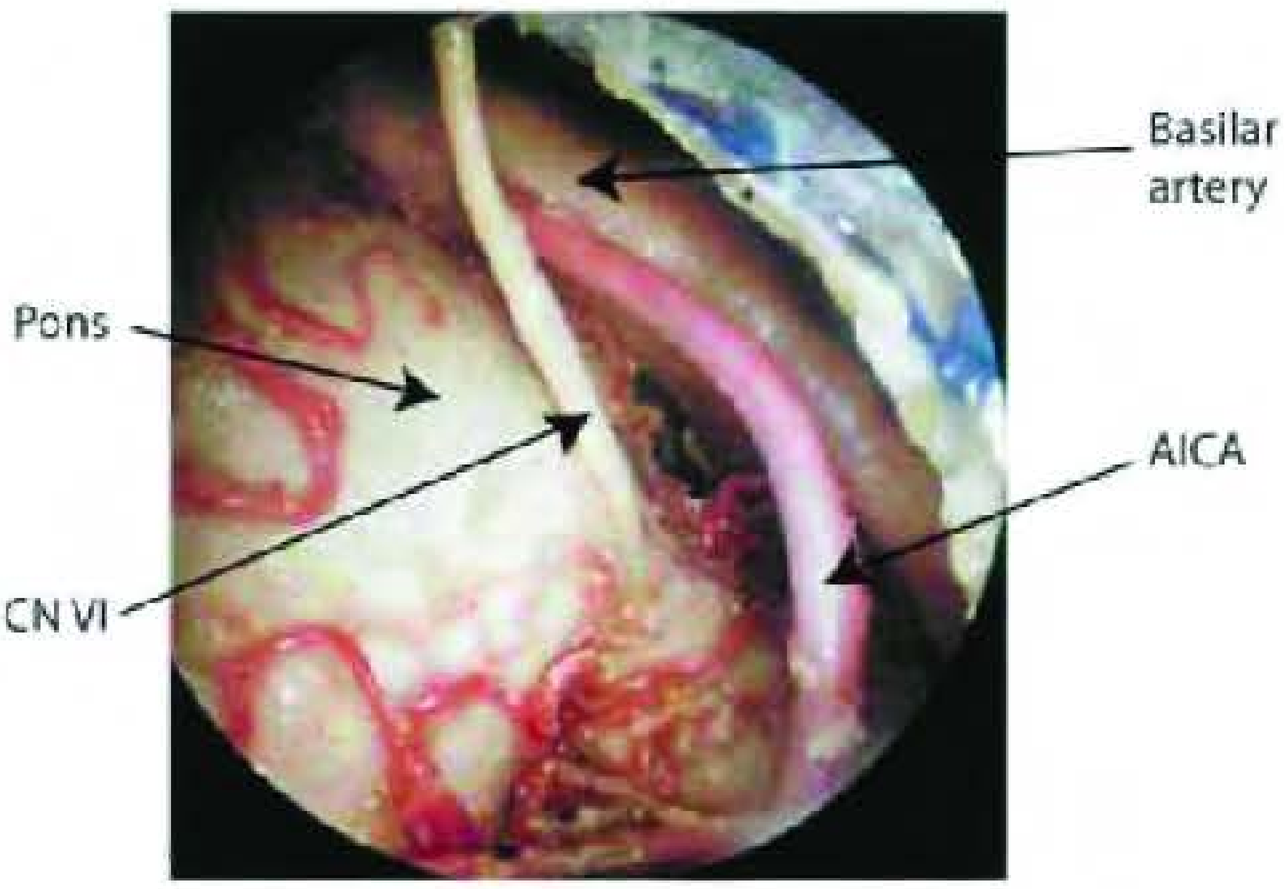


FIGURE 11–15 High-power view of cranial nerve (CN) VI coursing from the pontomedullary sulcus to Dorello's canal. The basilar artery and the anterior inferior cerebellar artery (AICA) also are seen.

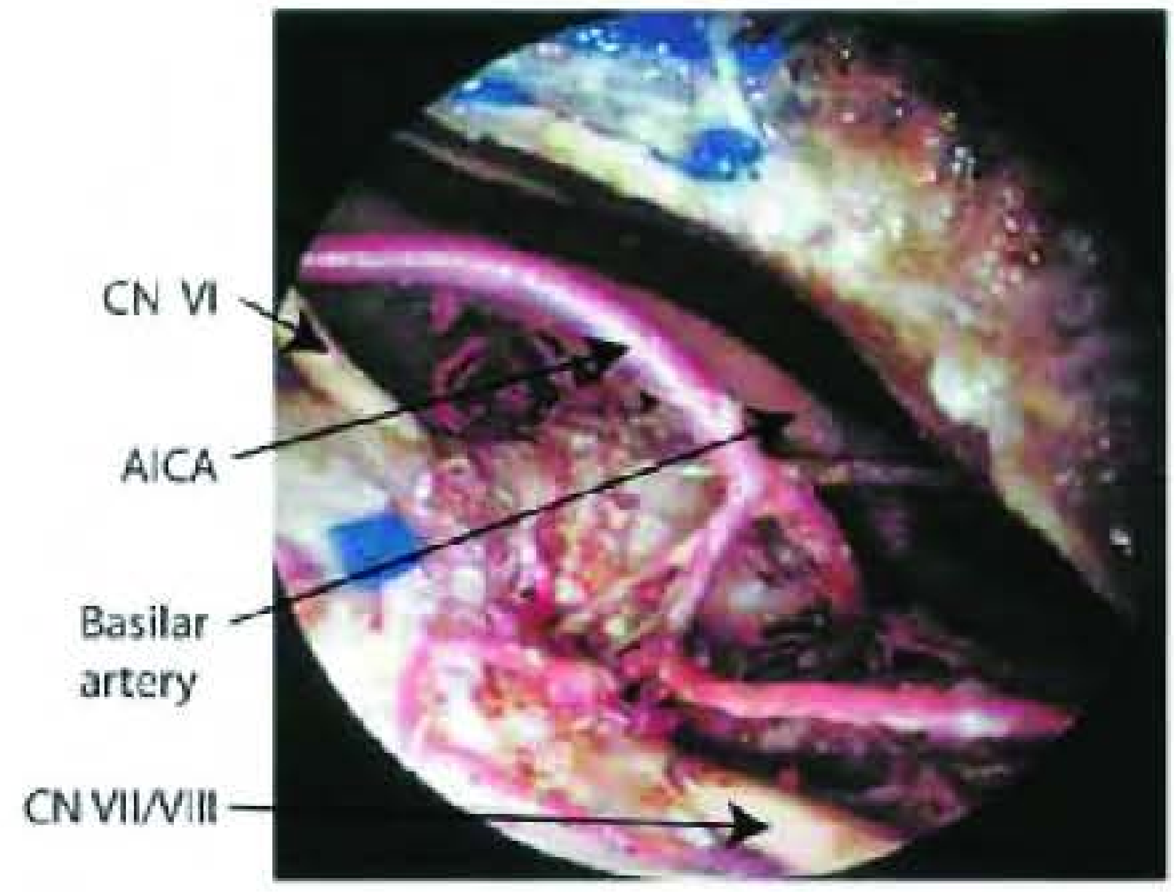


FIGURE 11–16 Following the basilar artery inferiorly, anterior inferior cerebellar artery (AICA) and the tower cranial nerves can be visualized.

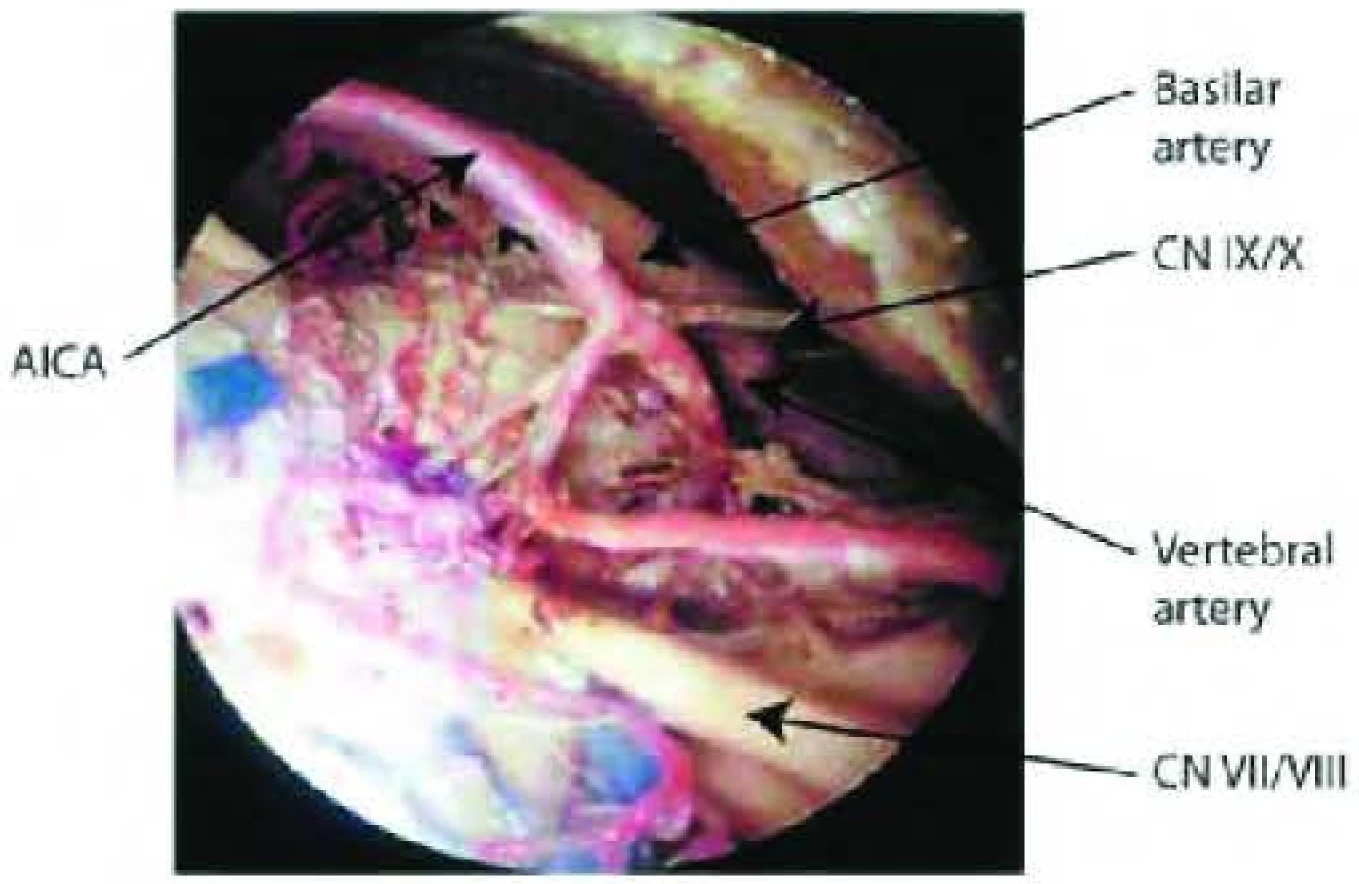


FIGURE 11–17 The anterior inferior cerebellar artery and the vertebral artery are visualized. Cranial nerves (CNs) VI, VII/VIII, and IX/X are visualized. AICA, anterior inferior cerebellar artery.

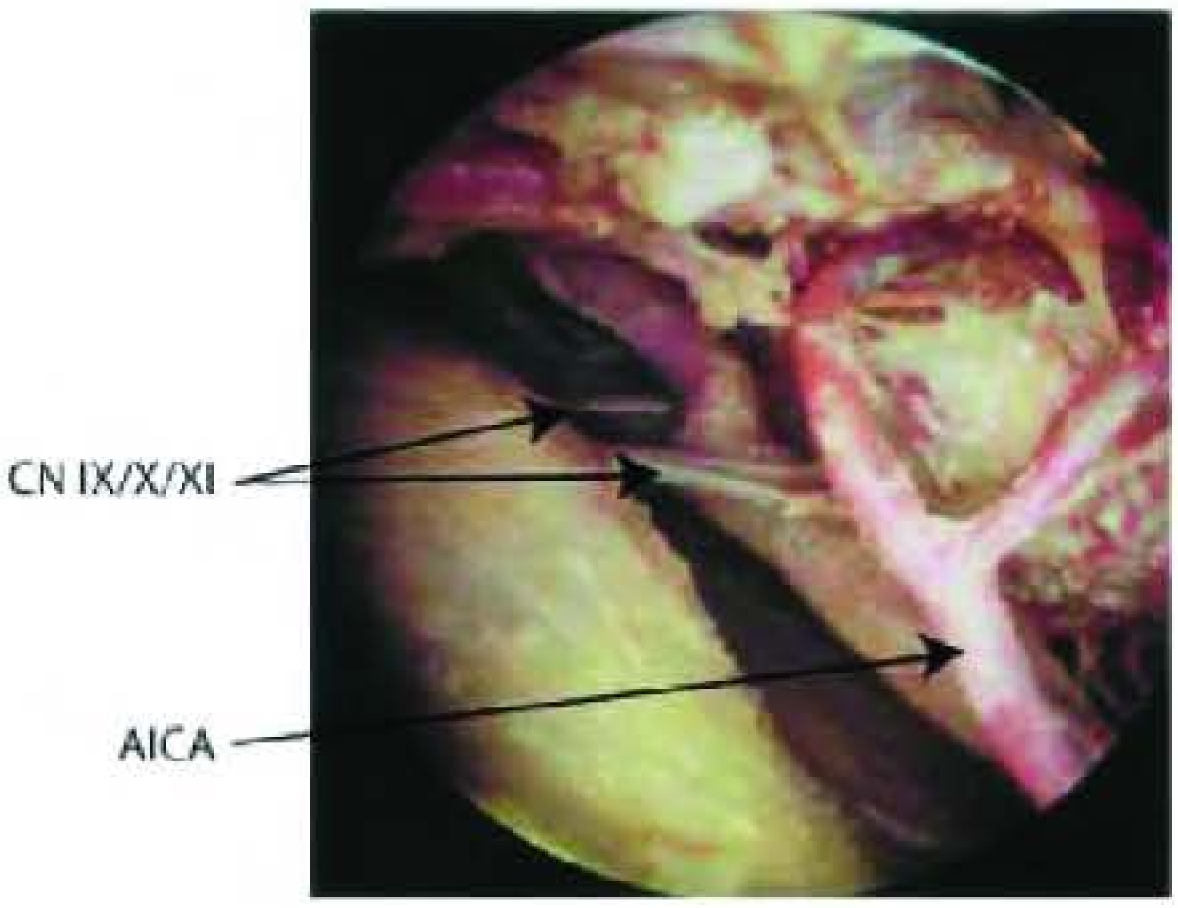


FIGURE 11–18 The vertebrobasilar junction can be seen surrounded by rootlets of the lower cranial nerves. AICA, anterior inferior cerebellar artery; CN, cranial nerve.

PITFALLS, PEARLS, CONSIDERATIONS

- Facial nerve injury
- Temporal lobe contusions
- Cochlear injury
- Internal carotid artery injury

SUGGESTED READINGS

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TRANSPETROSAL APPROACH

Carlos Acevedo, Emel Avci, Sajjan Sarma, Damirez Fossett

INDICATIONS FOR APPROACH

- Access to the basilar trunk and apex
- Cerebellar–pontine angle tumors
- Midclival and upper clival lesions
- Anteromedial midbrain and pontine lesions
- Petroclival lesions

POSITIONING AND SKIN INCISION

The patient is placed in the supine position in Mayfield three-point fixation, with a heavy roll under the shoulder and hip ipsilateral to the lesion. The head is turned 70 degrees away from the surgical side, and the vertex is lowered slightly to the floor. This orientation places the base of the petrous pyramid at the highest point in the surgical field. During the operation, rotating the table from side to side and up and down will change the angle of vision.

A postauricular C-shaped incision is generally performed. The anterior and inferior extents of the incision are dependent on which of the transpetrosal approaches is being performed (Fig. 12–1 A, B). If combined approaches are planned, additional incisions such as the frontotemporal or slight modifications to the one described herein (i.e., increasing the distance to the postauricular crease or extending the lower limb to the neck) may be performed.

SURGICAL TECHNIQUE

Once incised, the skin and subcutaneous tissues are separated from the underlying periosteum and the deep fascia over the sternocleidomastoid muscle and reflected anteriorly. A horizontal incision is made in the pericranium at the base of the mastoid process. The superior portion of the pericranium, along with the posterior aspect of the temporalis muscle, is separated from the bone and reflected anteriorly and used for subsequent reconstruction. The inferior portion of the pericranium and the attachment of the Stern-

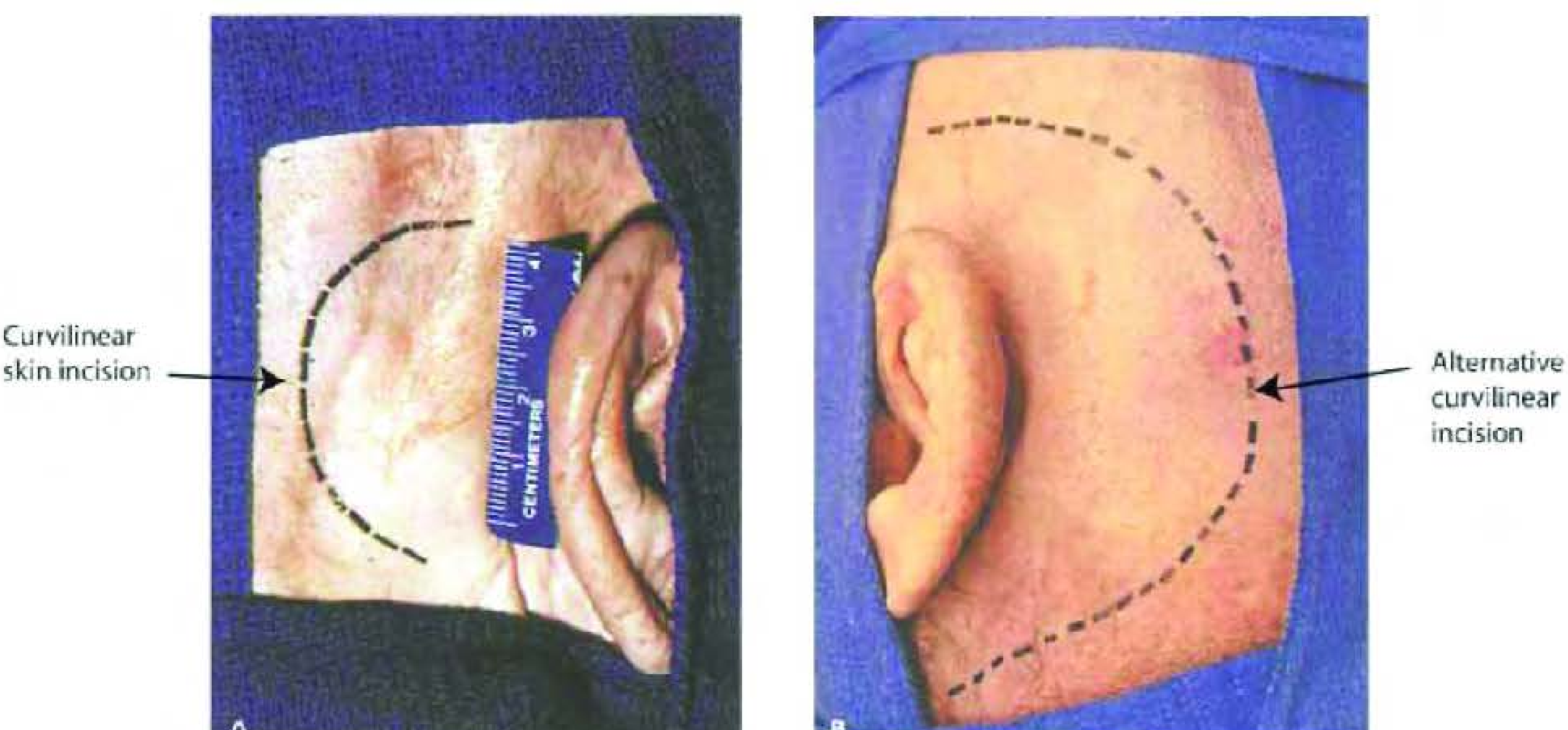

FIGURE 12–1 **A:** Right-sided C-shaped postauricular skin incision for a retrosigmoid-retrolabyrinthine approach. **B**: C-shaped postauricular incision for more extensive transpetrosal approaches.

ocleidomastoid muscle are detached from the mastoid process and reflected interiorly, taking care to preserve the accessory nerve.

The translabyrinthine and transcochlear approaches require division of the external ear canal. It is cut at the junction of its cartilaginous and bony segments. The skin of the cartilaginous external auditory canal is everled and closed. A small musculoperiosteal flap from the mastoid provides a second layer of closure and reinforcement.

Once the musculocutaneous flap has been elevated, the following landmarks should be identified: the root of the zygoma, the posterior edge of the external auditory canal (EAC), the mastoid tip, and the asterion. An imaginary line connecting the root of the zygoma with the inion is traced and serves as the superior limit of mastoid drilling. A second line over the posterior border of the mastoid bone (occipitomastoid suture) is also traced and serves as the posterior limit of drilling (Fig. 12–2A). The angle made by the junction of these two lines is slightly posterior and superior to the asterion, which should be included within the bone removal. The anterior margin of drilling depends on the specific approach to be performed. The retrolabyrinthine and partial labyrinthine approaches preserve the posterior wall of the EAC, whereas the translabyrinthine and transcochlear approaches require the removal of the EAC. All approaches require a mastoidectomy (Fig. 12–2B).

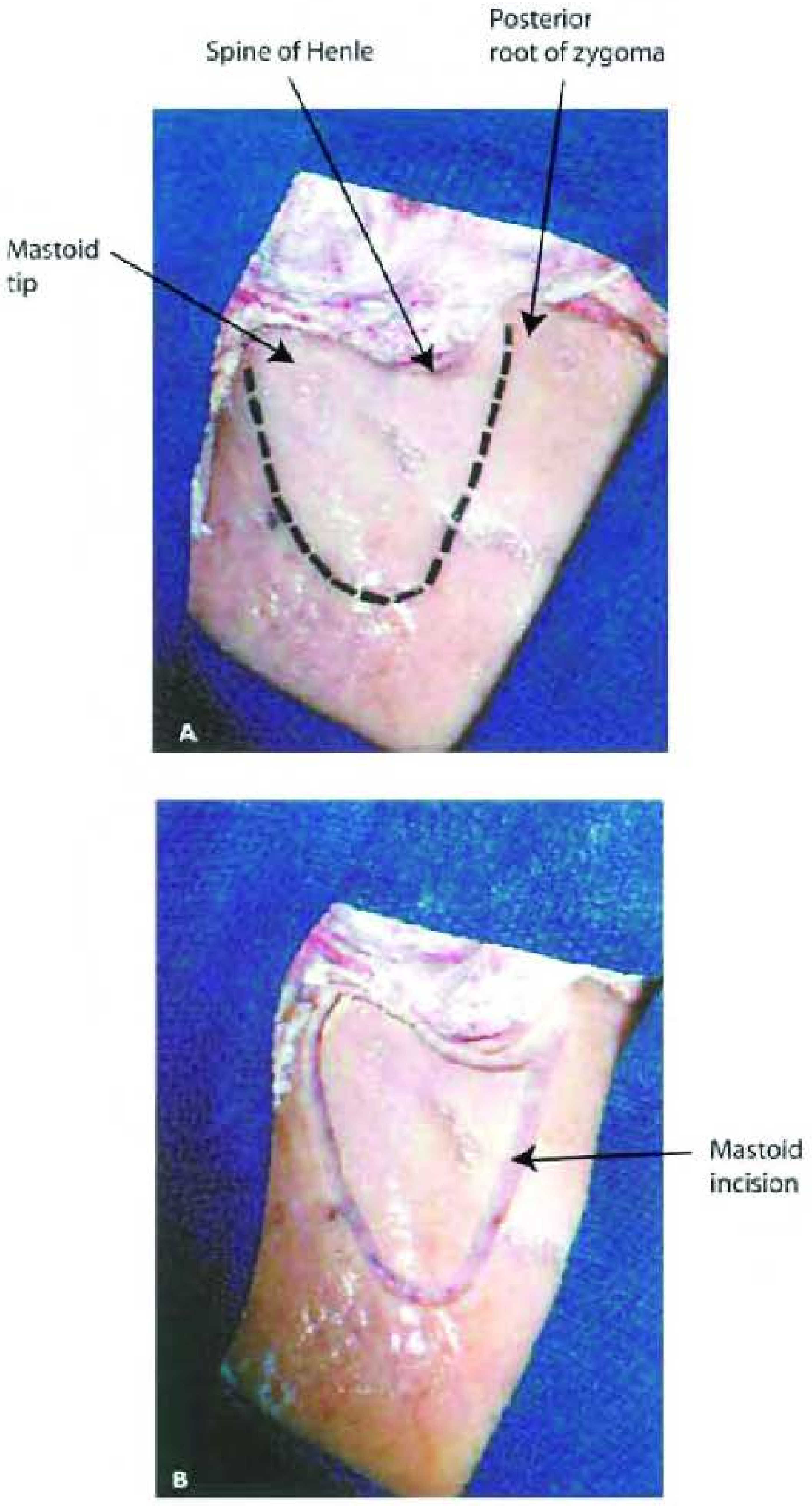

FIGURE 12–2 **A:** The mastoidectomy is outlined. **B**: The mastoidectomy surface bone cut is made.

MASTOIDECTOMY

The cortex over the mastoid bone is removed by using a high-speed drill with a large cutting bur. The anterior border of the bone removal is a slightly curved tine that extends between the top of the external auditory meatus and the mastoid tip. The superior limit is a line perpendicular to the first line, extending from the root of the zygoma posteriorly to the asterion. The major landmarks in the mastoid area are the lateral semicircular canal, the mastoid antrum superiorly, and the digastric ridge inferiorly.

As the cortical bone is drilled, air cells will begin to be encountered (Fig. 12–3). Bone is drilled 1 cm behind the sigmoid sinus, maintaining a uniform depth until the sigmoid sinus is exposed. The sigmoid sinus is skeletonized along its length down through the region of the jugular bulb using a diamond bur. The mastoid air cells are removed anteriorly and superiorly to expose the middle fossa dura. The air cells are drilled further anteriorly to expose the compact hone of the bony labyrinth. The key landmark in

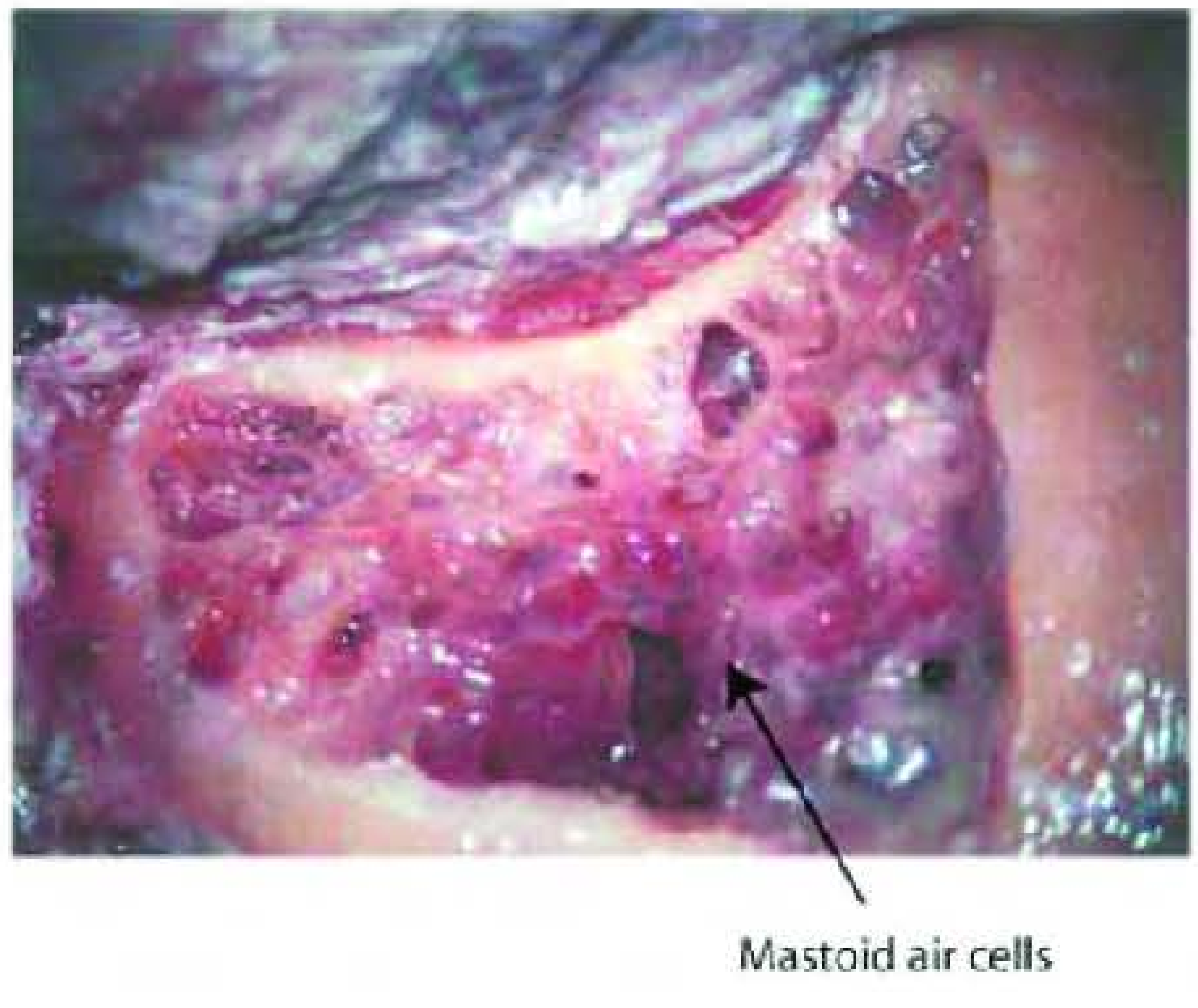

FIGURE 12–3 The mastoid air cells come into view as the cortical bone is removed.

this area is the mastoid antrum (Fig. 12–4). The lateral semicircular canal is located along the inferior wall of the antrum (Fig. 12–5). Opening the mastoid antrum reaches the anterior limits of the bone removal and allows identification of the lateral semicircular canal. The posterolateral portion of the bony labyrinth is completely defined to expose maximally the cerebellopontine angle in the retrolabyrinthine approach. The facial nerve is situated parallel and 1 to 2 mm anterior to the lateral semicircular canal (SCC) (Figs. 12–6 and 12–7). The posterior semicircular canal can be identified by moving more posteriorly. The retrofacial air cells are seen at the ulterior margin of the

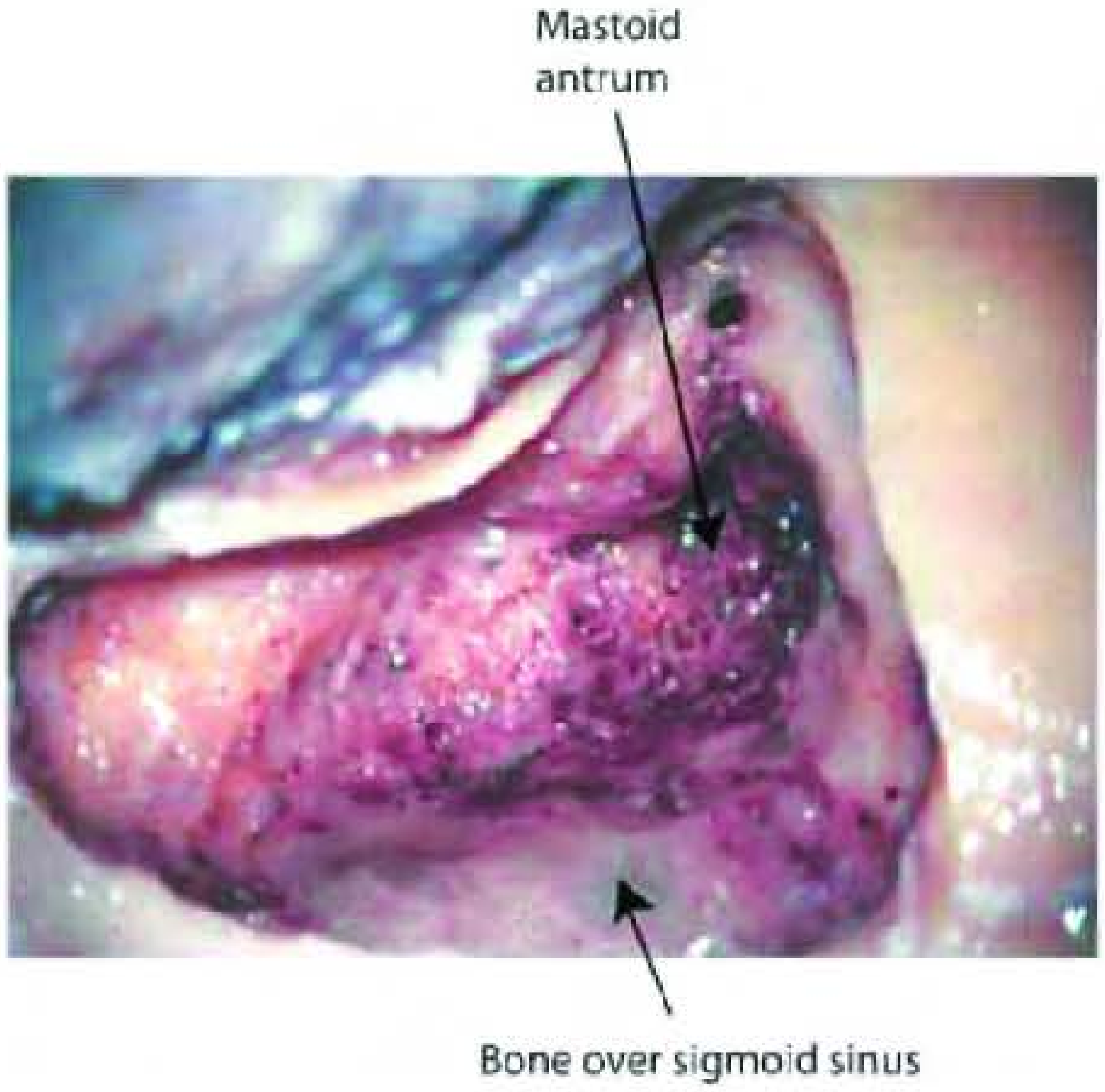

FIGURE 12–4 The antrum is a key landmark during mastoid drilling.

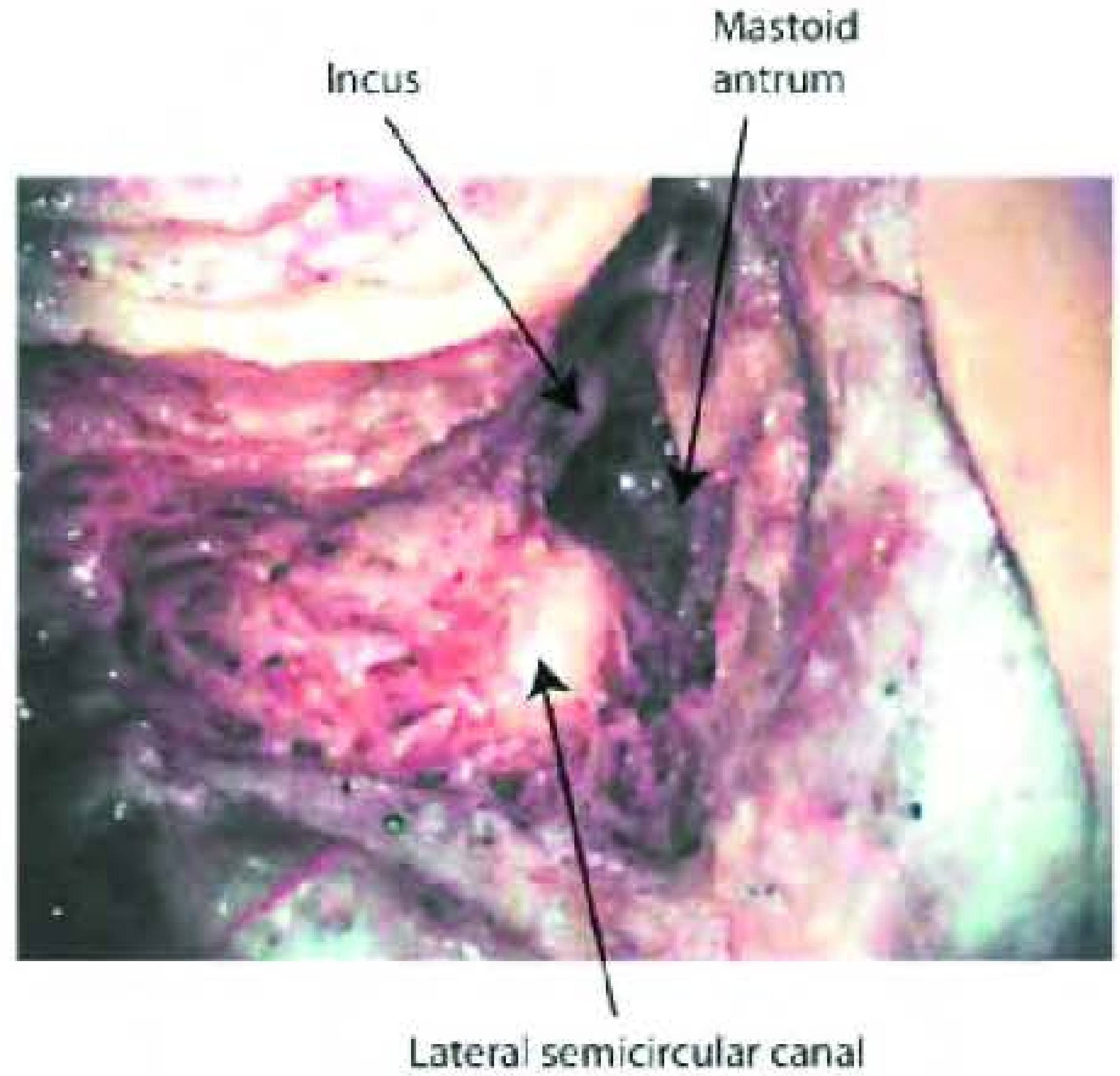

FIGURE 12–5 The lateral semicircular canal is exposed while drilling at the inferior border of the mastoid antrum.

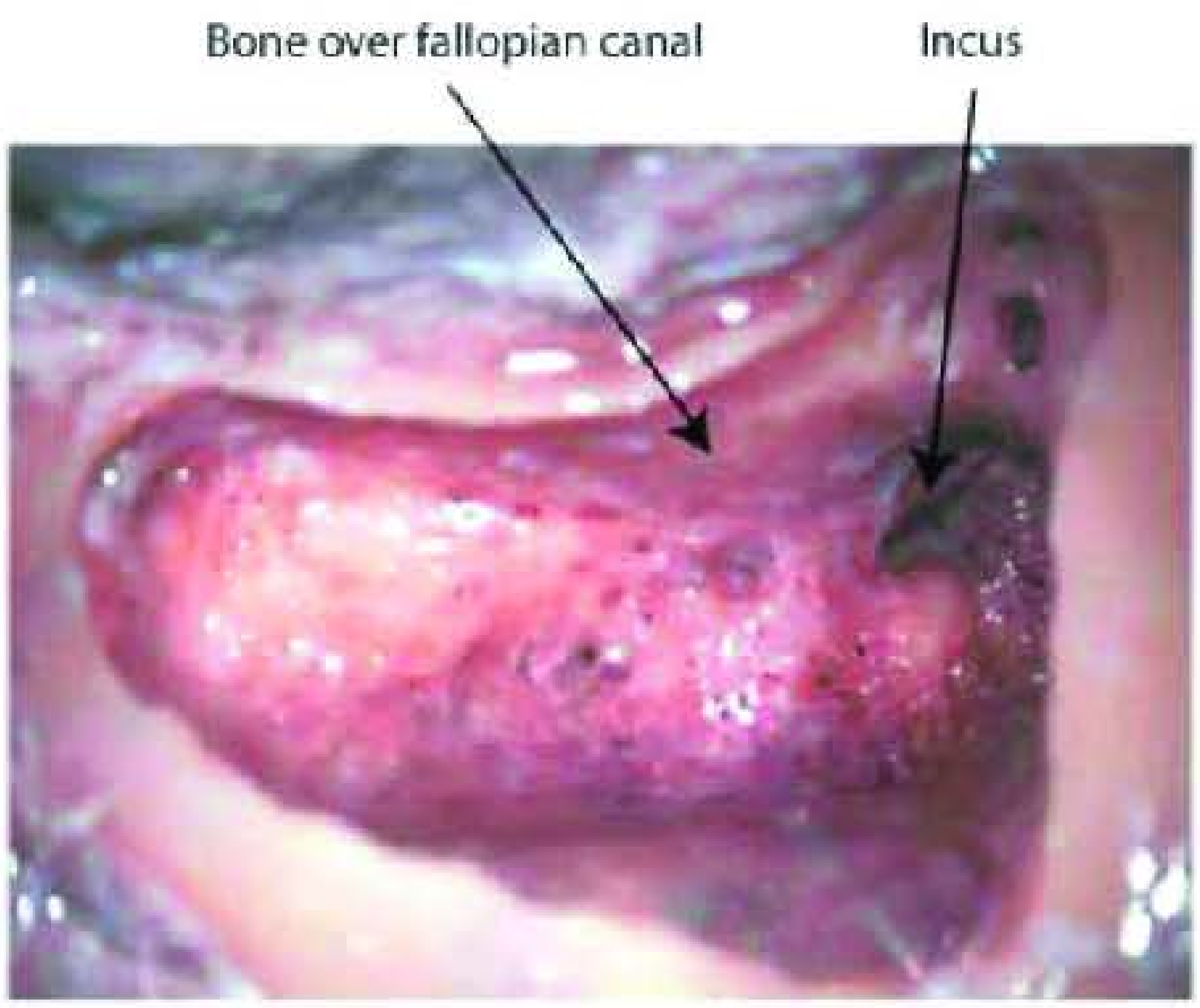

FIGURE 12–6 The antrum has been opened. The horizontal semicircular canal is partially exposed. The fallopian canal containing the facial nerve is partially exposed-

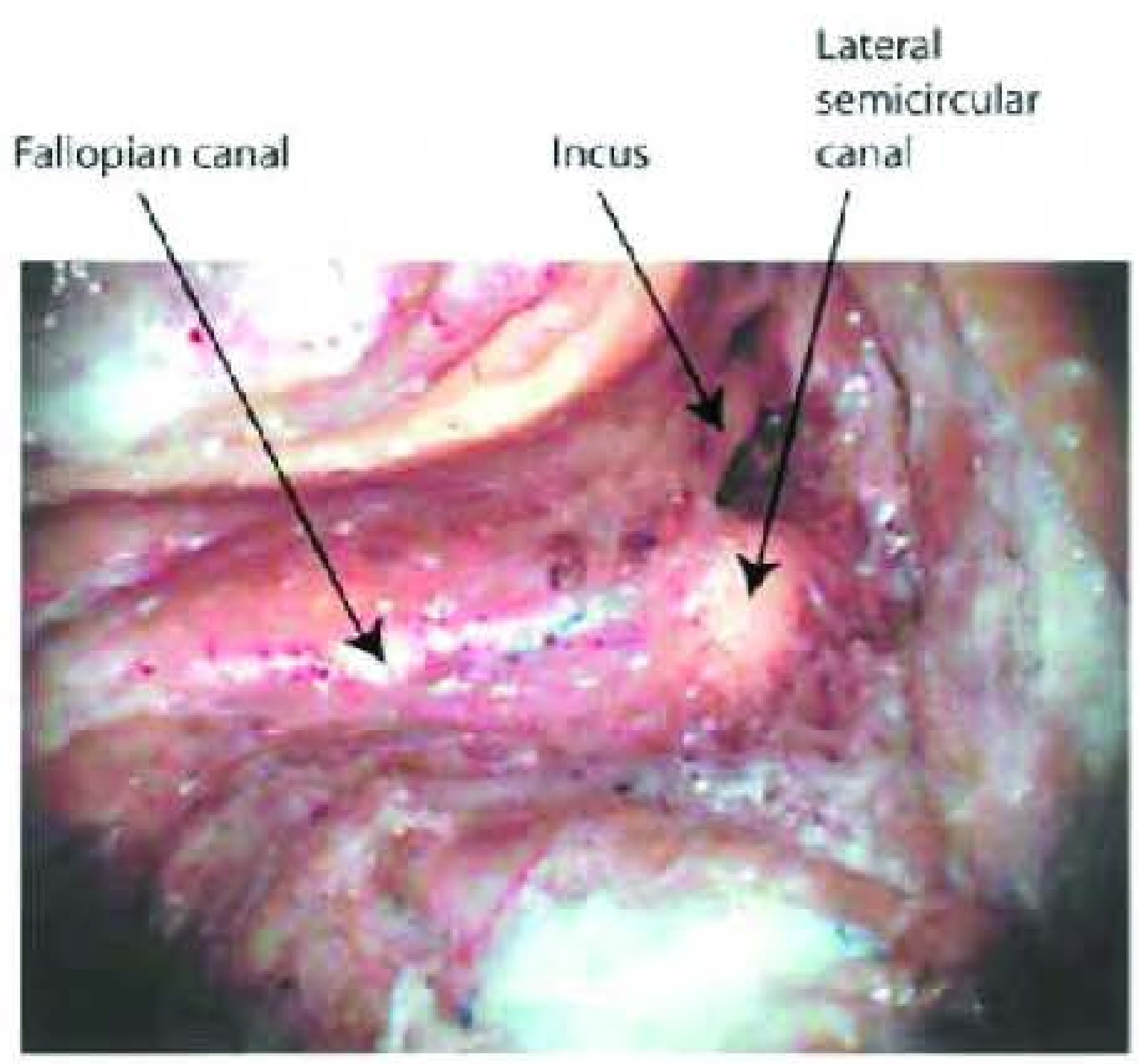

FIGURE 12–7 The facial nerve lies anterior and parallel to the lateral semicircular canal.

posterior semicircular canal toward the jugular bulb (Fig. 12–8). These air ceils are drilled to skeletonize the jugular bulb. The digastric ridge, another important landmark for defining the exit of the facial nerve from the fallopian canal through the stylomastoid foramen, is exposed as air cells are removed from the mastoid tip region. At this point, the presigmoid dura, the middle fossa dura, and the sinodural angle are completely skeletonized (Fig. 12–9). The superior petrosal sinus is exposed at the level of the transverse-sigmoid sinus junction. The technique of removing bone to the point of leaving a thin shell that may be removed with a dissector is practiced to avoid injury to the temporal and posterior fossa dura and the venous sinuses. A complete mastoidectomy spares the labyrinthine bone, thereby preserving hearing; however, if the middle ear ossicles are disturbed, a conductive hearing loss can result.

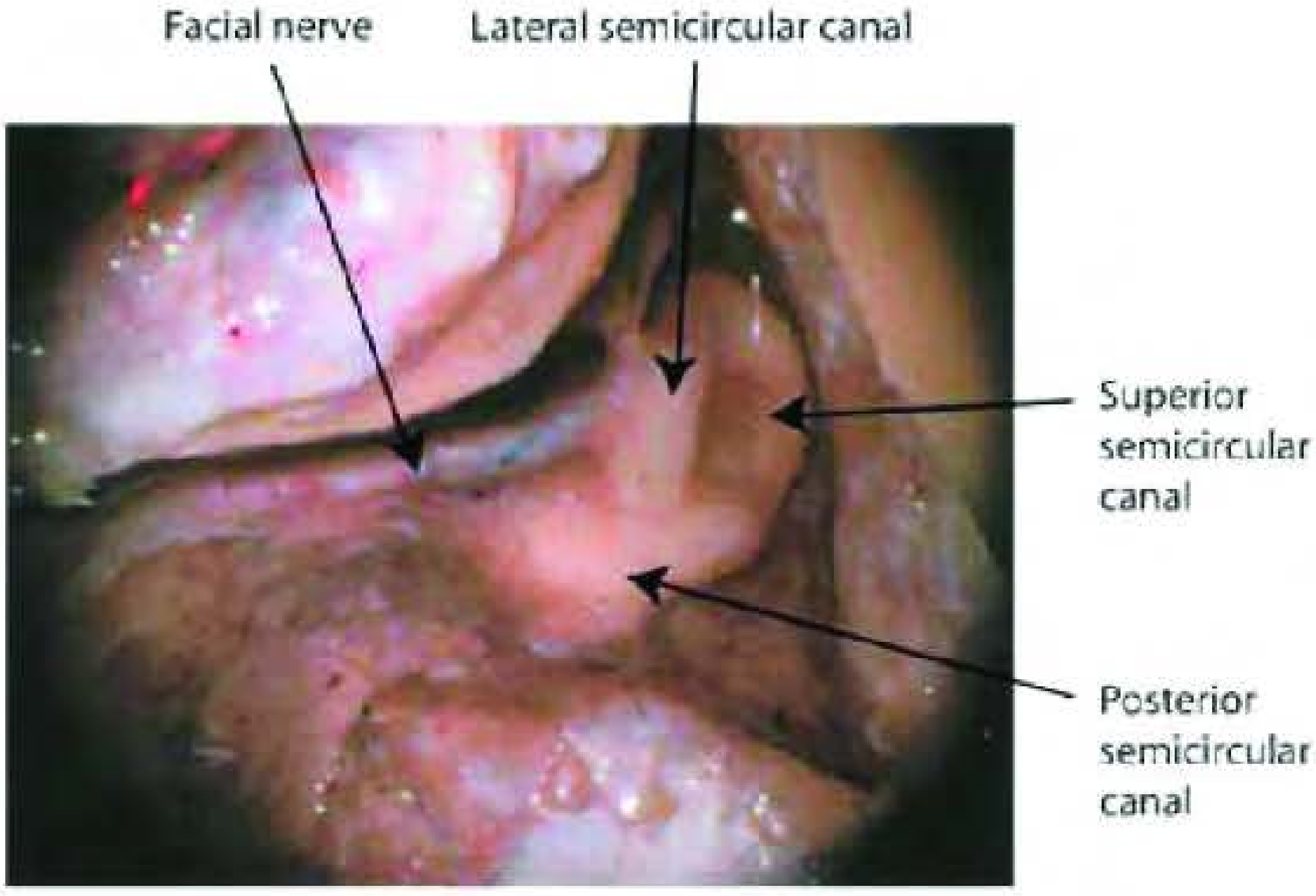

FIGURE 12–8 The posterior semicircular canal can be identified, as can the retrofacial air cells.

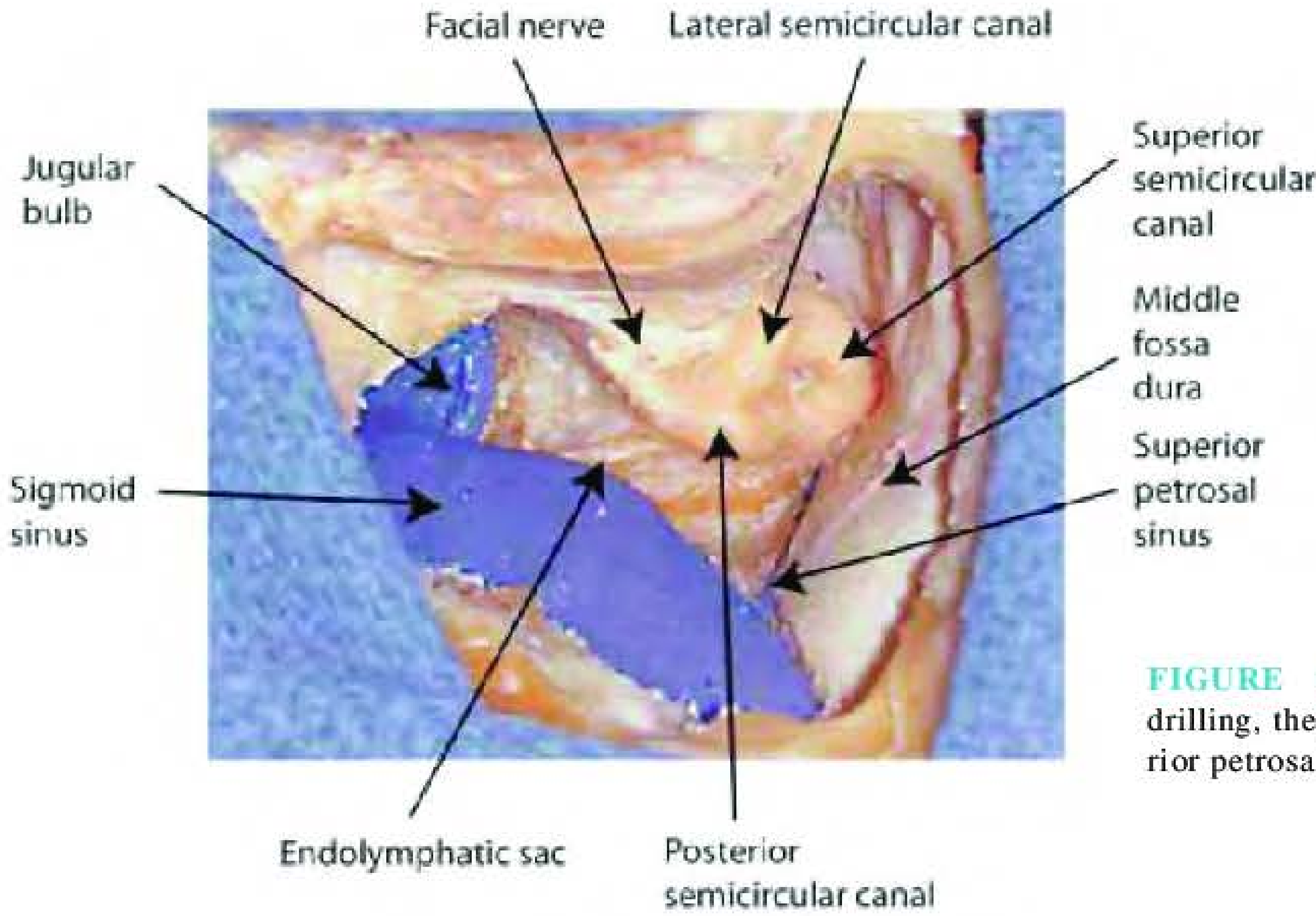

FIGURE 12–9 After completion of the mastoid drilling, the smodural angle can be visualized. The superior petrosal sinus can be identified.

CRANIOTOMY

Having exposed the dura of the floor of the middle fossa, the B1 foot-plated tool of the Midas Rex can be used to turn a craniotomy flap without placing any additional burr holes. In a similar fashion, the suboccipital craniotomy can be turned because the posterior fossa dura has been exposed during the mastoid drilling. Both craniotomies are sized by the pathology to be treated. Additional bone work for specific approaches is described in the following sections.

For all the petrosal approaches, once the bone work is complete, the dura of the posterior fossa just anterior to the sigmoid sinus is opened to allow drainage of cerebrospinal fluid (CSF) from the cerebellopontine angle (CPA) cistern and brain relaxation. After transecting the superior petrosal sinus, the Incision then can be carried along the floor of the temporal fossa. Depending on the specific anatomy of the vein of Labbé, it may need to be dissected along its course to avoid injury during temporal lobe retraction. After ligation or coagulation of the superior petrosal sinus, the tentorium is cut parallel to the petrous pyramid until the incisura is reached. Care is taken to preserve the fourth cranial nerve and the superior cerebellar artery, which may be adherent to it. This incision must be posterior to the insertion of the trochlear nerve. If possible, Meckel's cave should be opened after further occluding the superior petrosal sinus, which runs along its roof. The opening of Meckel's *cave* allows mobilization of the trigeminal root, thereby reducing the risk of injury to it, and improves the working space. A combined approach into the posterior and middle fossa allows more complete resection of petroclival lesions with extension into the middle cranial fossa

The dura must be closed in a watertight fashion. This may require the use of a dural patch graft. Muscle or fat can be used to pack the eustachian tube. Autologous fat, obtained from the abdominal area, is used to fill in the mastoidectomy and petrosectomy regions. The temporal muscle provides an excellent local vascularized flap to provide coverage of the exposed internal carotid artery (ICA) and to obliterate dead space. The bone plate is reattached, and a standard multilayer closure of the skin is performed.

SPECIFIC APPROACHES

RETROLABYRRINTHINE APPROACH

The retrolabyrinthine approach to the cerebellopontine angle provides access to the cerebellomedullary and posterolateral aspects of the cerebellopontine cistern. The sigmoid sinus forms the posterior boundary, and the floor of the middle fossa forms the superior limit. Anteromedially, the otic capsule (labyrinthine portion of the petrous bone) limits the surgical visualization of the anterolateral aspect of the CPA. The jugular bulb forms the inferior boundary of the exposure. In the retrolabyrinthine approach, the dura is exposed between the sigmoid sinus and the posterior semicircular canal.

An incision is made in the presigmoid space up to the region of the sinodural angle, and a tapered self-retaining retractor blade is placed on the cerebellum (Fig. 12–10). Superiorly, the superior cerebellar artery, cranial nerve (CN) V, and the superior petrosal vein can be observed (Fig. 12–11). Looking more interiorly into the cerebellopontine angle, the VII/VIII nerve complex and the lower CNs can be seen (Figs. 12–12 and 12–13). This approach provides

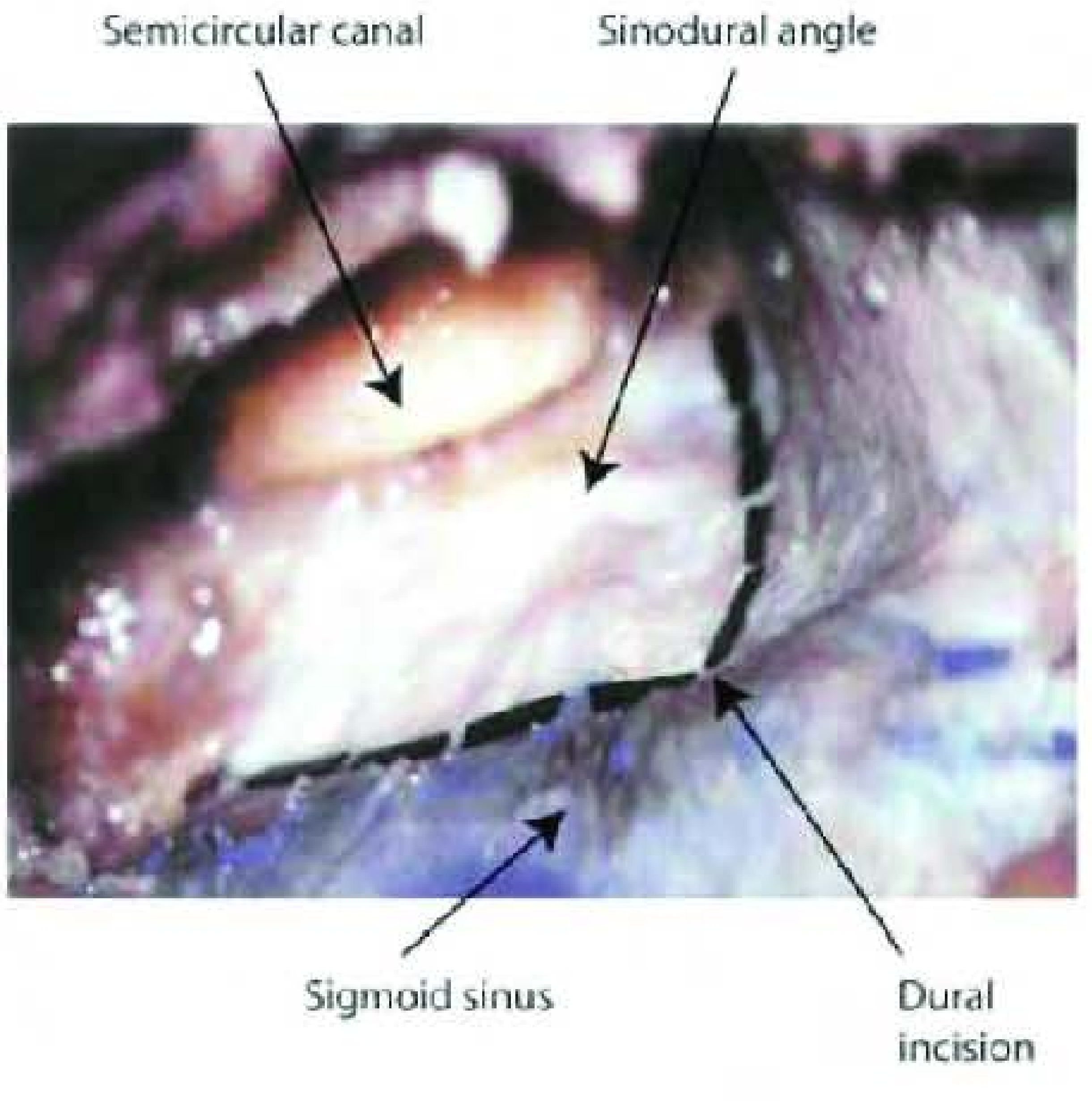

FIGURE 12–10 Retrolabyrinthne approach. A presigmoid dural incision is outlined.

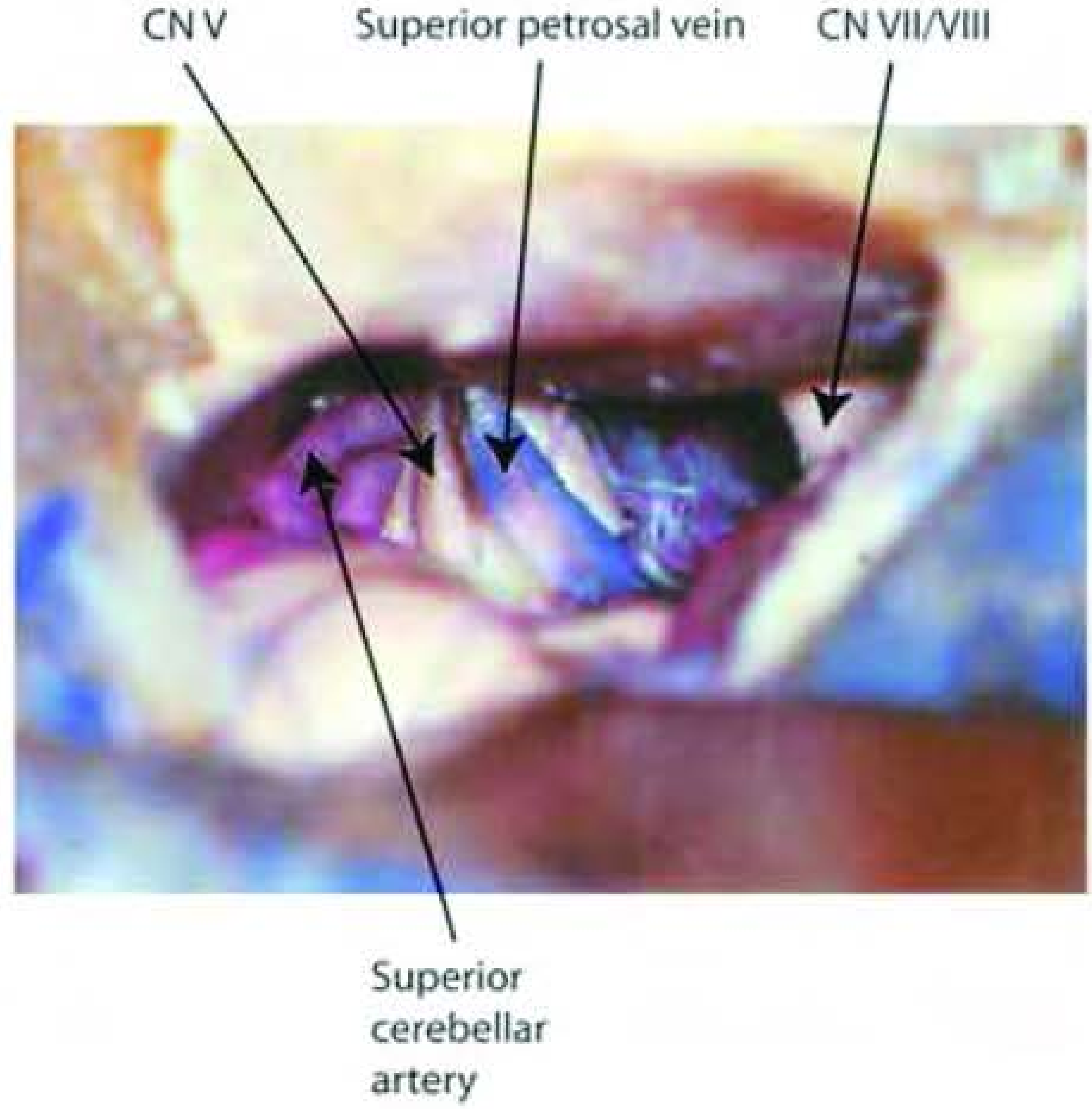

FIGURE 12–11 Retrolabyrinthine approach. The superior cerebellar artery, cranial nerve (CN) V, superior petrosal vein, and the VIII/VIII complex are visualized.

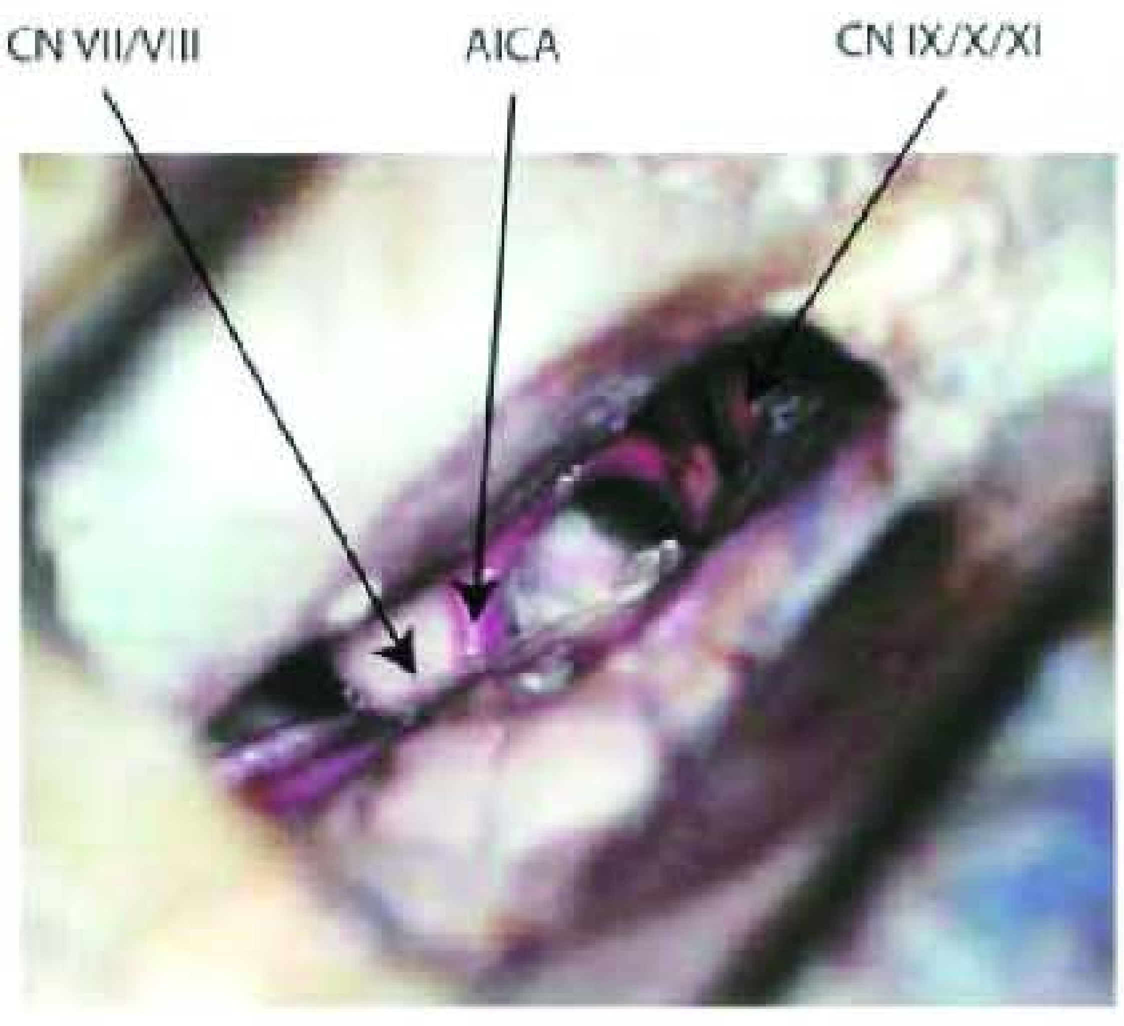

FIGURE 12–12 Retrolabyrinthine approach. The cranial nerve (CN) VII/VIII complest and the interior inferior cerebellar artery (AICA) are exposed. Inferiorly, in the depths, one can appreciate the lower cranial nerves.

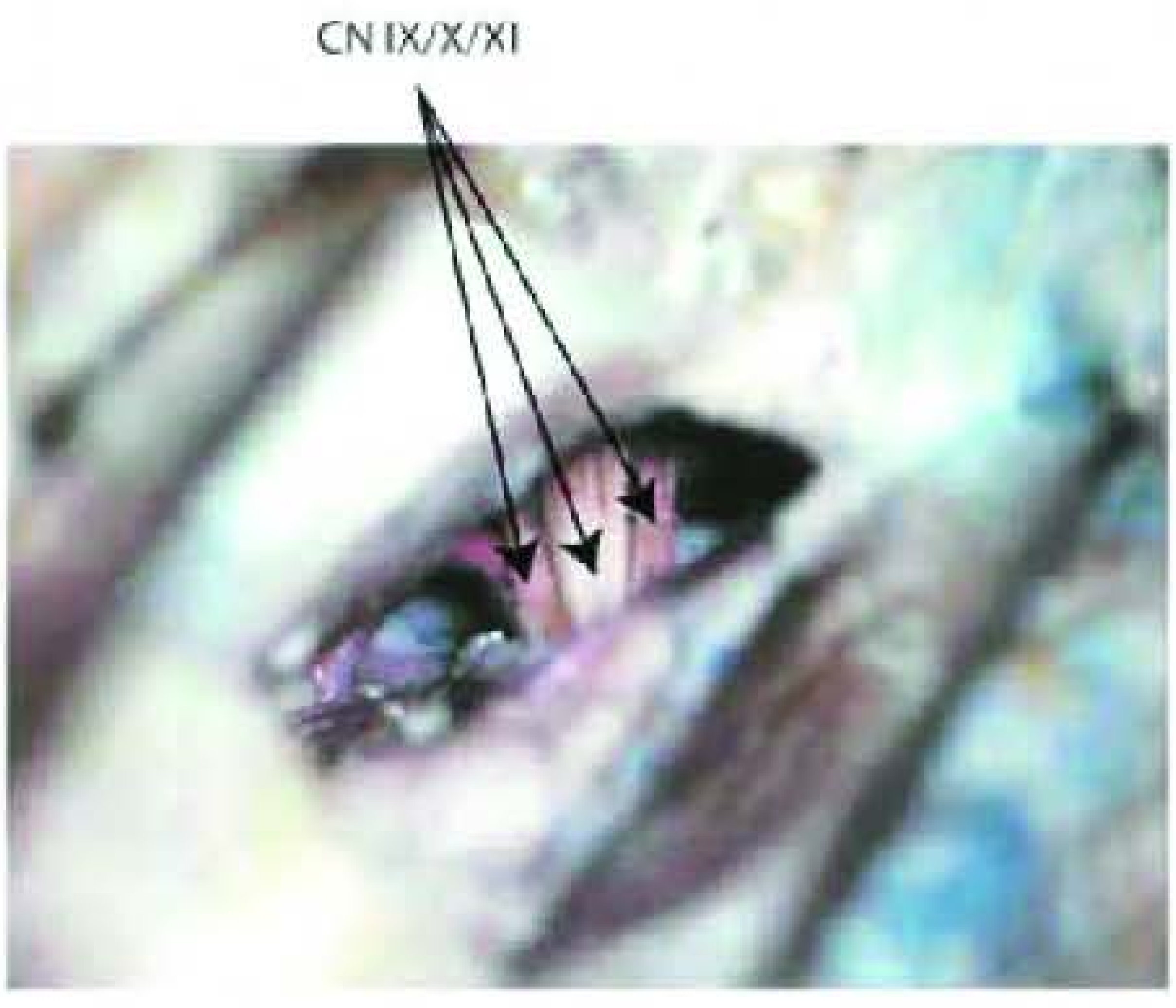

FIGURE 12–13 Retrolabyrinthine approach. The lower cranial nerves and the posterior inferior cerebellar artery are seen.

access to all the CPA with hearing preservation; however, the exposure is generally quite narrow.

PARTIAL LABYRINTHECTOMY PETROUS APICECTOMY (PLPA) APPROACH

After performing a radical mastoidectomy, the sigmoid sinus, the semicircular canals, the vestibular aqueduct, the jugular bulb, and the mastoidal segment of the facial nerve are exposed. The facial nerve is left inside a thin shell of bone (the fallopian canal), and the endolymphatic sac is occluded to prevent the loss of endolymphatic fluid. The bone encasing the superior and posterior semicircular canals is thinned until it is transparent, and four fenestrations are made, two adjacent to the ampullae and two adjacent to the common crus. Once opened, the canals are occluded with bone wax. The bony and membranous labyrinths of the superior and posterior semicircular canals are drilled away (Figs. 12–14–12–16).

A petrous apicectomy then is performed. The extent of bone resection is superior to a line drawn between the ampullae of the SCC and the entrance of the vestibular

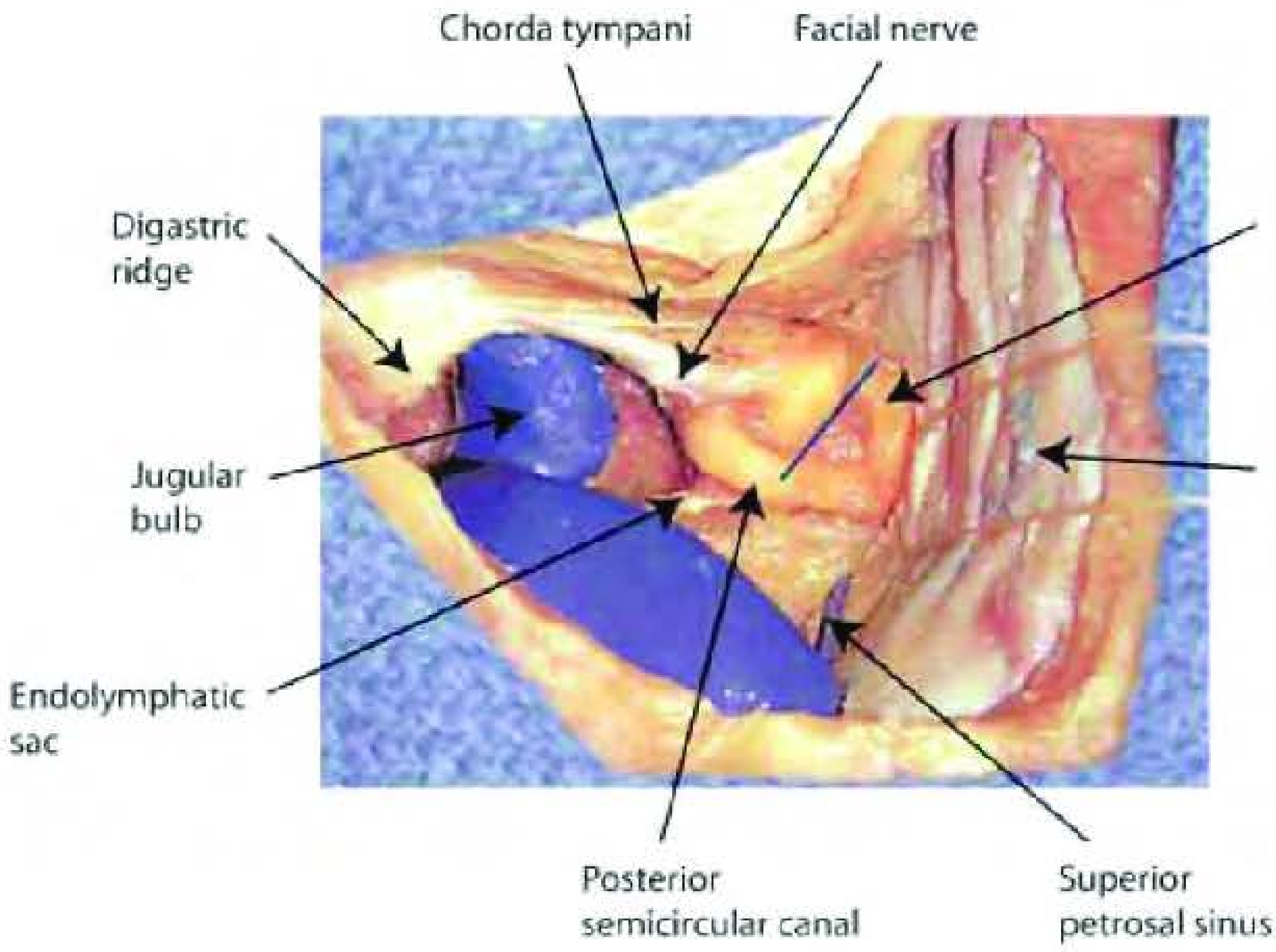

FIGURE 12–14 The partial labyrinthectomy petrous apicectomy (PLPA) approach. The landmarks of the PLPA approach are defined. The superior and one half of the posterior semicircular canal are removed to access the petrous apex.

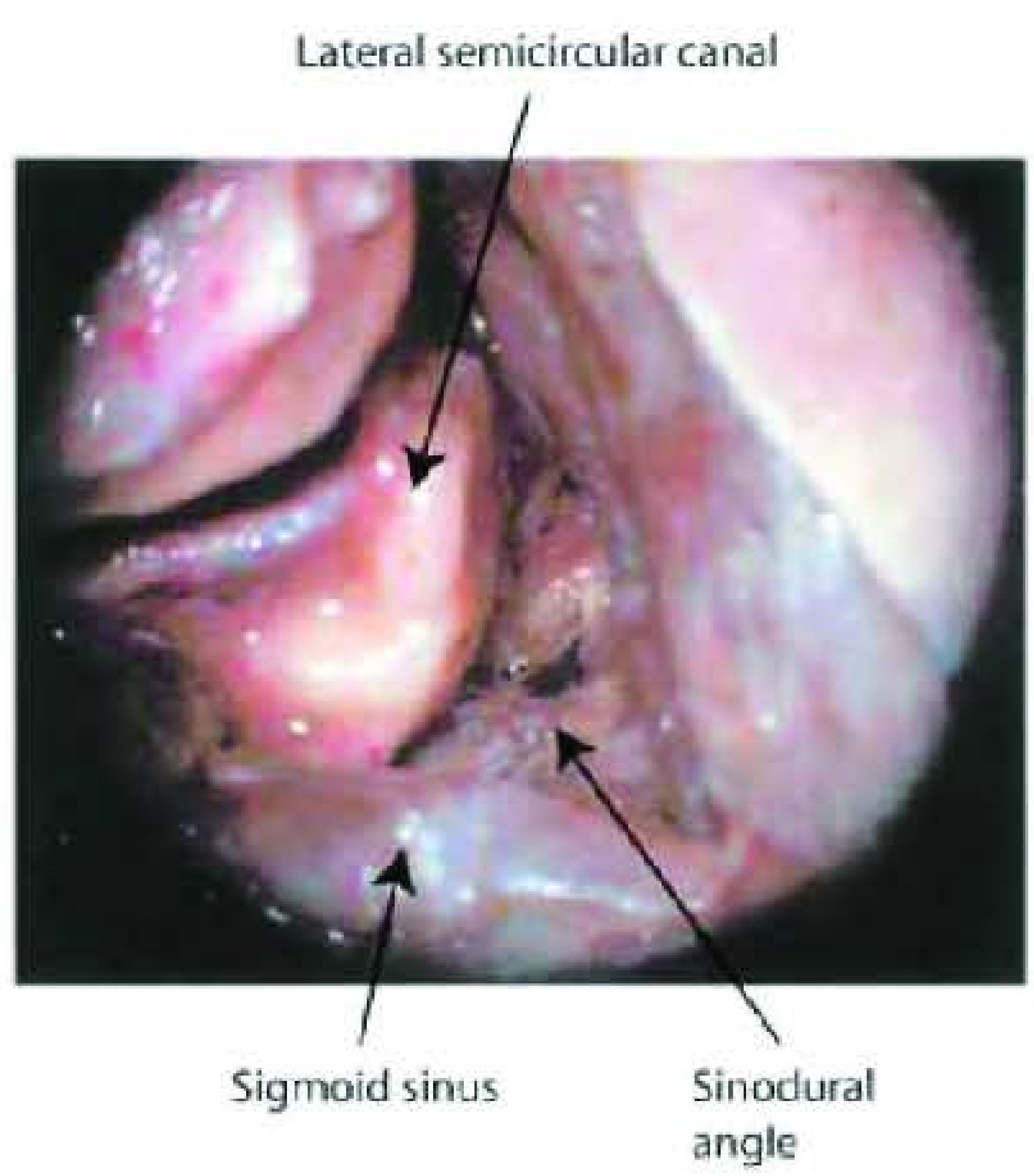

FIGURE 12–15 The partial labyrinthectomy petrous apicectomy (PLPA) approach. The superior and one half of the posterior semicircular canal have been removed to allow access to the petrous apex.

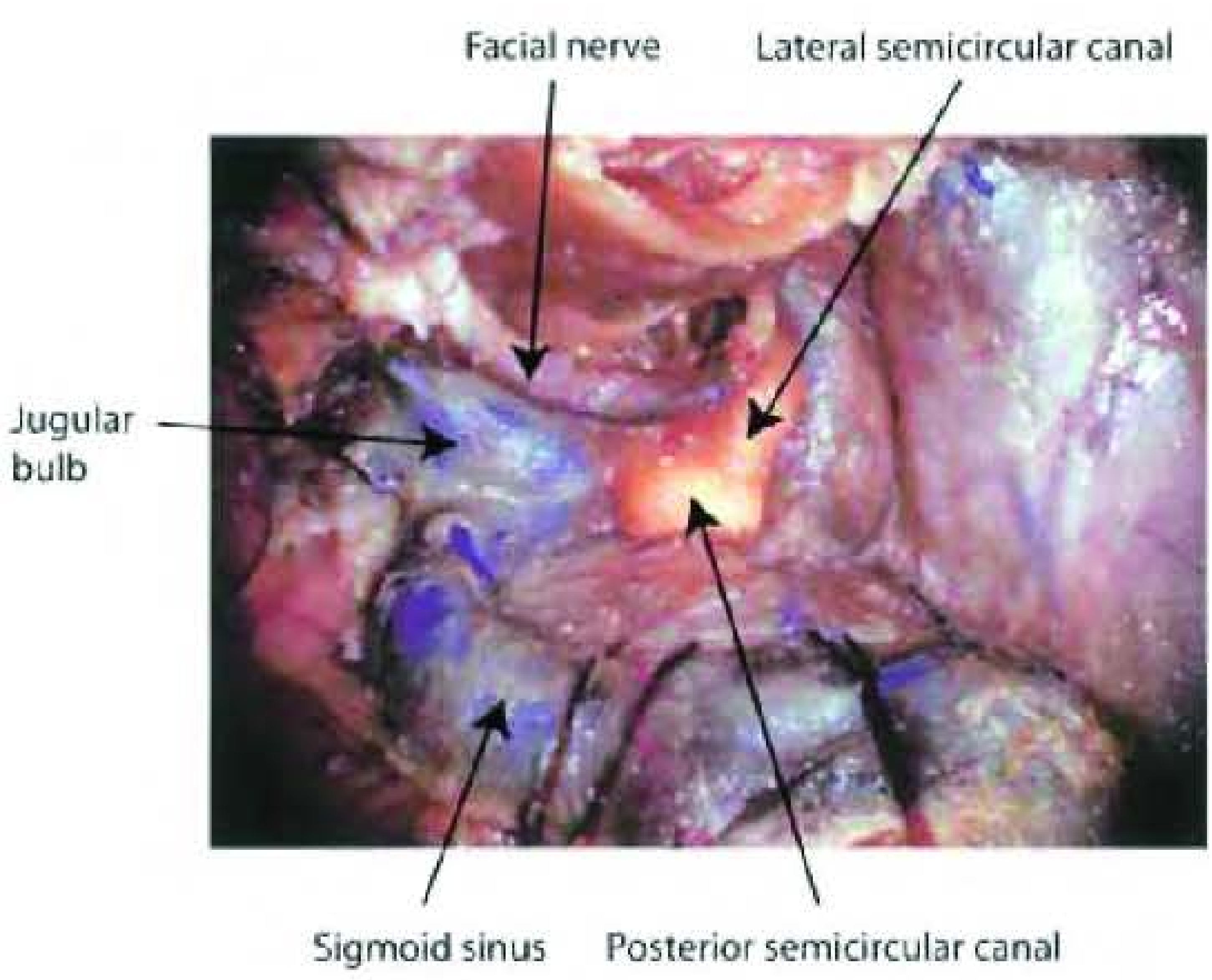

FIGURE 12–16 The partial labyrinthectomy petrous apicectomy (PLPA) approach. Bony removal for the PLPA approach.

aqueduct into the petrous dura. During removal of the petrous apex, the superior wall of the internal auditory canal (IAC) is skeletonized. The dura is opened in a presigmoid fashion, allowing visualization into the cerebellopontine angle (Figs. 12–17–12–19). The contents of the middle cranial fossa also can he seen if a craniotomy has been performed and the temporal dura incised and opened. Meckel's cave can he opened and the fifth nerve mobilized. Entrance can be made into the posterior cavernous sinus (Fig. 12–20).

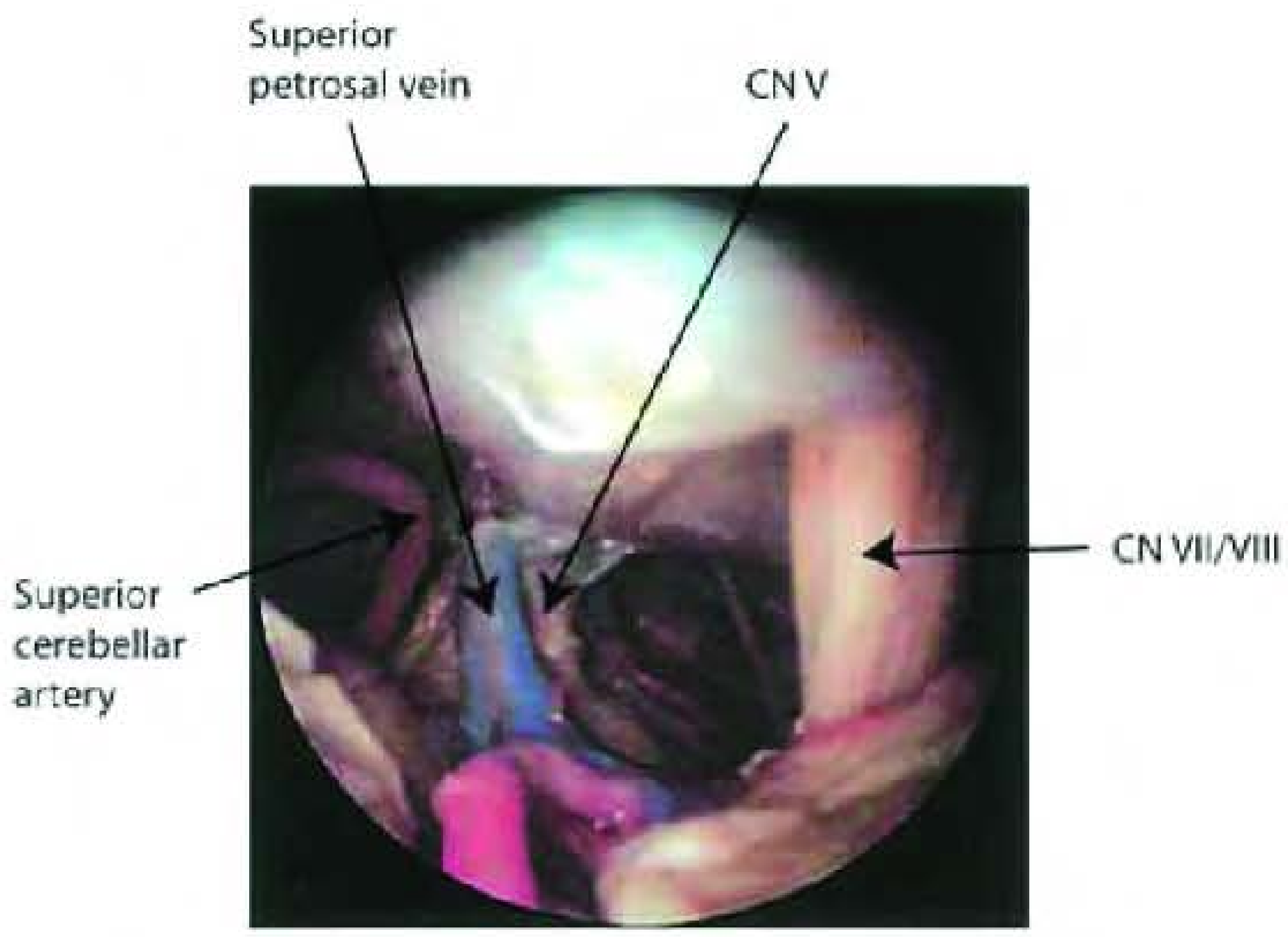

FIGURE 12–17 The partial labyrinthectomy petrous apicectomy (PLPA) approach. The superior cerebellar artery, superior petrosal vein, and fifth nerve are seen.

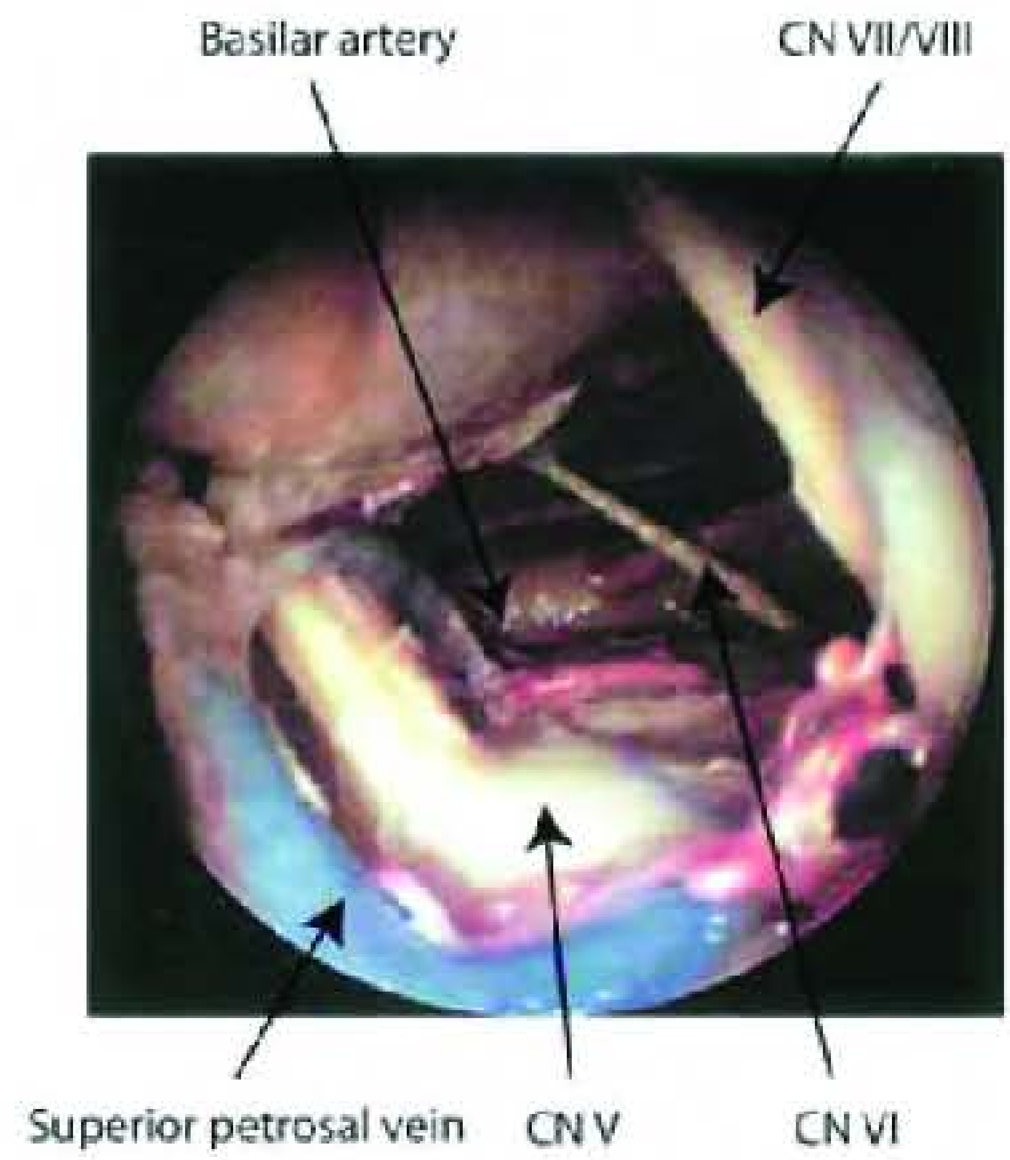

FIGURE 12–18 The partial labyrinthectomy petrous apicectomy (PLPA) approach. The superior petrosal vein; cranial nerves (CN) V, VI, and VII/VIII; and the basilar artery are visualized.

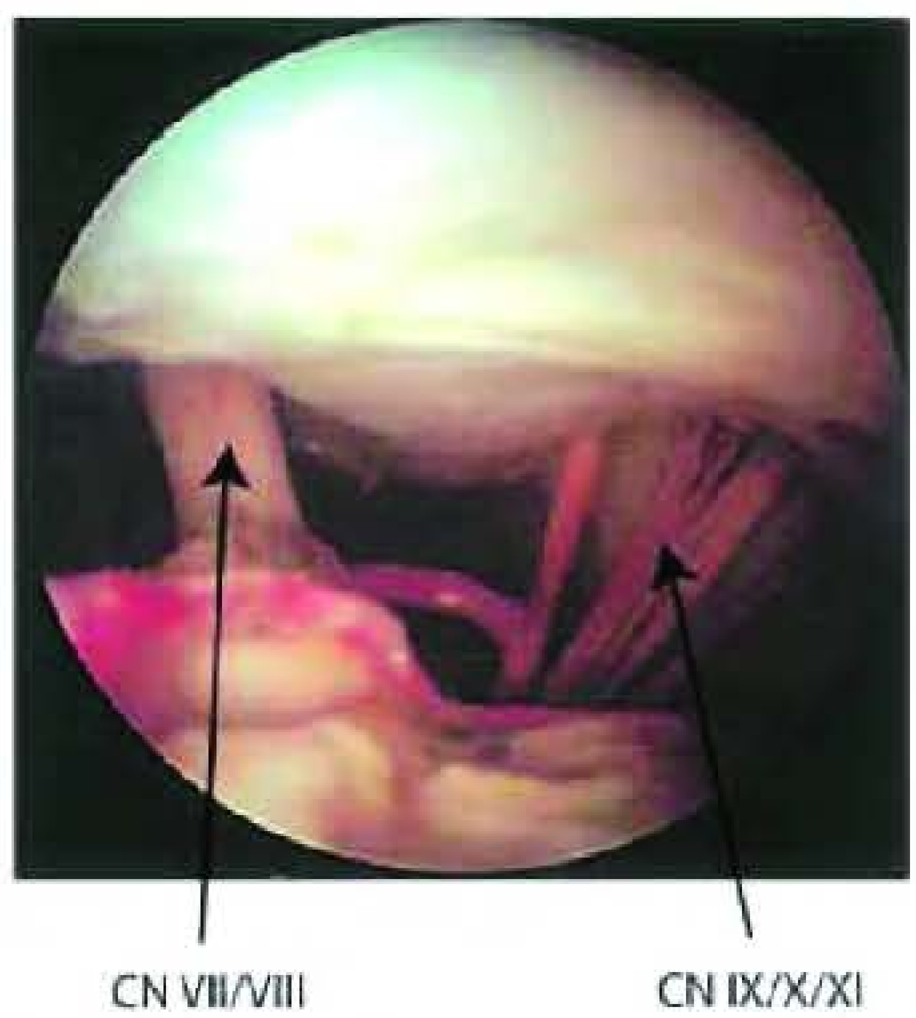

FIGURE 12–19 The partial labyrinthectomy petrous apicectomy (PLPA) approach. The VII/VIII complex and the lower cranial nerves can be seen.

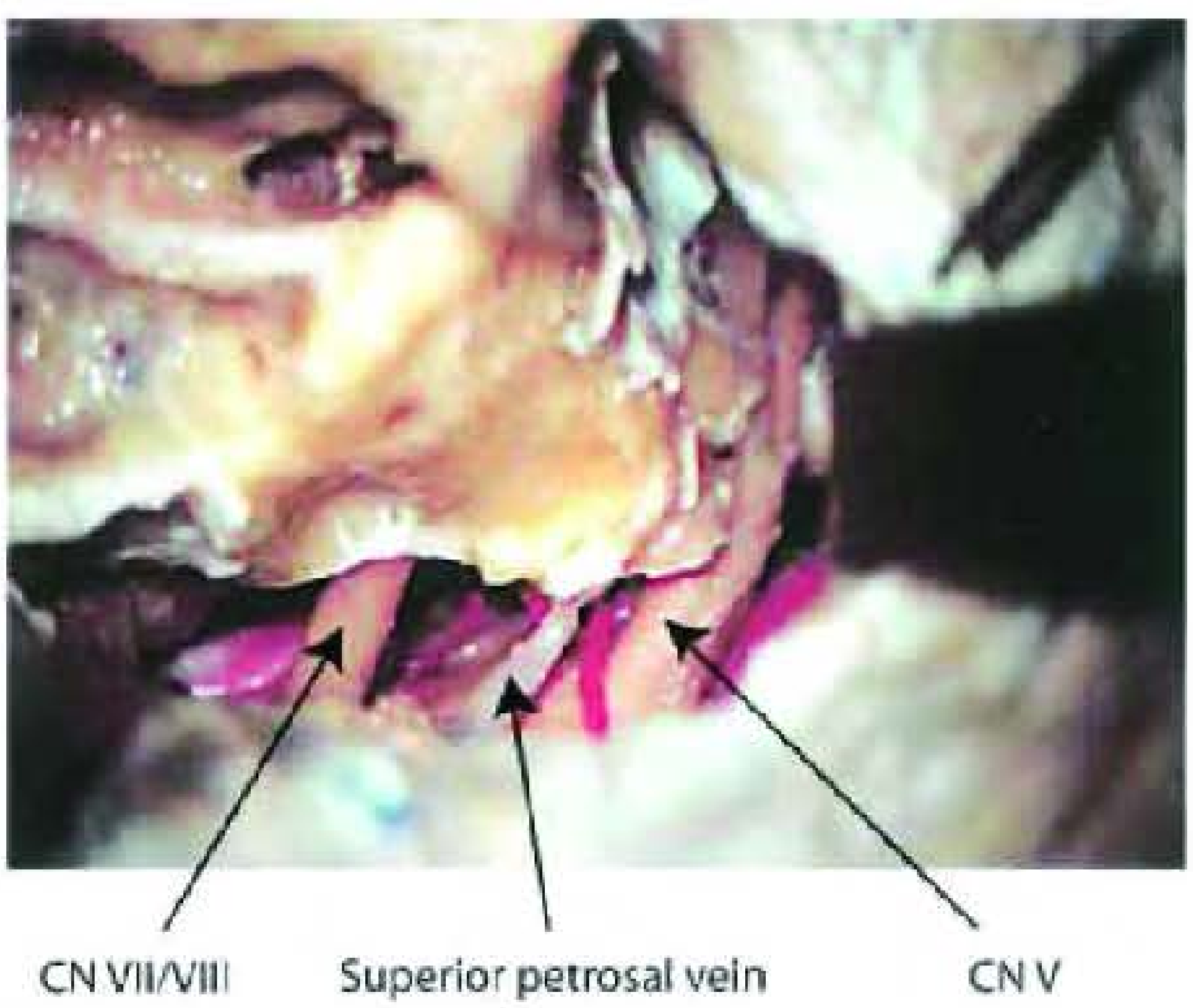

FIGURE 12–20 The partial labyrinthectomy petrous apicectomy (PLPA) approach, Meckel's cave has been opened fully, exposing the fifth CN. The superior cerebellar artery, petrosal vein, and VII/VIII nerve complex can be seen.

TRANSLABYRINTHINE APPROACH

When hearing preservation is not a consideration, the CPA can be explored more widely by resecting the vestibular labyrinth and skeletonizing the IAC by using the translabyrinthine approach. This is the most direct route to the CPA and lessens the need for cerebellar retraction while providing superior exposure of the facial nerve. The operative field extends from the anterior border of the sigmoid sinus superiorly to the middle fossa dura and anteromedially to the IAC. The dura is exposed between the sigmoid sinus and the IAC in the translabyrinthine approach. The lateral and posterior SCCs are first drilled and removed. The anterior end of the lateral SCC is removed, bearing in mind the close relationship of the tympanic portion of the facial nerve (Fig. 12–21A, B). As the posterior SCC is removed, the common crus and the posterior aspect of the superior SCC are exposed. The superior SCC is resected by drilling. Because the inferior limb of the posterior SCC is opened to the vestibule, drilling of the lateral and inferior vestibule exposes the vestibular aqueduct as it courses laterally toward the endolymphatic sac. Continuing to remove bone down to the common crus opens the vestibule. The contents of the IAC are separated from the wall of the vestibule by only a thin shell of bone. The IAC is surrounded by compact bone superiorly and inferiorly (Fig. 12–22A). It is important to remove bone around the

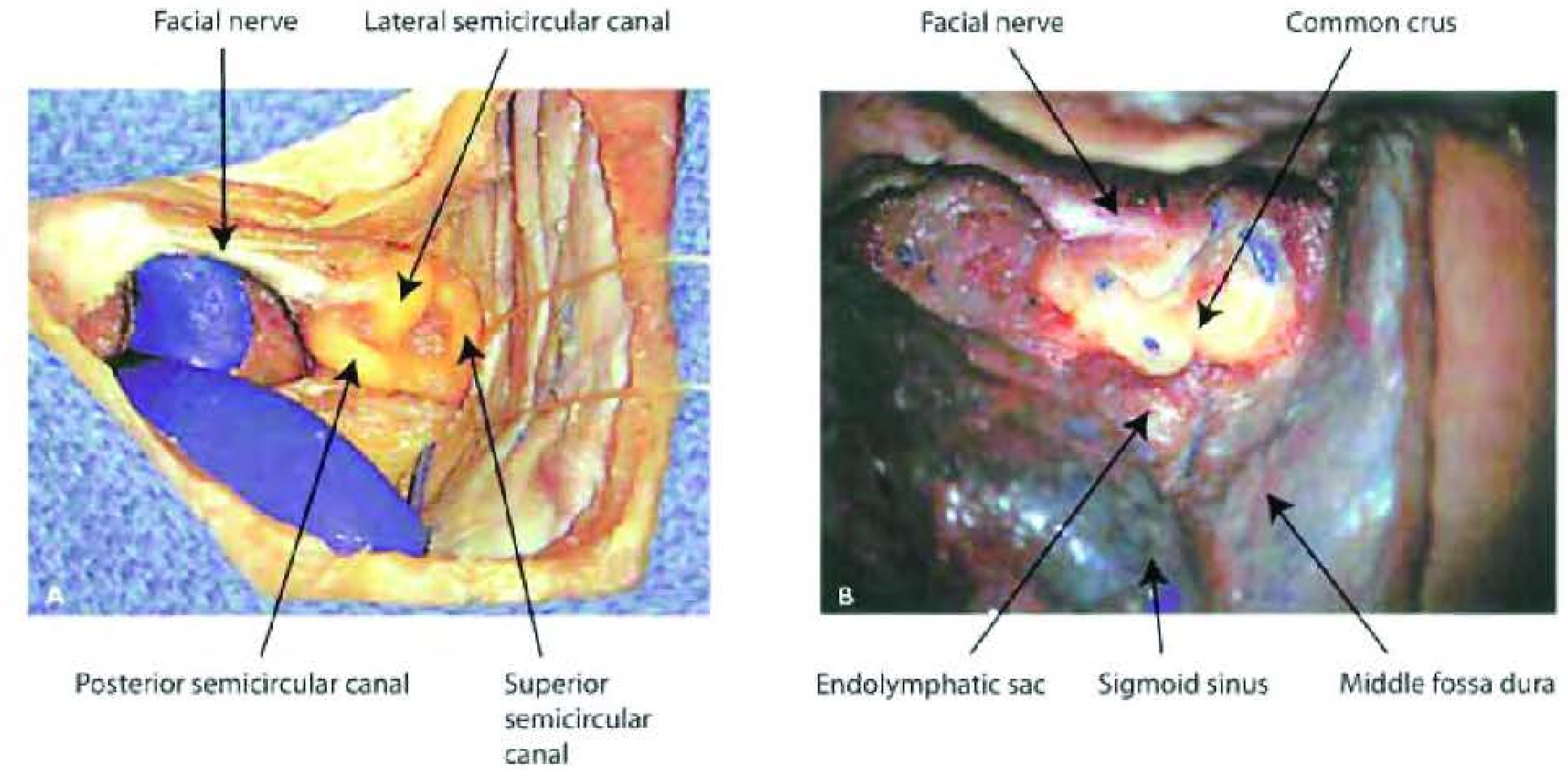

FIGURE 12–21 A: Translabyrinthine approach. The semicircular canals are seen in relationship to the middle and posterior fossa dura as well as the sigmoid sinus and jugular bulb. B: Translabyrinthine approach. The semicircular canals have been partially drilled to bean the translabyrinthine approach.

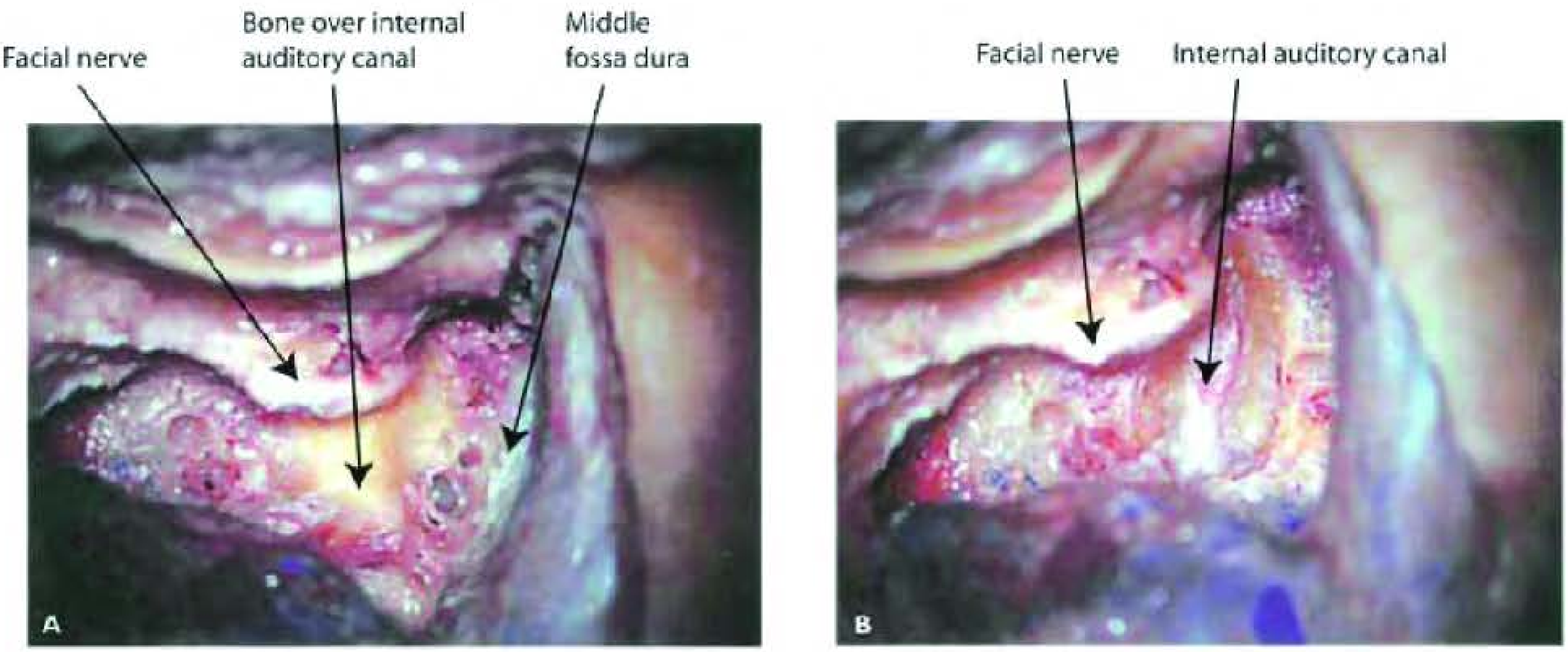

FIGURE 12–22 A: Translabyrinthine approach. The semicircular canals have been removed, exposing the compact bone over the internal auditory canal. B: Translabyrinthine approach. The bone over the internal auditory canal (IAC) has been removed to expose the dura.

canal such that a greater than 180-degree circumference of the canal is skeletonized to maximize exposure (Fig. 12–22B). As the bone around the IAC is carefully removed, the horizontal crest is identified as a thin septum of bone separating the superior from the inferior vestibular nerve at the lateral end of the canal. Bill's bar can be seen separating the facial and cochlear nerves from the superior and inferior vestibular nerves (Figs. 12–23A, B and 12–24).

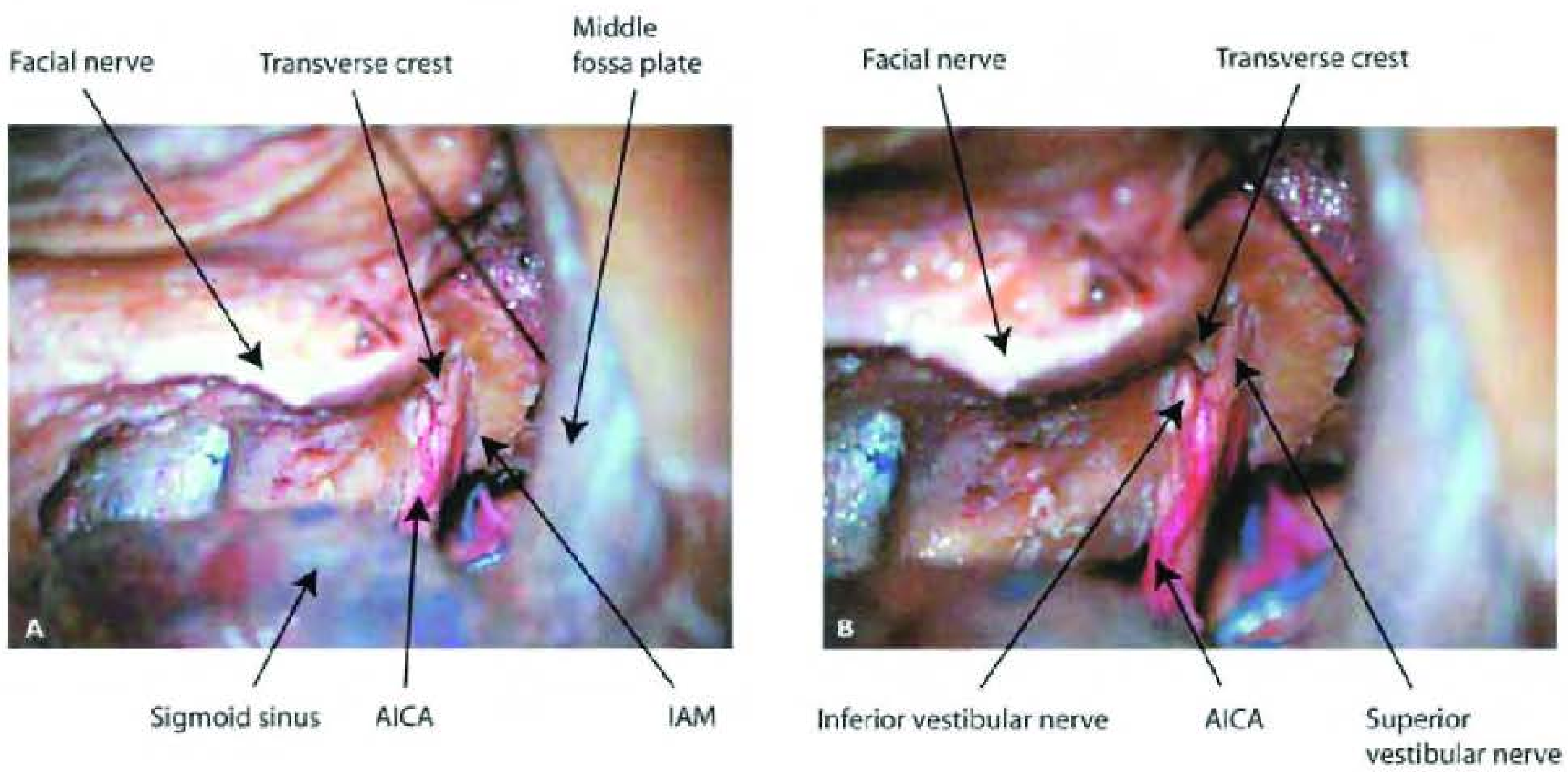

FIGURE 12–23 A: Translabyrinthine approach. The dura of the internal auditory canal (IAC) has been opened to expose its contents. AICA, anterior inferior cerebellar artery; IAM, internal auditory meatus. B: Translabyrinthine approach. The transverse crest can be seen to separate the superior and inferior vestibular nerves. AICA, anterior inferior cerebellar artery.

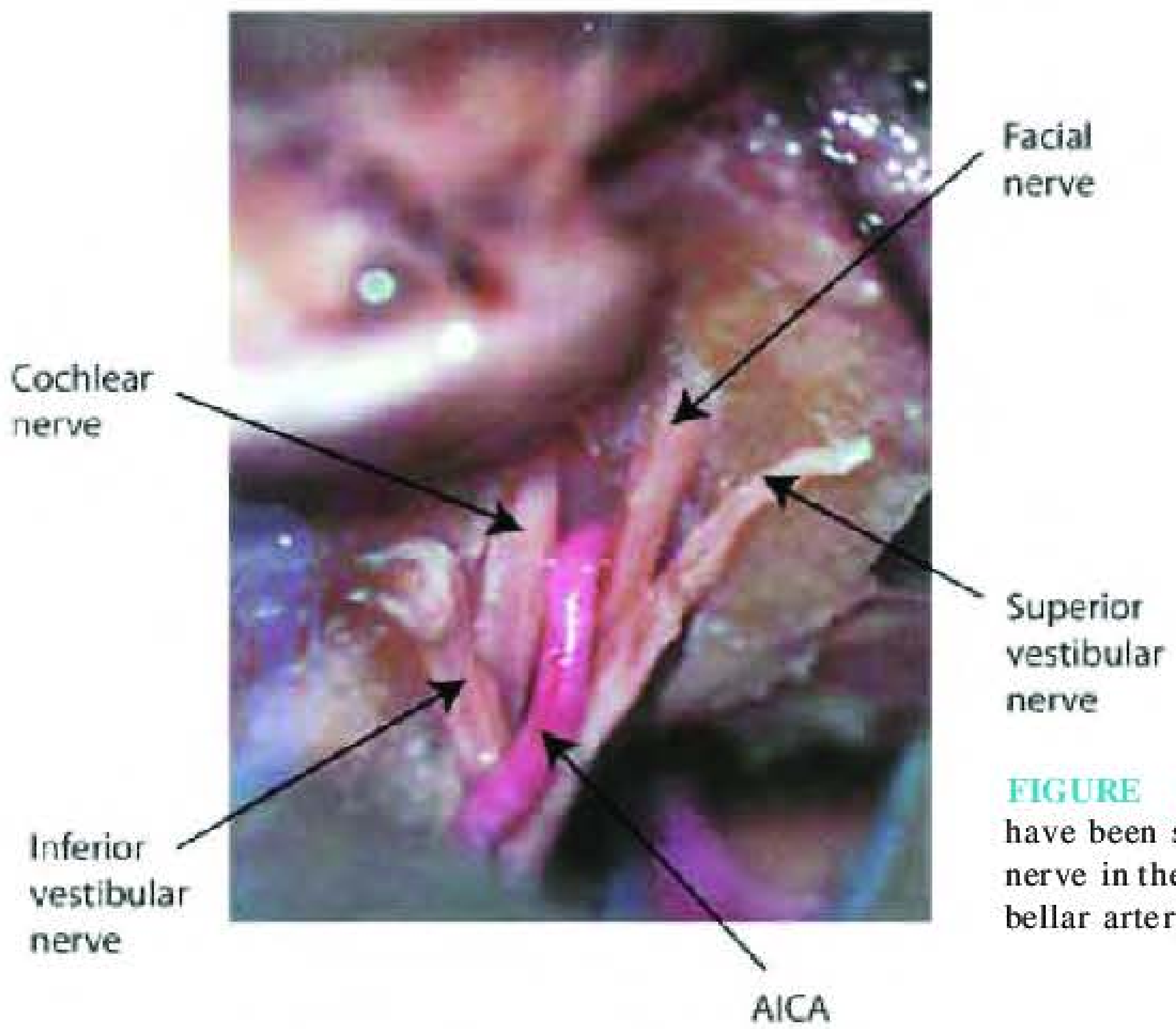

FIGURE 12–24 Translabyrinthine approach. The vestibular nerves have been sectioned and displaced to allow visualization of the facial nerve in the internal auditory canal (IAC). AICA, anterior inferior cerebellar artery.

The presigmoid dura is opened, and the dural incision can be extended into the middle fossa by incising the inferior temporal dura and sectioning the tentorium. The salient anatomy is the same as described in the preceding section (Figs. 12–25–12–28). The translabyrinthine approach sacrifices hearing. If this is not an issue, the approach affords a much greater anterior view into the cerebellopontine angle.

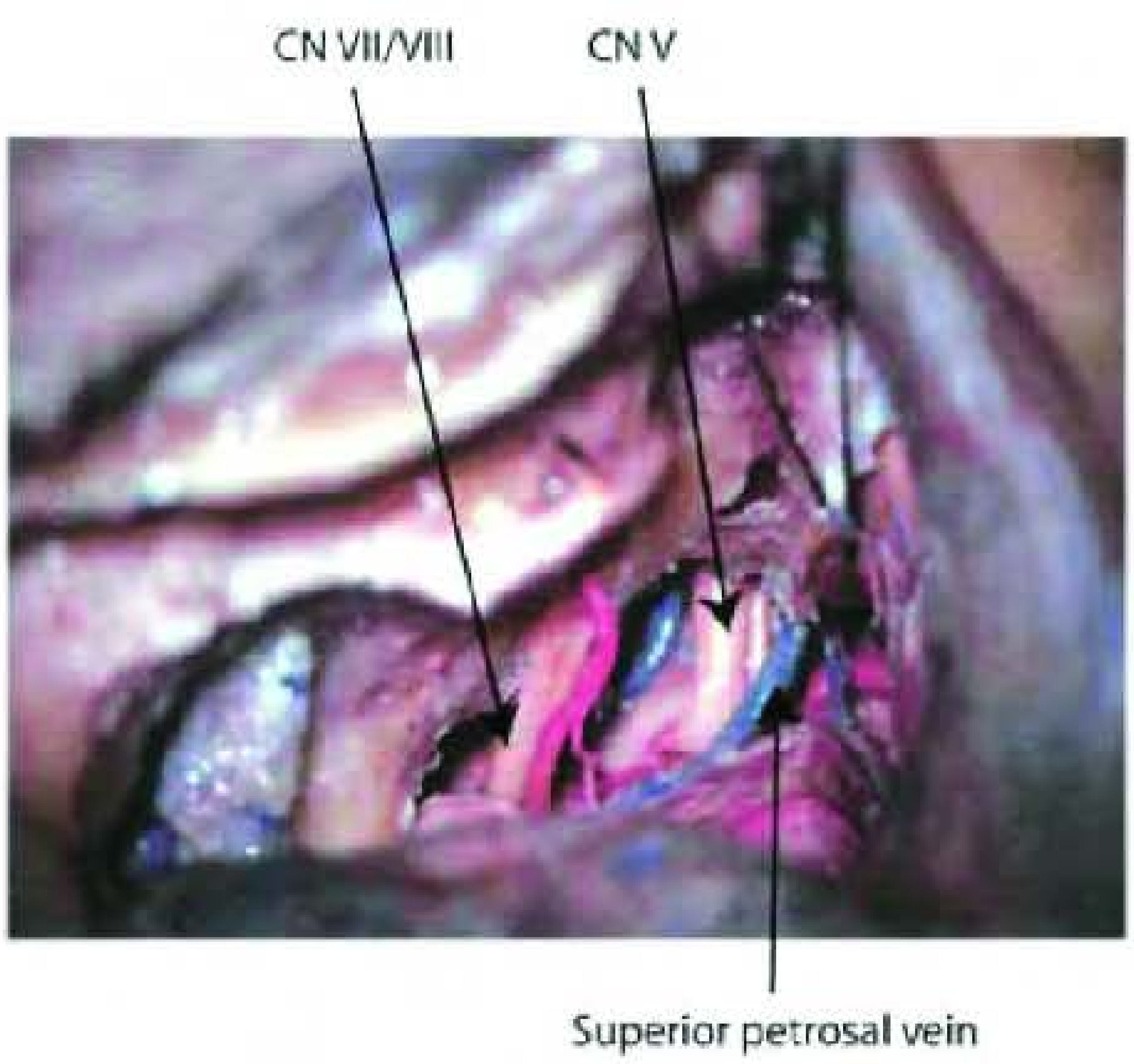

FIGURE 12–25 Translabyrinthine approach. The fifth nerve, superior petrosal vein, and cranial nerve (CN) VII/VIII can be seen.

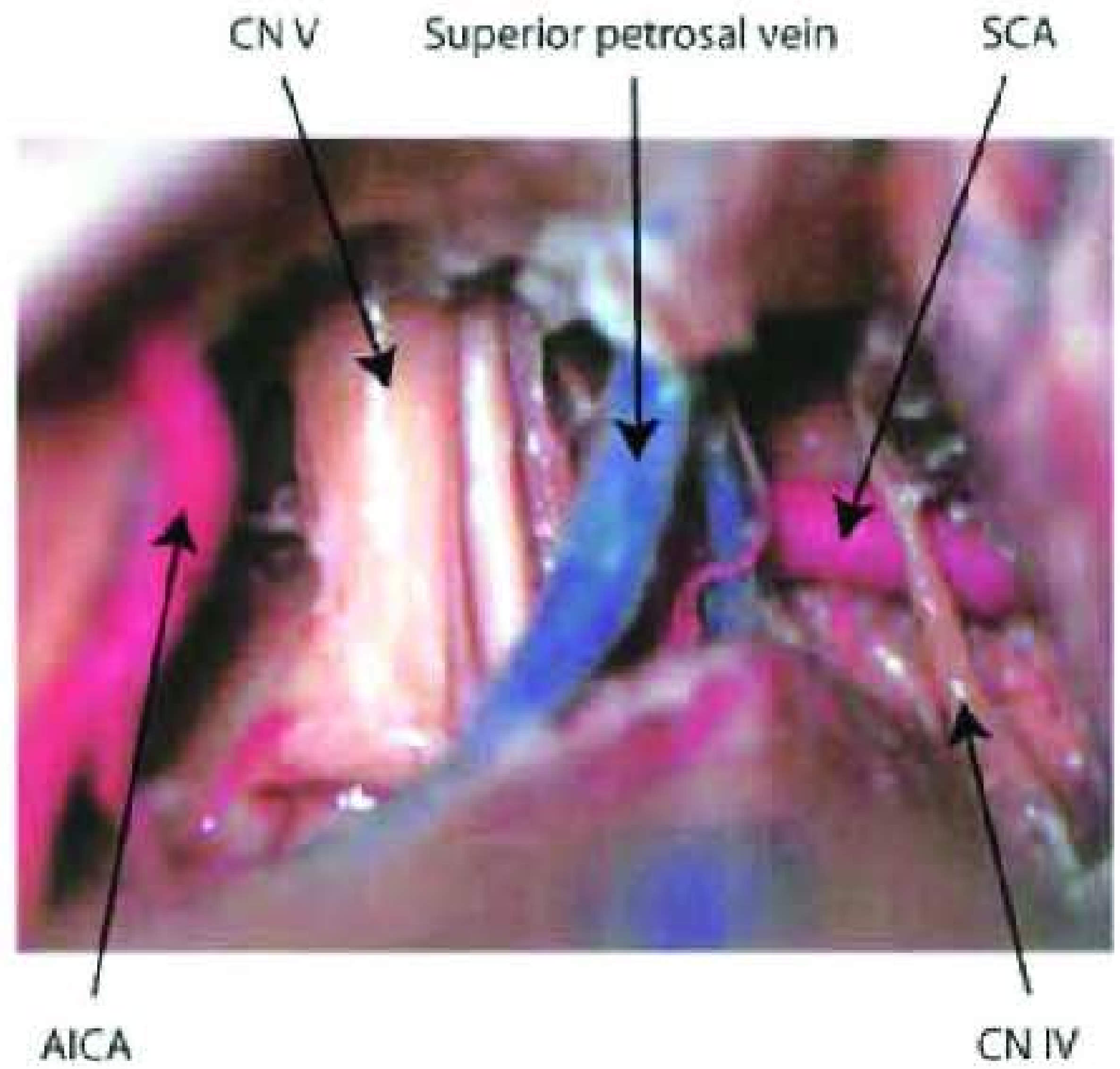

FIGURE 12–26 Translabyrinthine approach. The fourth and fifth cranial nerves, the anterior inferior cerebellar artery (AICA), superior cerebellar artery (SCA), and superior petrosal vein are seen.

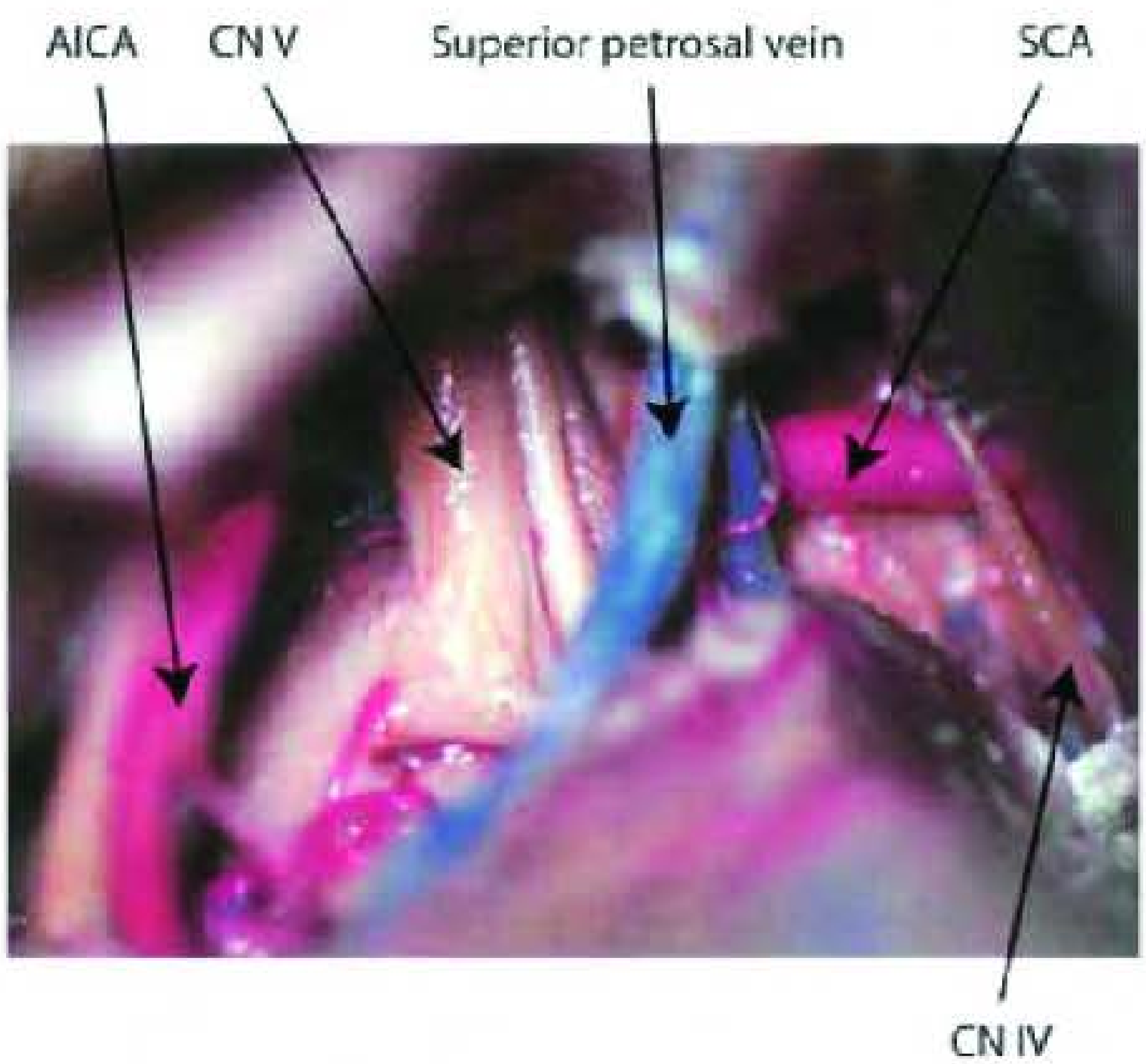

FIGURE 12–27 Translabyrinthine approach. Cranial nerves IV and V, the anterior inferior cerebellar Artery (AICA), superior cerebellar artery (SCA), and superior petrosal vein are visualized.

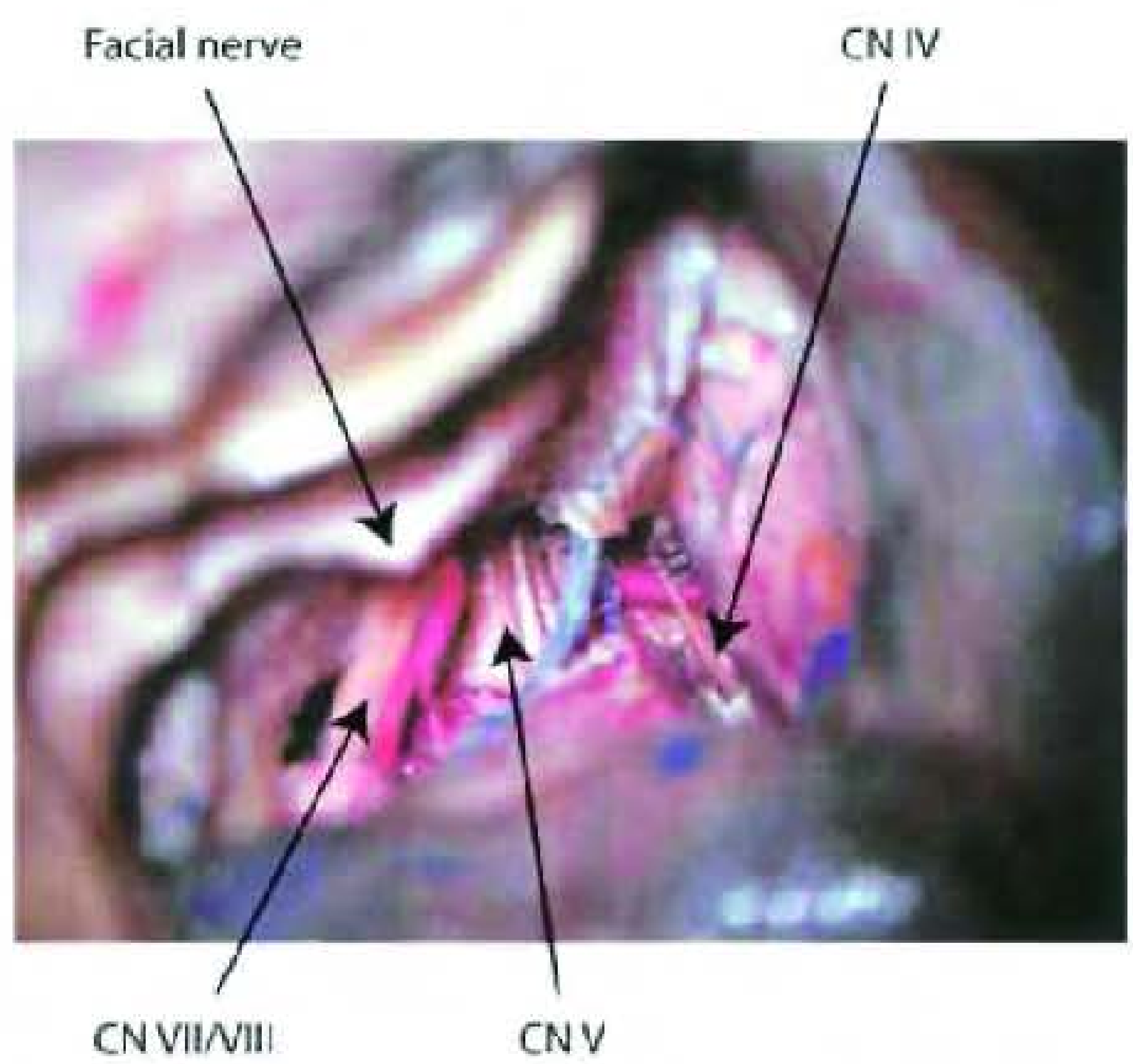

FIGURE 12–28 Translabyrinthine approach. Cranial nerve (CN) IV, V, VII, and VIII are seen.

TRANSCOCHLEAR APPROACH

Blind sac closure of the external auditory canal allows the musculocutaneous flap to be mobilized anteriorly over the parotid gland. The skin is removed from the bony external ear canal. The posterior annulus is elevated, and the incudostapedial joint is separated. The incus is extracted, and the tensor tympani muscle is cut. The malleolus with the tympanic membrane then is removed, thus completing removal of all squamous epithelium (Figs. 12–29 and 12–30).

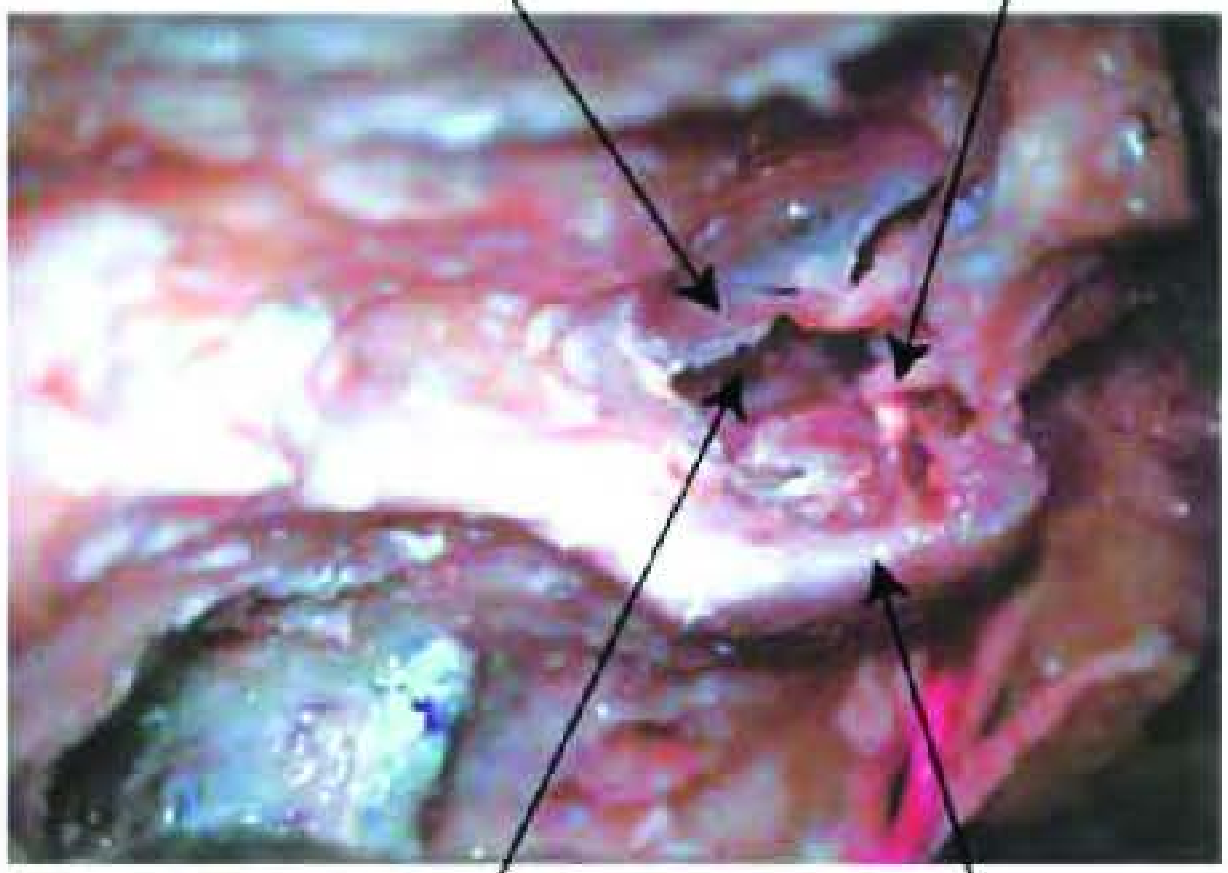

FIGURE 12–29 Transcochlear approach. The middle ear structures are visualized.

A radical mastoidectomy is performed as previously described, and the posterior and superior bony external canal walls are removed. After a complete labyrinthectomy with exposure of the IAC, the facial nerve is skeletonized from the stylomastoid foramen to the fundus of the IAC. Bone from the superior, posterior, and inferior aspects of the IAC should be removed. The sigmoid sinus is skeletonized down to the jugular bulb. If the bulb is high, it may be lowered using Surgicel and bone wax. The last shell of bone over the facial nerve is carefully removed, taking special care while uncovering the region of the geniculate ganglion and the labyrinthine segment. The GSPN is exposed and transected. Using an angled pick, the geniculate ganglion and the labyrinthine part of the nerve are carefully separated from the underlying bone. Once the whole nerve is liberated, it is gently rerouted posteriorly and fixed to the posterior fossa dura (Fig. 12–31). Drilling is continued with removal of the remaining fallopian canal, the cochlea, and the anterior wall of the IAC. The vertical segment of the ICA is identified and dissected free by drilling the anterior wall of the external auditory canal (Figs. 12–32 and 12–33). Sometimes anterior displacement of the mandibular condyle is required to achieve circumferential uncovering of the artery. The petrous apex is drilled further to the level of the midclivus, and the ICA is exposed at its entrance into the anterior foramen lacerum. The inferior petrosal sinus is usually encountered and closed by packing it with Surgicel. The dura is opened in a triangular fashion, superiorly along the superior petrosal sinus, and inferiorly along the jugular bulb and the inferior petrosal sinus. Special attention is paid to the opening of the dura in front of the internal

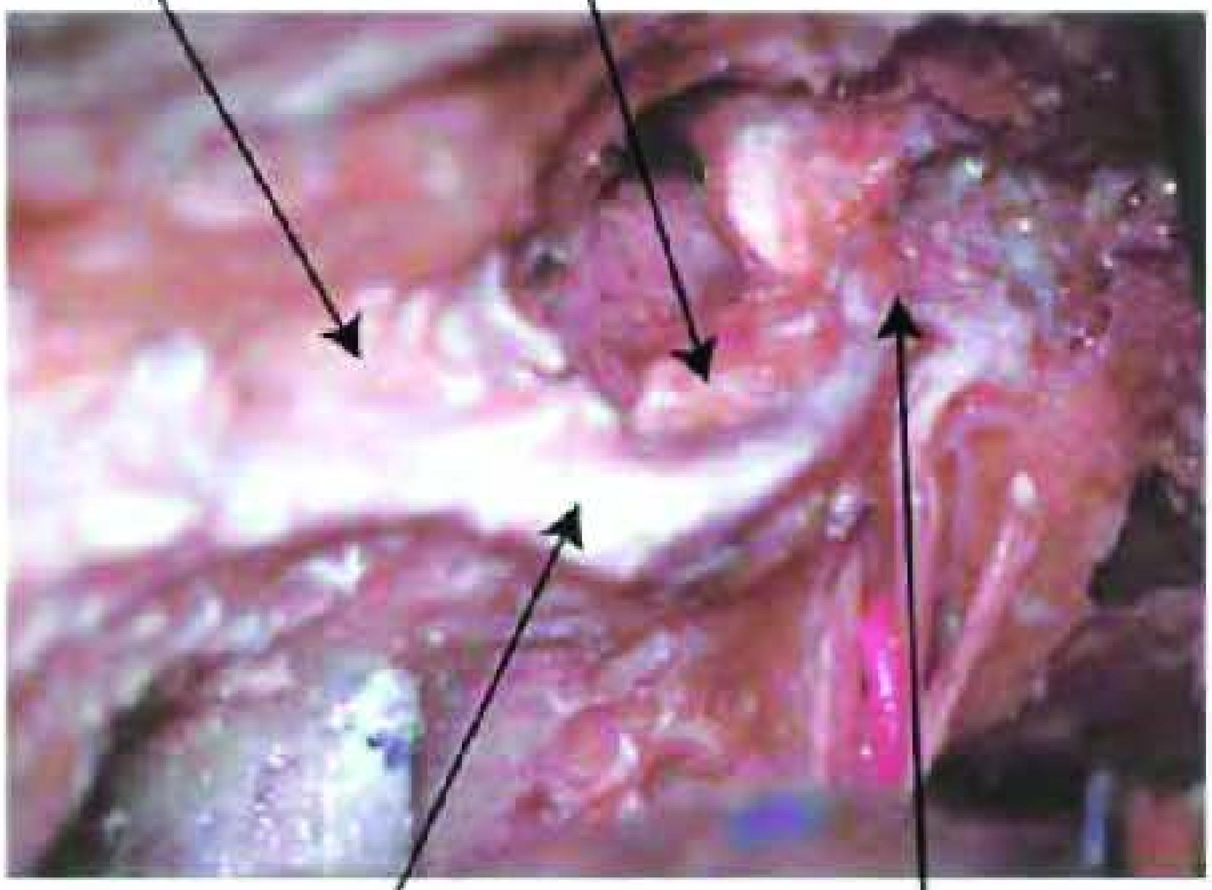

FIGURE 12–30 Transcochlear approach. The anatomic relationship between the middle and inner ear structures can be appreciated.

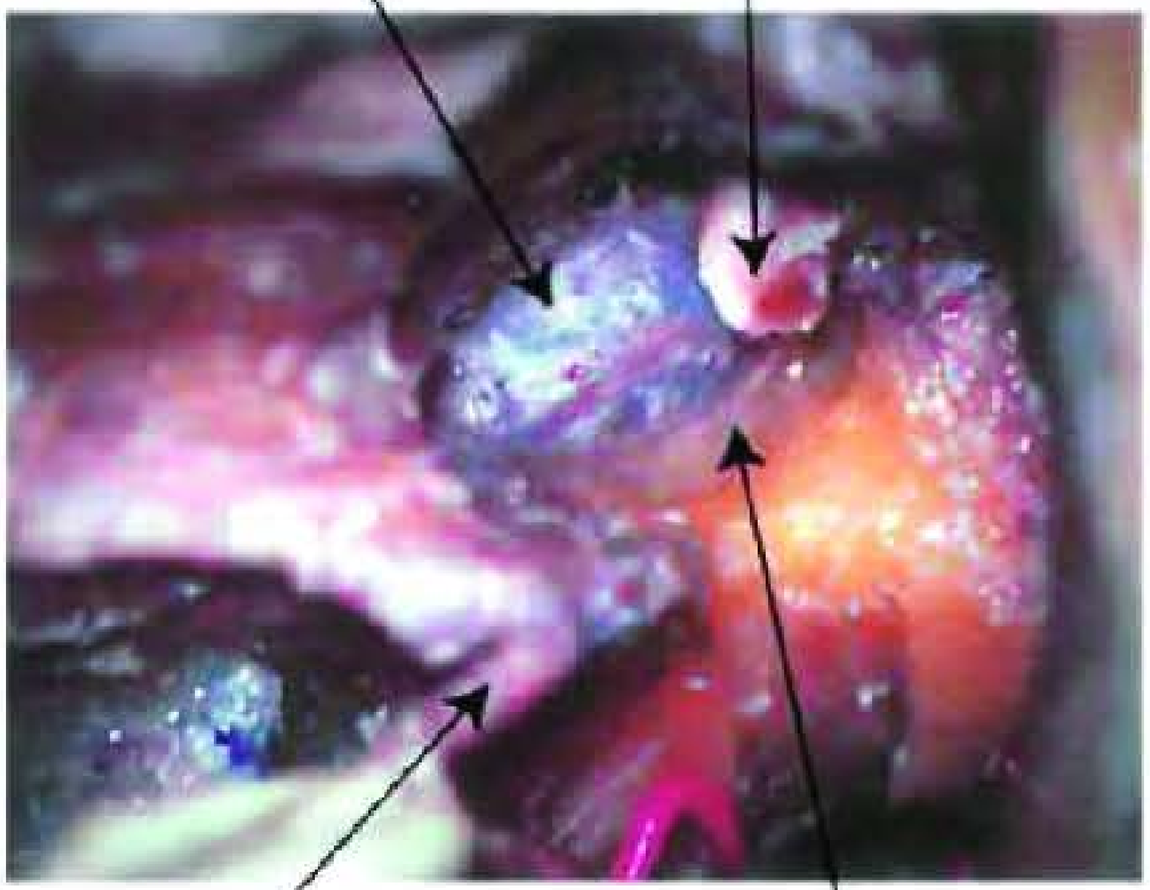

FIGURE 12–31 Transcochlear approach. The facial nerve has been transposed and the posterior wall of the petrous apex drilled Note the proximity of the facial nerve to the petrous carotid artery.

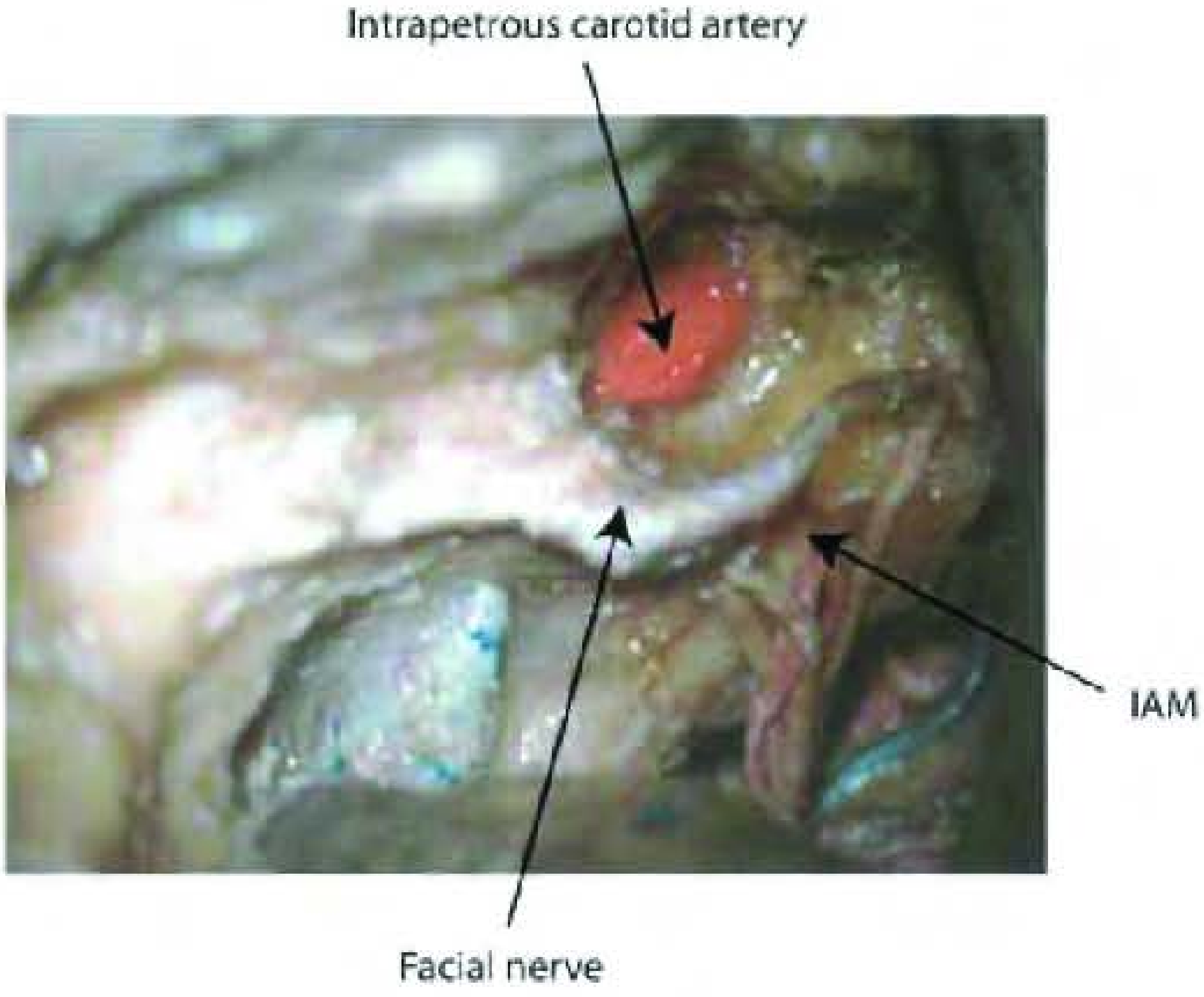

FIGURE 12–32 Transcochlear approach. The anterior wall of the external auditory meatus has been drilled to allow visualization of the internal carotid artery. IAM, internal auditory meatus.

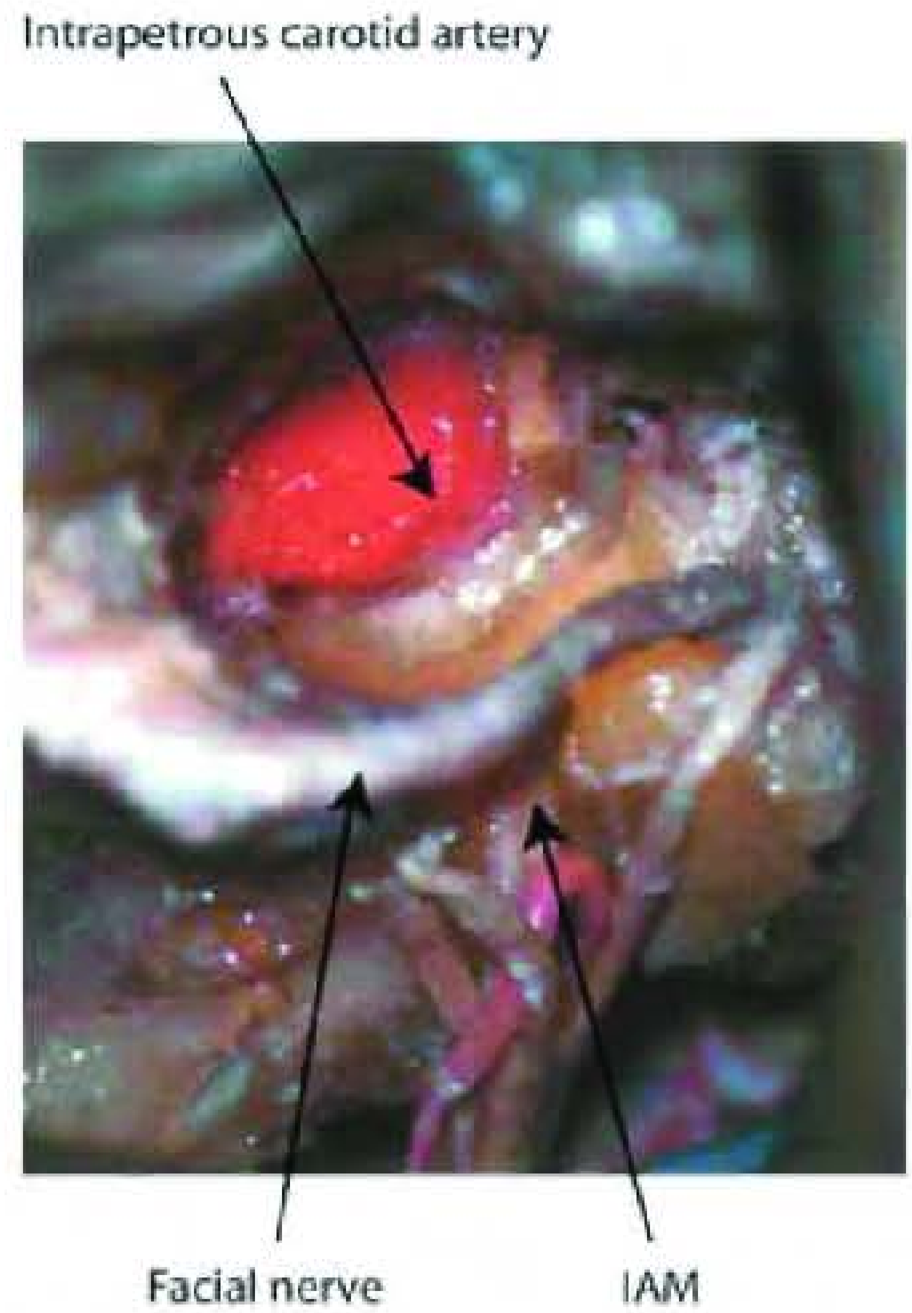

FIGURE 12–33 Transcochlear approach. The internal carotid artery is seen after drilling the petrous apex and opening the external auditory meatus. IAM, internal auditory meatus.

auditory meatus so as not to injure the facial nerve. Through this exposure, anatomic structures spanning from the posterior cavernous sinus to the lower cranial nerves can be visualized (Figs. 12–33–12–38).

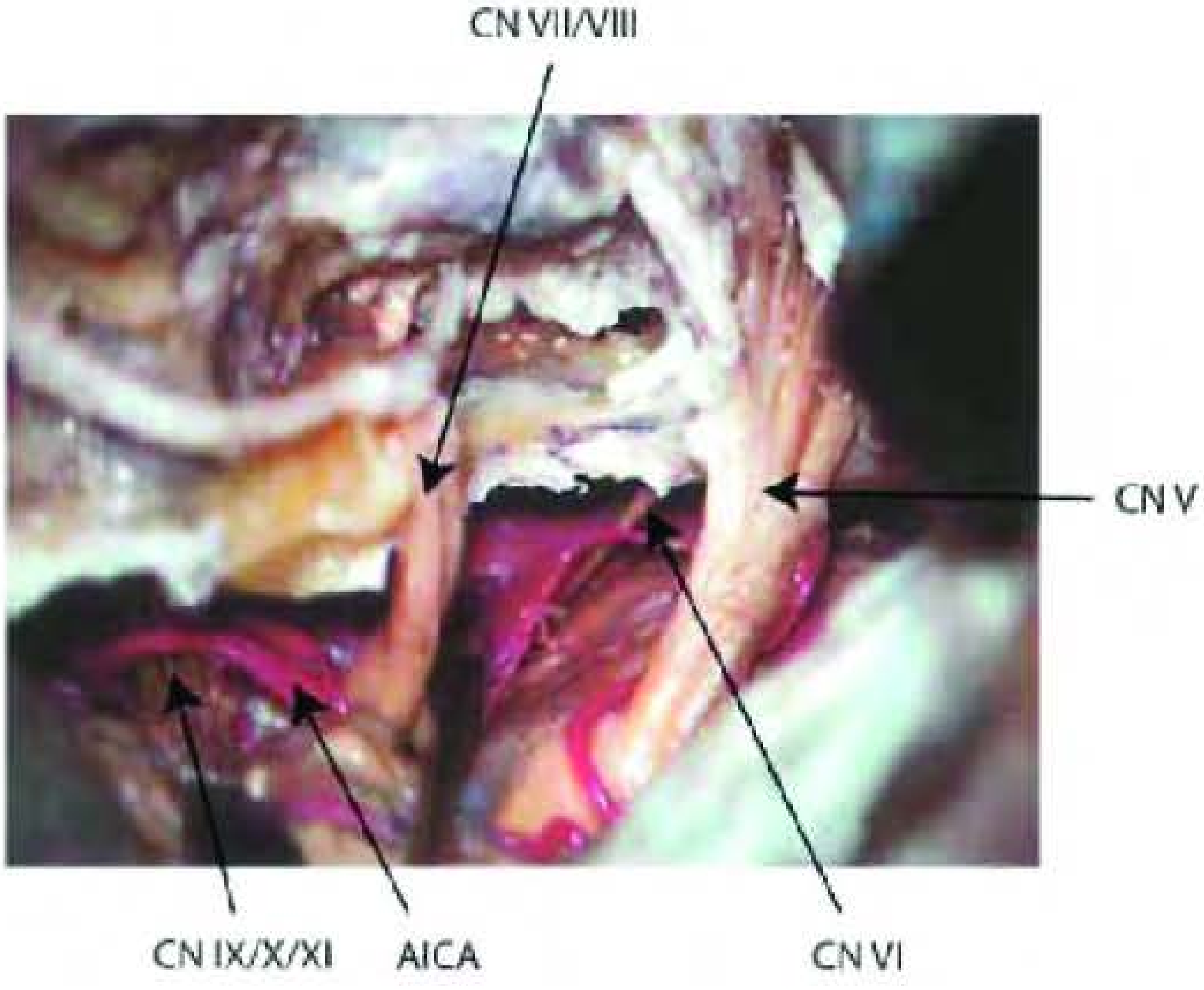

FIGURE 12–34 Transcochlear approach. Cranial nerves (CN) V through XI are visualized. AICA, anterior inferior cerebellar artery.

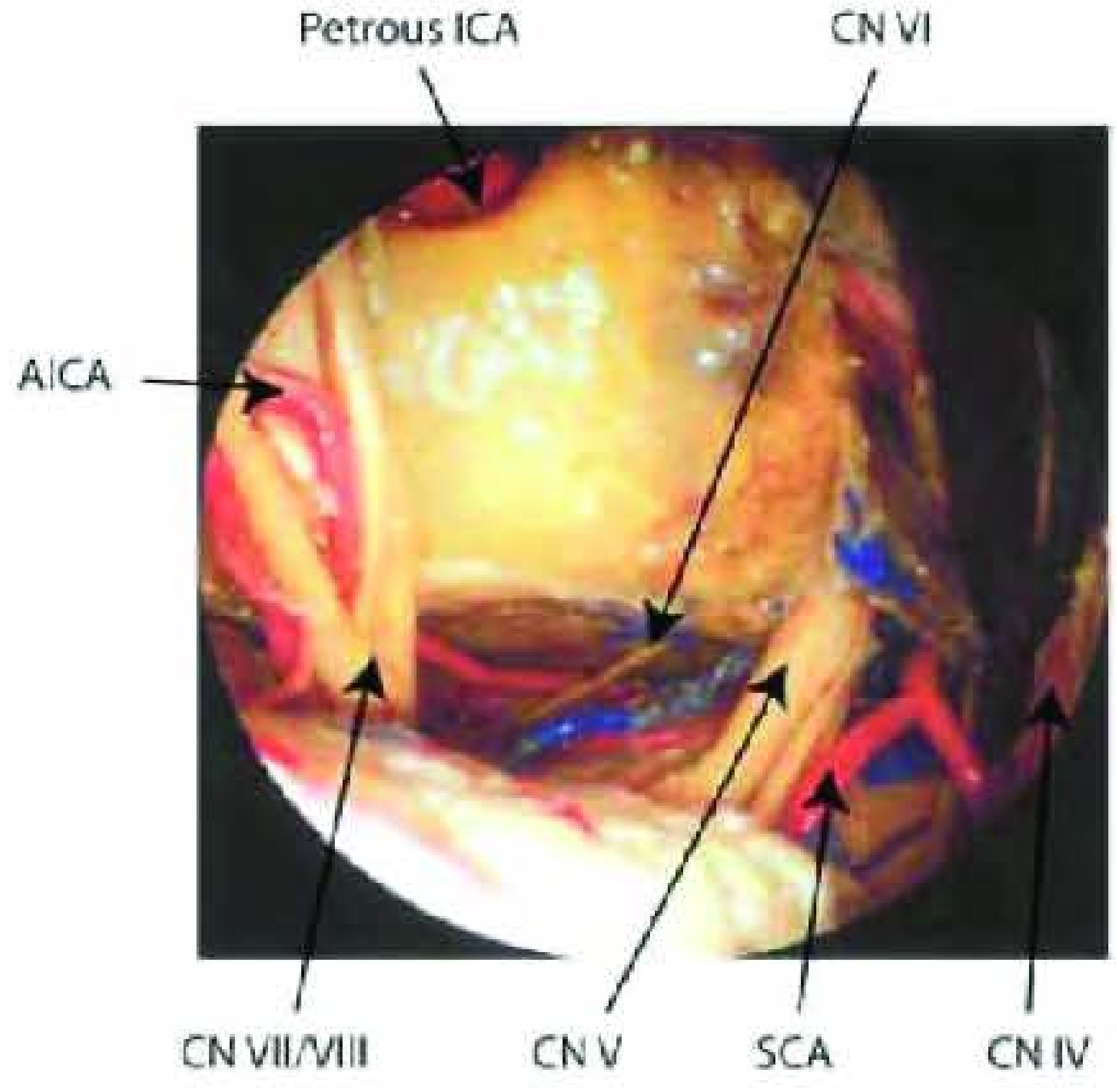

FIGURE 12–35 Transcochlear approach. Cranial nerves (CN) V through VIII are seen, as is the superior cerebellar artery (SCA), anterior inferior cerebellar artery (AICA), and petrous carotid artery. ICA, internal carotid artery.

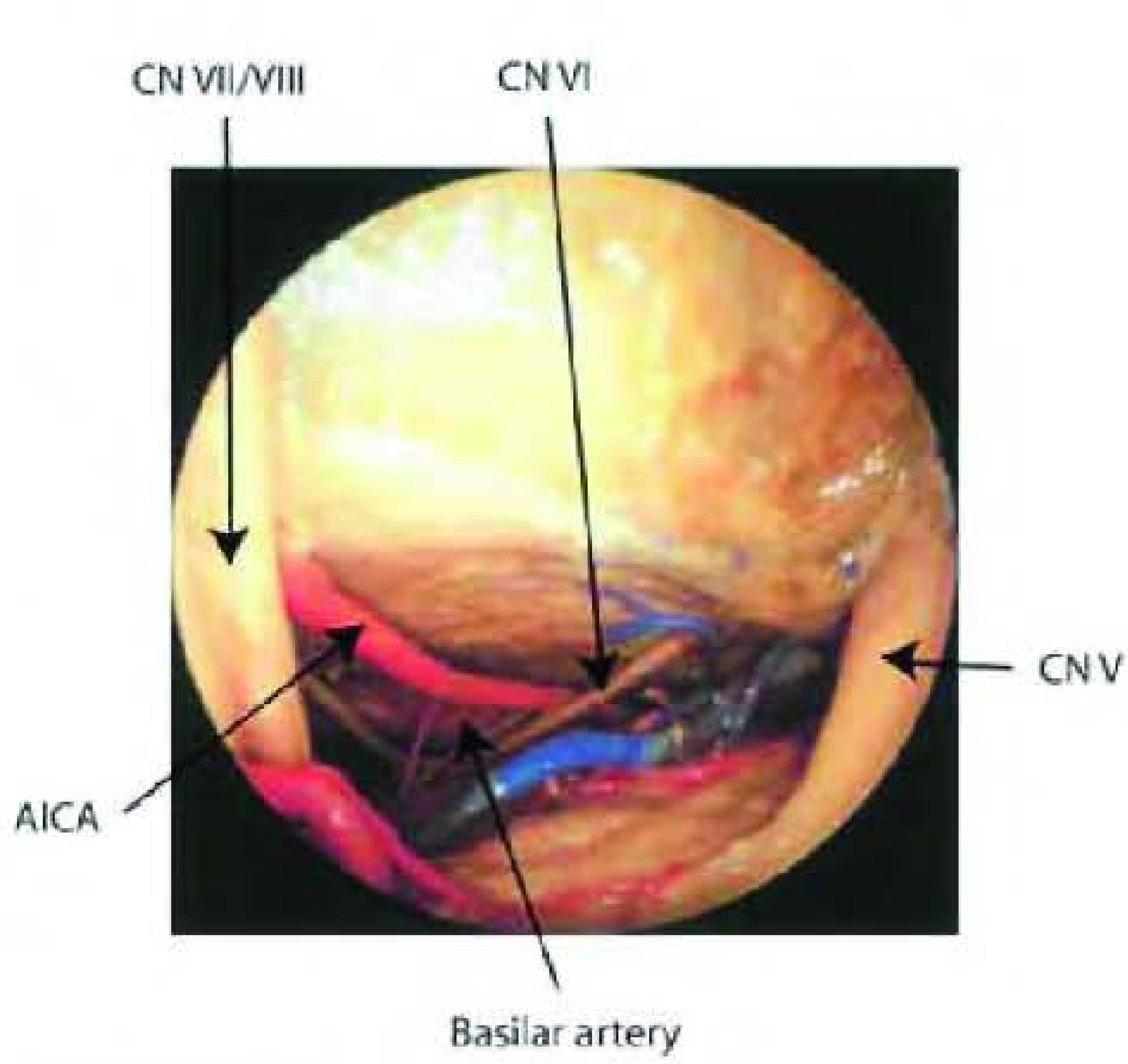

FIGURE 12–36 Transcochlear approach. High-power view of cranial nerve (CN) V through VIII and the anterior inferior cerebellar artery (AICA).

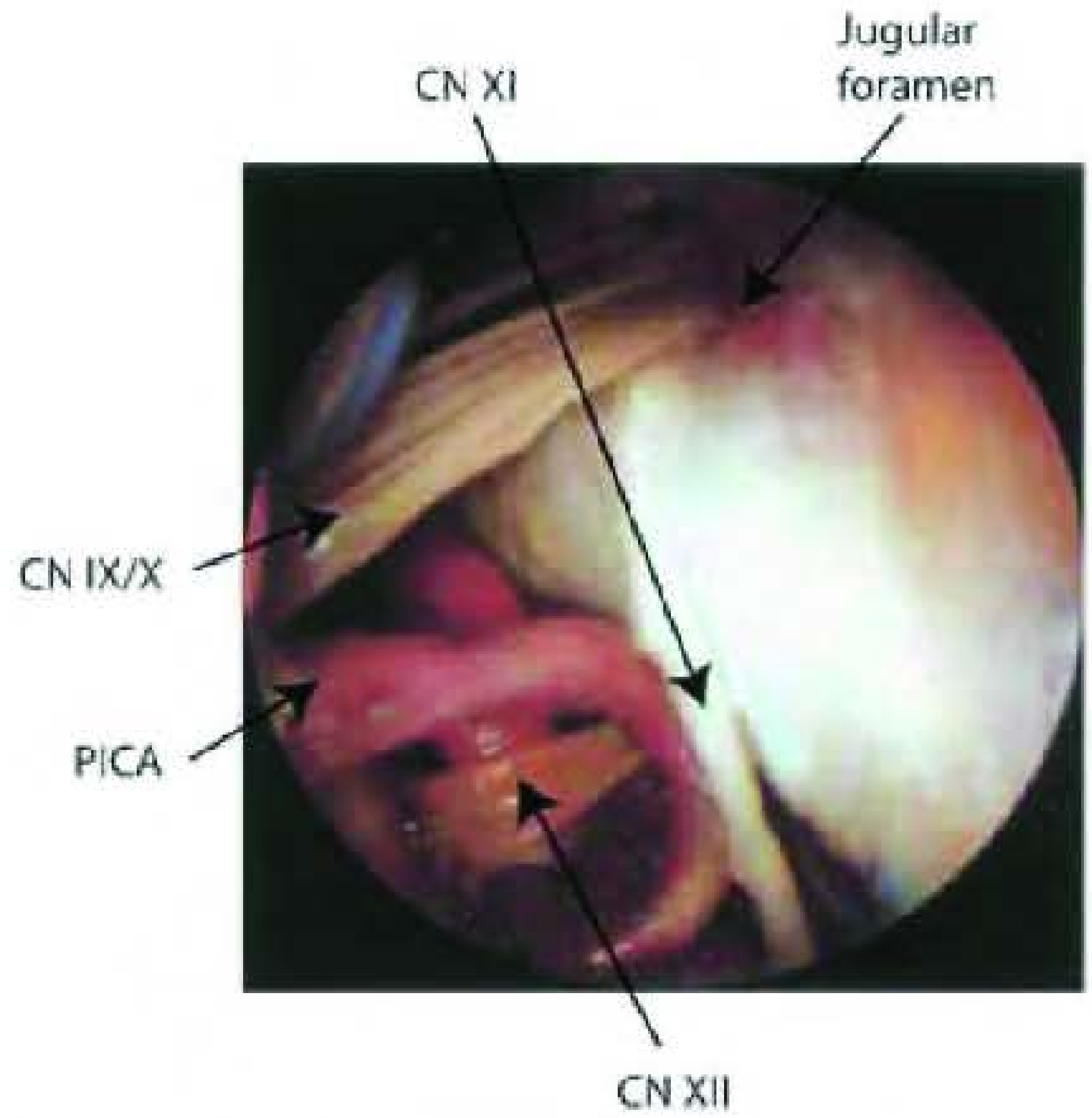

FIGURE 12–37 Transcochlear approach. The lower cranial nerves are seen exiting the jugular foramen. The posterior inferior cerebellar artery (PICA) is seen.

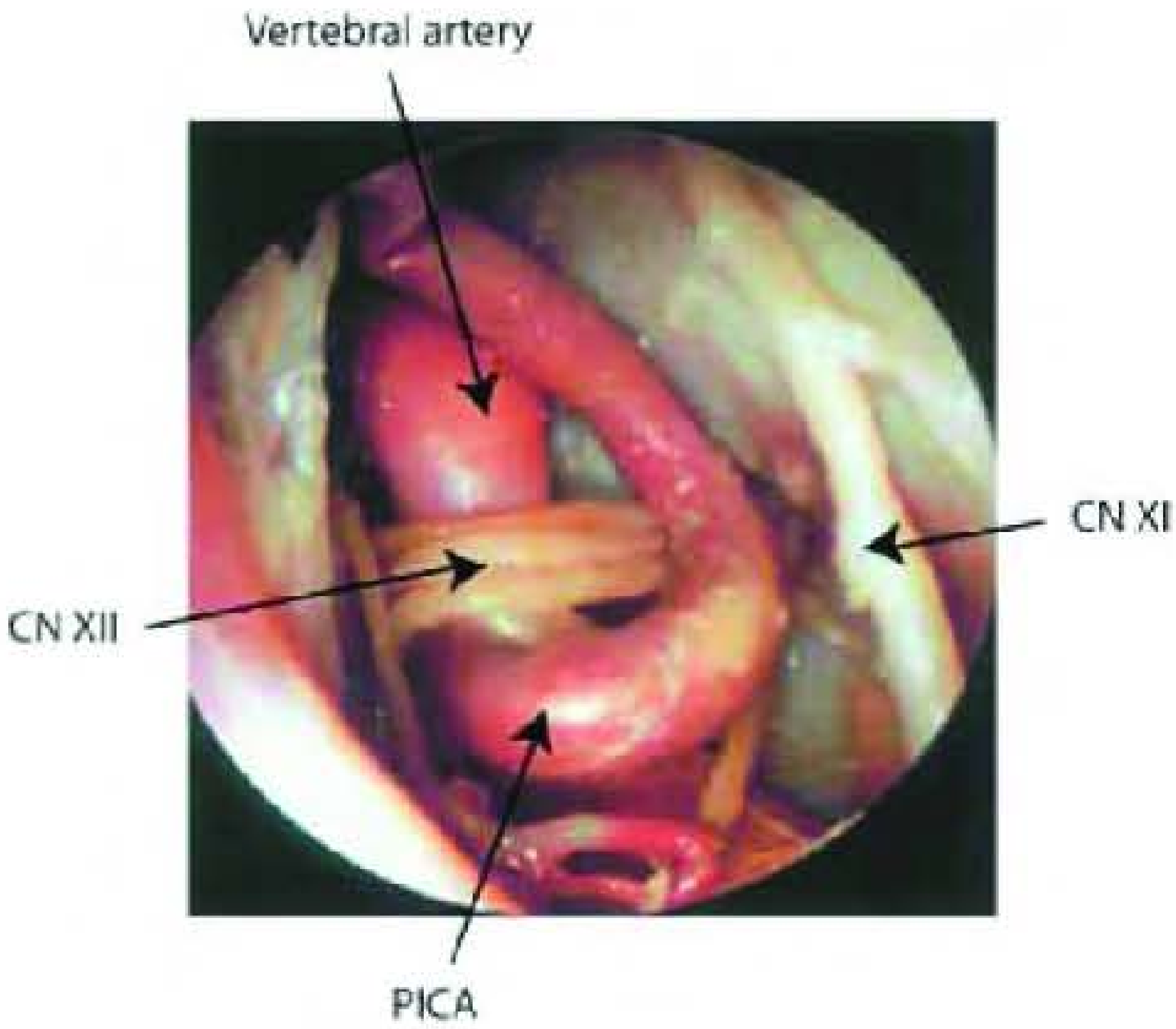

FIGURE 12–38 Transcochlear approach. The hypoglossal nerve is seen exiting the posterior fossa. Its relationship to the posterior inferior cerebellar artery (PICA) can be appreciated.

FACIAL NERVE TRANSPOSITION

Long-segment or short-segment mobilization of the facial nerve may be performed. Short-segment mobilization consists of mobilization of the nerve from its second genu to the stylomastoid foramen. Long-segment mobilization consists of mobilizing the nerve along its entire temporal bone course from the root exit zone at the pontomedullary junction to the stylomastoid foramen. Anterior mobilization allows access to the jugular foramen, hypotympanum, ascending intrapetrous carotid artery, sigmoid sinus, upper neck, infratemporal fossa, and posterior fossa anterior to the sigmoid sinus. Anterior rerouting of the facial nerve is subtotal because the labyrinthine, intracanalicular, and intracranial portions of the facial nerve and their blood supply are left intact. Posterior mobilization is performed in total temporal bone resection.

Anterior Mobilization Technique

With the canal wall up technique, the entire tympanic and mastoid portions of the facial nerve are mobilized, and the mastoid tip is removed by following the digastric groove forward (lateral to the stylomastoid foramen) and detaching from it the sternocleidomastoid muscle, which is retracted posteriorly. The posterior belly of the digastric muscle is elevated and retracted anteriorly. The soft tissue of the stylomastoid foramen (SMF), including the periosteum and the enclosed facial nerve, is sharply elevated from the medial attachment. The extratemporal facial nerve is followed to the pes anserinus, and the attached fibers to the digastric, postauricular, and stylohyoid muscles are divided. The created stylomastoid cone of tissue and nerve is displaced and anchored to the fibrous tissue of the glenoid fossa. This holds the facial nerve superiorly and anteriorly and prevents its being stretched. With the canal wall down technique, the posterior and inferior canal walls are taken down for a second genu pivot point, and additional resection of the anterior canal wall is required for the first genu pivot point. Complete exposure of the middle ear and hypotympanum is followed by removal of the tympanic membrane and the ossicles. Then the anterior rerouting proceeds in the same way as described in the canal up technique.

Posterior Mobilization Technique

After a complete labyrinthectomy, the facial nerve is identified at the second genu and labyrinthine segment. The internal auditory canal can be traced from a widely opened vestibule, medial to the porus acusticus. The superior and inferior walls of the IAC are drilled to delineate its contents more fully. The mastoid segment is identified and followed distally to the stylomastoid foramen, liberating the nerve by sharp dissection with a beaver knife. The tympanic bone, external auditory canal skin, ossicles, and tympanic membrane are removed. The corda tympani nerve is divided. The horizontal portion of the facial nerve is dissected and isolated using angled picks after dividing the tensor tympani and stapedius tendons. Mobilization of the facial nerve from its fallopian canal requires division of the GSPN. Once the nerve has been liberated from the labyrinthine, mastoid, and stylomastoid areas, attention should be turned to the internal auditory canal in which the facial nerve is found in the anterosuperior region. Care must be taken in manipulating this segment because the epineurium that maintains the fascicles together is absent, making this region more vulnerable to damage. After completion of the facial liberation, the nerve is transposed posteriorly and fixed to the posterior fossa dura. Application of the suction device directly on the nerve should be avoided by protecting it with cottonoids.

INTERNAL AUDITORY CANAL DRILLING

The orientation of the IAC is a direct medial extension of the EAC. Three techniques have been described to complete drilling the IAC. In the House technique, the GSPN is traced to the geniculate ganglion and the labyrinthine segment of the nerve into the fundus of the IAC. At this point, the bone of the IAC is skeletonized. In the Fisch technique, the superior SCC is identified at the arcuate eminence. At this point, a 60-degree angle from the anterior end of the superior SCC defines a safe zone for drilling the IAC. In the Garcia-Ibanez technique, once the arcuate eminence and geniculate ganglion are identified, drilling is begun medially on a line bisecting the angle between the arcuate eminence and the GSPN close to the porus acusticus. Drilling of the IAC is performed with diamond burs. The latter technique is advantageous because the initial drilling prior to the clear identification of the IAC is performed away from the susceptible inner ear structures.

ANTERIOR PETROSAL DRILLING

Beginning posteriorly and working anteriorly, the dura along the floor of the temporal fossa is elevated. By following the middle meningeal artery, the foramen spinosum is identified. The artery is coagulated and divided. Medial to the foramen spinosum, the GSPN and LSPN are identified as they course in the sphenopetrosal groove. The horizontal portion of the ICA runs parallel to and deep to the GSPN and posterior to the foramen ovale and the mandibular division of the trigeminal nerve (V_3). The bone overlying this part of the ICA is removed using a diamond burr (Glassock's triangle). The petrous bone anterior to the IAC, anteromedial to the cochlea, and medial to the ICA is removed at the level of the foramen lacerum until the inferior petrosal sinus and the dura of the posterior fossa inferiorly and medially, respectively (Kawase's triangle), are visualized. This exposure permits direct access to the superior CPA, clivus, and cavernous sinus.

PITFALLS, PEARLS, CONSIDERATIONS

- Facial nerve injury
- Sinus injury and/or occlusion
- ICA injury
- Cerebellar edema/contusion
- Cerebrospinal fluid leak
- Meningitis

SUGGESTED READINGS

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RETROSIGMOID CRANIOTOMY

Sajjan Sarma, Emel Avci, Damirez Fossett

INDICATIONS FOR SURGERY

- Cerebellopontine angle tumors
- Tic douloureux
- Hemifacial spasm
- Vestibular neurectomy
- Glossopharyngeal and geniculate neuralgia
- Vascular lesions of the posterior circulation

ANATOMY

The retrosigmoid region is that part of the cranium situated just behind the sigmoid sinus and below the transverse sinus. Adequate knowledge of the cisterns, vessels, and cranial nerves in this area is important when this approach is used.

The lateral cerebellomedullary and cerebellopontine cisterns are encountered in this approach. As their names imply, they are located between the cerebellum and the medulla and the cerebellum and the pons, respectively. These cisterns intercommunicate.

Three important arteries are encountered bilaterally in this region: the posterior inferior cerebellar arteries (PICA), the anterior inferior cerebellar arteries (AICA), and the superior cerebellar arteries (SCA). If these are very tortuous, part of the vertebral or basilar artery also may be seen in the cerebellopontine angle. The PICA, which arises from the vertebral artery, is seen in relation to the lower cranial nerves. Occasionally, it may reach high enough to come into contact with the lower limit of the VII/VIII complex. The AICA, which arises from the basilar artery, may arise as more than one trunk. The distal AICA is seen in relation to the VII/VIII complex. This nerve-related segment is divided into premeatal, meatal, and postmeatal parts. The meatal part forms a loop (meatal loop), which travels along the VII/VIII nerve complex for a variable distance toward the internal acoustic meatus (IAM), remaining usually anterior-inferior to the nerves. Several nerve-related branches of the AICA exist: the internal auditory arteries, recurrent perforating arteries, subarcuate artery, and cerebellosubarcuate artery. The internal auditory artery is the most constant branch of the AICA. The SCA arises from the basilar quadrification courses back along the side of the mesencephalon and pons, and is seen in the cerebellopontine angle in front of cranial nerve (CN) V.

The veins of the posterior fossa can be divided into superficial, deep, brainstem, and bridging veins. Accordingly, veins seen in this area are anterior hemispheric veins, veins of the cerebellopontine fissure and middle cerebellar peduncular veins, lateral medullary and lateral mesencephalic veins, and petrosal bridging veins. Petrosal veins are divided into superior and inferior veins, depending on whether they drain into the superior or inferior petrosal sinus. The superior petrosal veins are the most prominent bridging veins of posterior fossa. They drain blood from a large part of the cerebellar hemisphere and brainstem. Superior petrosal veins are divided into a lateral, intermediate, or medial group based on their relation to the site of drainage into the superior petrosal sinus and IAM. The intermediate group drains just above the IAM.

Cranial nerves V through XII are seen in this approach. CN V is a stout nerve arising from the upper and outer aspect of the anterior pons. Its motor component arises as a separate rootlet just anterior to the main nerve, and both quickly merge to form a single nerve. Loops of the SCA can be seen in front of the nerve at this level. The nerve courses anteriorly and outward to cross the petrous apex and enter into the Meckel's cave.

Cranial nerve VI arises medially at the pontomedullary sulcus. It courses up the surface of the clivus exiting the posterior fossa through Dorello's canal. It enters the posterior cavernous sinus on its way through the middle cranial fossa to the orbit.

The VII/VIII complex, with the nervous intermedius in between, arises from the pontomedullary junction surrounded by the same fascial sheath. They course backward, downward, and outward toward the internal acoustic meatus. A loop of AICA is seen coursing along the nerve anteroinferiorly for a variable distance. In some occasions, the arterial loop also can go between the VII/VIII complex. The nerves traverse through the internal acoustic canal, with CN VIII supplying the auditory and vestibular apparatus in the inner ear and the facial nerve coursing through the petrous bone to exit the cranial cavity at the stylomastoid foramen. The facial nerve and cochlear nerve lie anterior to the superior and inferior vestibular nerve. The facial nerve is superior to the cochlear nerve and is separated from it by the transverse crest in the internal auditory canal (IAC). Both anteriorly placed nerves are separated from the posteriorly placed vestibular nerves by Bill's bar.

Cranial nerves IX, X, and XI arise as a Linear series of rootlets from just below the pontomedullary junction in the anterolateral medullary sulcus. After their origin, they converge outward and backward toward the jugular foramen. The spinal root of the accessory nerve ascends up through the foramen magnum and joins its cranial counterpart at the level of the jugular foramen. CN IX, X, and XI exit the cranial cavity through the jugular foramen; CN IX exits in a separate dural sheath from that surrounding CN X and XI. CN XII lies in close proximity to the vertebral artery-PICA junction. Its many rootlets exit through the hypoglossal canal.

Positioning and Skin Incision

The retrosigmoid craniotomy can be performed with the patient in the sitting, park-bench, lateral, or supine position with the head rotated maximally to the contralateral side. The head is placed in Mayfieid three-point fixation regardless of the position chosen. In the lateral or park-bench position, an axillary roll must be placed in the contralateral axilla. The head is slightly flexed toward the floor and the ipsilateral shoulder pulled down to open the angle between the head and the shoulder. The head of the bed may be rotated to give the surgeon access to the region of interest. The patient must be securely taped to the operating table.

The retroauricular skin incision may be C shaped, linear, or a lazy "S" (Fig. 13–1). It should begin above the inion and should be paramedian in nature, typically about 5 mm medial to the mastoid notch. Depending on the location of the pathology, the incision may extend more proximally or distally. Important landmarks for posterior fossa surgery include the mastoid groove and mastoid tip, the inion, and a line that connects the posterior root of the zygoma with the inion (Fig. 13–2). A craniotomy beneath this line will be over the posterior fossa. The sigmoid sinus will lie beneath the mastoid groove.

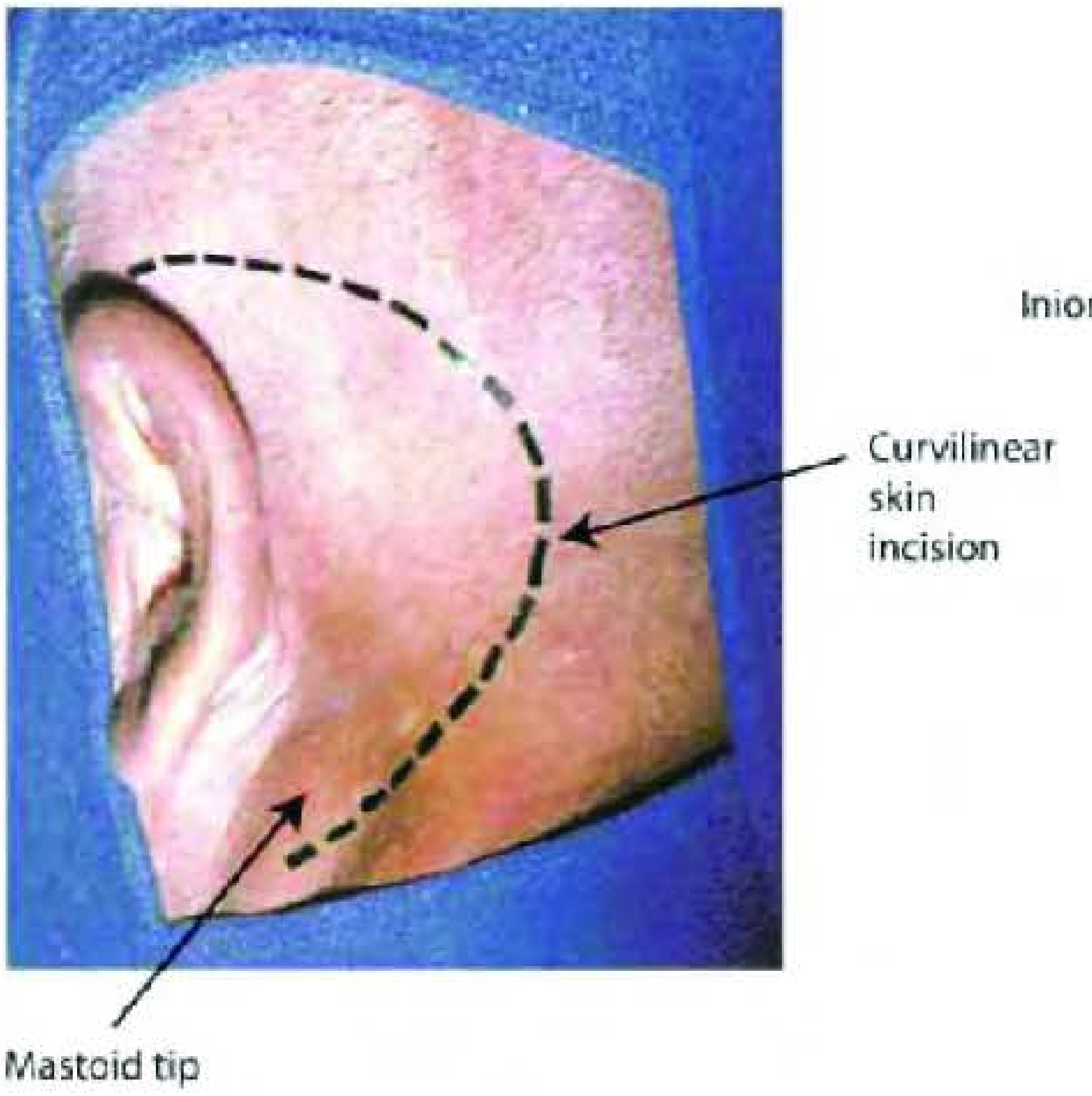

FIGURE 13–1 Semicircular retroauricular incision.

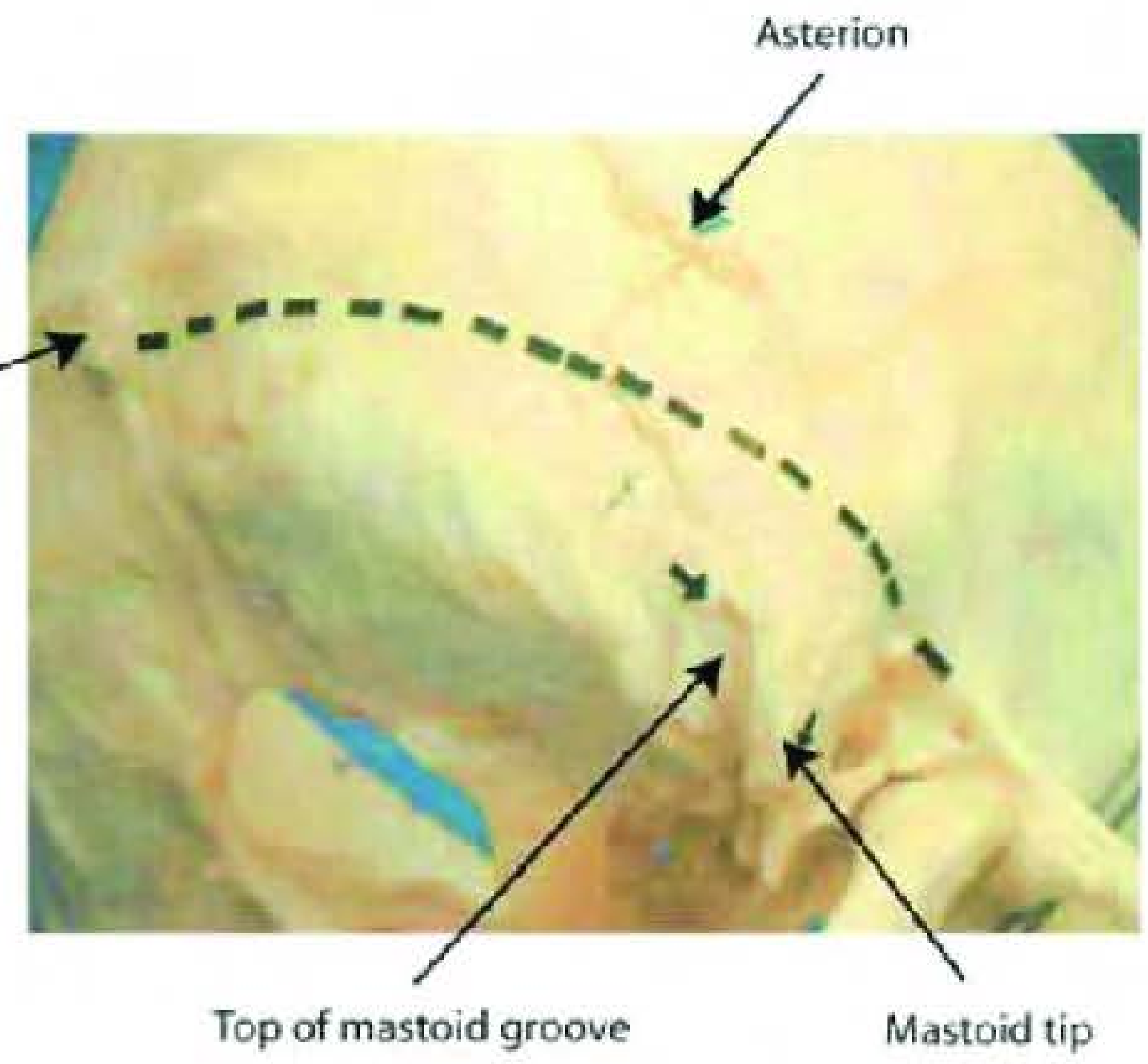

FIGURE 13–2 Impotant landmarks for posterior fossa surgery include the mastoid tip and groove, the inion, and a line between the inion and the posterior zygomatic root.

Surgical Technique

The suboccipital muscles are stripped away from the underlying bone in a subperiosteal fashion and a self-retaining retractor placed. Either a craniotomy or a craniectomy may be performed (Fig. 13–3). A craniectomy is performed by placing multiple burr holes that are then connected with a rongeur. A craniotomy flap can be turned with the aid of a high-speed air drill. For pathology in the region of the fifth nerve and tentorium, the craniotomy musl allow for visualization of the transverse/sigmoid junction superiorly. The bone opening need not include an opening of the foramen magnum. For pathology in the region of the VII/VIII complex, the transverse/sigmoid junction should be visualized and, depending on the size of the tumor, the foramen magnum may need to be opened. For pathology involving the lower CNs, the transverse sinus need not be visualized, but the sigmoid sinus remains the lateral border. The foramen magnum should be opened.

Typically a K-shaped incision is made in the dura with the edges being based on the sinus. Occasionally, this is

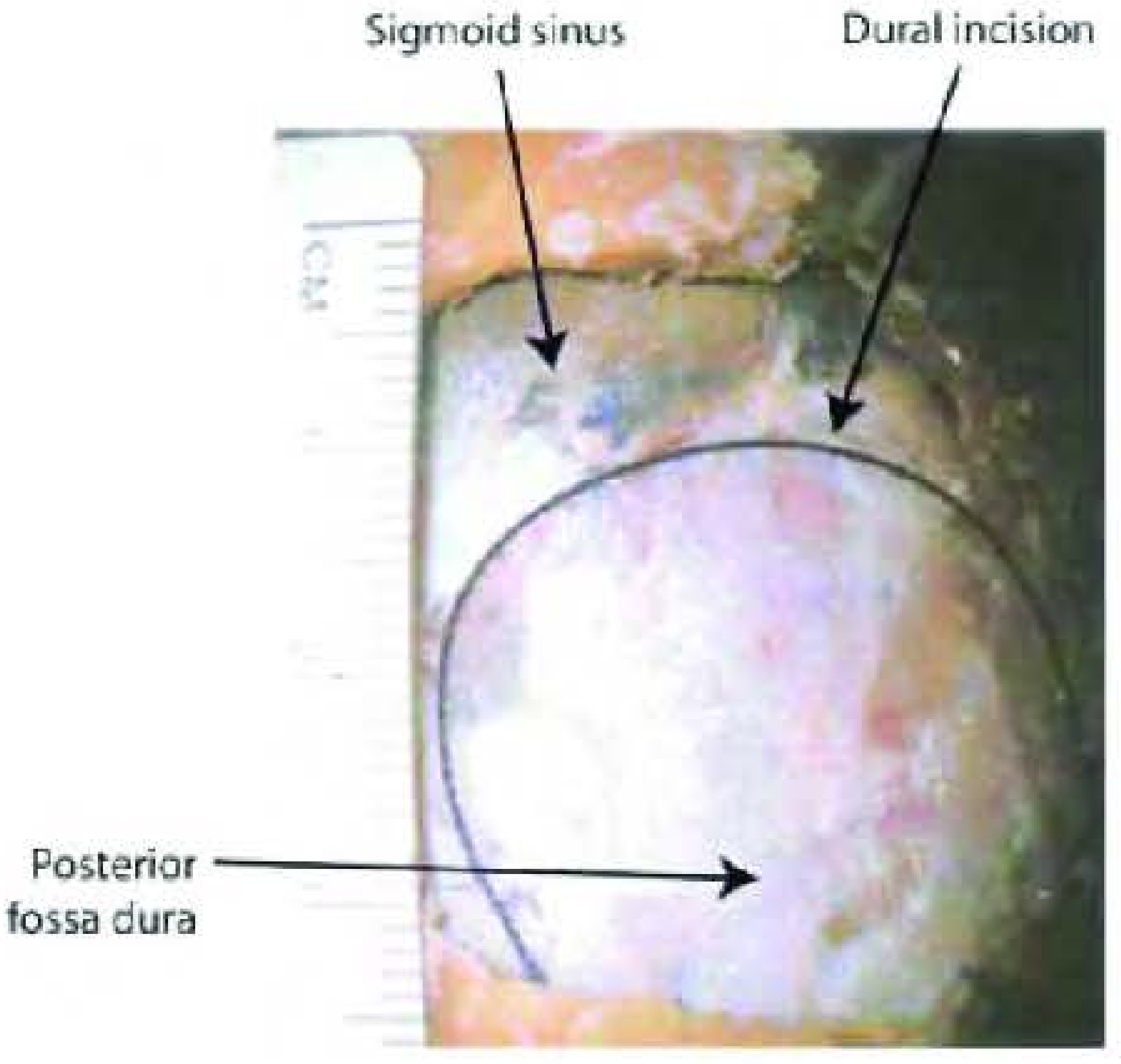

FIGURE 13–3 A craniotomy has been turned and a dural incision outlined.

done in the reverse, with the cut being made close to the sinus and the flaps reflected back toward the midline.

The lateral surface of the cerebellar hemisphere is visualized, and the operating microscope is brought into the field. With gentle medial and superior retraction on the inferior portion of the Lateral cerebellum, the cisterna magna comes into view. The arachnoid of this cistern is opened with an arachnoid knife to allow the egress of cerebrospinal fluid (CSF). This maneuver generally will relax the cerebellum to the extent that almost no retraction is needed for the remainder of the procedure.

For upper cerebellar pontine pathology, the retractor is placed superiorly and the cerebellum is gently retracted medially. This will bring into view, most prominently, the superior petrosal vein, the superior cerebellar artery, and the fifth nerve coursing toward Meckel's cave (Fig. 13–4). The tentorium is just above. The fourth nerve may be seen running toward the medial edge of the tentorium. Placement of the retractor slightly more inferior, and retracting gently medially, brings into view the seventh and twelfth nerve complex along with the anterior inferior cerebellar artery and its branches (Figs.13–5 and 13–6). These nerves will head toward the internal auditory canal. Moving the retractor slightly more inferiorly on the lateral surface of the cerebellum allows visualization of the CN IX/X/XI complex along with the vertebral artery, the posterior inferior cerebellar artery, and the vertebrobasilar junction

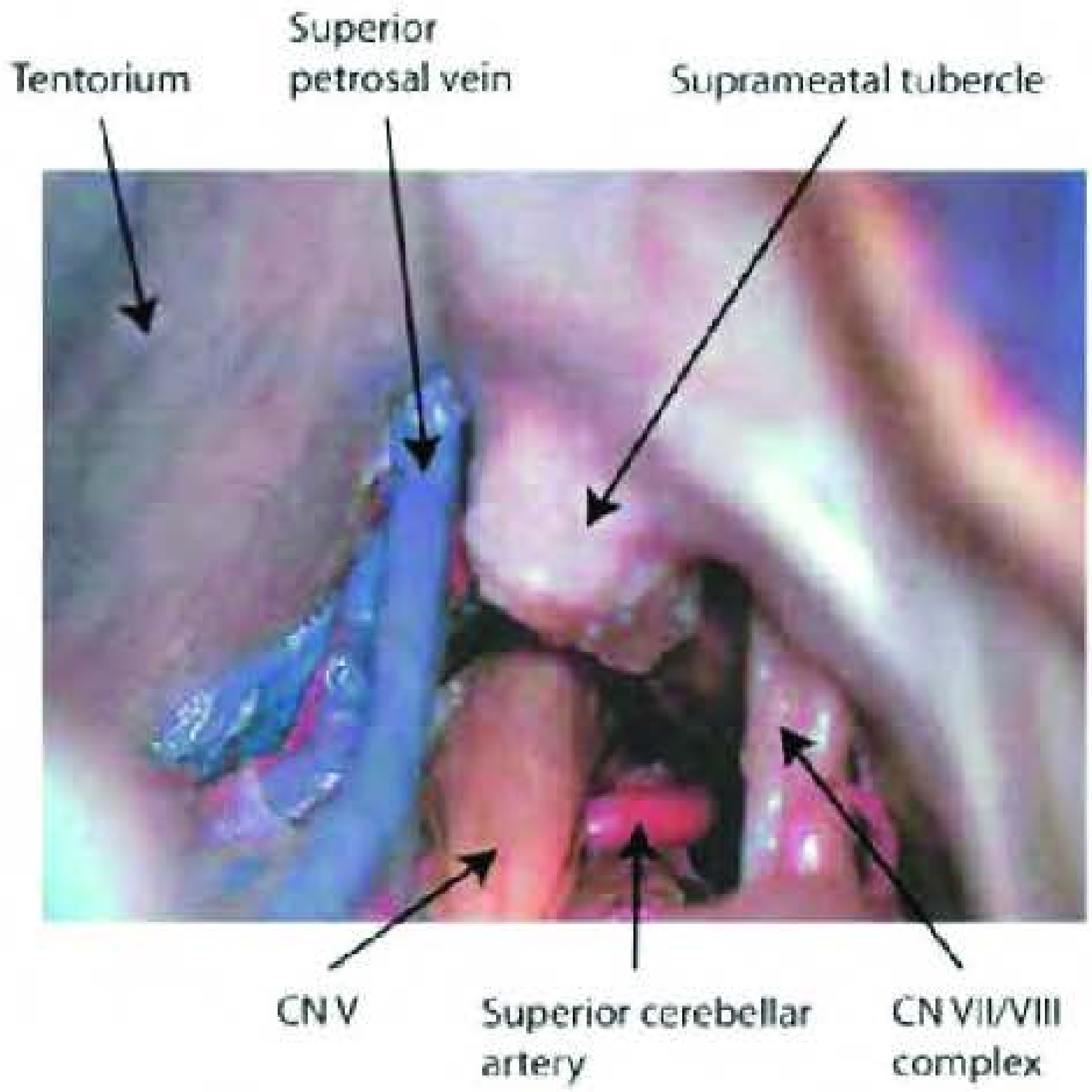

FIGURE 13–4 Superiorly in the cerebellopontine angle, the tentorium is seen, under which lies the superior petrosal vein overlying cranial nerve (CN) V. Interiorly, the VII/VIII complex is seen with branches of the anterior inferior cerebellar artery (AICA).

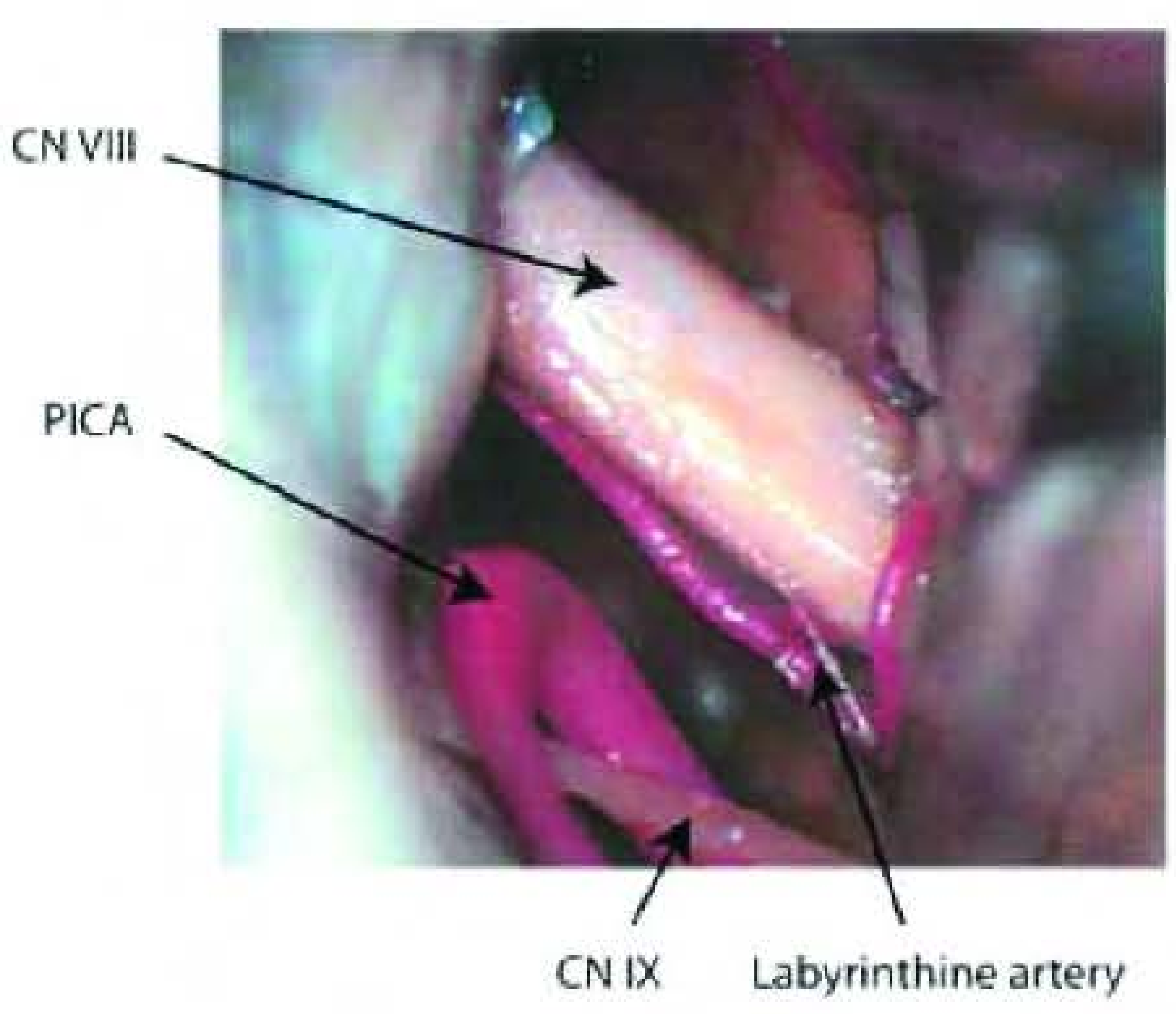

FIGURE 13–5 High-power view of the VII/VIII complex. The labyrinthine artery is seen coursing with the nerves. Inferiorly, the posterior inferior cerebellar artery (PICA) loop is visualized. CN, cranial nerve.

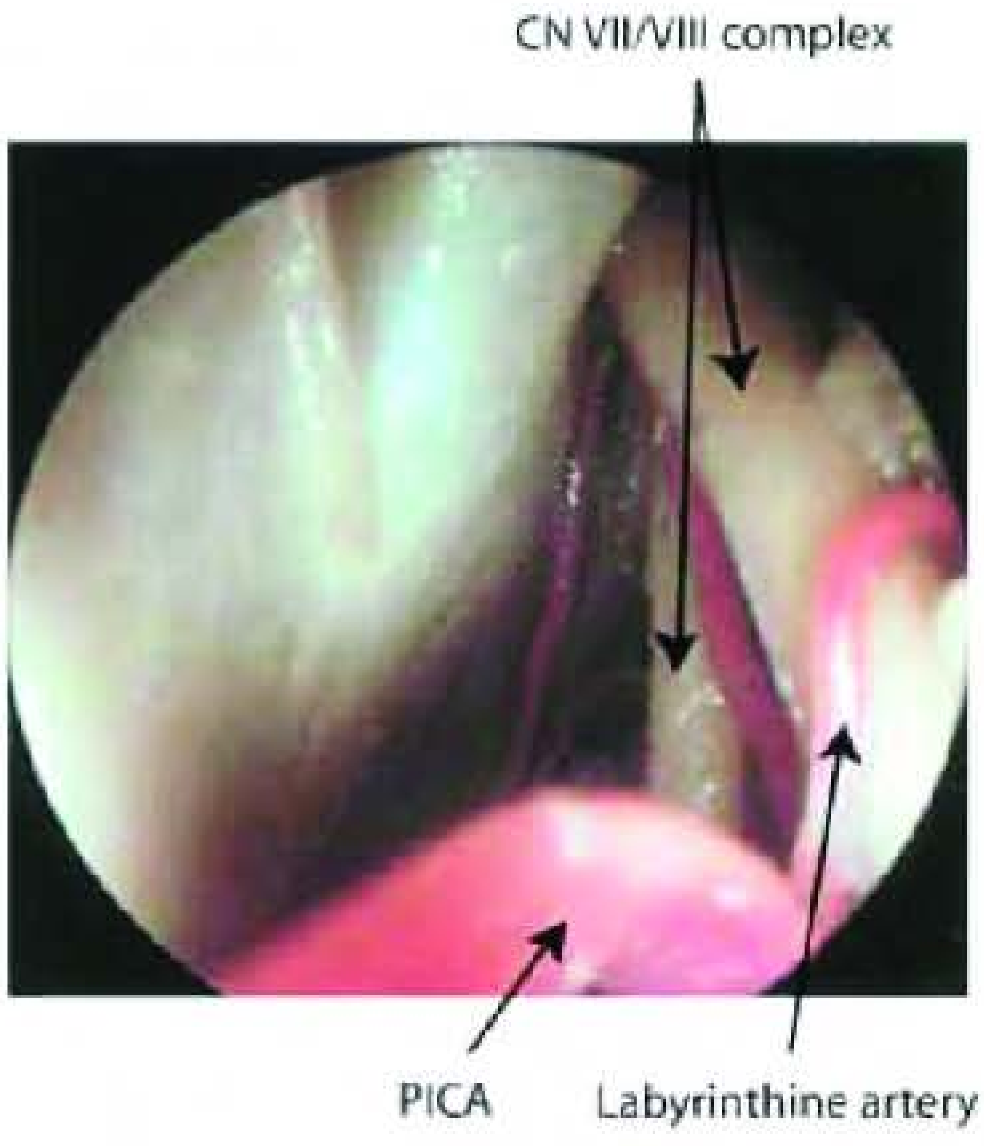

FIGURE 13–6 Endoscopic view. From inferiorly, the seventh nerve is seen anterior to the eighth nerve. The labyrinthine artery is seen coursing with the VII/VIII complex. The posterior inferior cerebellar artery (PICA) loop is well visualized. CN, cranial nerve.

(Fig. 13–7). CN XII can also usually be seen exiting through the hypoglossal canal (Fig. 13–6).

The internal auditory canal must be opened for the resection of some lesions. An inverted U-shaped incision is made in the dura at the opening of the porus acusticus (Fig. 13–9). The dura is gently elevated from the underlying bone and, with a small cutting or diamond burr, the roof of the IAC is opened for a distance of about 1 cm or untit the dura of the IAC is reached. The bone superior and inferior to the canal is drilled to open 180 degrees circumferentially around the IAC. The VII/VIII complex can then he fully visualized within the IAC (Figs. 13–10–13–12).

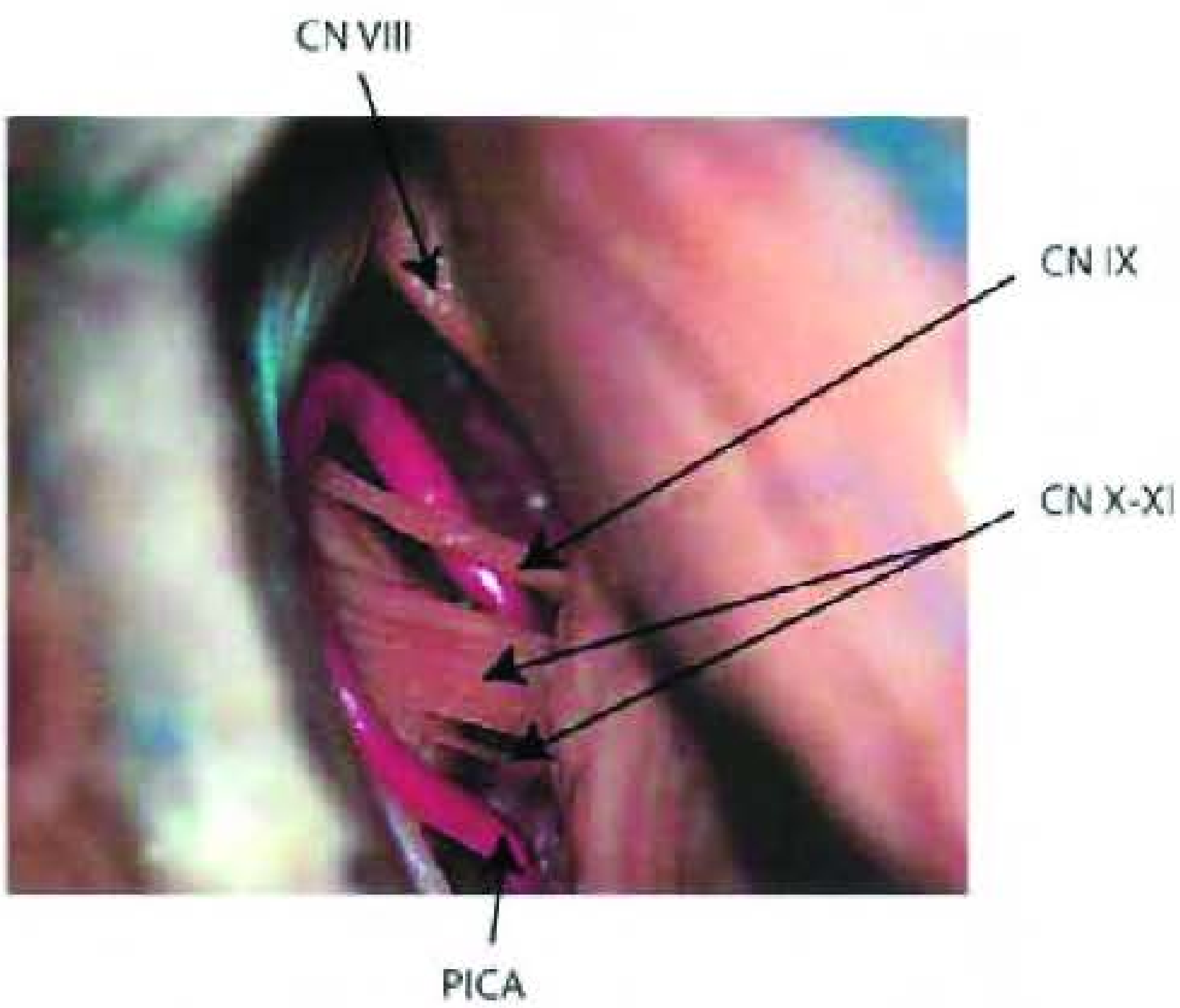

FIGURE 13–7 The lower cranial nerves are seen editing through the jugular foramen. The posterior inferior cerebellar artery (PICA) is seen looping around them. CN, cranial nerve.

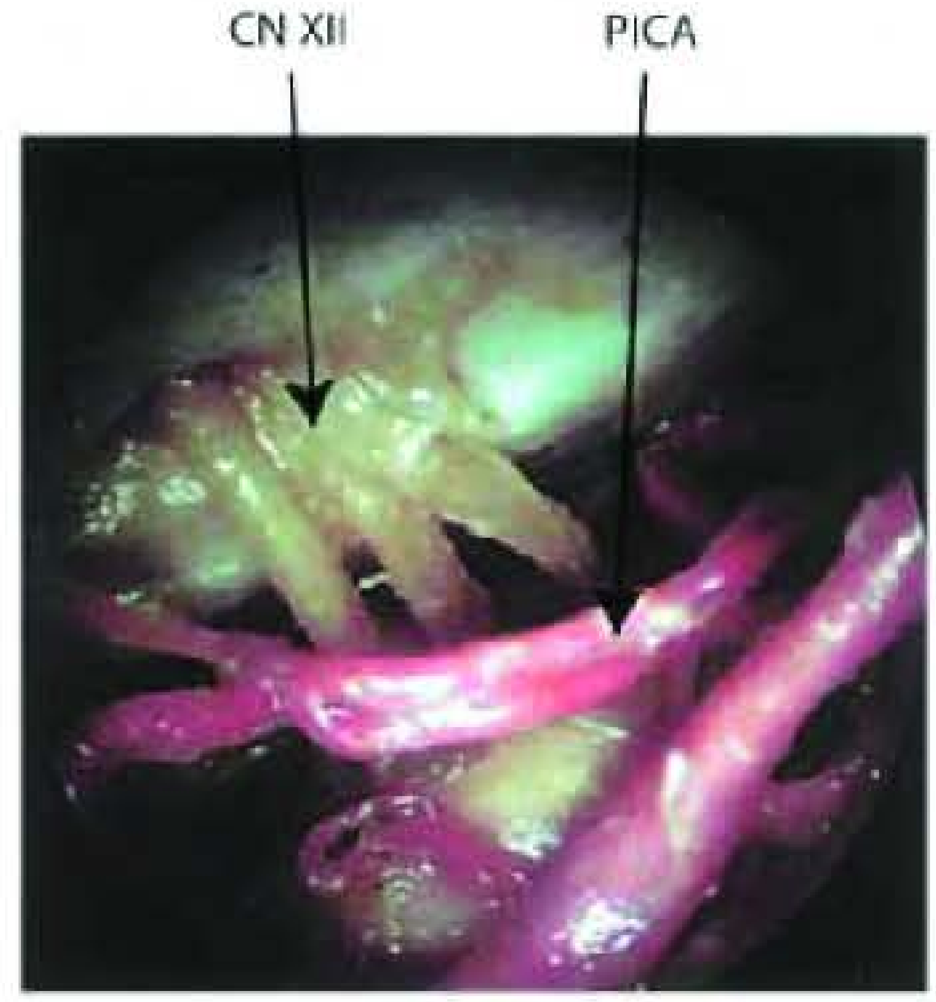

FIGURE 13–8 Twelfth nerve rootlets are seen exiting the hypoglossal canal. Posterior inferior cerebellar artery (PICA) is seen looping around them. CN, cranial nerve.

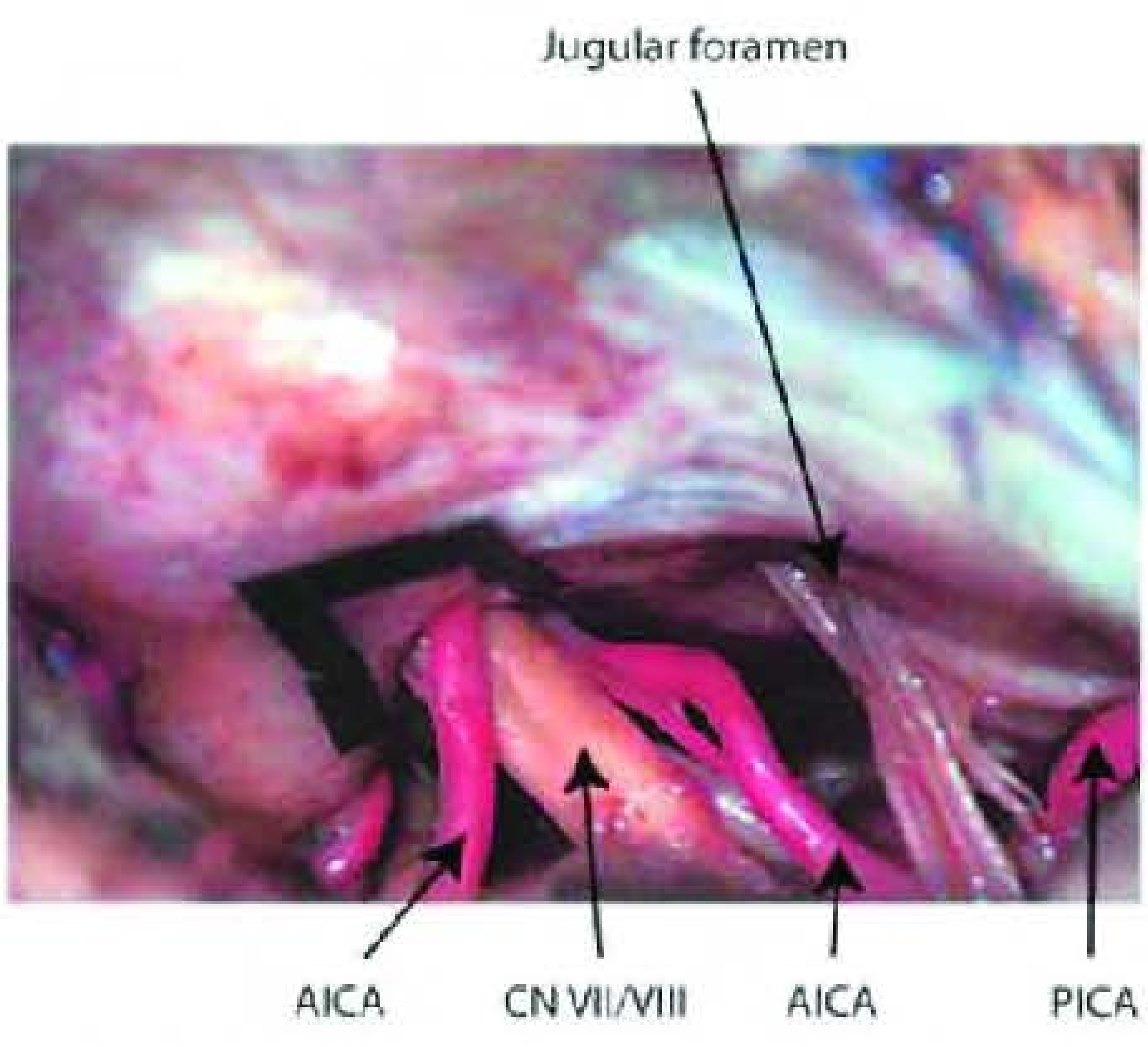

FIGURE 13–9 The dural opening over the porus acusticus is outlined. CN, cranial nerve; PICA, posterior inferior cerebellar artery; AICA, anterior inferior cerebellar artery.

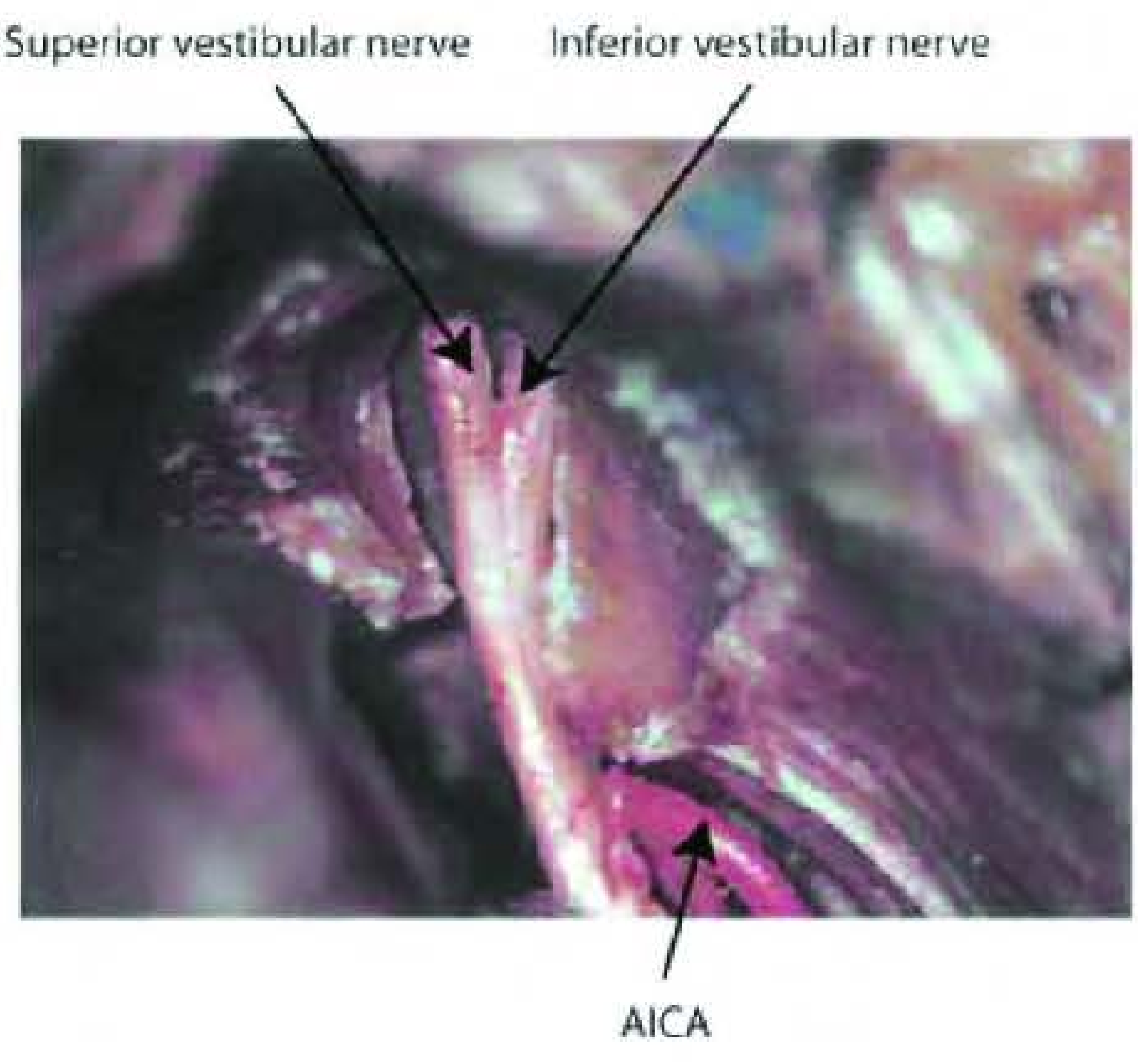

FIGURE 13–10 The internal auditory canal has been drilled exposing the two divisions of the vestibular nerve. The transverse crest separates the two. AICA, anterior inferior cerebellar artery.

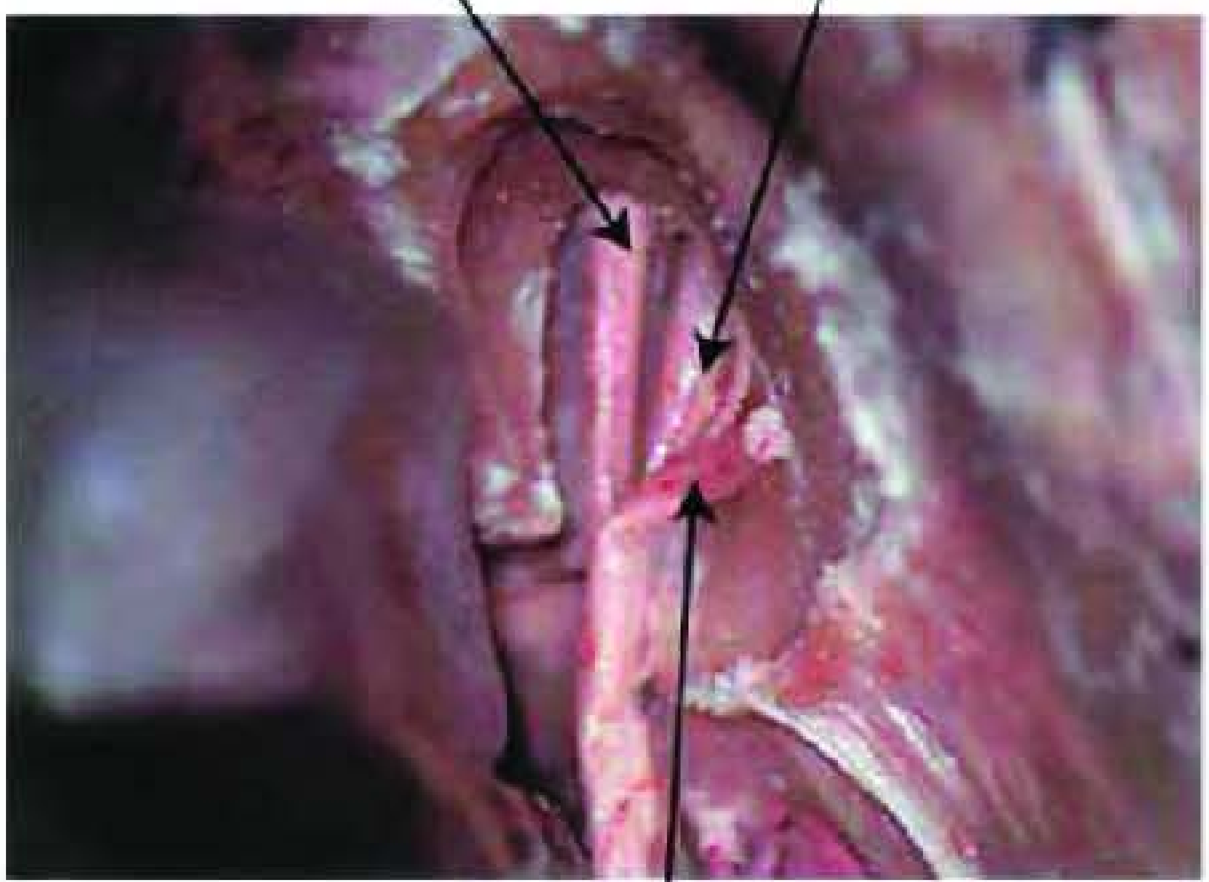

FIGURE 13–11 The vestibular nerve has been reflected to show the facial and cochlear nerves.

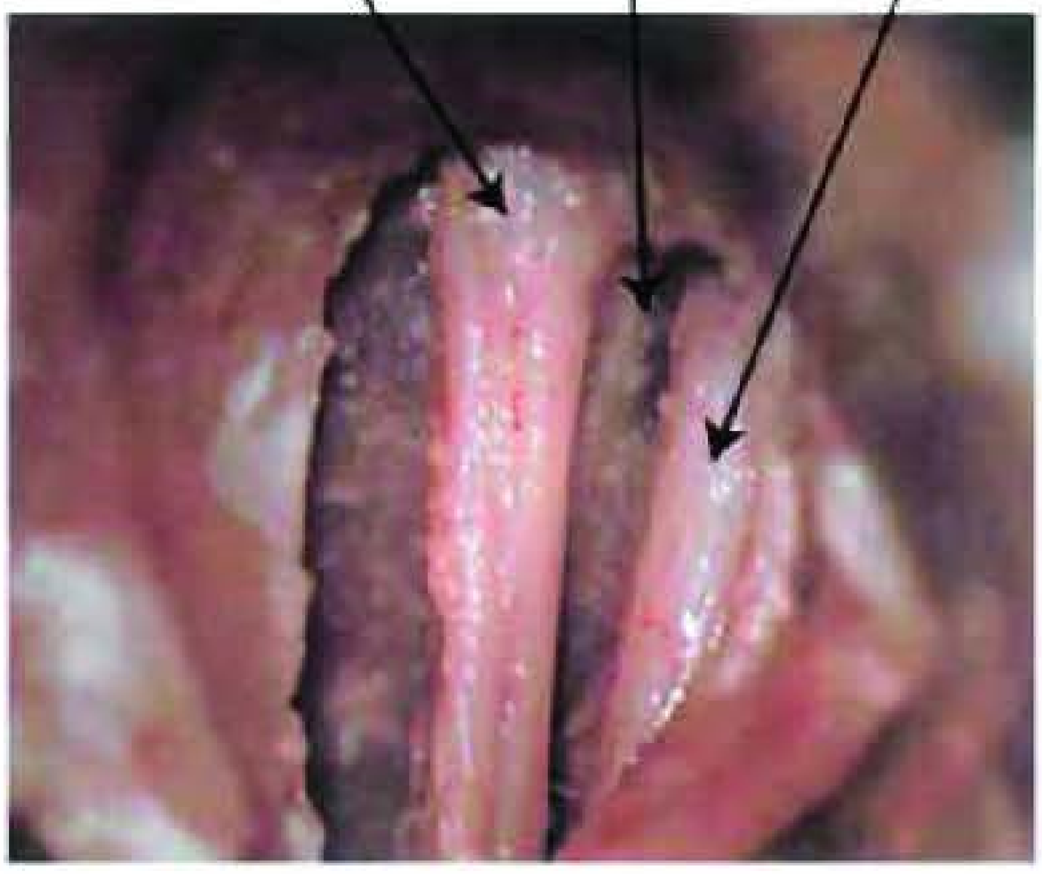

FIGURE 13–12 The facial and cochlear nerves are separated by Bill's bar.

PITFALLS, PEARLS, CONSIDERATIONS

- Air embolism
- Sinus lacerations or occlusions
- Cerebellar contusions
- Hydrocephalus and posterior fossa swelling
- CSF leak
- Postcraniectomy headaches
- Aseptic meningitis
- Bacterial meningitis

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Chapter 14

Midline and Paramedian Suboccipital Approaches

Sajjan Sarma, Damirez Fossett

Indications for Approach

- Vascular and neoplastic pathology of the cerebellar hemispheres, vermis, fourth ventricle, brainstem, and foramen magnum
- Chiari decompression

Anatomy

The cerebellum is divided into a median part, the vermis, and two lateral parts, the cerebellar hemispheres. The vermis is separated clearly from the hemispheres only inferiorly. Each part of the vermis is continuous with some portion of the cerebellar hemispheres, with the exception of the inferior portion of the vermis. Each cerebellar hemisphere is divided into lobes by several fissures. The primary fissure on the superior surface separates the anterior and posterior lobes. The horizontal fissure extends from one middle cerebellar peduncle to the next within the posterior lobe. The posterolateral fissure separates the posterior lobe from the flocculonodular lobe, which is located on the inferior surface of the cerebellum close to the brainstem. The flocculonodular lobe consists of the nodule in the vermis and the laterally located flocculus. The nodulus lies in the undersurface of the midline, and the flocculus lies adjacent to the vestibulocochlear nerve.

The cerebellum attaches to the brainstem via the peduncles. The inferior cerebellar peduncle connects the cerebellum to the medulla. The middle cerebellar peduncle, the largest of the cerebellar peduncles, attaches the cerebellum to the base of the pons. The superior cerebellar peduncle projects from the midbrain and diencephalon. From lateral to medial, there are four intracerebellar nuclei: the dentate nucleus, the emboliform nucleus, the globose nucleus, and the fastigial nucleus.

The cerebellum is separated from the brainstem by the fourth ventricle. The upper part of the tent-shaped roof of the fourth ventricle, which extends between the two superior cerebellar hemispheres, is called the *anterior medullary velum*. The lingula, a midline portion of the cerebellum, is attached to the anterior medullary velum. The lower portion of the roof, from which is attached the choroid plexus of the fourth ventricle, is formed by a thin pia–ependymal lining. This membrane is referred to as the *posterior medullary velum*. The anterior medullary velum is contiguous with the posterior medullary velum at the apex of the fourth ventricle, called the *fastigium*. Two lateral apertures, the foramina of Luschka, allow the egress of cerebrospinal fluid (CSF) into the cerebellopontine cistern. The foramen Magendie, a median aperture, allows the egress of CSF into the cerebellomedullary cistern.

The floor of the fourth ventricle is rhomboid shaped. A median sulcus can be seen in the midline that divides the rhombus into symmetrical sides. On each side runs a ridge called the *median eminence*, each bounded laterally by the sulcus limitans. At the most inferior end of the fourth ventricle is the obex. In the floor of the fourth, the stria medullaris can be seen connecting the arcuate nucleus with the middle cerebral peduncle. The facial colliculus overlies the abducens nucleus and the genu of the facial nerve. The locus ceruleus lies just rostral to the facial colliculus. Just posterior to the stria medullaris lies the hypoglossal trigone, which overlies the hypoglossal nerve. The vagal trigone lies lateral and posterior to the hypoglossal trigone and overlies the vagus nerve nucleus. The vestibular area lies just beneath and lateral to the stria medullaris and overlies the eighth nerve nucleus.

Positioning and Skin Incision

Both the midline and paramedian approaches can be performed with the patient in either the prone or sitting position (Fig. 14–1A, B). The prone position has the advantages of (1) minimizing the likelihood of air embolism and (2) achieving the controlled release of CSF. In the sitting position, blood, by virtue of gravity, drains out of the field, ventilation is unencumbered, and venous drainage may be enhanced, thus reducing intracranial pressure. Air embolism and surgeon's arm fatigue are disadvantages of the sitting position.

If the prone position is chosen, the head is placed in Mayfield three-point fixation, the patient is placed on chest rolls, and all pressure points are well padded. For paramedian incisions, the head can be rotated so that the operative side is uppermost. In the sitting position, three-point fixation is also used; however, precordial Dopplers and a central venous line to the right atrium should be placed to detect and evacuate air emboli.

The skin incision uses knowledge of several surface landmarks, including the mastoid tip for paramedian incisions and the inion and spinous processes of C2 and the lower cervical spine. The transverse sinus runs approximately from the level of the inion to the external auditory meatus. The sigmoid–transverse junction is near the mastoid notch. The sigmoid sinus is under the mastoid groove,

For a midline suboccipital approach, the skin incision begins 2 to 3 cm above the inion and is carried to the upper cervical spine region. For paramedian lesions, the skin incision may be an inverted U-shaped incision or a linear or slightly curvilinear one based over the location of the lesion.

SURGICAL TECHNIQUE

The underlying muscles are stripped away from the suboccipital bone, upper cervical lamina, and spinous processes in a subperiosteal fashion (Fig. 14–2). Cerebellar or bent Adson self-retaining retractors are used to maintain adequate exposure. For paramedian exposures, the occipital artery must be identified and coagulated appropriately to maintain intraoperative and postoperative hemostasis.

Either a craniotomy or a craniectomy can be performed. Two burr holes can be placed on either side of the midline septum with a Codman perforating burr, and after dural separation, the Midas B1 foot-plated tool can be used to turn a craniotomy flap. Alternatively, a B1 or C1 tool can be used to score the margins of a flap, and then a Kerrison 1 can be used to liberate the bone flap. A craniectomy is performed by perforating the bone with multiple burr holes. Rongeurs can be used to connect the burr holes, thereby completing the bone removal. For a paramedian approach, the same techniques can be used. The foramen magnum is generally opened with rongeurs, and for pathology that extends into the upper cervical spine, posterior cervical laminectomies can be performed in the usual fashion

For the midline approach, dura is generally opened in a Y-shaped fashion. The straight limb of the "Y" is carried down to the region of the foramen magnum or below if the pathology extends into the spinal canal. The inferior sagittal sinus occasionally is prominent and requires ligation. Dural flaps are reflected superolaterally and held by stitches. The cerebellar hemispheres and vermis come immediately into view (Figs. 14–3 and 14–4). The arachnoid over the cistema magna is then entered to drain CSF and allow for brain relaxation.

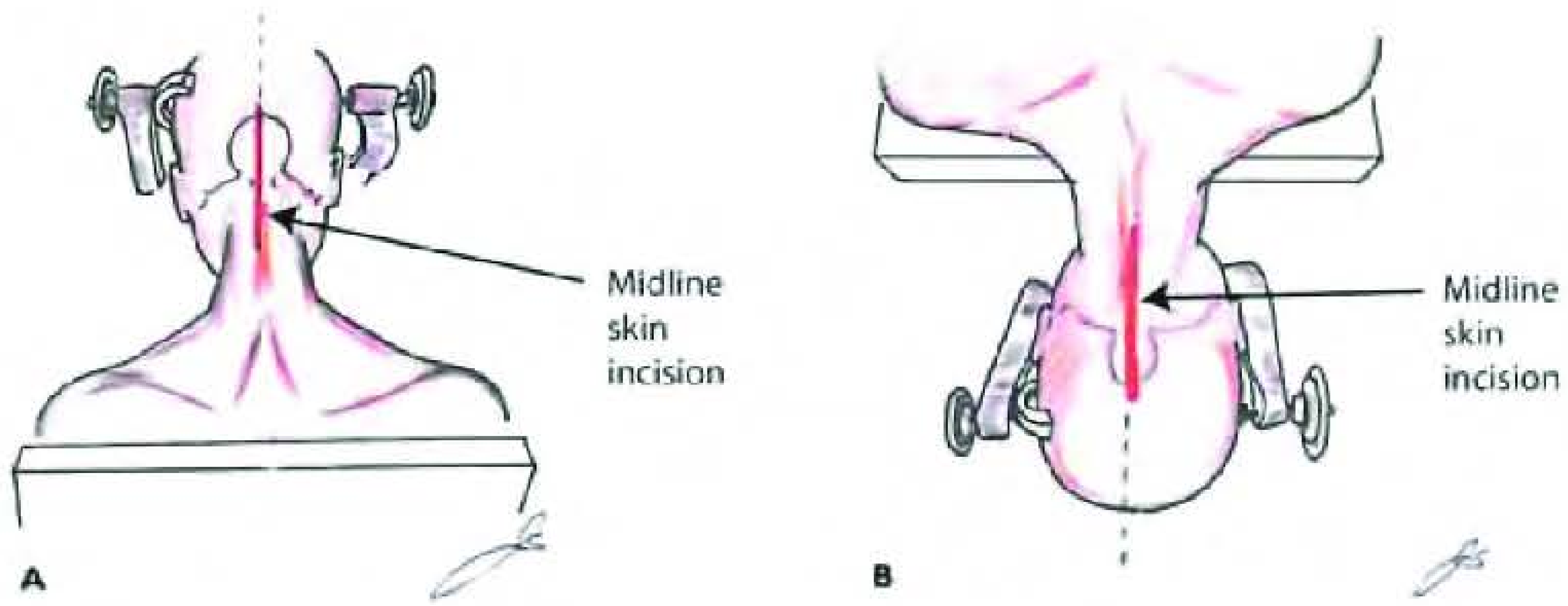

FIGURE 14–1 A: Midline skin incision done with the patient in the sitting position. B: Midline skin incision with patient in the prune position.

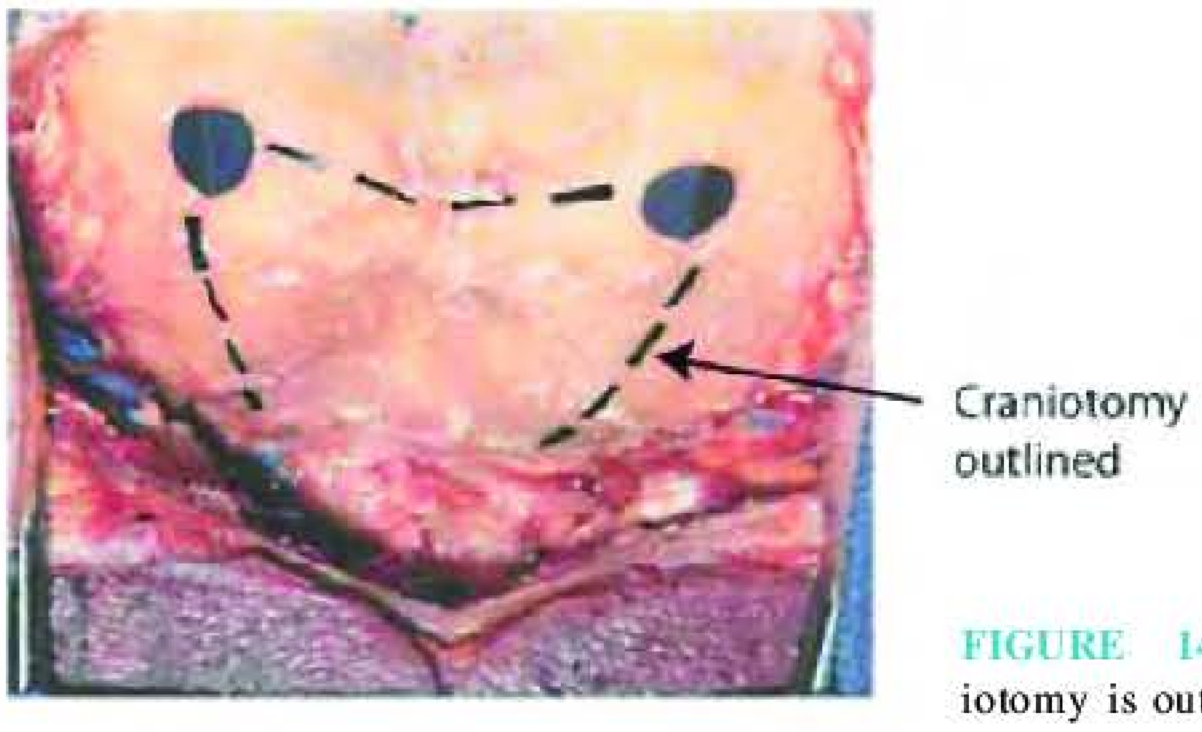

FIGURE 14–2 The inion and lamina of C1 are seen. The craniotomy is outlined.

As the arachnoid is separated, the cerebellar tonsils arc seen abutting in the midline. Interiorly, the loops of the posterior inferior cerebellar artery (PICA) may be seen in relation to the tonsils. PICA anatomy may be variable; therefore, a review of the preoperative angiogram is probably wise. The tonsils may be carefully mobilized by sectioning arachnoid bands. Then they are retracted laterally with self-retaining retractors, taking care not to injure or compress PICA. As the tonsils are retracted, the foramen Magendie is opened and the floor of the fourth ventricle Can be Seen. To reach the lateral recesses of the fourth ventricle, the tonsils and flocculus of the cerebellum need to be mobilized further by incising tethering arachnoid bands and retracting laterally. As the tonsils are retracted laterally, the inferior medullary velum can be seen covering the region of the foramen of Luschka (Fig. 14–5). The inferior and lateral portions of the ventricle are now visualized (Fig. 14–6). To view the upper part of the fourth ventricle, a small incision is made in the inferior section of the vermis between the vermian arteries, and the two cerebellar hemispheres are retracted laterally. The upper portion of the ventricle and aqueductal orifice can be appreciated.

For the paramedian approach, entrance into the hemispheres is made by coagulating the pia–arachnoid and performing a corticectomy that uses the bipolar cauterization and suction technique,

Closure of the posterior fossa must be in a watertight fashion and occasionally will require the use of dural substitutes or autologous grafts. The muscles and skin should be closed in multiple layers to act as a barrier against CSF leakage.

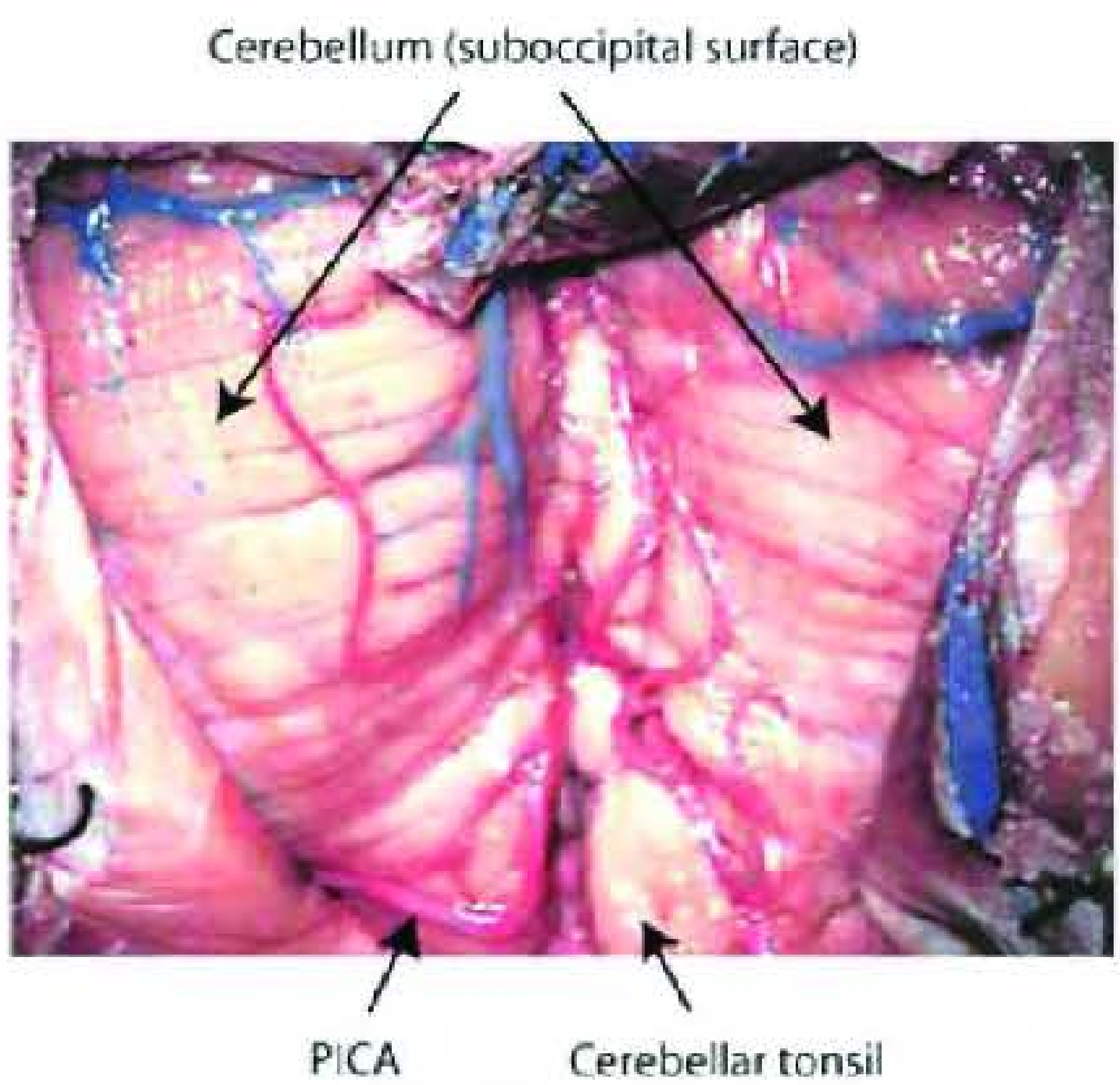

FIGURE 14–3 Both cerebellar hemispheres are visible after opening the dura.

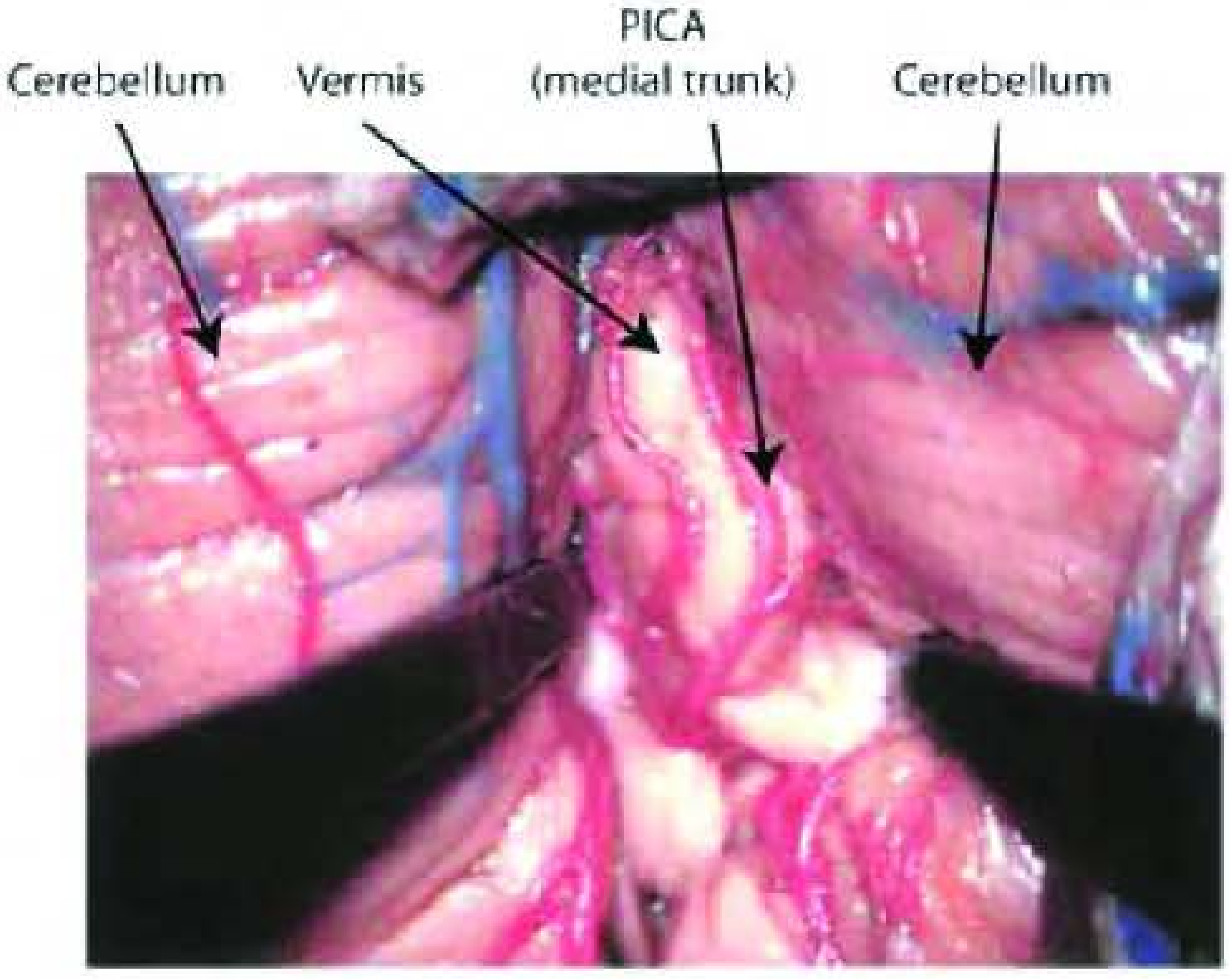

FIGURE 14–4 Separation of the hemispheres exposes the vermis and both posterior inferior cerebellar arteries (PICAs).

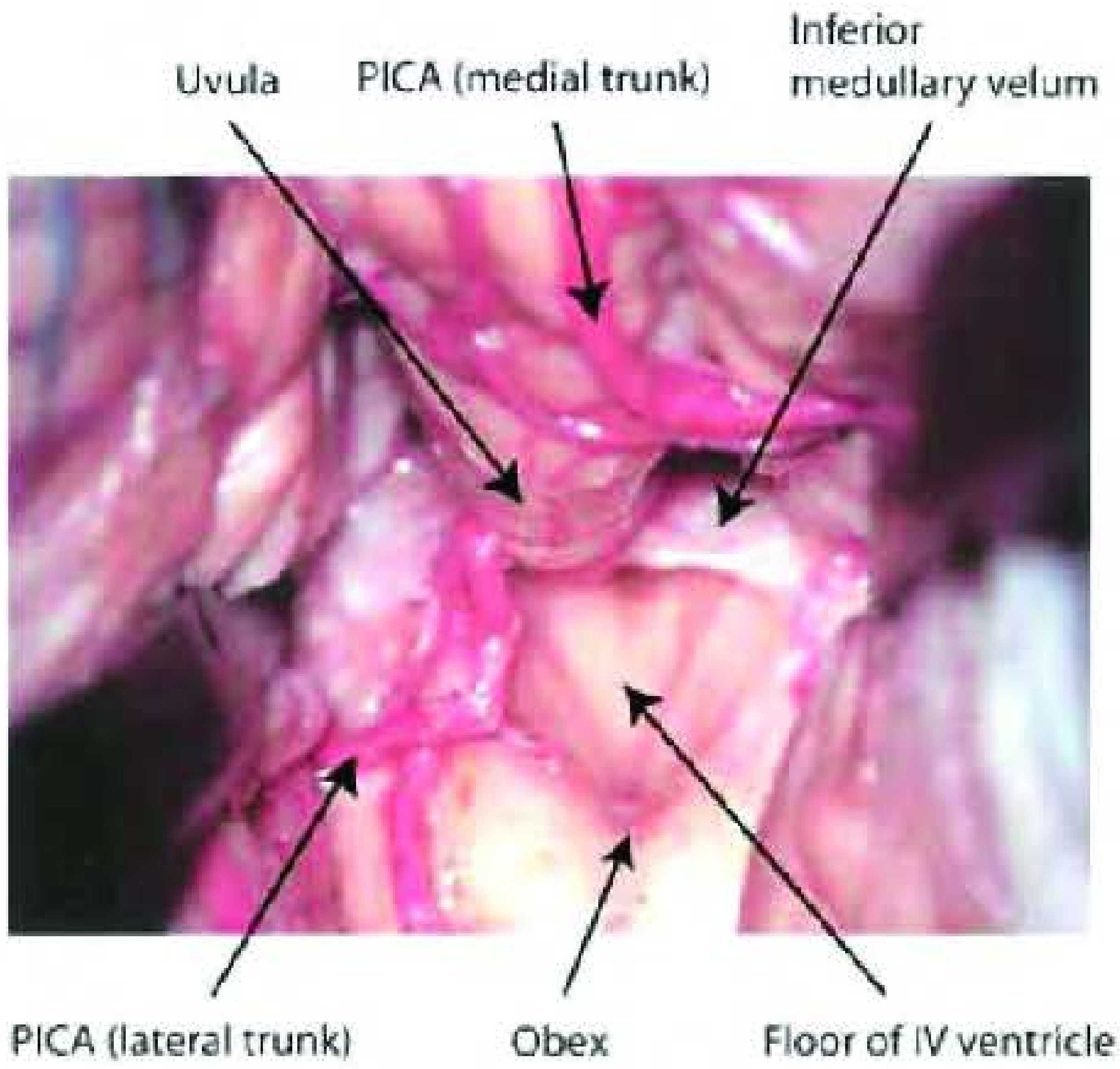

FIGURE 14–5 The floor of the fourth ventricle is seen. A posterior inferior cerebellar artery (PICA) branch, the obex, inferior medullary velum, and uvula are also well visualized.

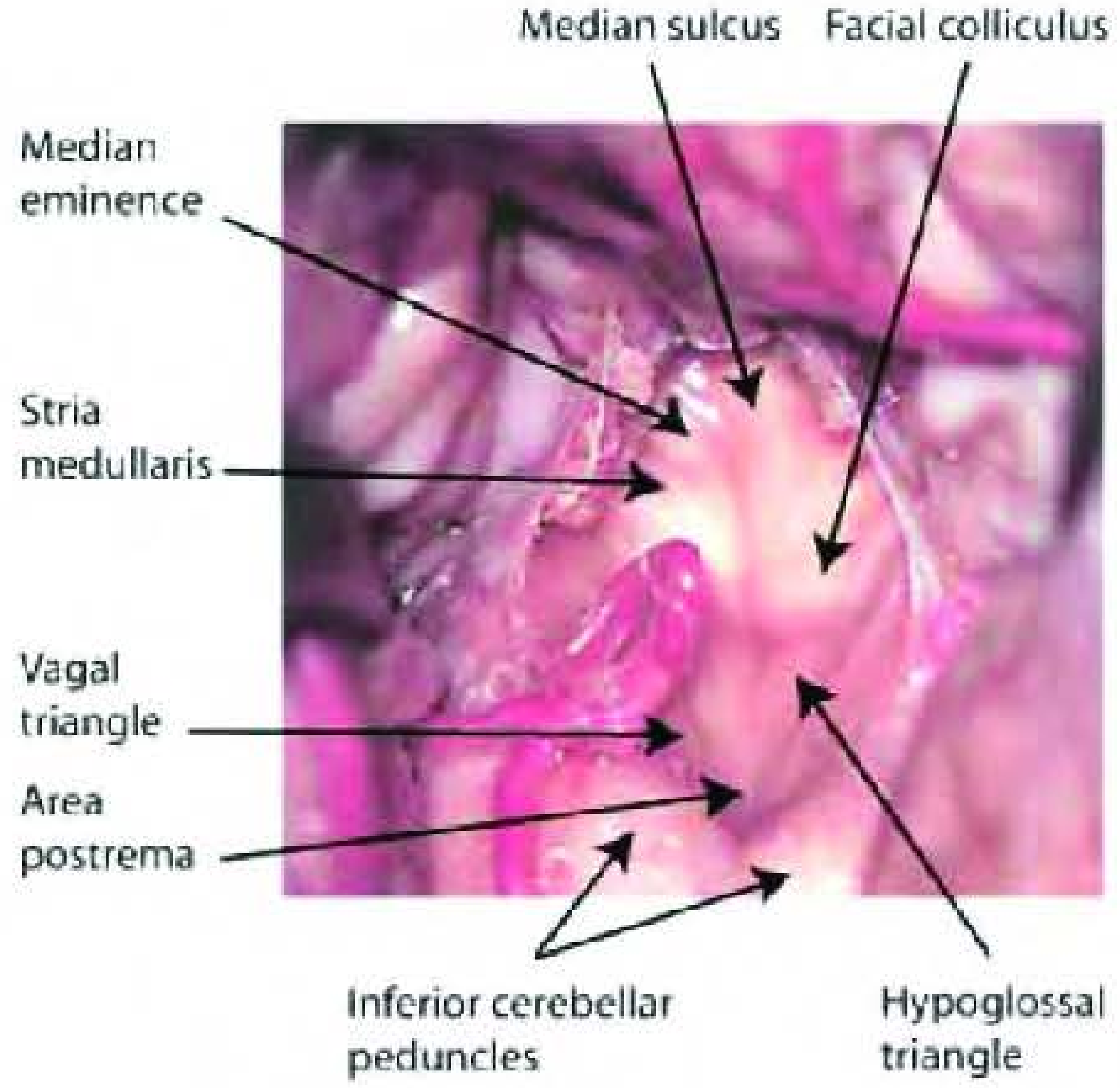

FIGURE 14–6 The inferior cerebellar peduncle and structures in the floor of the fourth ventricle are visualized.

PITFALLS, PEARLS, CONSIDERATIONS

- Good hemostasis must be achieved
- Postoperative hematomas
- Avoid sinus injuries
- Avoid cerebellar contusions
- Avoid vascular compression or injury especially to PICA
- Watertight closure to prevent CSF fistula
- Air embolism

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EXTREME LATERAL APPROACH

Emel Avci, Carlos Acevedo, Damirez Fossett

INDICATIONS FOR APPROACH

- Intradural mass lesions ventral to the cervicomedultary junction
- Extradural tumors involving the lower clivus, occipital condyle, or jugular foramen
- Vertebral artery involvement in rheumatological and developmental disease
- Vertebral artery and vertebral–basilar junction aneurysms
- Arteriovenous malformations located anteriorly near the midline

ANATOMY

Performance of the extreme lateral approach requires understanding the musculoskeletal and neurovascular anatomy of this complex region.

MUSCLES

The muscles are grouped in three layers. The first and most superficial layer of muscles encountered includes the sternocleidomastoid (SCM) laterally and the trapezius medially (Fig. 15–1). The sternocleidomastoid overlies the C1 transverse process and attaches to the mastoid process. The middle layer of muscles encountered includes the splenitis capitis, longissimus capitis, semispinalis capitis, and splenius cervicis. Detaching the SCM and reflecting it laterally exposes the upper extension of the splenitis capitis (Fig. 15–2A). Detaching the splenius capitis muscles and reflecting them medially exposes the longissimus capitis muscle (Fig. 15–2B). Reflecting the longissimus muscle downward exposes the semispinalis capitis and the superior and inferior oblique muscles as well as the transverse process of the atlas. The semispinalis capitis is reflected medially to expose the inner muscle layer that bounds the suboccipital triangle (Fig. 15–3), The inner muscle layer is composed of the superior and inferior oblique muscles and the rectus capitis posterior major. The triangle deep to this muscle is covered by a layer of dense fibrofatty tissue. The structures in the triangle are the vertebral artery and the C1 nerve.

BONE

The occipital bone surrounds the foramen magnum. It is divided into a squamosal part located above and behind the foramen magnum, a basal part situated in front of the foramen magnum, and paired condylar parts located lateral to

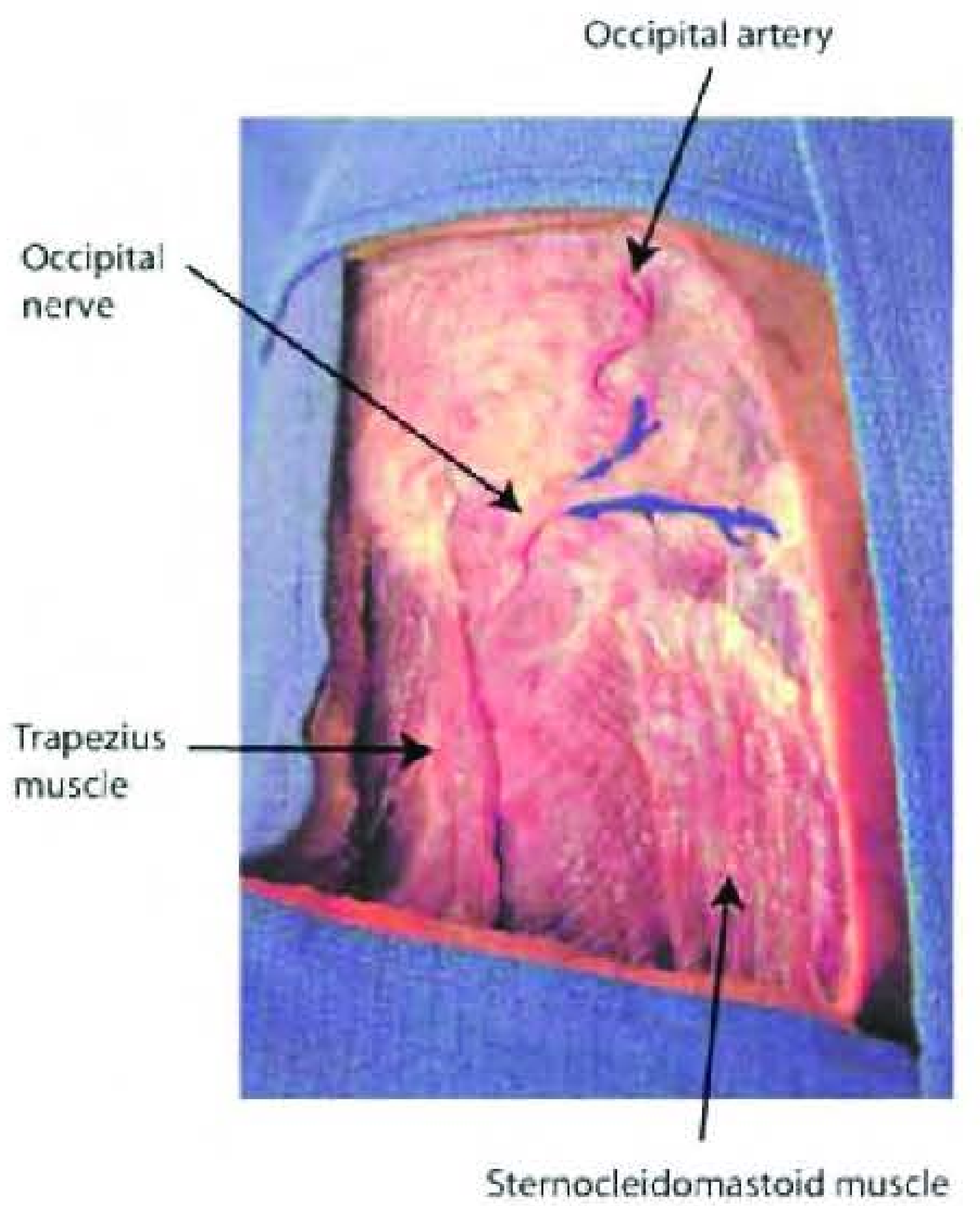


FIGURE 15–1 The superficial-most muscle layer is composed of the trapezius and sternocleidomastoid muscles

the foramen magnum. The paired occipital condyles articulate with the superior articular processes of the atlas. These condyles are located lateral to the anterior half of the foramen magnum. The hypoglossal canal, which transmits the hypoglossal nerve, is situated above the condyle and is separated from the jugular foramen by the jugular tubercle. The hypoglossal canal is surrounded by cortical bone. The contents of the hypoglossal canal are the hypoglossal nerve and meningeal branch of the ascending pharyngeal artery and the venous plexus of the hypoglossal canal. The intracranial end of the hypoglossal canal is located approximately 5 mm above the junction of the posterior and middle third of the occipital condyle and approximately 5 mm below the jugular tubercle. The canal is directed forward and laterally at a 45-degree angle with the sagittal plane. On the intracranial surface of the condylar part, an oval prominence, the jugular tubercle sits just superior to the hypoglossal canal and just medial to the lower extent of the petroclival fissure. The jugular foramen is situated lateral and slightly superior to the anterior half of the condyles. It is bordered posteriorly by the jugular process of the occipital bone and anteriorly and superiorly by the jugular fossa of the petrous portion

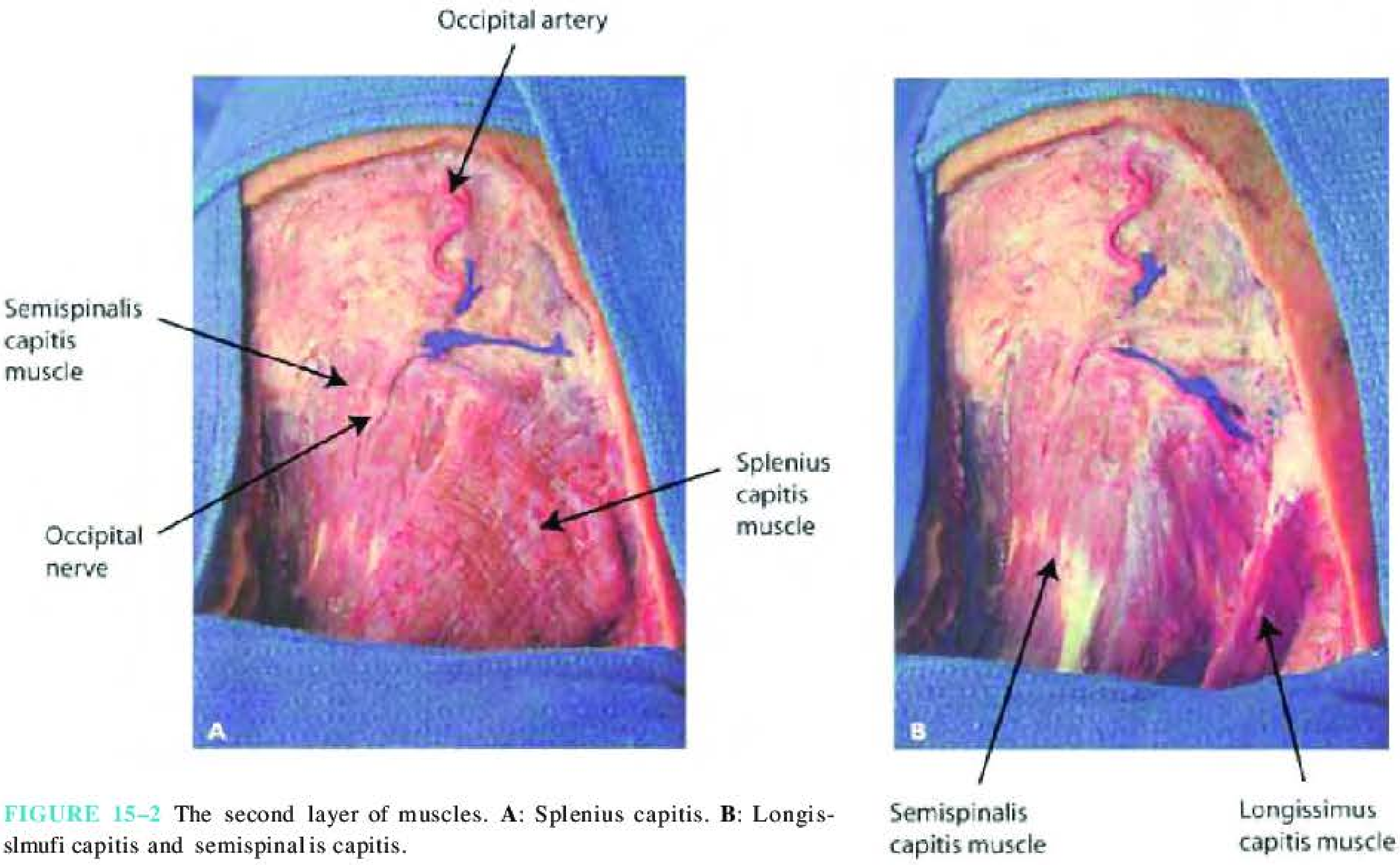


FIGURE 15–2 The second layer of muscles. **A**: Splenius capitis. **B**: Longisslmufi capitis and semispinal is capitis.

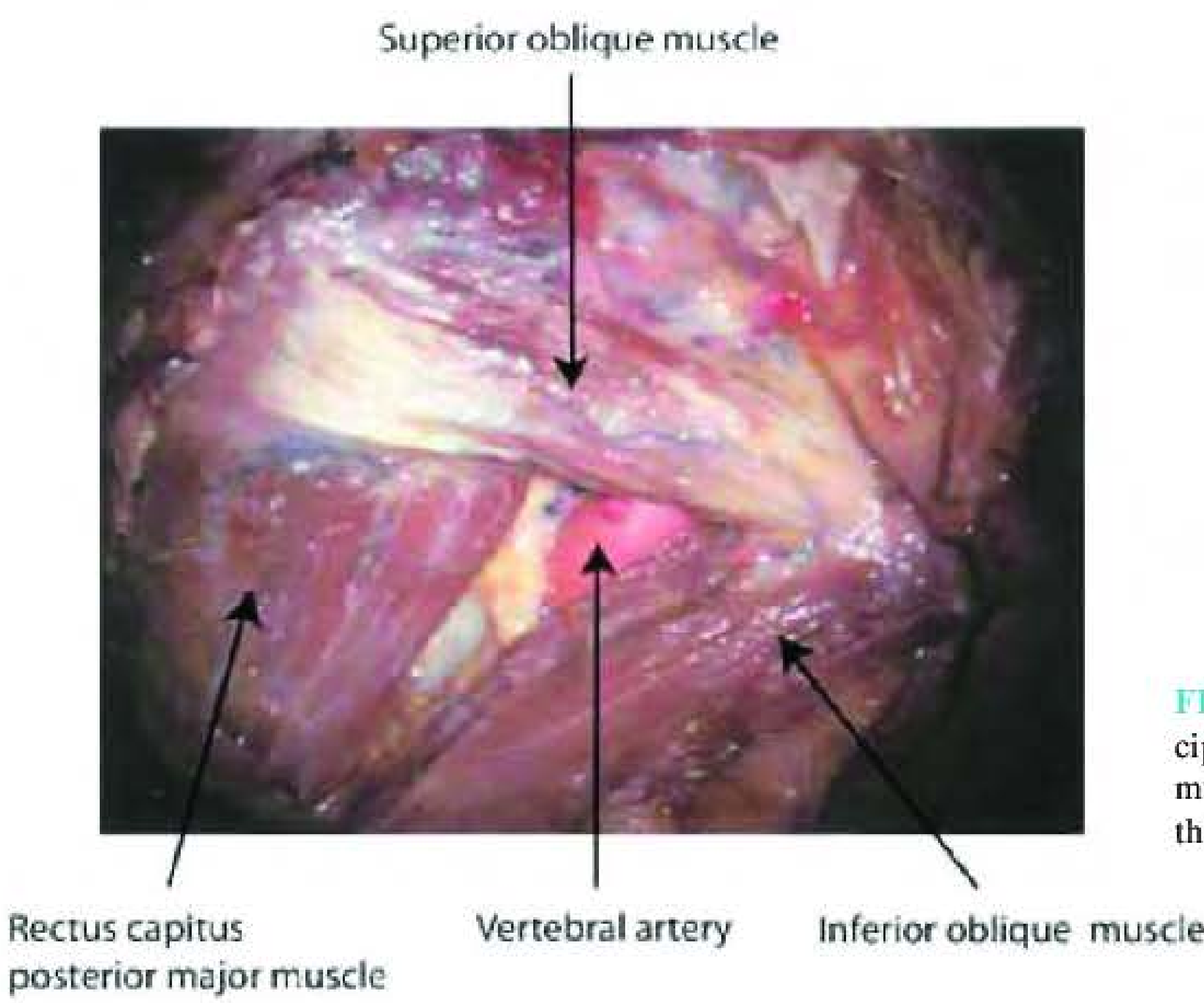


FIGURE 15–3 The deepest layer of muscles is the suboccipital triangle composed of the inferior and superior oblique muscles and the rectus capitis posterior major. In the floor of this triangle, the vertebral artery will be seen.

of the temporal bone. The structures that traverse the jugular foramen are the sigmoid sinus and jugular bulb, inferior petrosal sinus, inferior meningeal branch of the ascending pharyngeal artery, the occipital artery, the glossopharyngeal vagus, and accessory nerves with their ganglia.

The atlas, the first cervical vertebra, differs from the other cervical vertebra by being ring-shaped and lacking a vertebral body and spinous process. The upper surface of each lateral mass has an oval conchal facet that faces upward and medially and articulates with the occipital condyle that faces downward and laterally. Each transverse foramen that transmits the vertebral artery, and on which the nerve root sits is situated between the lateral mass and the transverse process. The axis, the second cervical vertebra, more closely resembles the typical vertebra than the atlas but is distinguished by the odontoid process, which projects upward from the body. The dens is 1.0 to 1.5 cm long and approximately 1.0 cm wide.

NEUROVASCULATURE

The paired vertebral arteries arise from the subclavian arteries and ascend through the process of the sixth cervical vertebral, pass behind the lateral masses of the axis, enter the dura mater behind the occipital condyles, ascend through the foramen magnum to the front of the medulla, and join to form the basilar artery at the pontomedullary junction. Each artery is divided into an intradural and an extradural part. The extradural part is divided into three segments: The first segment extends from the origin al the subclavian artery to the entrance into the lowest transverse foramen, usually at the C6 level. The second segment ascends through the transverse foramen of the upper six cervical vertebrae in front of the cervical nerve roots. This segment deviates laterally just above the axis to reach the laterally placed transverse foramen of the atlas. The third segment, the one most intimately related to the foramen magnum, extends from the foramen in the transverse process of the atlas to the site of passage through the dura mater. The vertebral artery is covered by fatty tissue and by a heavy venous plexus. The venous plexus may be encountered first in the fascial layer between the middle and inner muscle layers. The major emissary vein encountered during this approach is the posterior condylar emissary vein. It is located just posterior and lateral to the occipital condyle and joins the jugular bulb. The vertebral artery penetrates the atlantooccipital membrane and is surrounded by a thickened ring of dura as it enters the subarachnoid space. The C1 nerve root passes through the dura mater of the lower surface of the vertebral artery between the artery and the groove on the posterior arch of the atlas with the vertebral artery.

The intradural segment of the artery begins at the dural foramina just inferior to the lateral edge of the foramen magnum. The intradural part of the artery is divided into lateral and anterior medullary segments. The lateral medullary segment begins at the dural foramen and passes anterior and superior along the lateral medullary surface to terminate at the preolivary sulcus. The anterior medullary segment begins at the preolivary sulcus and crosses the pyramid to join with the other vertebral artery at or near the pontomedullary sulcus to form the basilar artery.

POSITIONING AND SKIN INCISION

The patient is placed in the lateral decubitus position with the axis of the body lying approximately 45 degrees from the horizontal. The head is held in Mayfield three-point fixation with the neck flexed to allow one fingerbreadth between the chin and sternum, rotated about 45 degrees to the contralateral side, and tilted about 30 degrees toward the contralateral shoulder. The ipsilateral shoulder is pulled down and secured to widen the angle of approach. The mastoid process is the highest point in the surgical field.

A C-shaped incision is generally fashioned; however, when an occipital–cervical fusion is planned as part of the procedure; or, as a second procedure, an inverted U-shaped incision may be used (Fig. 15–4A, B). The C-shaped incision begins at the level of the pitma of the ear and curves around the ear to the region of the mastoid tip, ending over the sternocleidomastoid muscle at about the level of C4. The horseshoe incision begins in the midline about 5 cm below the in ion and is directed up to 1 cm above the inion. It then curves over to the mastoid region and runs downward along the sternocleidomastoid muscle.

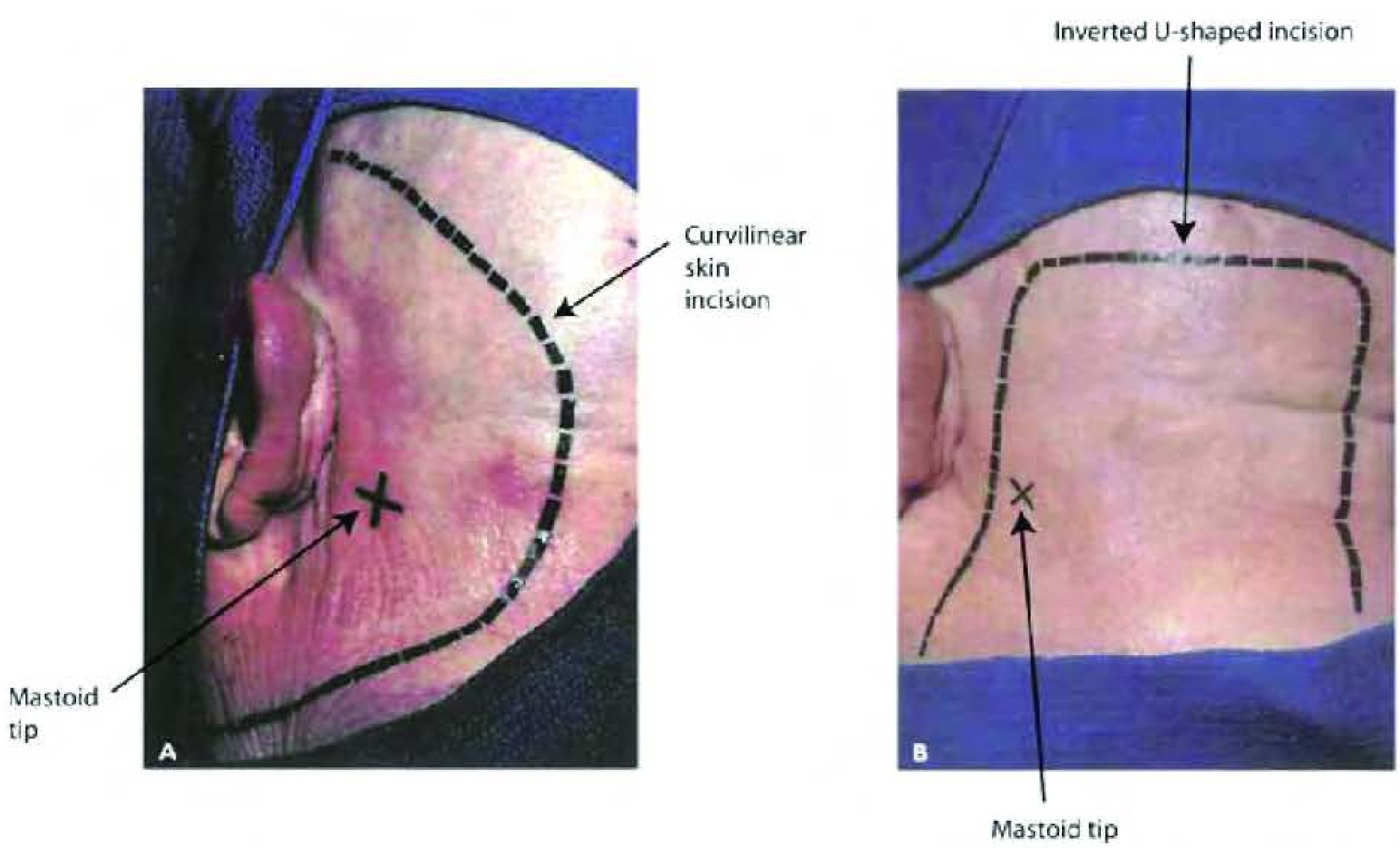


FIGURE 15–4 Skin incisions. The C-shaped incision is demonstrated in this right-sided approach. The U-shaped incision is Suggested if a fusion is planned.

SURGICAL TECHNIQUE

POSTEROLATERAL NECK DISSECTION AND VERTEBRAL ARTERY EXPOSURE

After the skin and superficial fascia have been reflected, the superficial muscle layer, which is composed of the sternocleidomastoid and trapezius muscles, is identified (Fig. 15–5). The sternocleidomastoid muscle is detached from the mastoid tip and reflected laterally to reveal the underlying middle layer of muscles raking origin from the superior nuchal line. The splenius capitis muscle is detached and reflected medially to reveal the underlying longissimus capitis and semispinal is capitis muscles as well as the occipital artery (Figs. 15–6 and 15–7). Reflection of the longissimus capitis and semispinal is capitis allows visualization of the deepest muscle layer consisting of the superior and inferior oblique muscles that attach laterally to the transverse process of C1 and the rectus capitis posterior major (Fig. 15–8). All muscles are reflected medially with

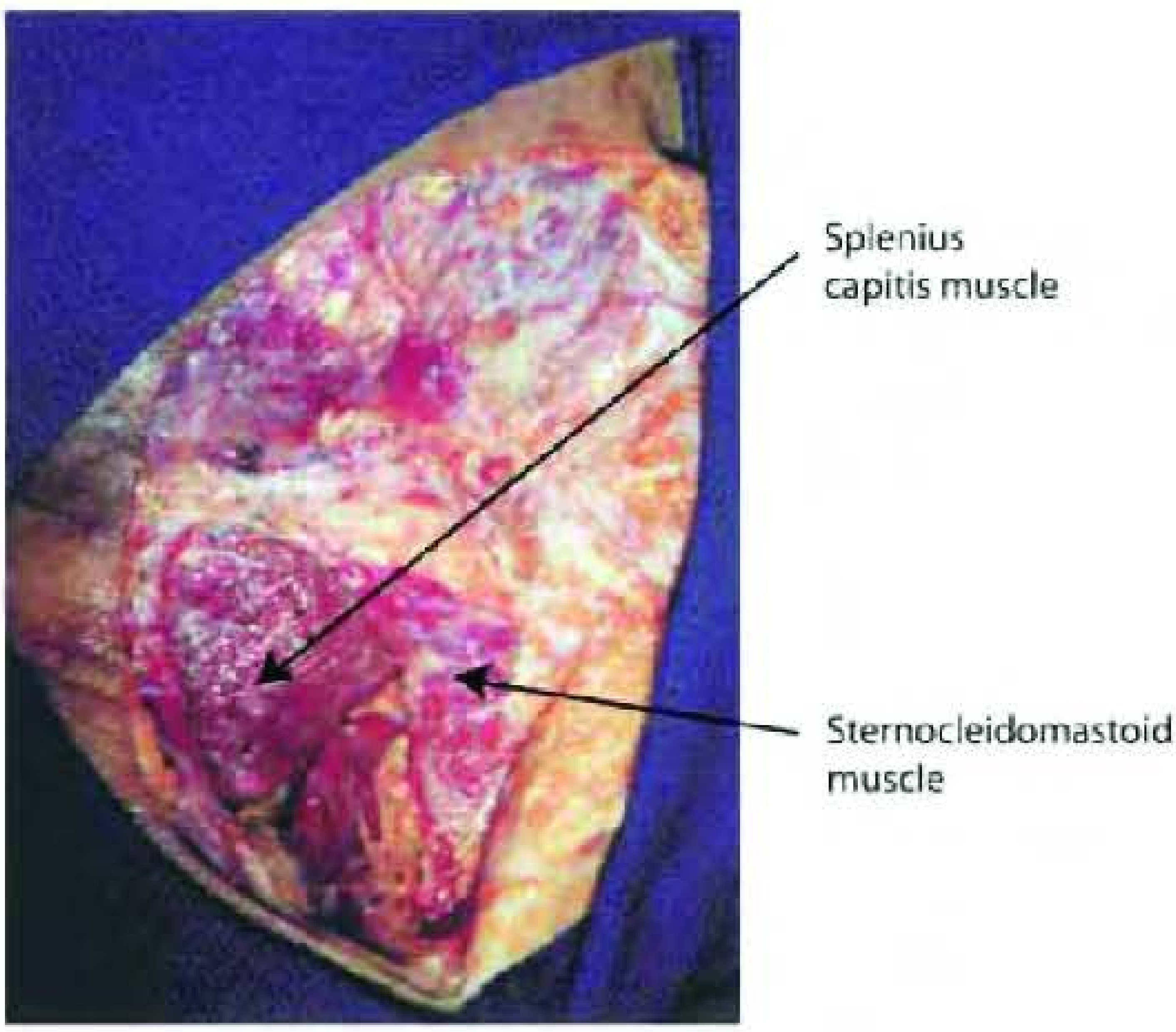


FIGURE 15–5 The superficial layer of muscles is exposed after the skin incision.

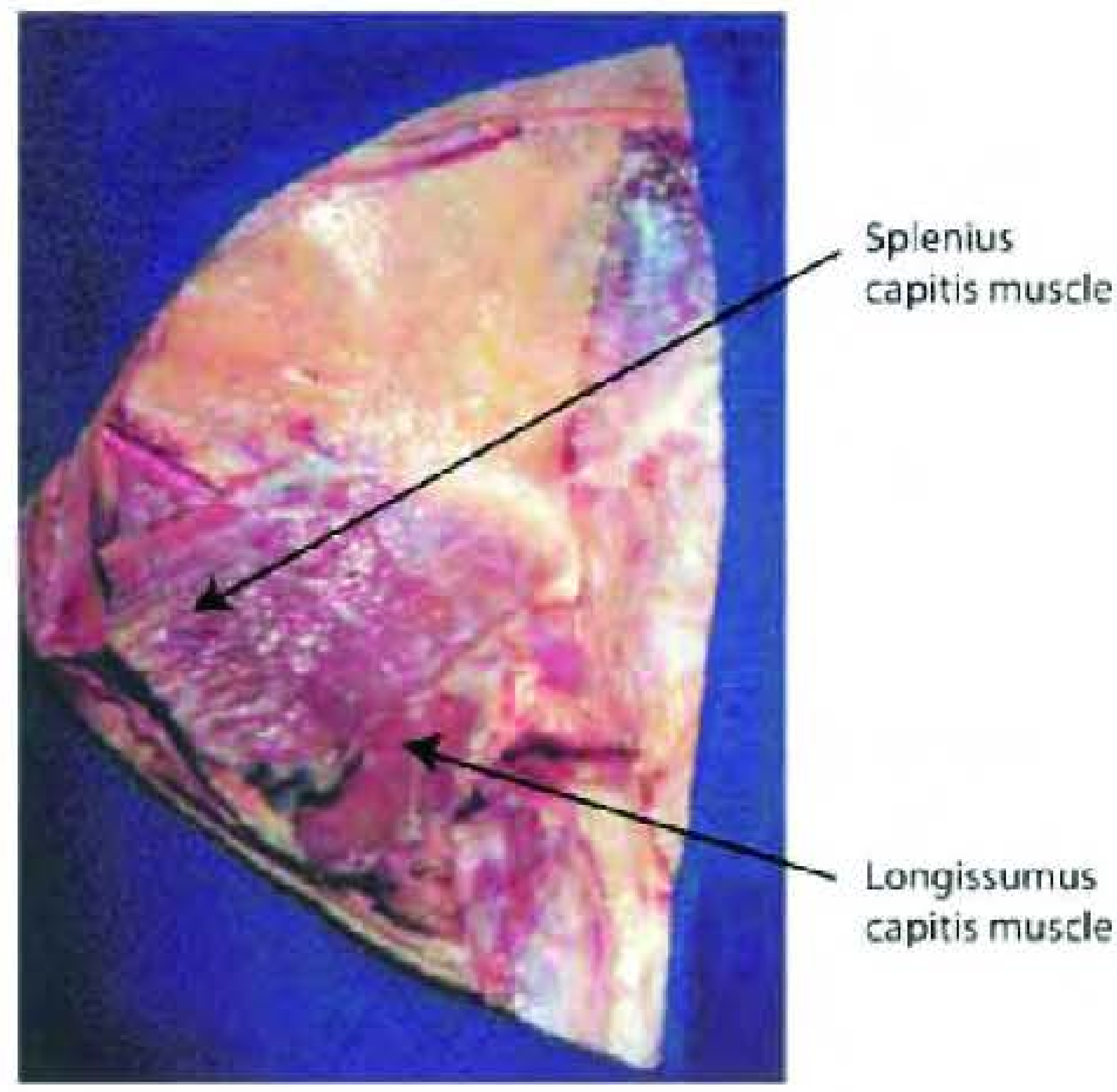


FIGURE 15–6 The sternocleidomastoid muscle has been reflected laterally to expose the splenitis capitis muscle. The arrow denotes the occipital artery.

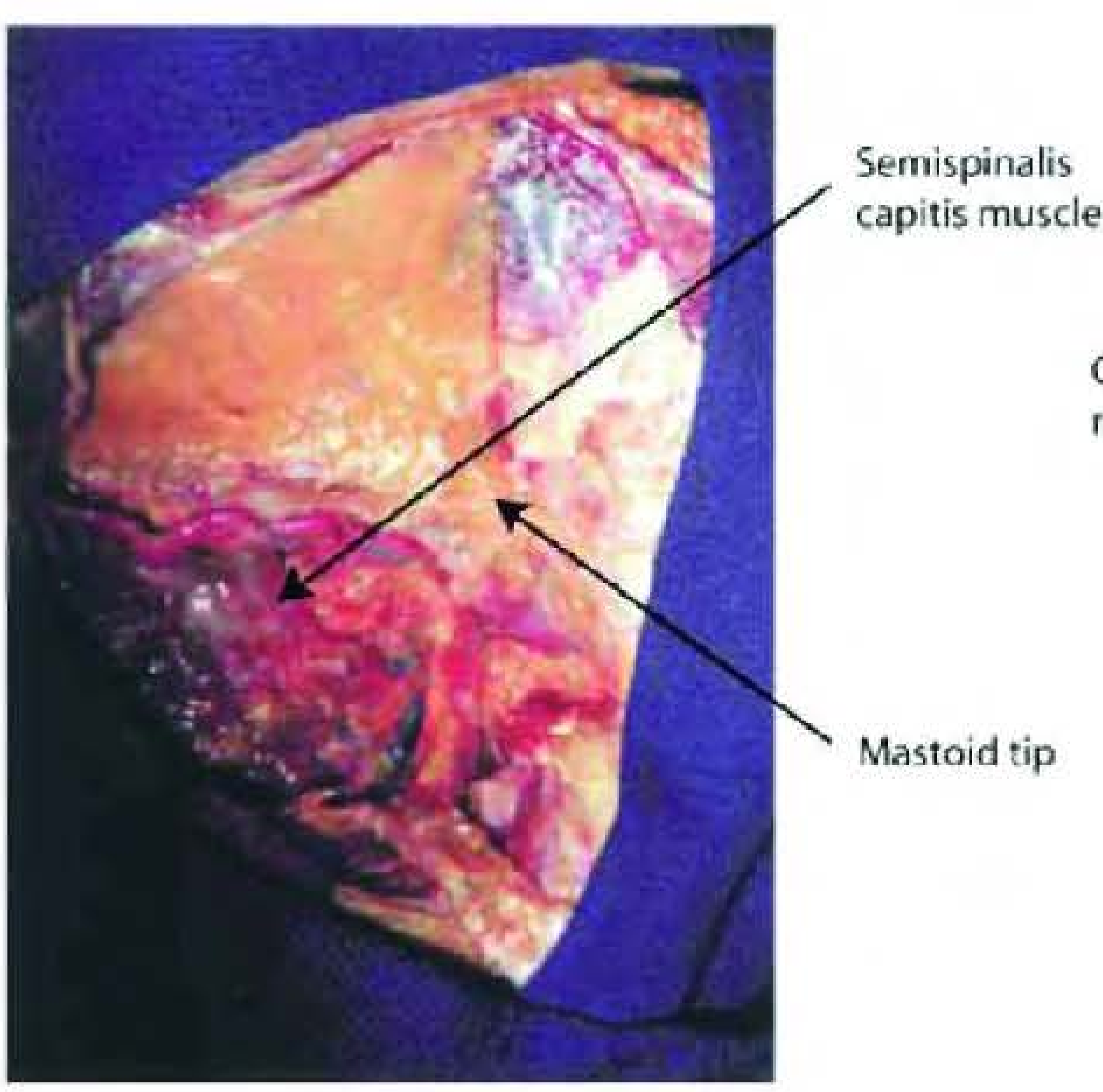


FIGURE 15–7 The splenius capitis and the longissimus capitis have been reflected to expose the semispinals capitis.

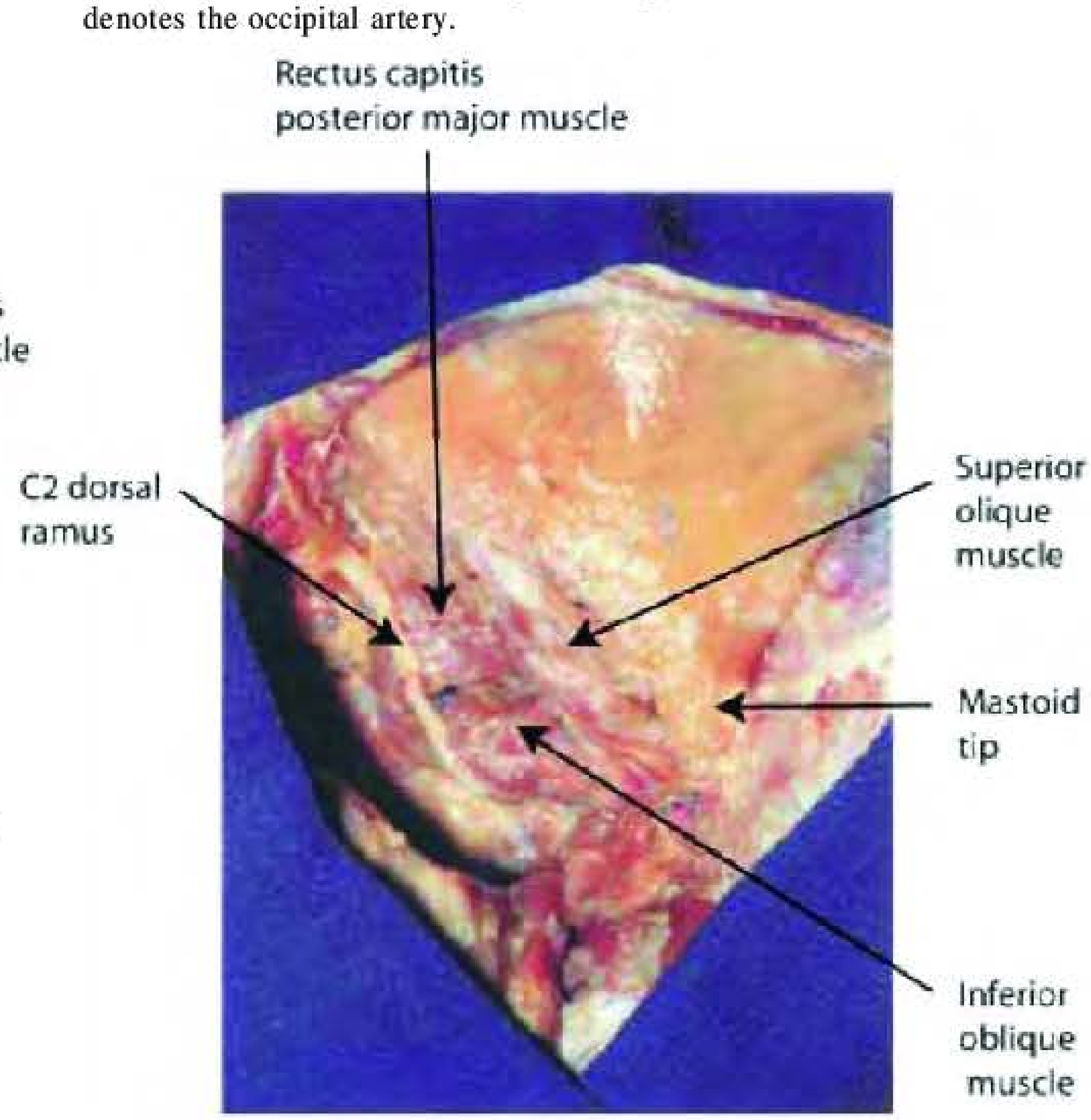


FIGURE 15–8 Reflecting the semispinals capitis muscle exposes the suboccipital triangle. The C2 dorsal ramus is also seen.

the exception of the sternocleidomastoid muscle, which is reflected laterally.

The vertebral artery must be identified early and this can be done in several ways (Fig. 15–9). The oblique muscles attach to the lateral mass of C1, which can be easily identified and palpated. The artery runs through the transverse foramen and the palpable bony landmark can help locate the artery. Additionally, the C2 dorsal ramus can be followed to the C1–2 region, where the vertebral artery can be found to course just anterior to it. The artery is encased in a dense venous plexus that must be entered to trace the vertebral

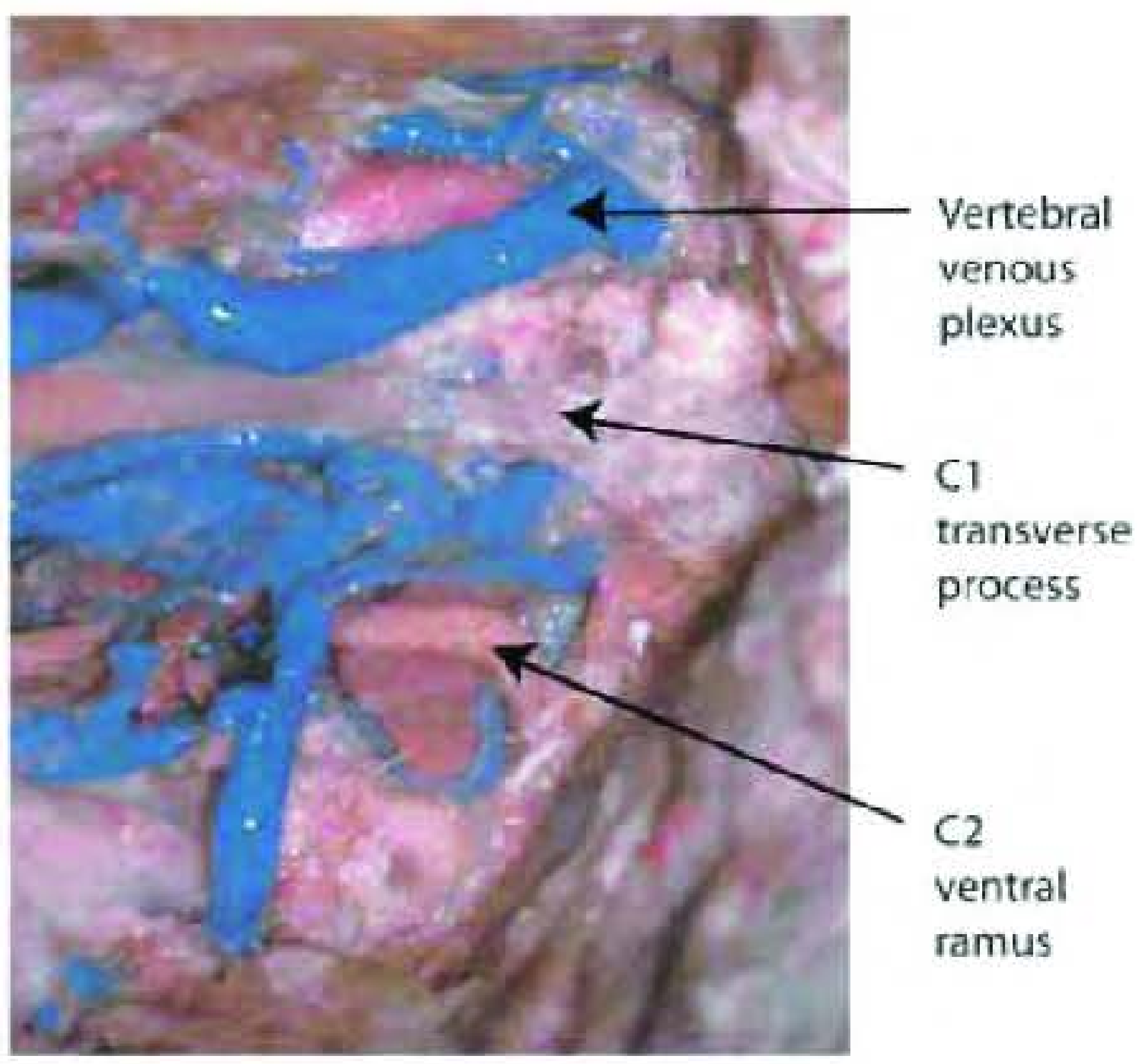


FIGURE 15–9 The arrows denote three landmarks for vertebral artery identification: the C2 nerve root, the vertebral venous plexus, and the C1 transverse process.

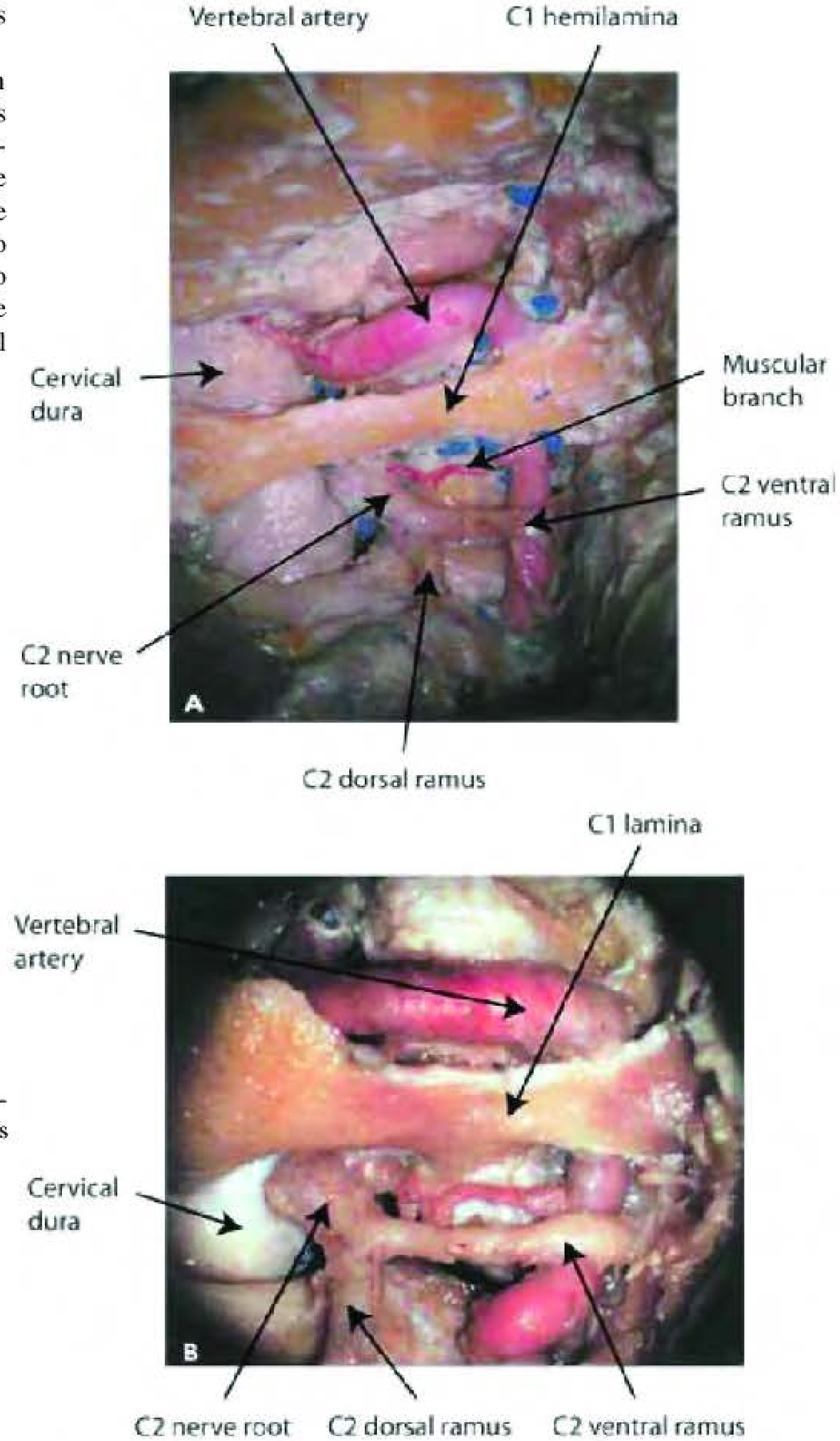


FIGURE 15–10 Exposure of the V_3 segment of the vertebral artery. The C1 lamina, the C2 nerve root, and the muscular branch of the vertebral artery are seen. The vertebral artery relationship with the occipital condyle and C1 lamina is seen.

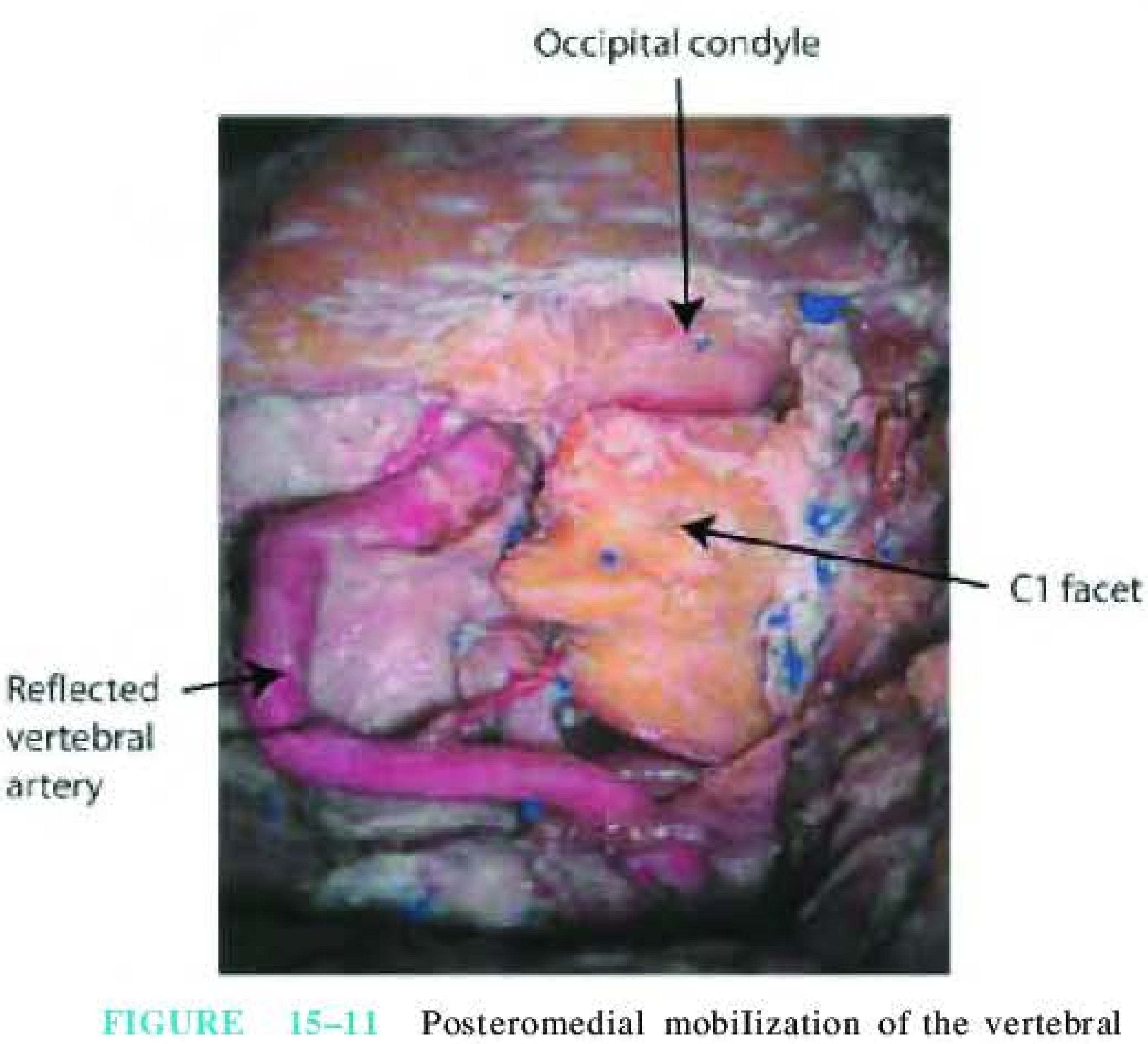


FIGURE 15–11 Posteromedial mobilization of the vertebral artery.

artery. Variations in the anatomy of the vertebral artery are common and should be identified. Vertebral artery branches should be identified but not sacrificed. The muscular branch of the vertebral artery occasionally supplies regions of the posterior fossa. In addition, the posterior inferior cerebellar artery (PICA) also may arise from the vertebral artery extradurally. Through a subperiosteal dissection, the lamina of C1 and C2 are exposed. The vertebral artery is mobilized by opening the C1 transverse foramen and displacing the artery from its groove superior to the hemilamina of C1 (Figs. 15–10A, B and 15–11).

LATERAL SUBOCCIPITAL CRANIOTOMY AND CONDYLAR BONE RESECTION

Several variations of the extreme lateral approach have been described, including transfacetal, retrocondylar, partial transcondylar, transcondylar, transtubercular, and transjugular approaches. Each requires early identification and mobilization of the vertebral artery but differs in the amount of bone resection performed to achieve exposure.

1. *Transfacetal approach* (Fig. 15–12): No suboccipital craniotomy or craniectomy is performed. The first step is to perform a C1 and C2 hemilaminectomy. The posterior half of the C1–2 facet joint and the occipital condyle are drilled until the C1 and C2 nerve roots are exposed. An occipitocervical fusion is often required following this approach.
2. *Retrocondylar approach* (Fig. 15–13): A suboccipital craniotomy or craniectomy is performed along with removal of the C1 hemilamina and transverse process- There is no drilling of the occipital condyle for this approach.
3. *Partial transcondylar approach* (Figs. 15–14A, B and 15–15): A suboccipital craniotomy or craniectomy is performed. After posteromedial mobilization of the vertebral artery, the posterior third of the occipital condyle and the superior facet of C1 are drilled. The landmark for the limit of condylar drilling is the hypoglossal canal.

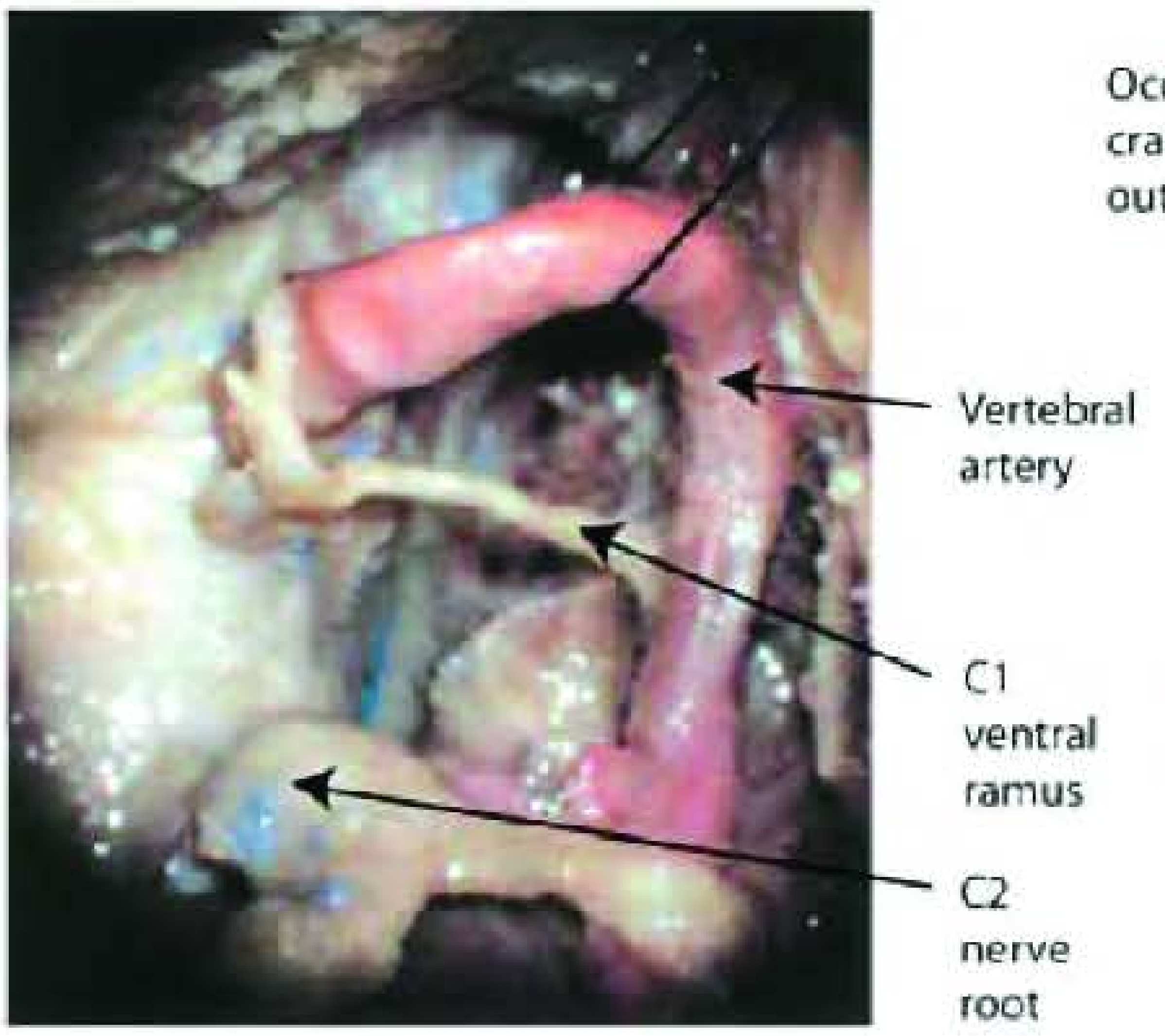


FIGURE 15–12 Transfacetal approach. The arrow is showing removal of the medial part of the facet.

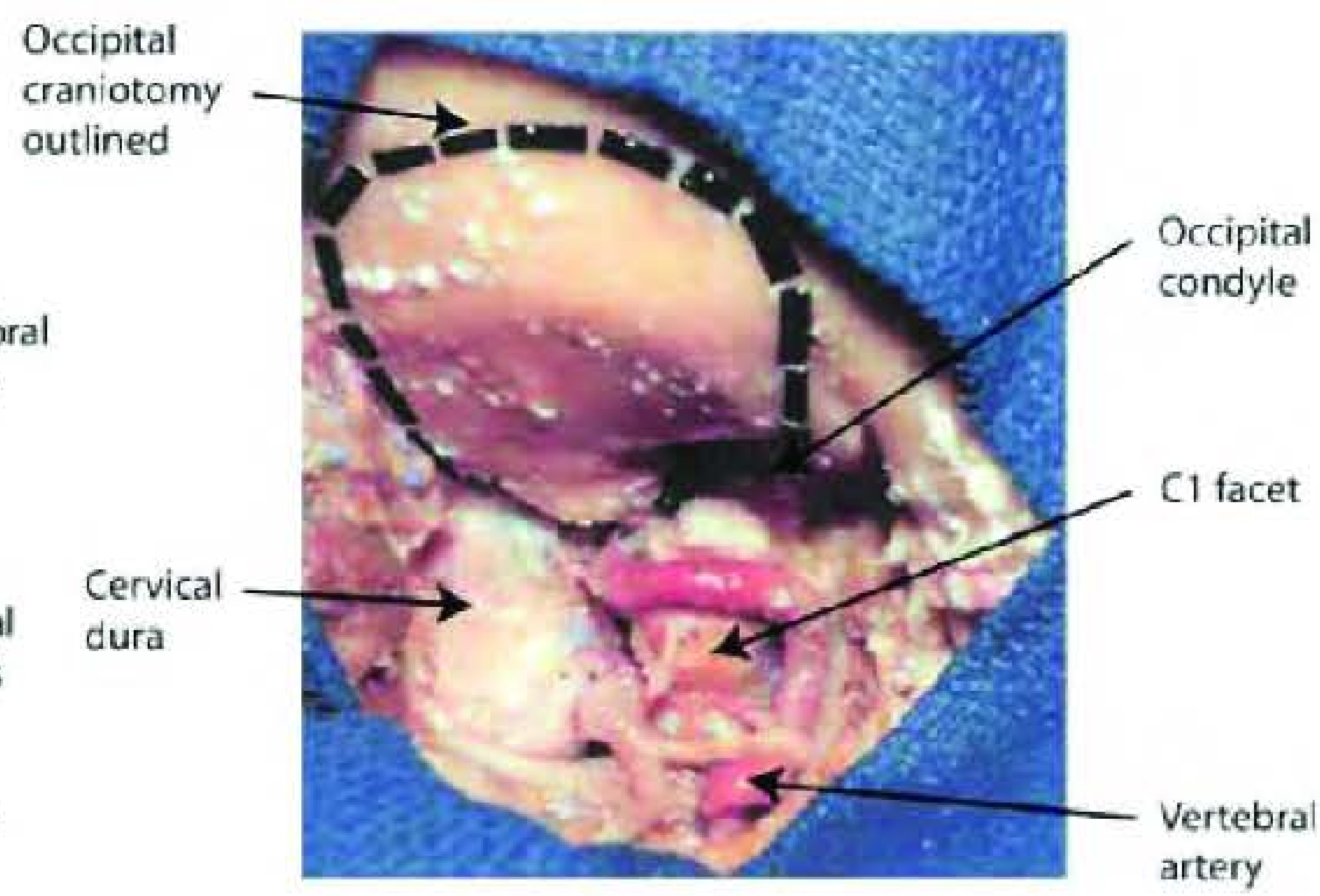
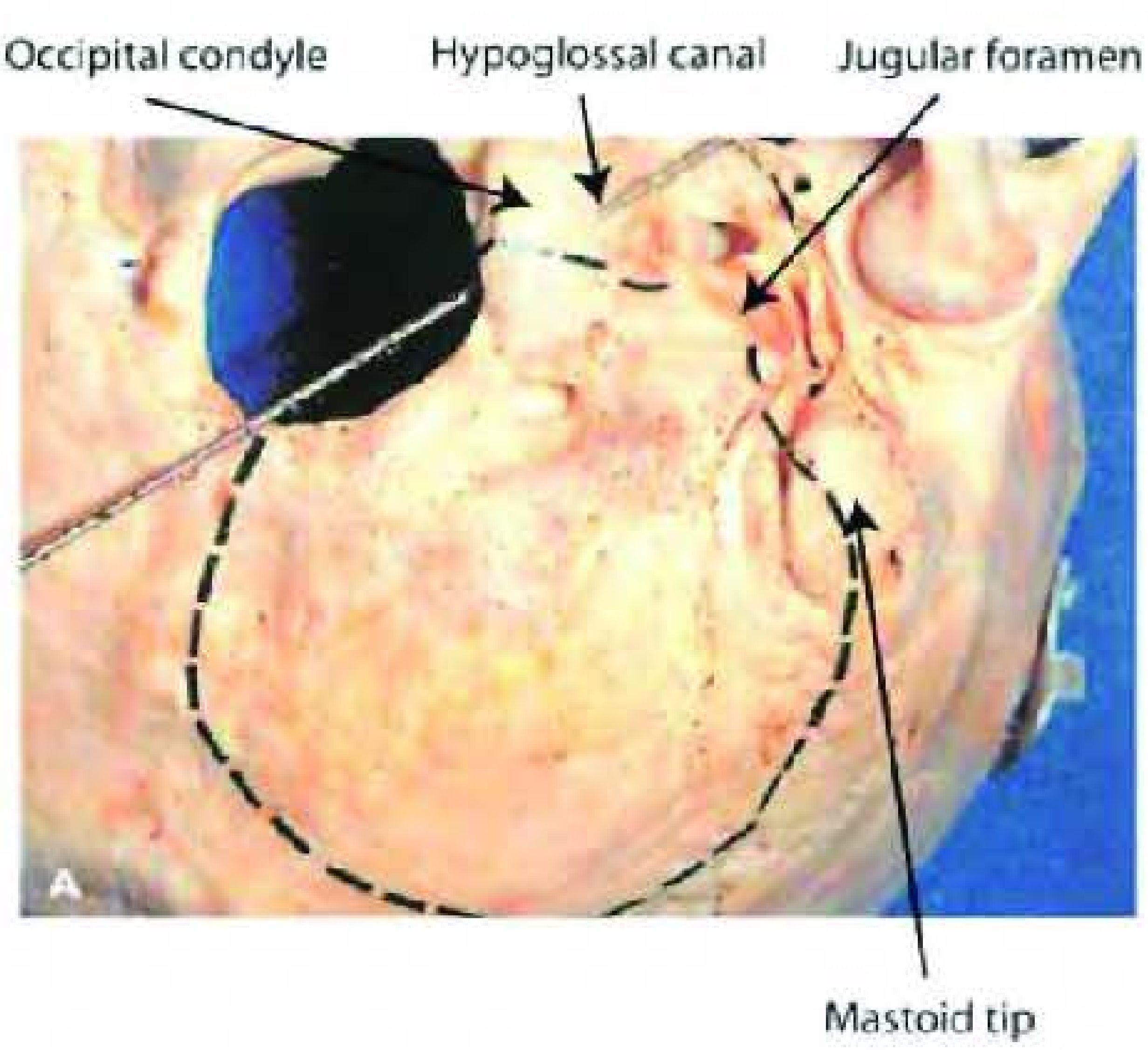


FIGURE 15–13 Retrocondylar approach. The suboccipital craniotomy is outlined. A hemilaminectomy at C1 has been performed.



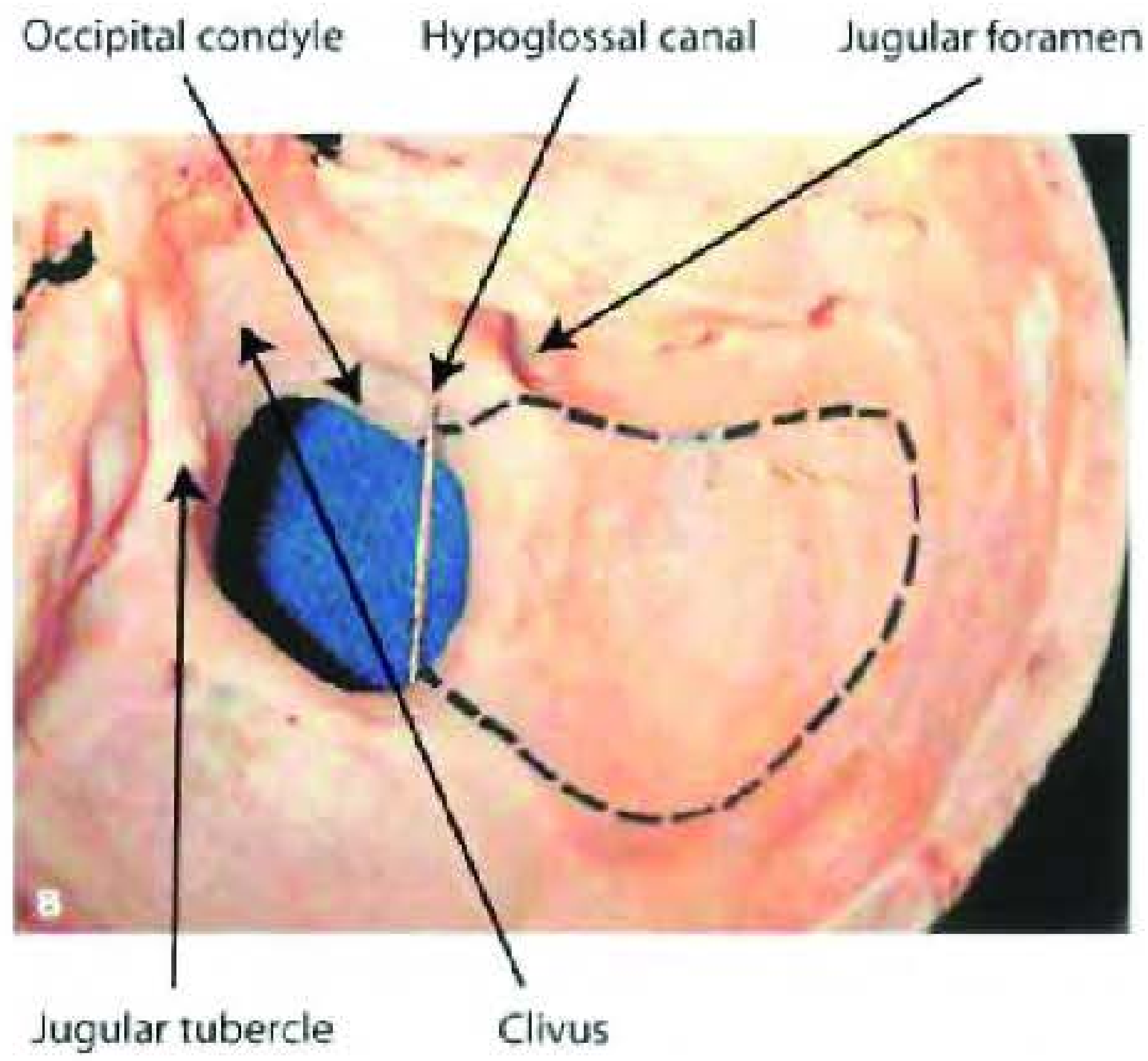


FIGURE 15–14 Partial transcondylar approach inferior view of the skull with an instrument passed through the hypoglossal canal to demonstrate its orientation in respect to the sagittal plane. Superior view of the same skull.

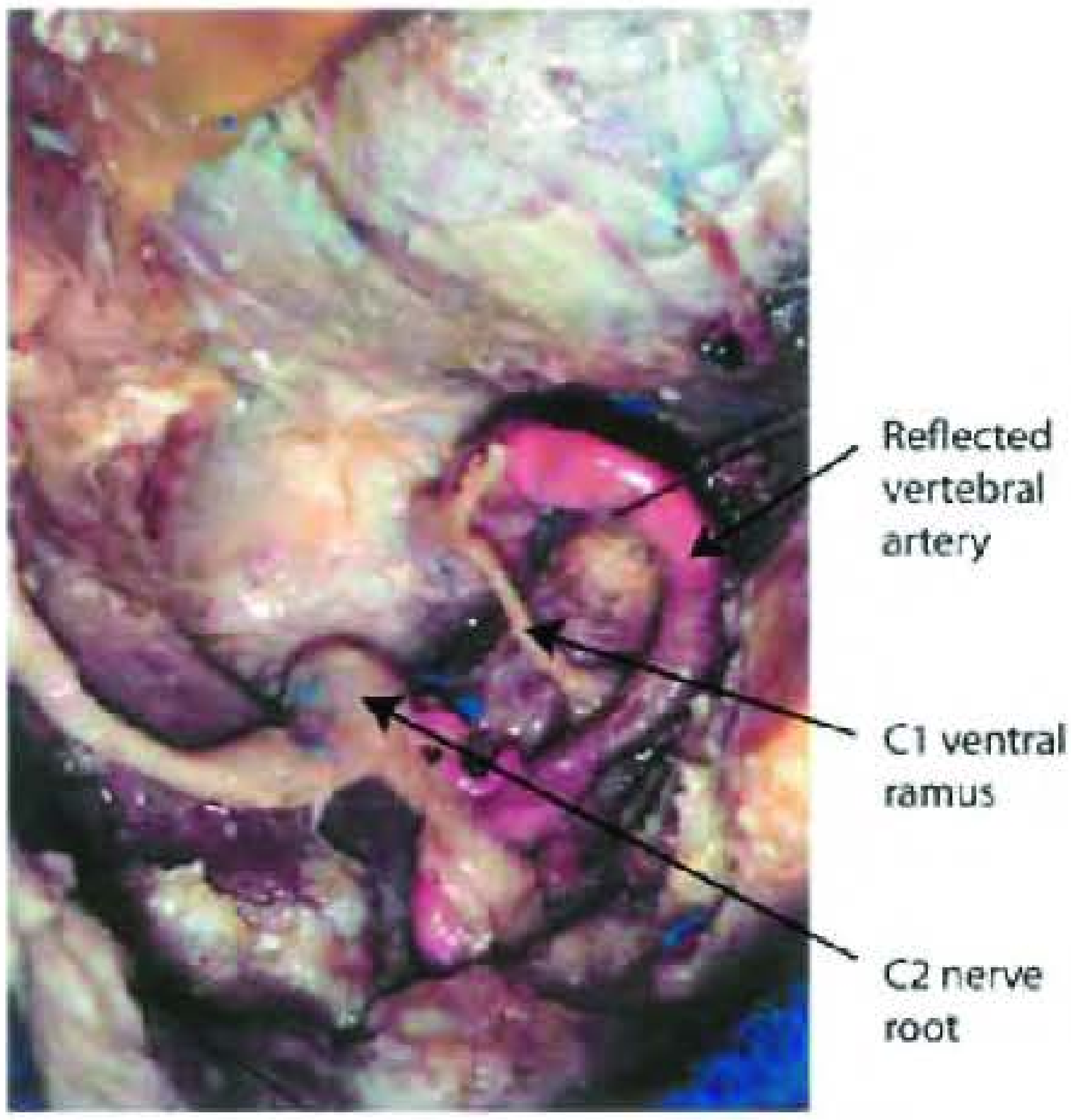


FIGURE 15–15 A partial transcondylar approach has own performed.

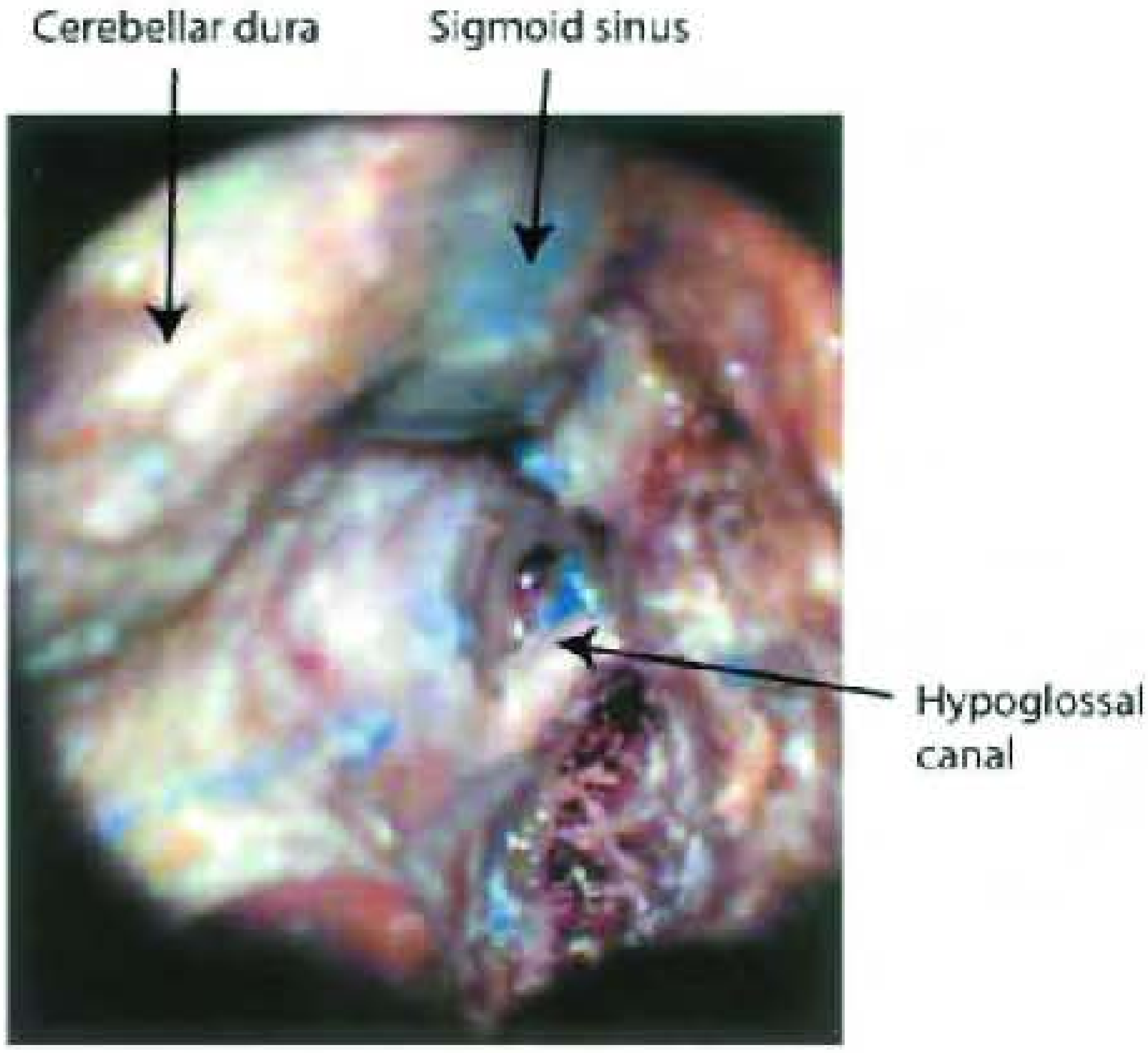
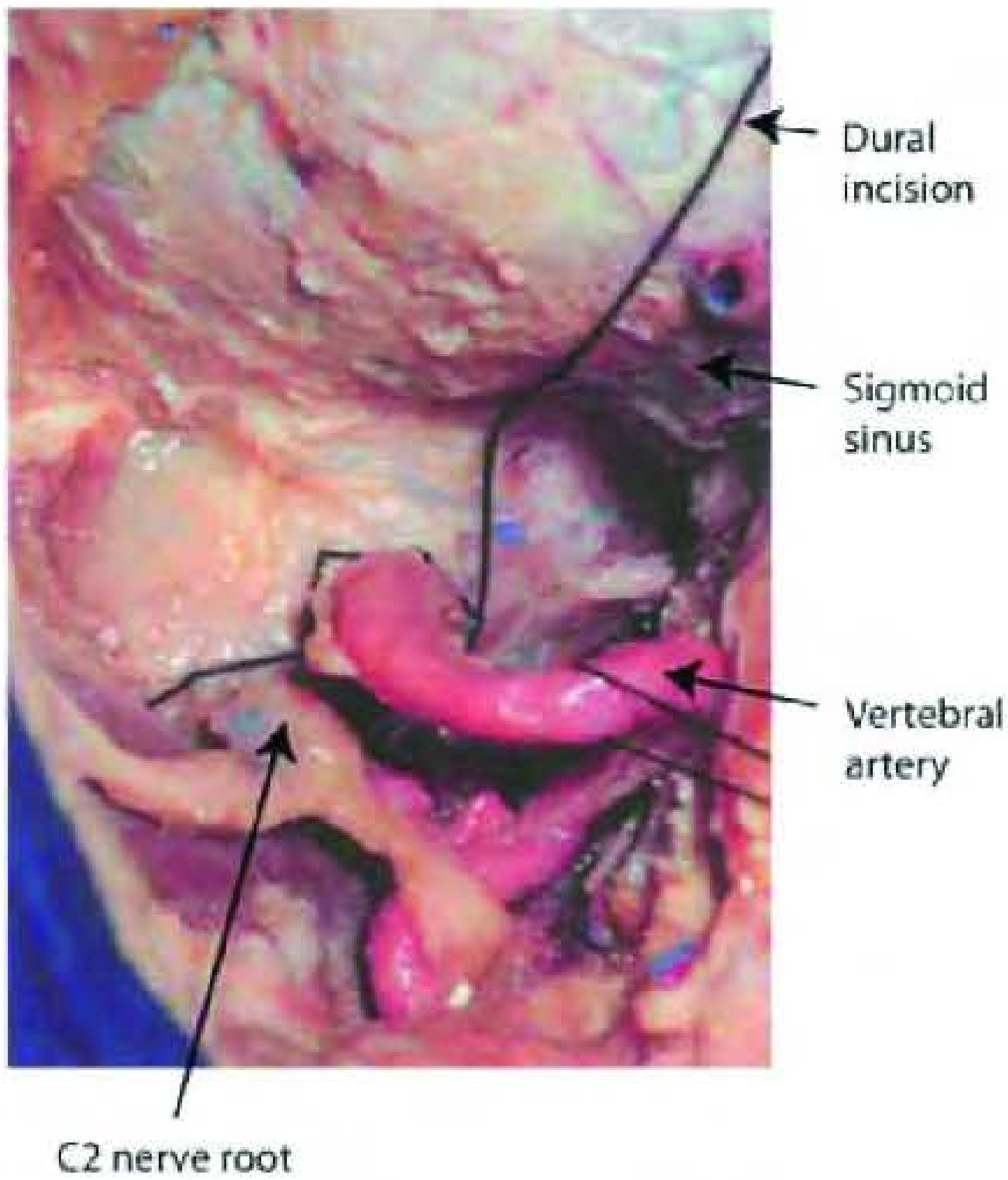


FIGURE 15–16 Transcondylar approach. The arrow denotes the hypoglossal canal.

4. *Transcondylar approach* (Fig. 15–16): After a suboccipital craniotomy or craniectomy and posteromedial mobilization of the vertebral artery, the posterior half of the occipital condyle is drilled and the hypoglossal canal exposed. Depending on the extent of the lesion, the whole condyle may require drilling. An occipitocervical fusion is required after this procedure.

5. *Transtubercular approach* (Figs. 15–17 and 15–18): The bone above the hypoglossal canal is the jugular tubercle. Drilling this provides access to the middle clivus. The posteromedial third or half of the occipital condyle–facet joint complex is drilled. The jugular tubercle is removed extradurally to provide additional space for intradural exposure.



15–17 A transtubercular approach has been performed and the dural incision has been outlined.

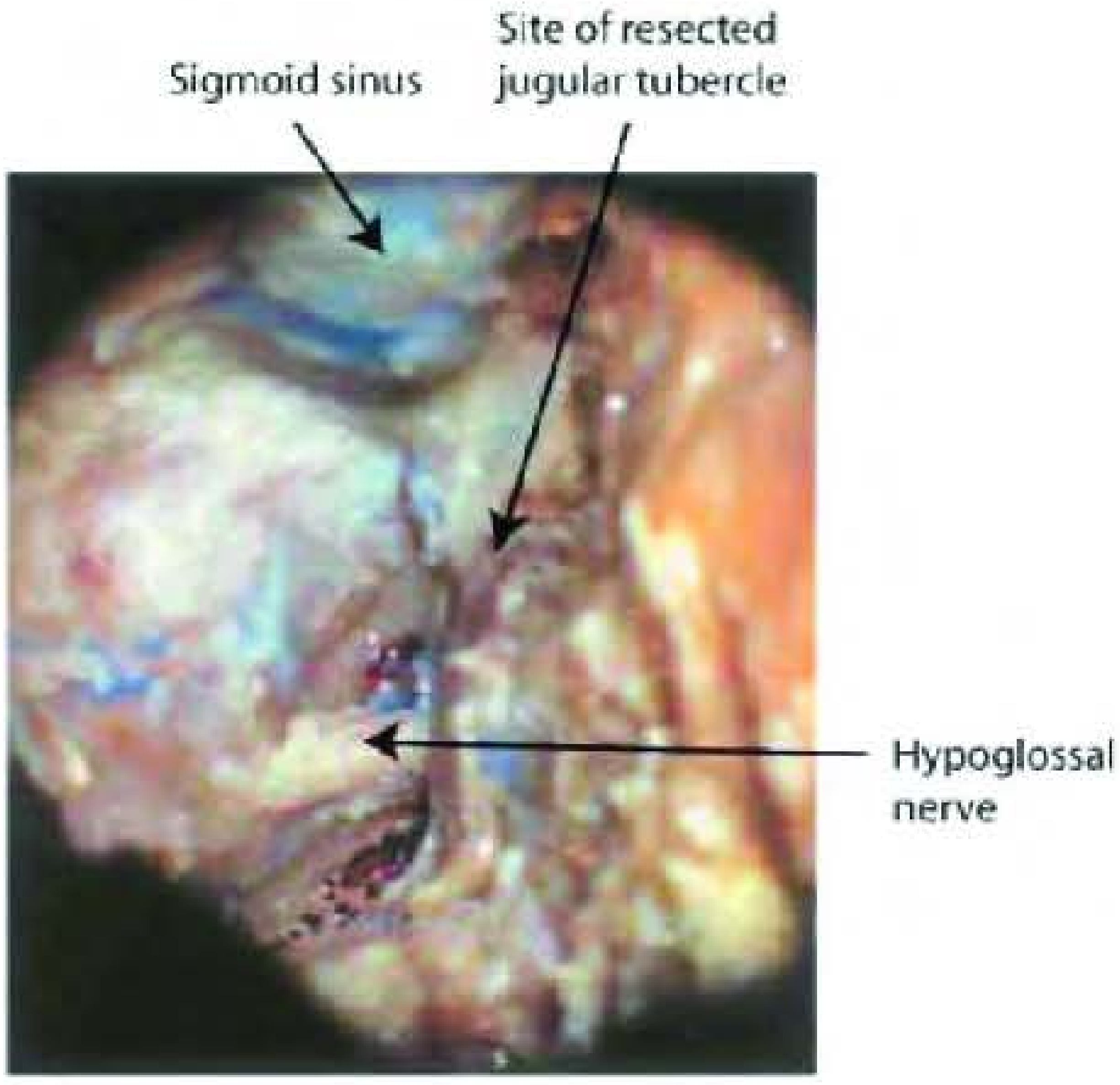


FIGURE 15–18 The jugular tubercle has been resected. The arrow denotes where it was located.

6. *Transjugular approach* (Fig. 15–19): A total mastoidectomy with anterior mobilization of the mastoid segment of the facial nerve from the fallopian canal is required. The lateral aspect of the jugular bulb and vein must be exposed. The jugular process of the occipital bone, which forms the posterior and inferior wall of the jugular bulb, is drilled away.

The dura is opened posterior to the sigmoid sinus, leaving a cuff of dura around the vertebral artery allowing the artery to be mobilized anteriorly. It extends down across the region of the foramen magnum longitudinally into the region of the upper cervical spine. The cervical dura is opened on the lateral aspect of the thecal sac immediately posterior to the exiting nerve roots. The dural ring around the vertebral artery is completely opened to allow for maximum mobilization of the artery (Fig. 15–17). This opening also avoids inadvertent injury to the vertebral branches that arise extradurally or near the dural entrance of the vertebral artery. Once the dura is opened, a self-retaining retractor may be placed to superiorly and medially reflect the cerebellar hemisphere. Opening the cisterna magna will allow the egress of cerebrospinal fluid (CSF) to relax the brain. Clear identification can then be made of cranial nerve (CN) VI, through XII as well as the vertebral artery, posterior inferior cerebellar artery (PICA), the

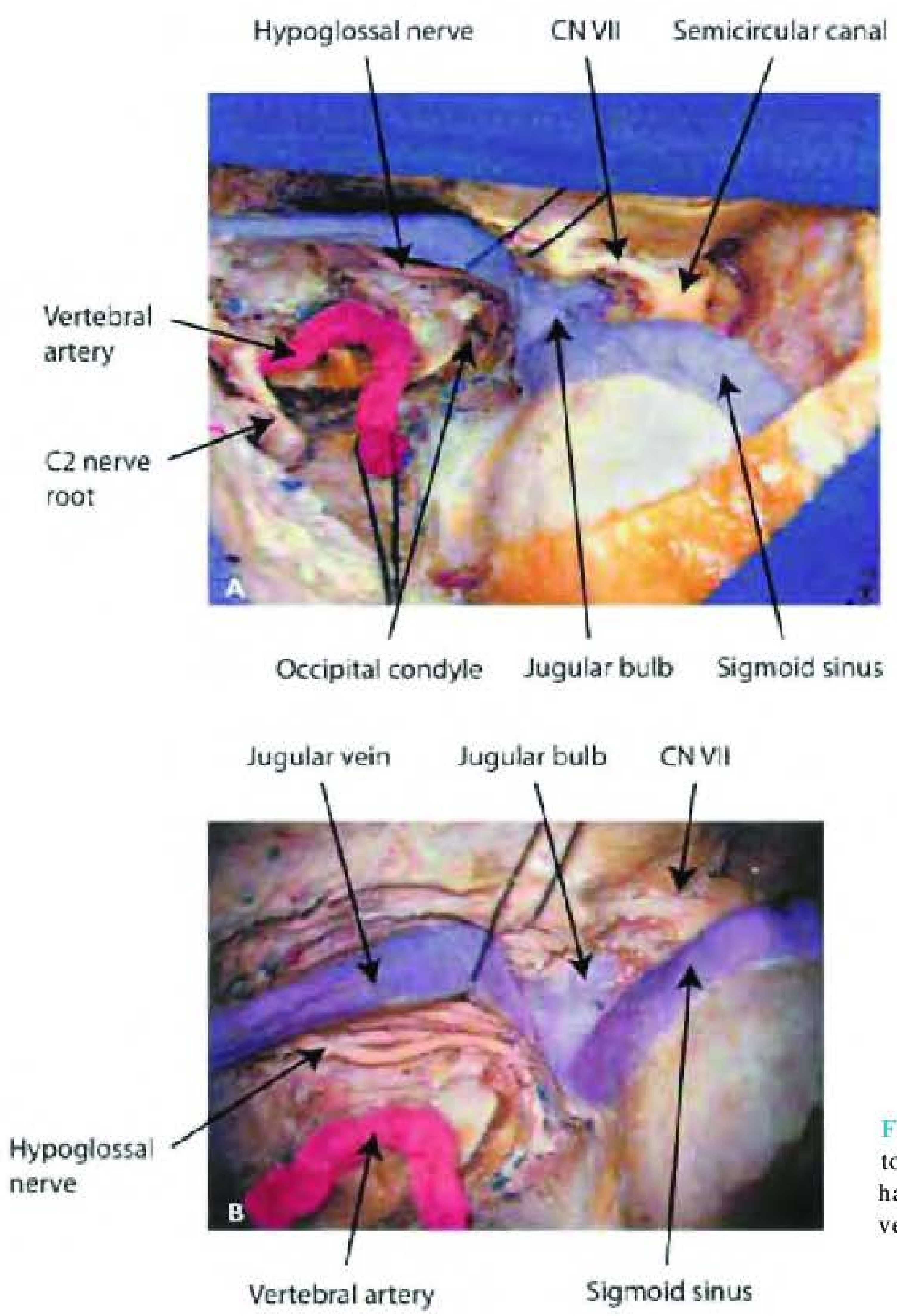


FIGURE 15–19 Transjugular approach. A total mastoidectomy has been performed and the hypoglossal canal has been opened. The jugular bulb and the internal jugular vein are seen. CN, cranial nerve.

vertebrobasilar junction, and the contralateral vertebral artery (Figs. 15–20–15–23).

At the end of the procedure, the dura is closed in a watertight fashion, and if a craniotomy was turned, the bone is reattached. Stability of the transcervical junction is an issue that must be addressed if more than two thirds of the condyle is drilled. If such is the case, an occipital to cervical fusion with instrumentation may be performed in the same sitting or with a second operative procedure.

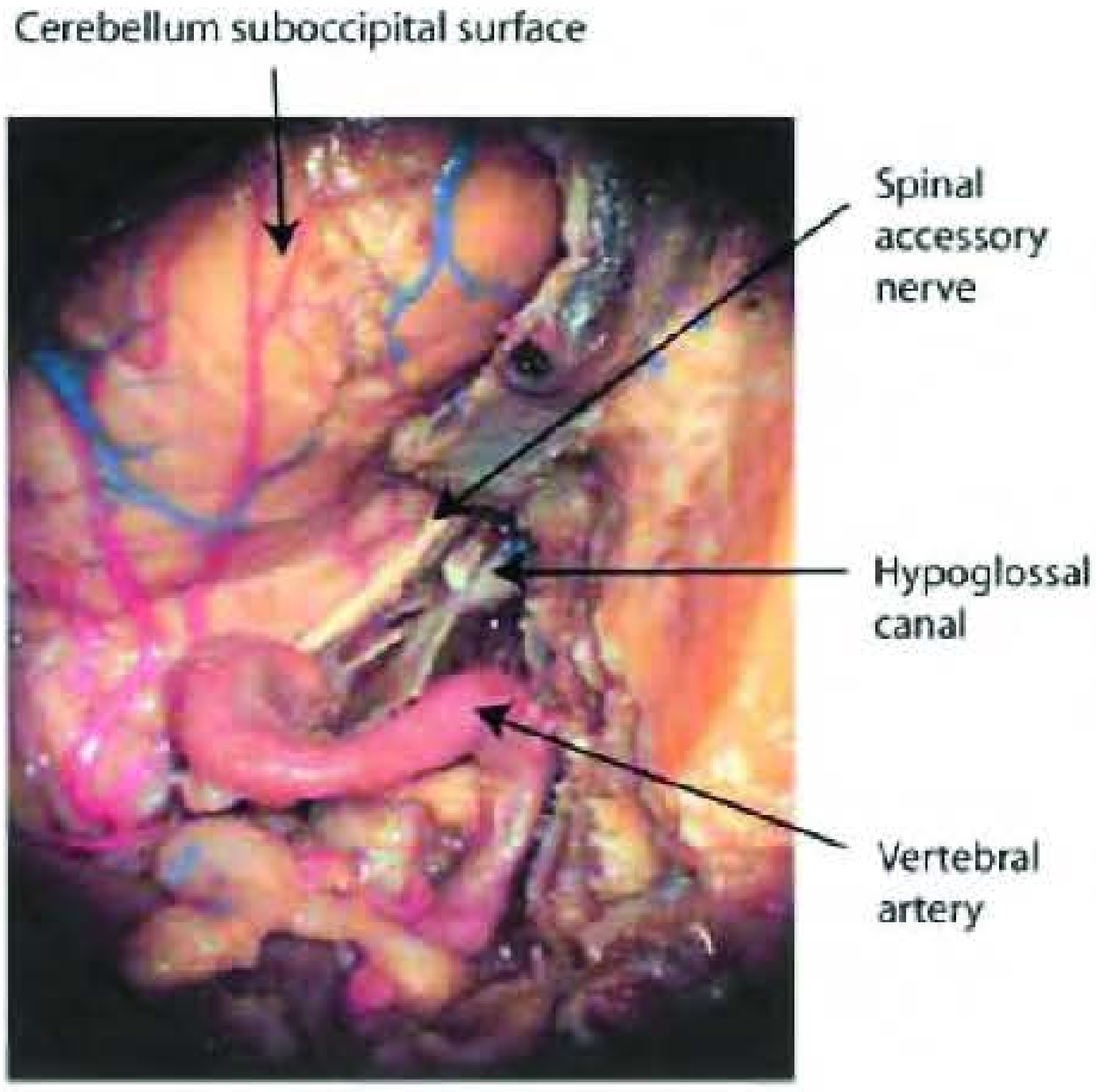


FIGURE 15–20 A panoramic view after the extreme lateral approach has been performed. The hypoglossal and spinal accessory nerves as well as the vertebral artery are seen.

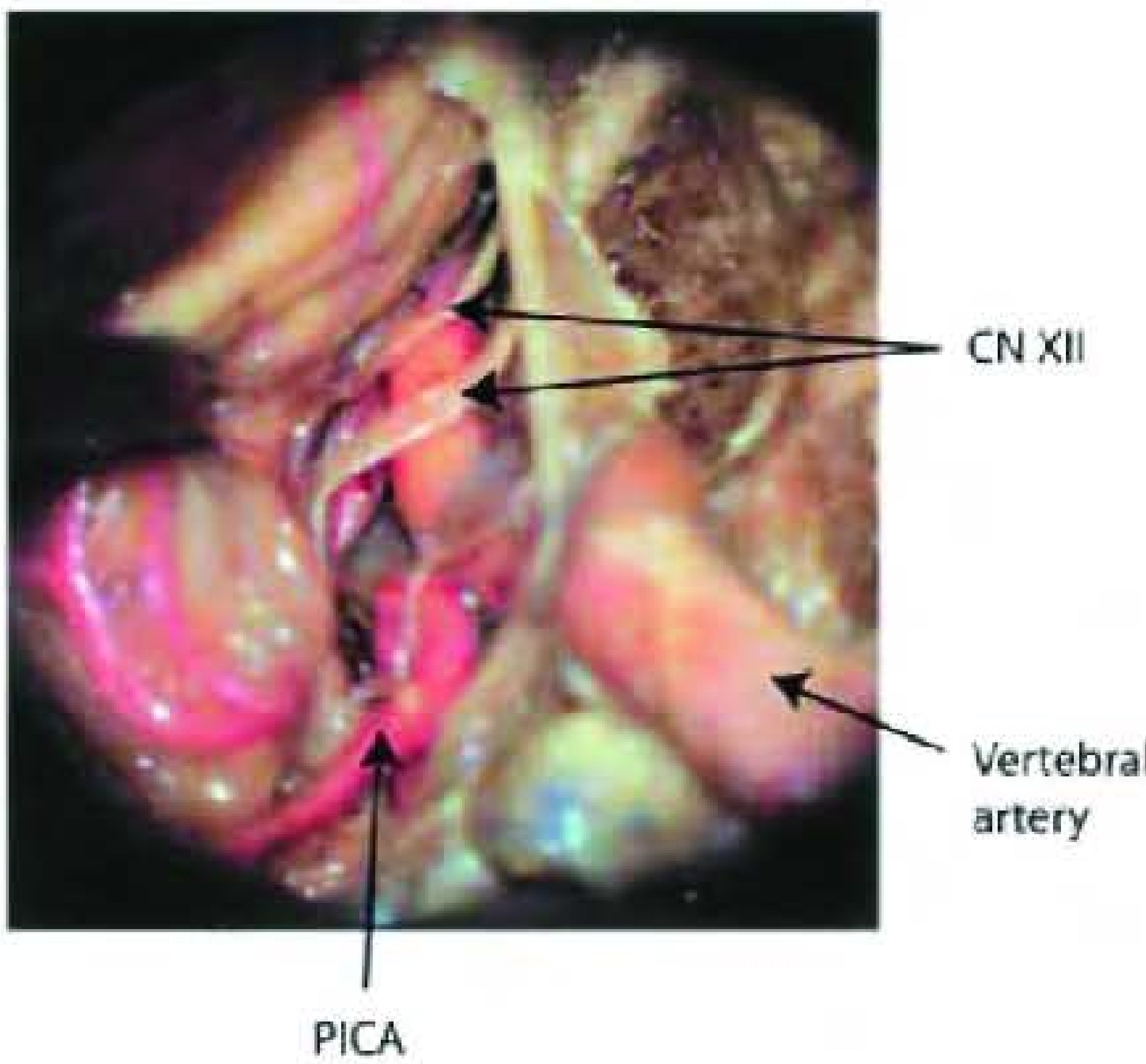


FIGURE 15–21 The relationship between the lower cranial nerves (CN) and the vertebral artery is demonstrated, PICA, posterior inferior cerebellar artery.

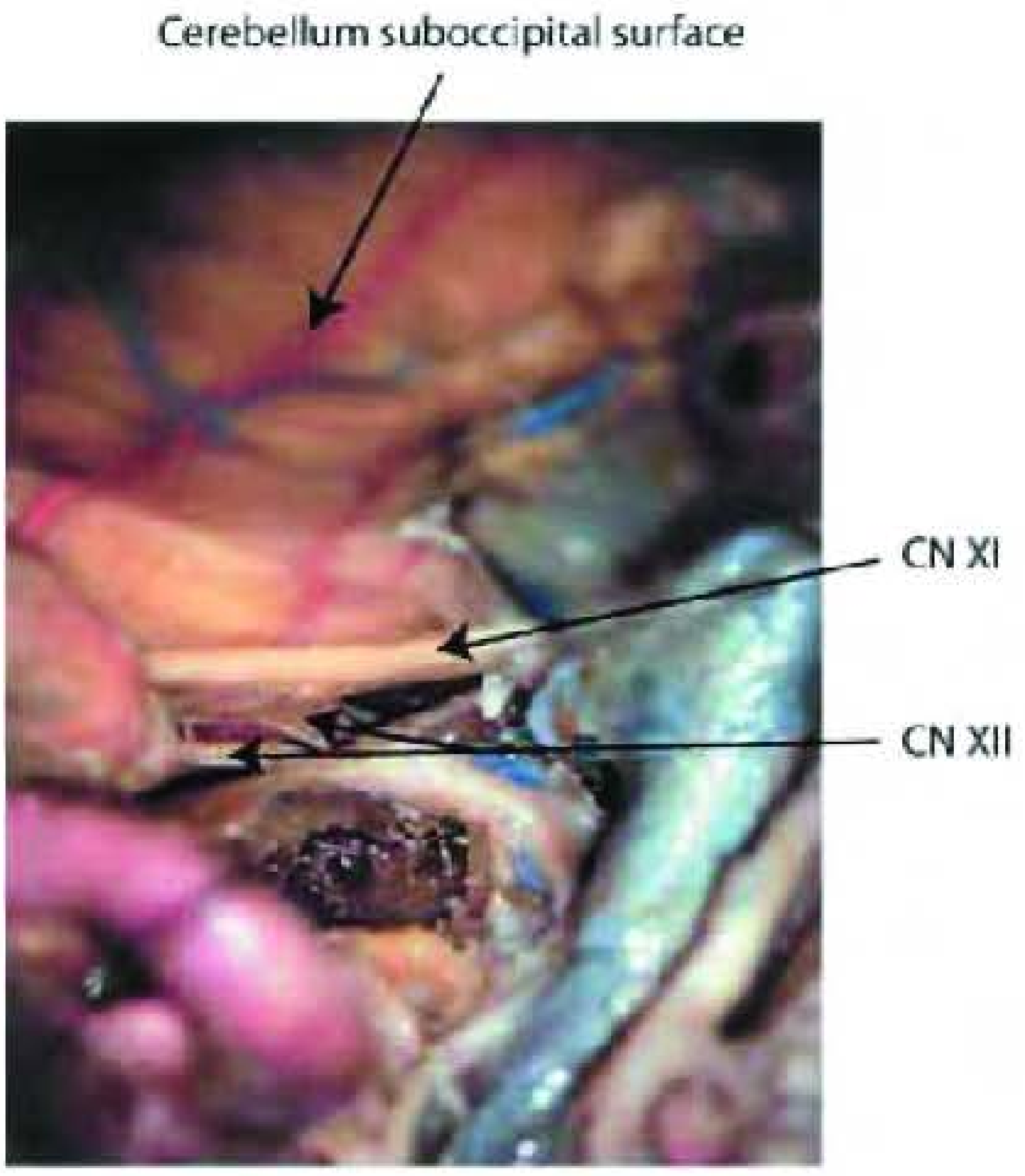


FIGURE 15–22 The jugular bulb, hypoglossal canal, and spinal accessory nerve are seen. CN, cranial nerve.

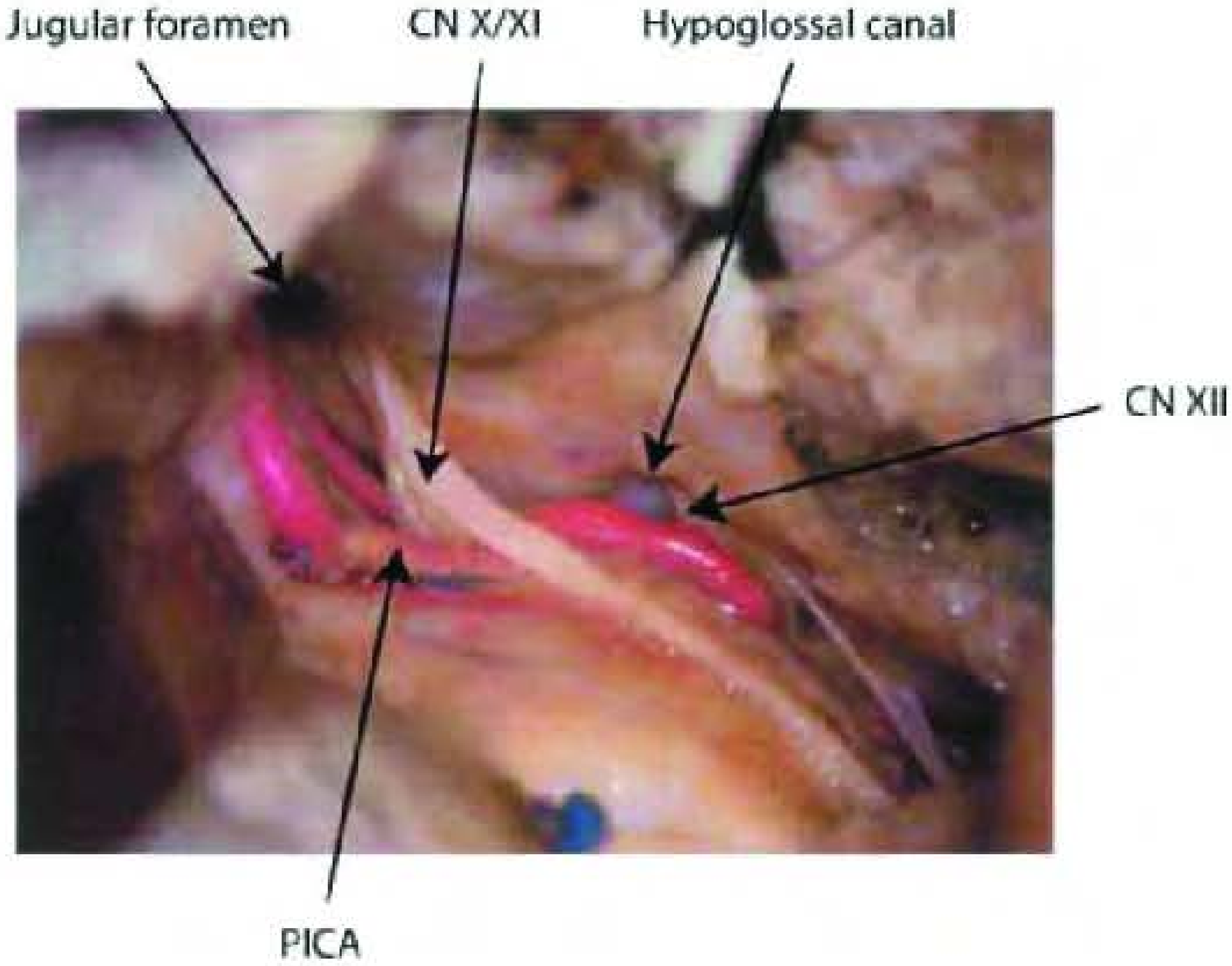


FIGURE 15–23 The jugular foramen, hypoglossal foramen, and posterior inferior cerebellar artery (PICA) are seen. CN, cranial nerve.

PITFALLS, PEARLS, CONSIDERATIONS

- CSF leak
- Vertebral injury
- Lower cranial nerve injury
- Cranial-cervical instability

SUGGESTED READINGS

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APPROACHES TO THE POSTERIOR THIRD VENTRICLE AND PINEAL REGION

Emel Avci, Amitabha Chanda, Damirez Fossett

INDICATIONS FOR APPROACH

- Pineal and third ventricular lesions

ANATOMY

The posterior third ventricular or pineal region is the deepest portion of the intracranial cavity. Surgery in this region is complicated by the depth of field and the potential for inadvertent injury to the major veins and neural structures within the region.

CISTERNAL ANATOMY

The pineal region is a confluence of six arachnoidal cisterns: the quadrigeminal, cistern, bilateral ambient cisterns, posterior pericallosal cistern, superior cerebellar cistern, and cisterna velum interpositum. The cisterns are separated by thick arachnoidal trabeculations.

The quadrigeminal cistern sits in both the supratentorial and infratentorial compartments. It is bounded anteriorly by the superior medullary velum, the quadrigeminal plate of the midbrain, and the pineal gland. Posteriorly, its thick arachnoid attaches to the tentorium. Laterally, loose arachnoid trabeculations separate it from the ambient cisterns. The major structure contained in this cistern is the great vein of Galen. Also found in this cistern are the terminal portions of the internal cerebral veins, the basal vein of Rosenthal, the pericallosal veins, the internal occipital veins, and other tributaries of the vein of Galen. The posterior pericallosal artery originates in this cistern, the P4 segment of the posterior cerebral artery traverses this cistern, and the medial posterior choroidal artery courses through this cistern to enter the cisterna velum interpositum.

The ambient cistern also lies both supratentorially and infratentorially and is straddled laterally by the tentorial notch. It embraces the lateral aspect of the brainstem and is bounded medially by the mesial temporal lobe (supratentorial) and the quadrangular lobe of the cerebellum (infratentorial). Inferiorly, arachnoid separates it from the cerebellopontine cistern. It extends superiorly between the temporal lobe and midbrain over the pulvinar of the thalamus to its anteromedial limit in the region of the velum interpositum near the foramen of Monroe. The major contents of this cistern are the P2 and P3 segments of the posterior cerebral artery, the superior cerebellar artery, perforators to the brainstem, the basal vein of Rosenthal, and the fourth cranial nerve.

The pericallosal cistern is divided into anterior and posterior portions at the branching point of the pericallosal and callosomarginal arteries. As the cistern is traced posteriorly, it joins the quadrigeminal cistern and the cisterna velum interpositum. The pericallosal cistern contains the pericallosal arteries.

The superior cerebellar cistern covers the anterior vermis of the cerebellum and extends laterally as the subarachnoid space over the cerebellar hemispheres. Anterosuperiorly, it blends with the quadrigeminal cistern and cisterna ambiens. It contains the terminal portion of the superior cerebellar artery and the superior cerebellar and vermian veins.

The cisterna velum interpositum, a small slit-like compartment below the splenium, extends from the foramen of Monroe anteriorly to the Habenular commissure posteriorly. Anteriorly, the fornices form its roof, converging toward the foramen of Monroe. Below lies the roof of the third ventricle. The cisterna velum interpositum blends with the quadrigeminal cistern posteriorly. It contains the internal cerebral vein, medial posterior choroidal artery, and branches of the pericallosal artery.

NEUROVASCULAR ANATOMY

The pineal region is bounded anteriorly by the quadrigeminal plate, the pineal body, and the habenular complex. The spleninum of the corpus callosum forms the roof of this region. The lateral boundaries are the mesial temporal and occipital lobes and the pulvinar of the thalamus. The superior vermis forms the floor of the region (Fig. 16–1). Just above the pineal gland rests the posterior wall of the third ventricle (Fig. 16–2).

The major arteries of the region include branches of the posterior cerebral artery and the superior cerebellar artery. The medial posterior choroidal artery, the calcarine, and the parieto-occipital arteries cross the pineal region.

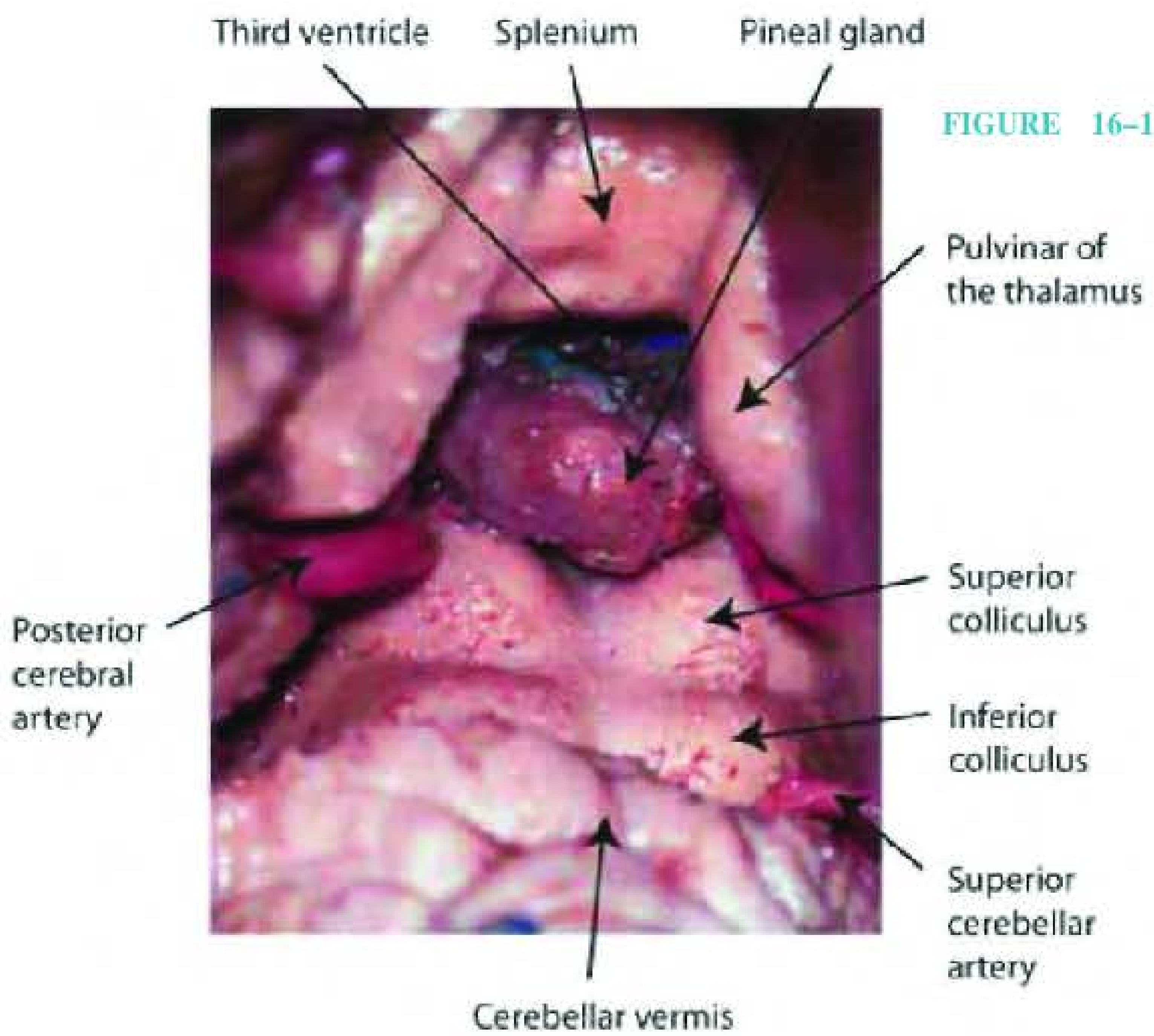

FIGURE 16–1 The anatomy of the pineal region.

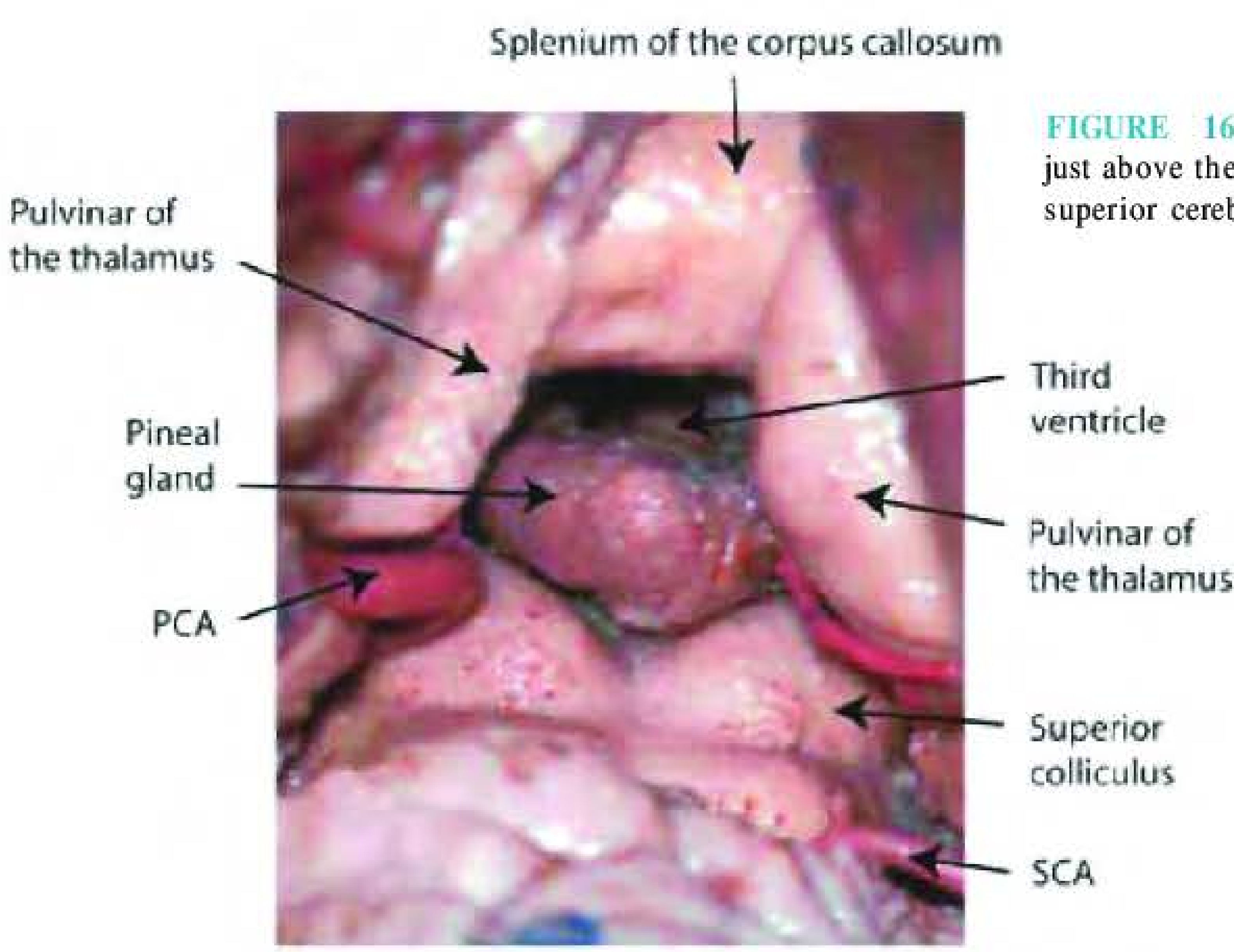

FIGURE 16–2 The posterior wall of the third ventricle rests just above the pineal gland, PCA, posterior cerebral artery; SCA, superior cerebellar artery.

The internal cerebral veins exit the cisterna velum interpositum and the basal veins of Rosenthal exit the ambient cisterns to reach the region of the pineal gland. The basal veins of Rosenthal most commonly drain into the internal cerebral veins; however, they also can drain into the vein of Galen and the confluence of the internal cerebral veins. The vein of Galen courses below the splenium of the corpus callosum to join the straight sinus. The vein of the cerebellomesencephalic fissure courses forward through the cerebellomesencephalic fissure to terminate with the superior vermian vein in the vein of Galen or the internal cerebral vein (Figs. 16–3–16–5).

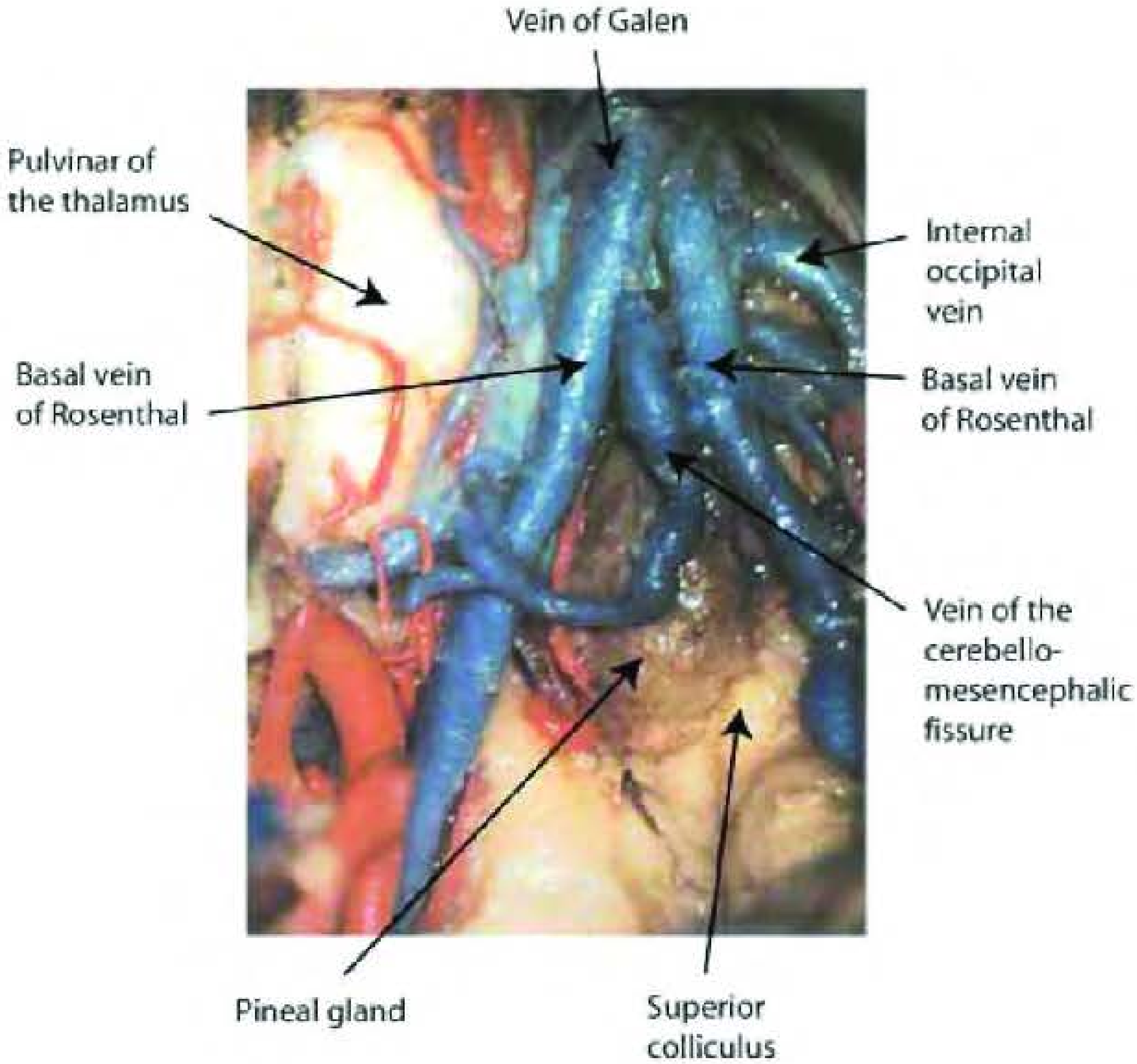

FIGURE 16–3 A vast venous complex surrounds the pineal gland.

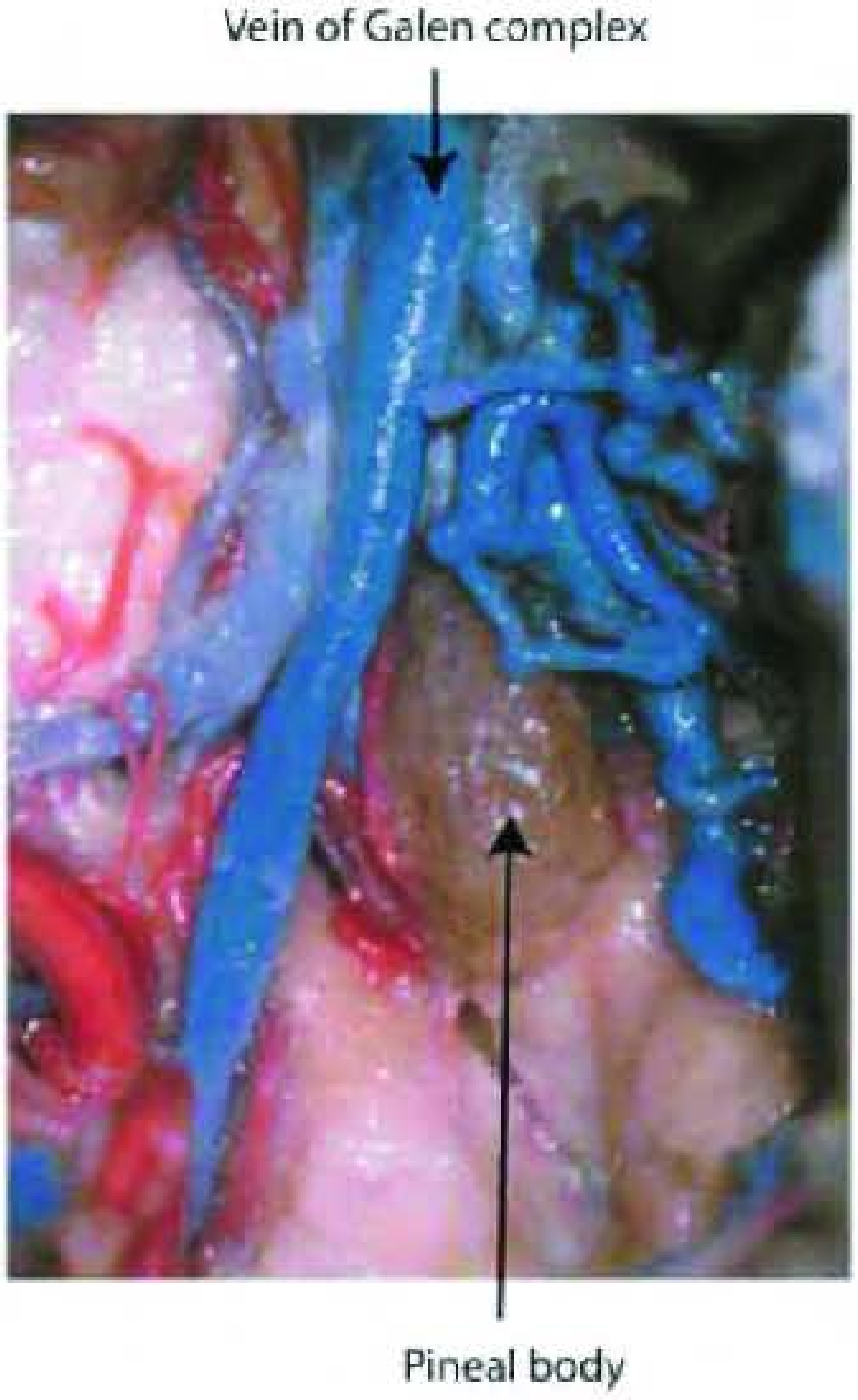

FIGURE 16–4 The vein of Galen anastomotic complex is visualized.

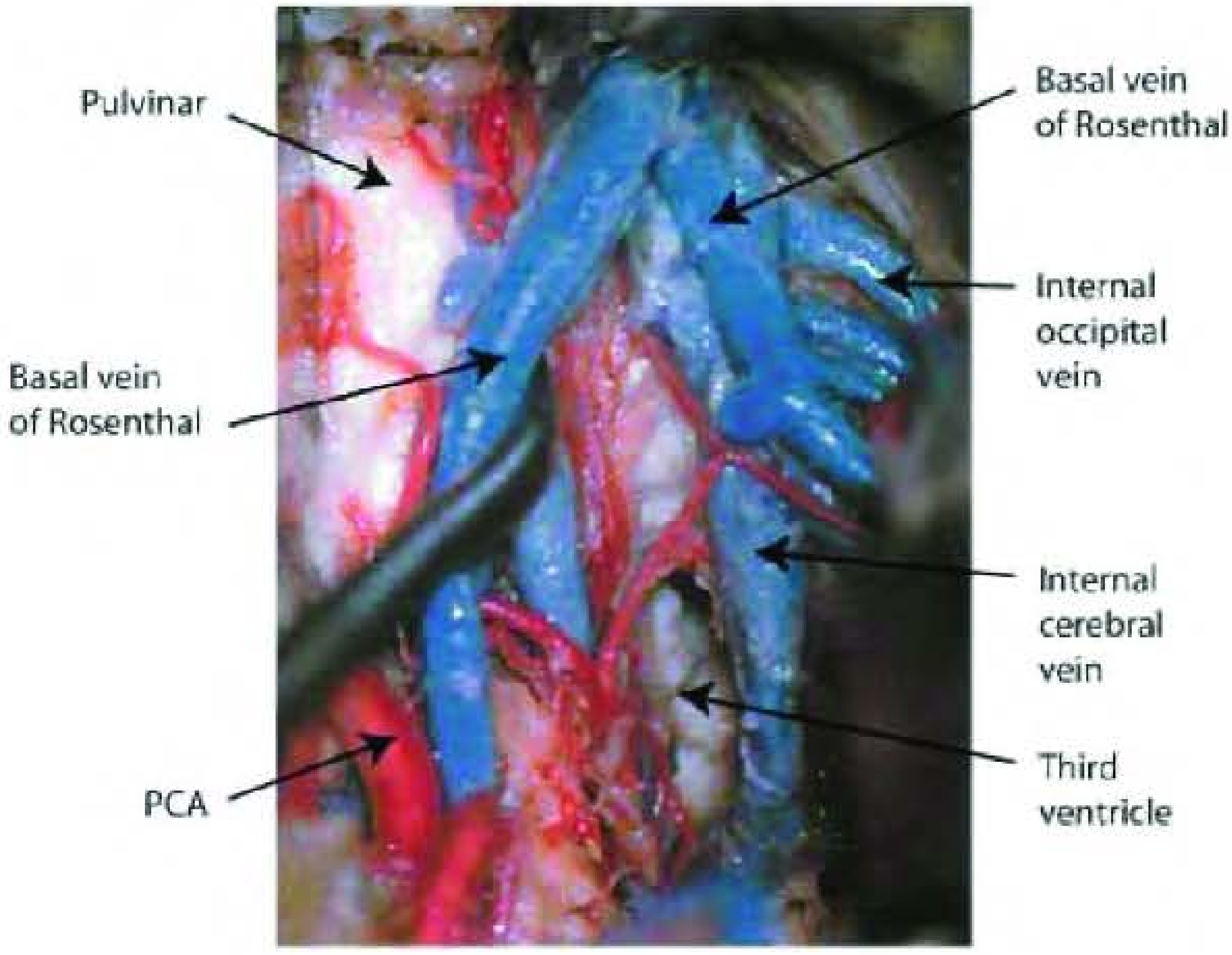

FIGURE 16–5 The basal veins of Rosenthal, the internal cerebral veins, and the occipital veins all drain through the Galenic anastomotic complex PCA, posterior cerebral artery.

SURGICAL TECHNIQUE

SUPRACEREBELLAR–INFRATENTORIAL APPROACH

This procedure is best accomplished with the patient either in the sitting position or the concord position. A midline incision is generally used; however, an inverted U-shaped incision can be used (Fig. 16–6). The downward reflection of the flap created with a U-shaped incision may obscure the line of sight of the surgeon to some degree. The muscles are dissected in a subperiosteal fashion and laterally reflected, A self-retaining retractor is placed to maintain adequate exposure.

Once the occipital bone is adequately exposed, the craniotomy is performed. The craniotomy can be made in one piece or two. The main purpose is to expose, without injuring, the torcula, the inferior portion of the superior sagittal sinus, and both transverse sinuses. After burr hole placement and careful separation of the dura, a suboccipital craniotomy is performed. Once the suboccipital craniotomy is made, the transverse sinuses and the torcula are separated from the overlying bone, and a small suprptentorial craniotomy is performed to expose fully the torcula, inferior portion of the superior sagittal sinus and both transverse sinuses. The dura is opened over the posterior fossa in a Y- or U-shaped fashion (Fig. 16–7).

After the dura is opened, the cerebellar hemisphere and vermis come into view (Fig. 16–8). Under the operating microscope, the posterior vermian vein is identified draining into the straight sinus or the torcula. This vein is bipolar coagulated and transected. Other small bridging veins from the cerebellum to the tentorium are likewise coagulated and sectioned. This maneuver assists in allowing the cerebellum to fall away from the tentorium with the aid of gravity. A self-retaining retractor blade is placed under the edge of the tentorium to elevate it. No retractor is placed on the cerebellum.

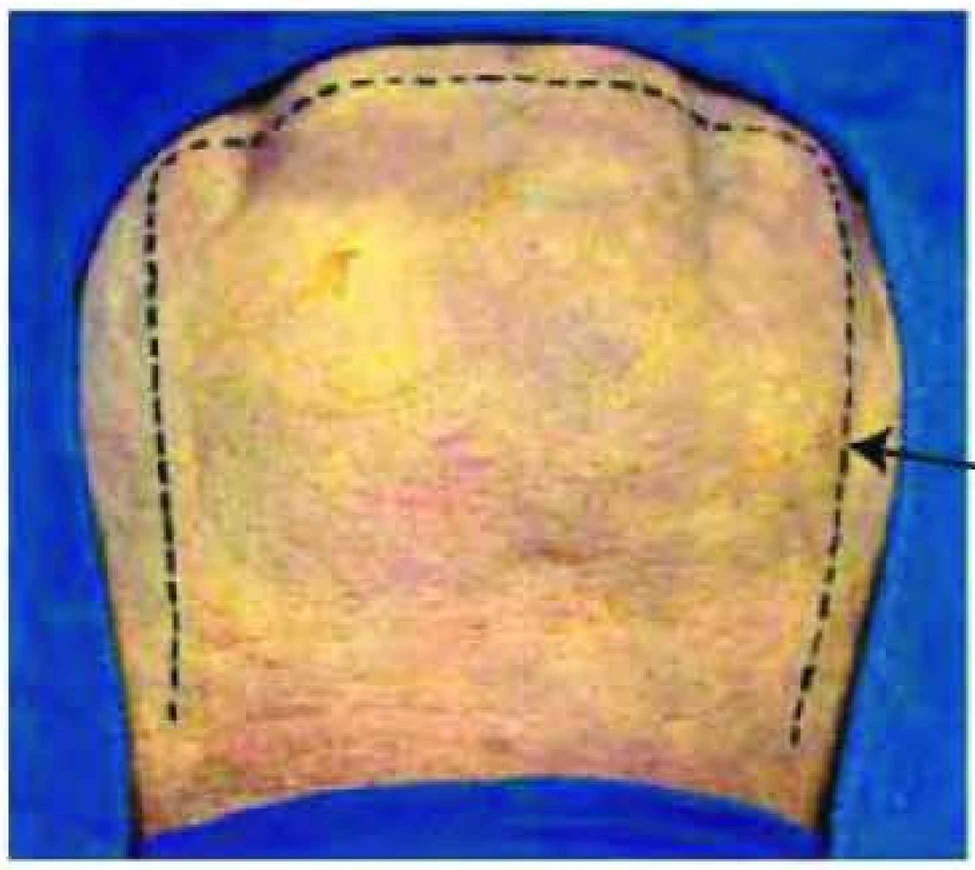

FIGURE 16–6 The skin incision for the supracerebellar-infratentorial approach.

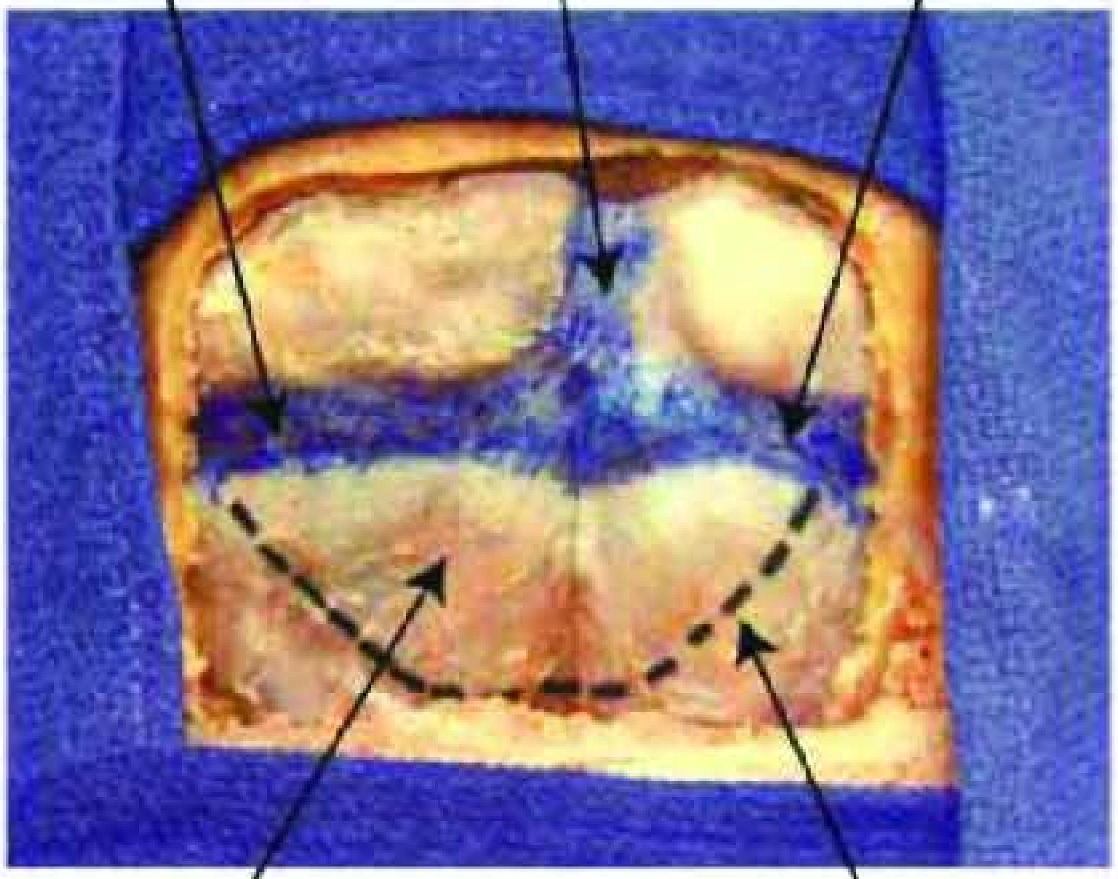

FIGURE 16–7 Dural incision for the supracerebcllar-infratentorial approach.

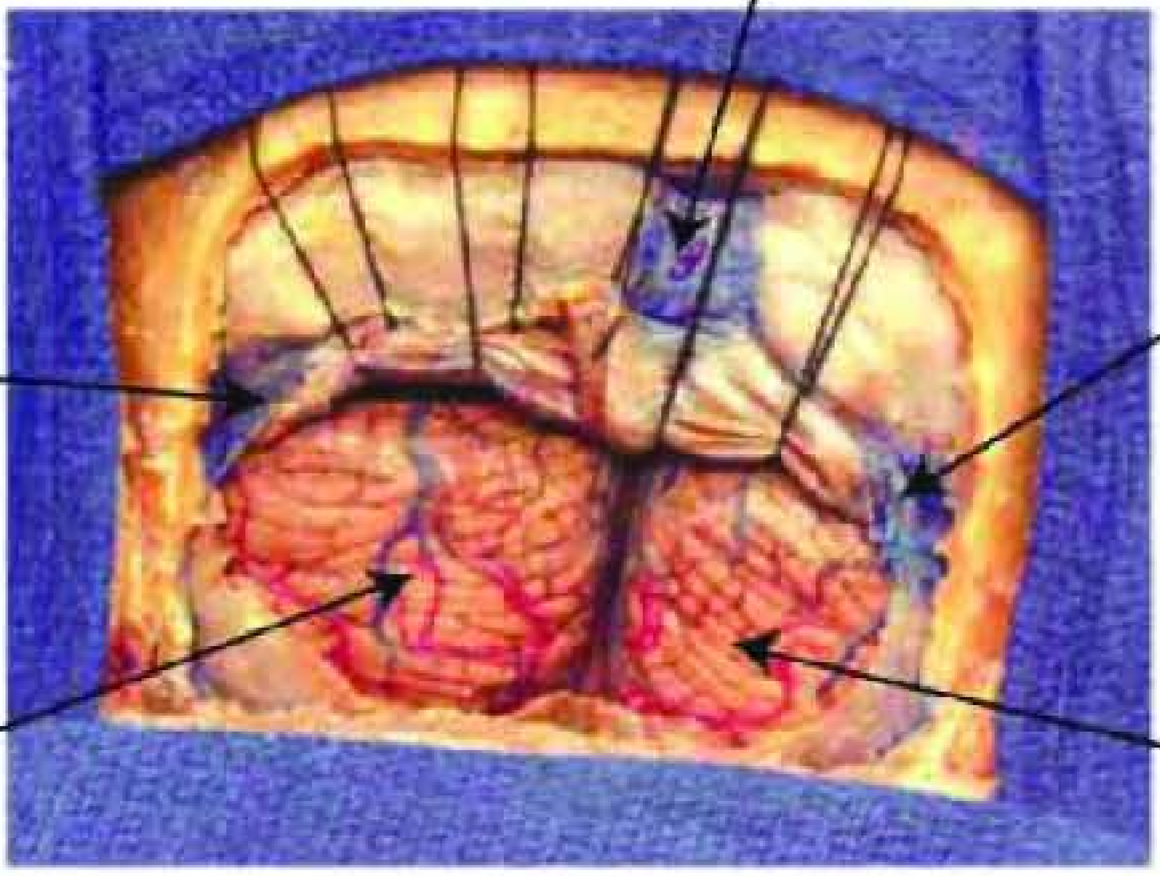

FIGURE 16–8 The cerebellar hemispheres and vermis are seen on opening the dura.

The thick arachnoid membrane that forms the posterior limit of the quadrigeminal cistern is opened, avoiding damage to the precentral cerebellar vein. The arachnoid membrane is gently separated from the vascular structures with a Rhoton 3 dissector (Baxter Healthcare Corp., McGraw Park, IL), and the arachnoid is opened widely on both sides. This exposes the complex anatomy of the deep venous system (Figs. 16–9 and 16–10).

The arachnoid beneath the internal cerebral vein is gently teased away, and the internal cerebral vein is retracted upward, which exposes the pineal gland, just above the pineal gland, the posterior limit of the third ventricle is seen (Figs. 16–2 and 16–5). The tela choroidea is sectioned, and it is possible to enter the cavity of the third ventricle. By dissecting the inferior surface of the internal cerebral vein, the velum interpositum can be entered, exposing the choroid plexus and the medial choroidal artery. The basal vein of Rosenthal and occipital vein can be seen laterally.

OCCIPITAL–TRANSTENTORIAL APPROACH

The patient is positioned in the three-quarters prone position in Mayfield three-point fixation with the operative side in the dependent position so that the occipital lobe fails away from the falx cerebri, thereby minimizing brain retraction. The sitting and semisitting positions also can be used.

An inverted J-shaped incision is made in the skin (Fig. 16–11). The long limb of the "J" runs along the mid-

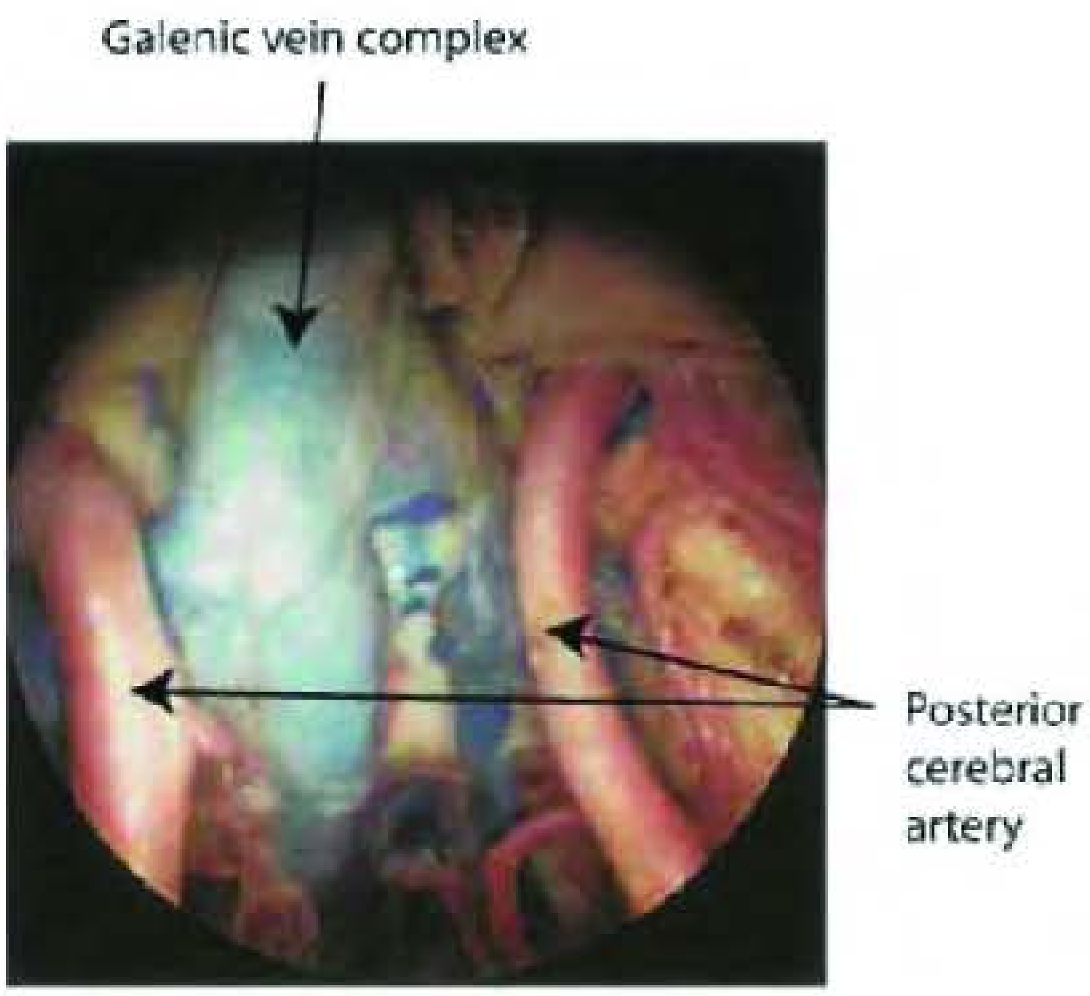

FIGURE 16–9 The supracerebellar-infratentorial anatomy is revealed. The galenic venous complex is revealed as are the posterior cerebral arteries.

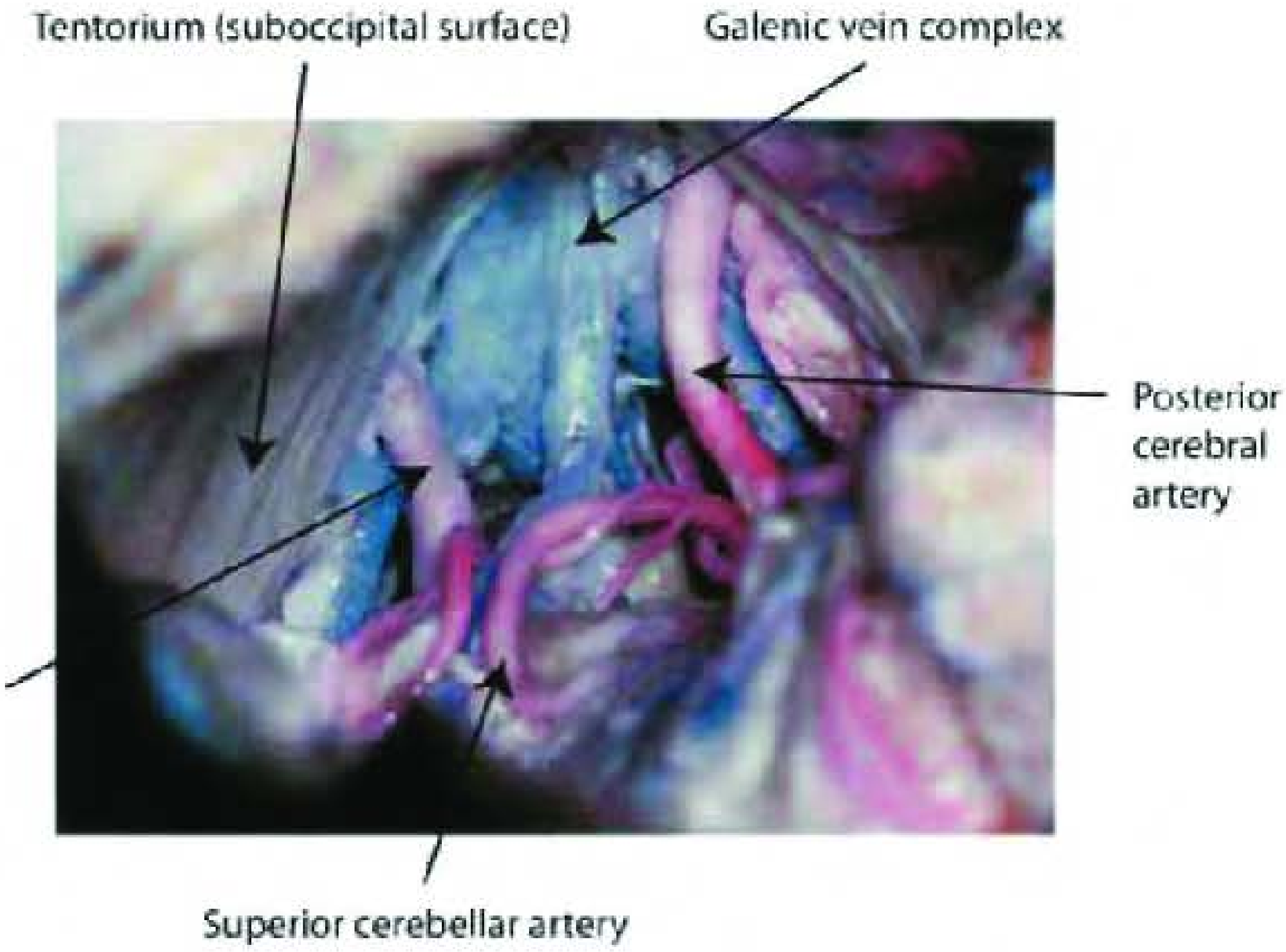

FIGURE 16–10 Panoramic view of the supracerebellar-infratentorial surface.

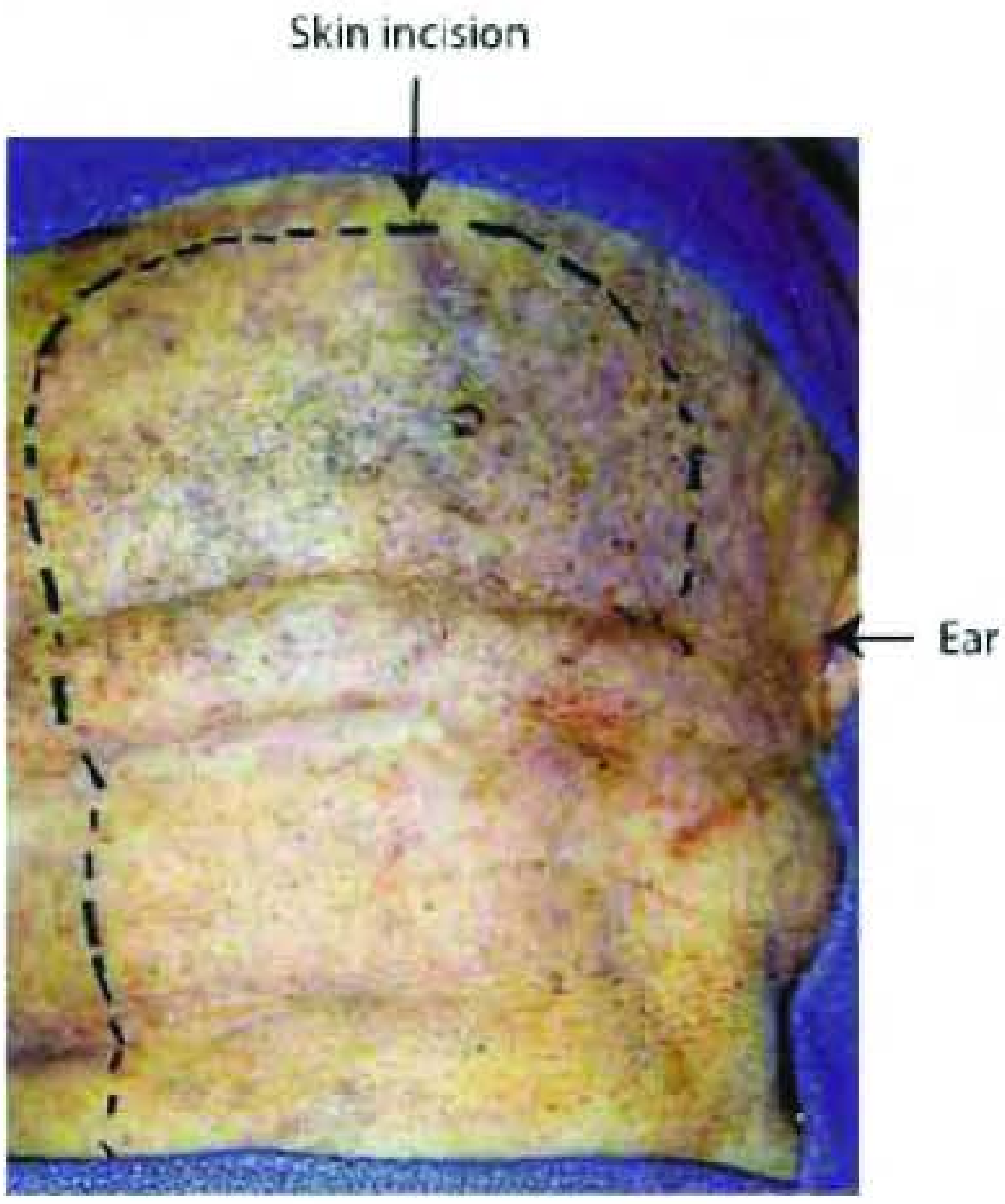

FIGURE 16–11 Skin incision for the occipital-transtentorial approach.

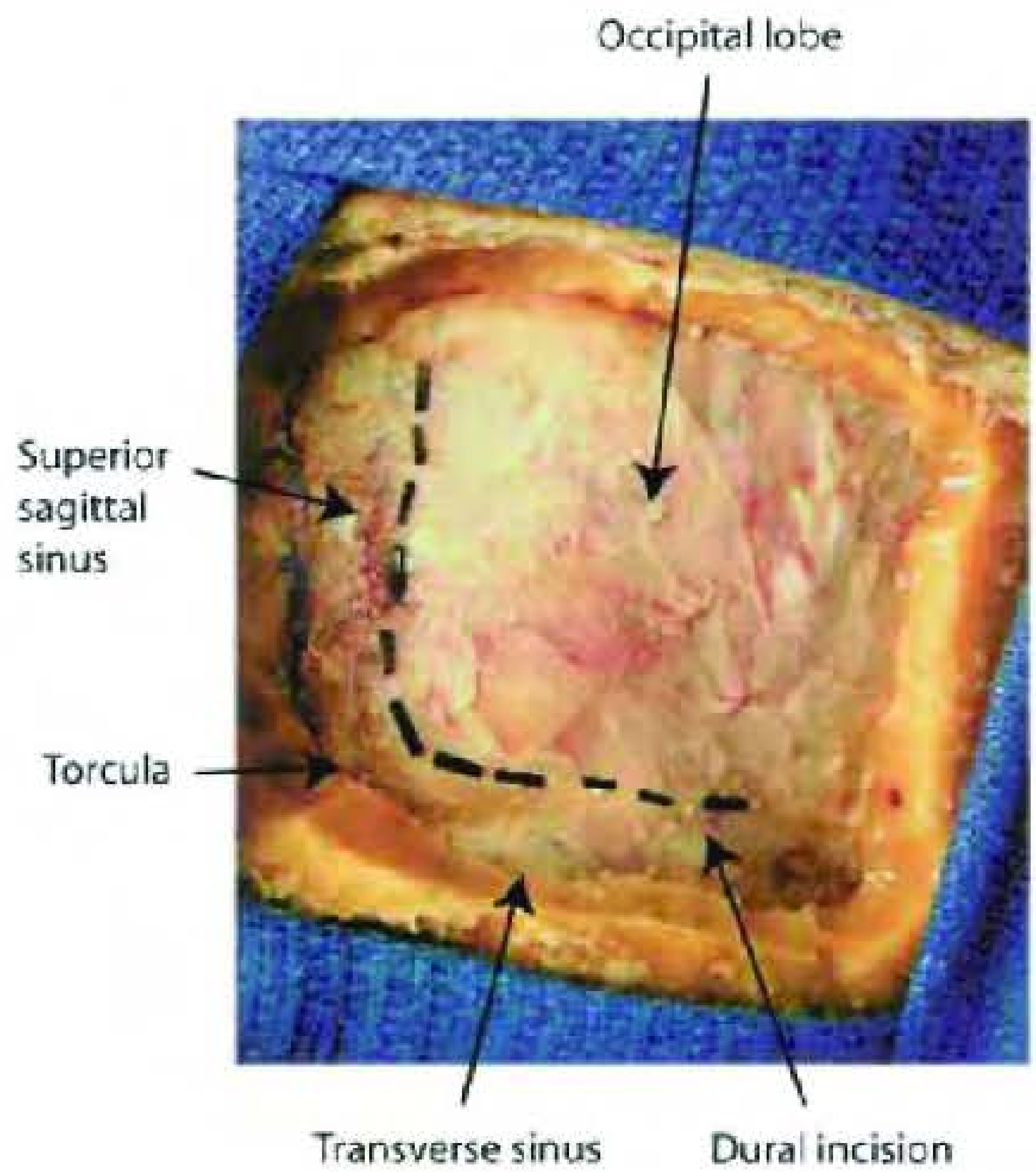

FIGURE 16–12 Dural incision for the occipital-transtentorial approach.

line and is extended below the inion so that a suboccipital craniotomy can be performed if necessary. The pericranium and skin are reflected laterally and inferiorly. A rectangular shaped craniotomy is made adjacent to the Superior sagittal and transverse sinuses. If necessary, a rongeur can be used to removed additional bone and thus expose the sinuses. The dura is opened in an L- or T-shaped fashion to keep the occipital lobe covered (Fig. 16–12). There are virtually no bridging veins between the occipital lobe and the superior sagittal sinus. Near the occipital pole, one or two bridging veins may be encountered.

Under the operating microscope, the arachnoid from the medial and inferior aspect of the occipital lobe is teased away to reach the tentorial notch, and the tentorium is cut (Fig. 16–13). Cutting the tentorium exposes the superior surface of the cerebellum and the vermis and will also expose the thick arachnoid membrane over the quadrigeminal cistern. The arachnoid is sharply opened to expose the venous system. The ipsilateral basal vein of Rosenthal is identified. The remainder of the dissection is similar to the previously described approach. A portion of the splenium of the corpus callosum may be resected in certain pathologic conditions to provide additional exposure.

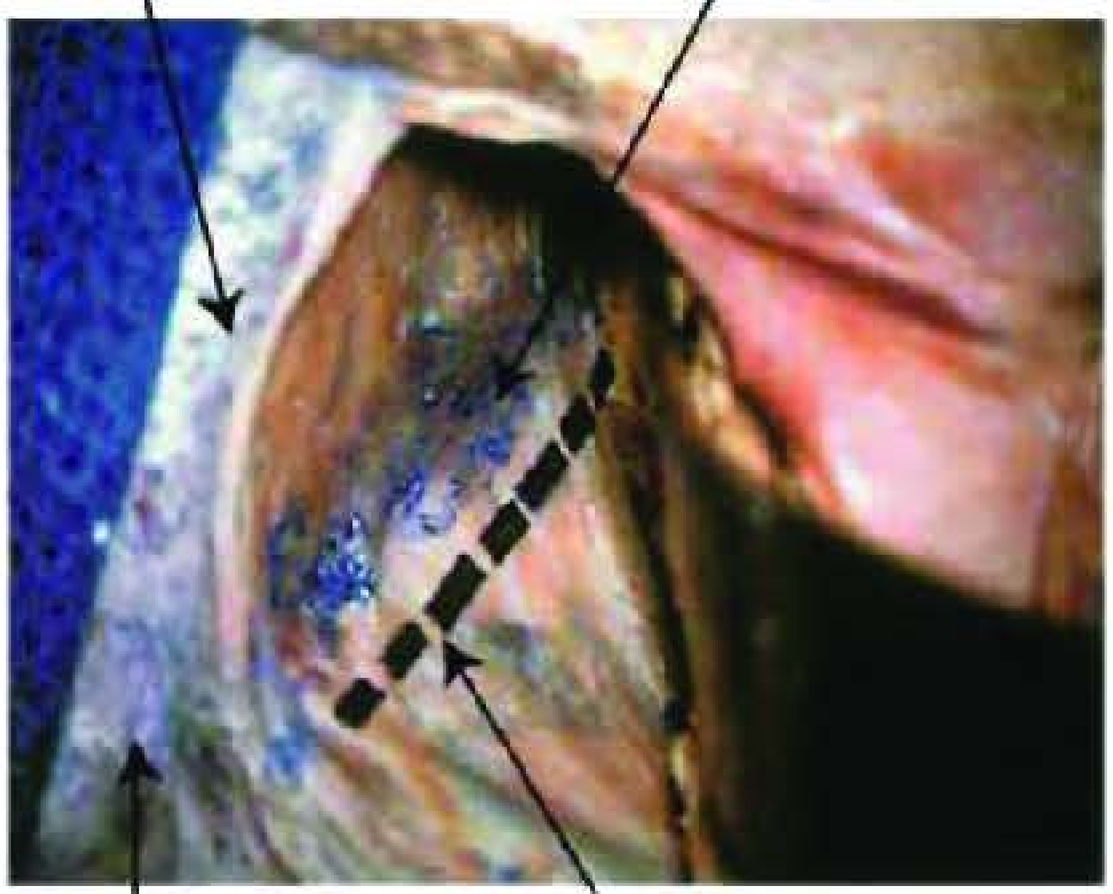

FIGURE 16–13 The tentorial incision is outlined.

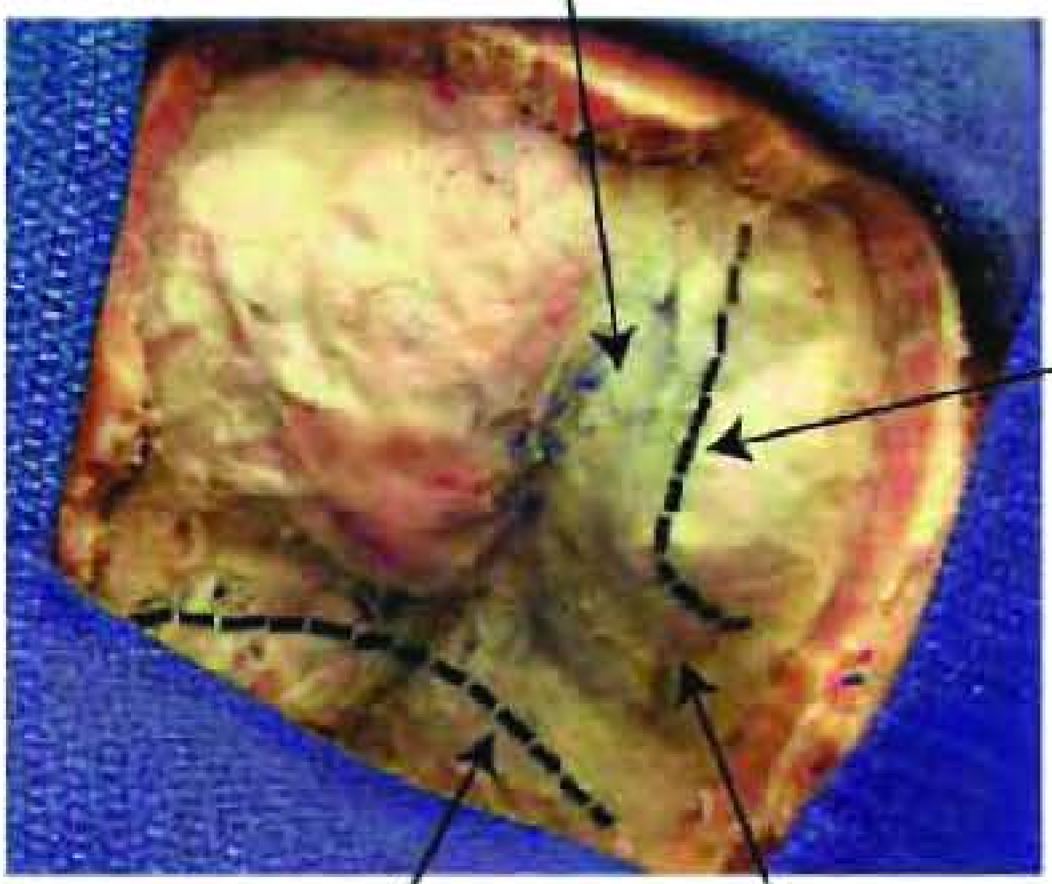

FIGURE 16–14 Dural incision for the combined approach.

COMBINED SUPRATENTORIAL–INFRATENTORIAL TRANSSINUS APPROACH

The patient is placed in a semiprone position in Mayfield three-point fixation with the side of the proposed transverse sinus sectioning down to provide gravity-assisted occipital lobe retraction. An inverted J-shaped incision is made that encompasses both the supratentorial and the infratentorial compartments. After making the skin incision, the skin flap, muscle layer, and the pericranium are elevated as a single layer.

The craniotomy is made in three pieces, and a suboccipital craniotomy is performed. The transverse sinus is separated from the overlying bone, and an occipital craniotomy not crossing the sagittal sinus is performed. After separating the sagittal sinus from the overlying bone, an occipital craniotomy is made on the contralateral side crossing the sinus. The infratentorial dura is opened transversely, with ligation of the occipital sinus. A small L-shaped dural opening is made lateral to the superior sagittal sinus and superior to the transverse sinus on the side of proposed sinus division (Fig. 16–14). The divided sinus should be on the hemodynamically nondominant side as determined by preoperative angiography.

During surgery, a 20-gauge butterfly needle is inserted into the sinus proximal to the site of proposed sinus division. Two temporary aneurysm clips are placed on the transverse sinus at the site of proposed sinus division (Fig. 16–15). If, after 5 minutes, the sinus pressure does not rise by more than 5 mm Hg, there is no brain swelling, and there is no deterioration of the somatosensory-evoked potentials (SSEPs), the sinus is cut between the two clips. Care must be taken to preserve the drainage of the vein of Labbé.

The opening of the supratentorial dura is widened. The tentorium is cut 1 cm lateral to the straight sinus. Traction sutures are placed in the tentorium, and retraction is provided. The occipital lobe and the cerebellum are gently retracted, providing a very wide exposure. The remainder of the dissection is as described above.

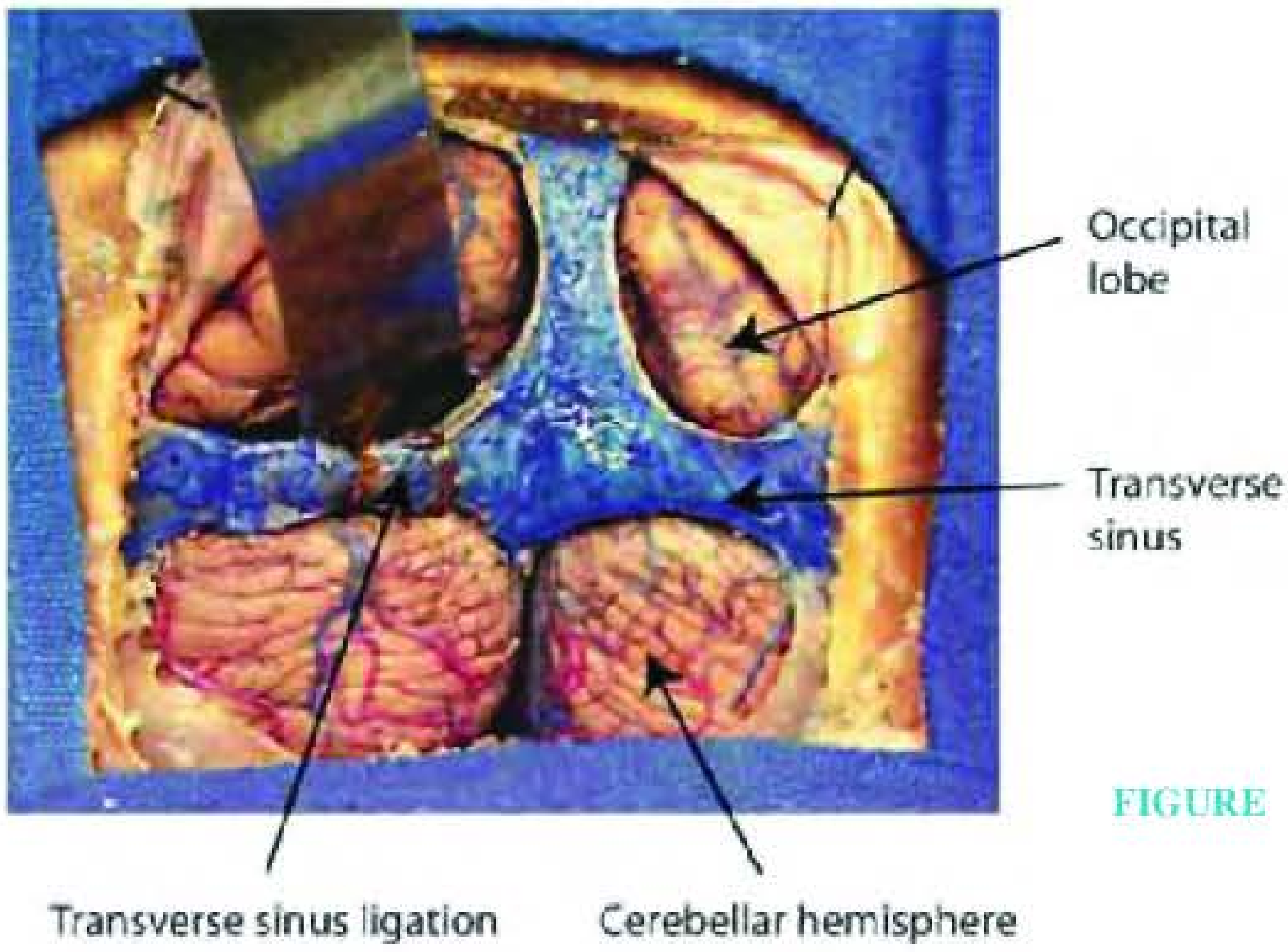

FIGURE 16–15 The sinus is clip ligated in preparation for sectioning.

PITFALLS, PEARLS, CONSIDERATIONS

SUPRACEREBELLAR–INFRATENTORIAL APPROACH

- Air embolism if sitting position is used
- Hemorrhage
- Pupillary abnormalities
- Venous occlusion
- Supracerebellar approach not suitable for tumors with lateral extension to trigone, or superior extension to the corpus callosum or tumors with downward displacement of venous system

OCCIPITAL–TRANSTENTORIAL APPROACH

- Visual field defects from traction on occipital lobes
- Disconnection syndrome with splenium injury
- Limited exposure if tumor extends to contralateral side
- Difficult to see contralateral vein of Rosenthal

COMBINED APPROACH

- Brain edema and venous infarct if dominant sinus is taken
- Consider primary re-anastomosis or vein patch graft

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INTERHEMISPHERIC APPROACH

Emel Avci, Damirez Fossett

INDICATIONS FOR APPROACH

- Lateral and third ventricular tumors
- Anterior cerebral artery complex aneurysms
- Midline neoplastic and vascular hemispheric pathology

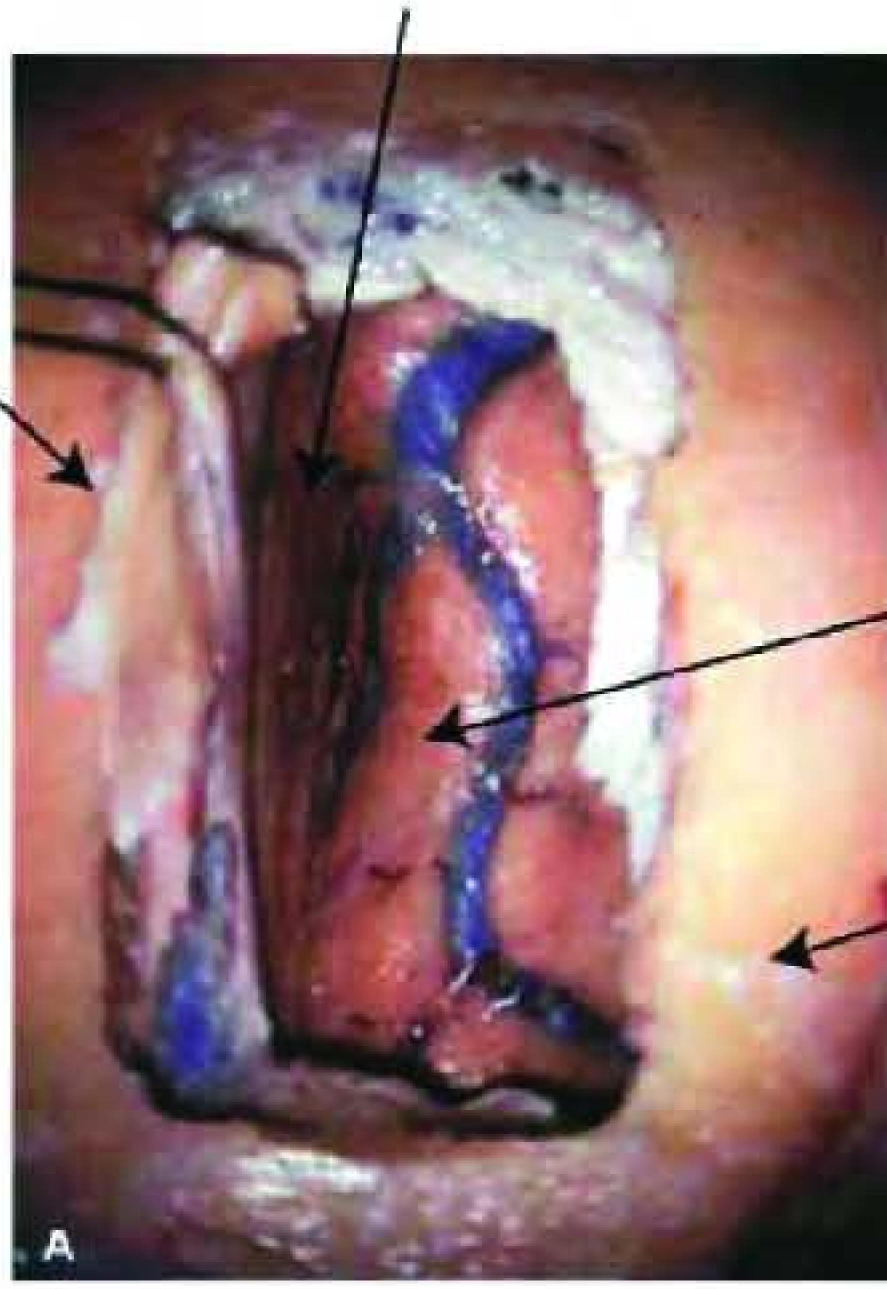
POSITIONING AND SKIN INCISION

The patient is placed in the supine position in Mayfield three-point fixation with the head in either the neutral position or slightly rotated to the contralateral side about 20 to 30 degrees. Preferably, a right-sided approach is chosen. Either a horseshoe shaped or a unilateral coronal incision is used.

SURGICAL TECHNIQUE

After burr hole placement, the B1 foot-plated tool of the Midas is used to create a bone flap with its medial edge extending either to the lateral edge of or, if desired, across the sagittal sinus. The flap is centered on the coronal suture and can be oriented slightly more anterior or posterior on the suture, depending on the location of the pathology. The size of the bone flap need only be 5 to 6 cm in the anterior to posterior direction and 2 to 3 cm in the medial-to-lateral direction. The dura is opened in a horseshoe fashion with its base on the sagittal sinus.

Cortical veins draining into the sinus should be protected (Figs. 17–1A-C). Occasionally, one vein may he taken if needed for exposure. With gentle retraction on the mesial cortex of the frontal lobe, visualization of the arachnoid



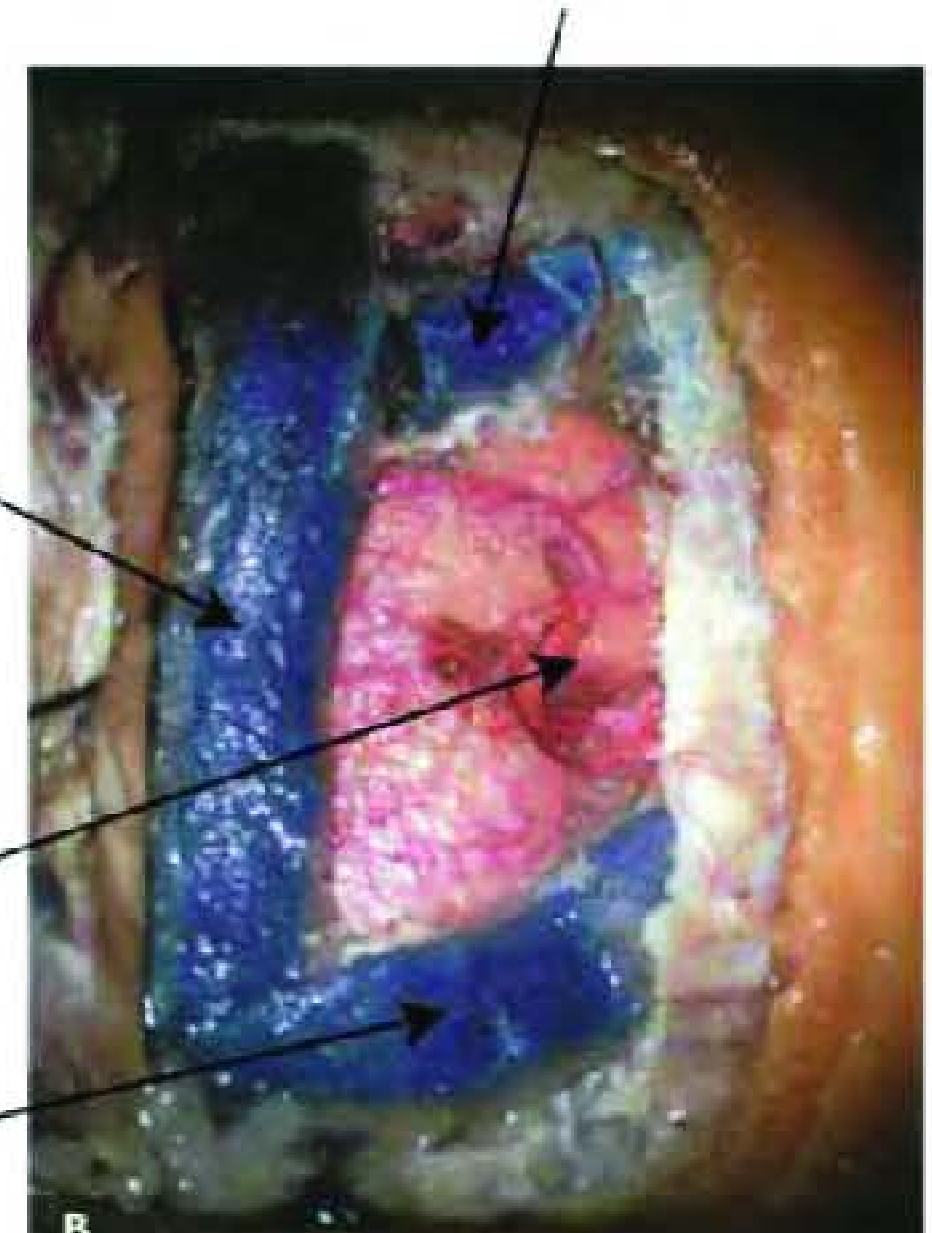


FIGURE 17–1 **A**: The bone flap is placed two thirds in front of the coronal suture and one third behind. The dura is flapped and based on the sagittal sinus. No bridging veins are seen. **B**: The bone flap is placed two thirds in front of the coronal suture and one third behind. The craniotomy crosses the midline to expose the sagittal sinus fully. Two large bridging veins are seen precluding the use of an interhemispheric approach. *(continued on page 108)*

emanating from the free lower edge of the falx can be obtained. This arachnoid is incised, allowing visualization of both cingulated gyri. The paired callosomarginal arteries must be identified coursing superficial to the cingulate gyrus and must be protected (Fig. 17–2A–C). The cingulated gyri, which are often adhesed, are separated, and the very white corpus callosum, with the overlying paired pericallosal arteries, is visualised (Fig. 17–3A–D). The paired pericallosal arteries can be followed proximally around the genu of the corpus callosum to visualize the anterior communicating

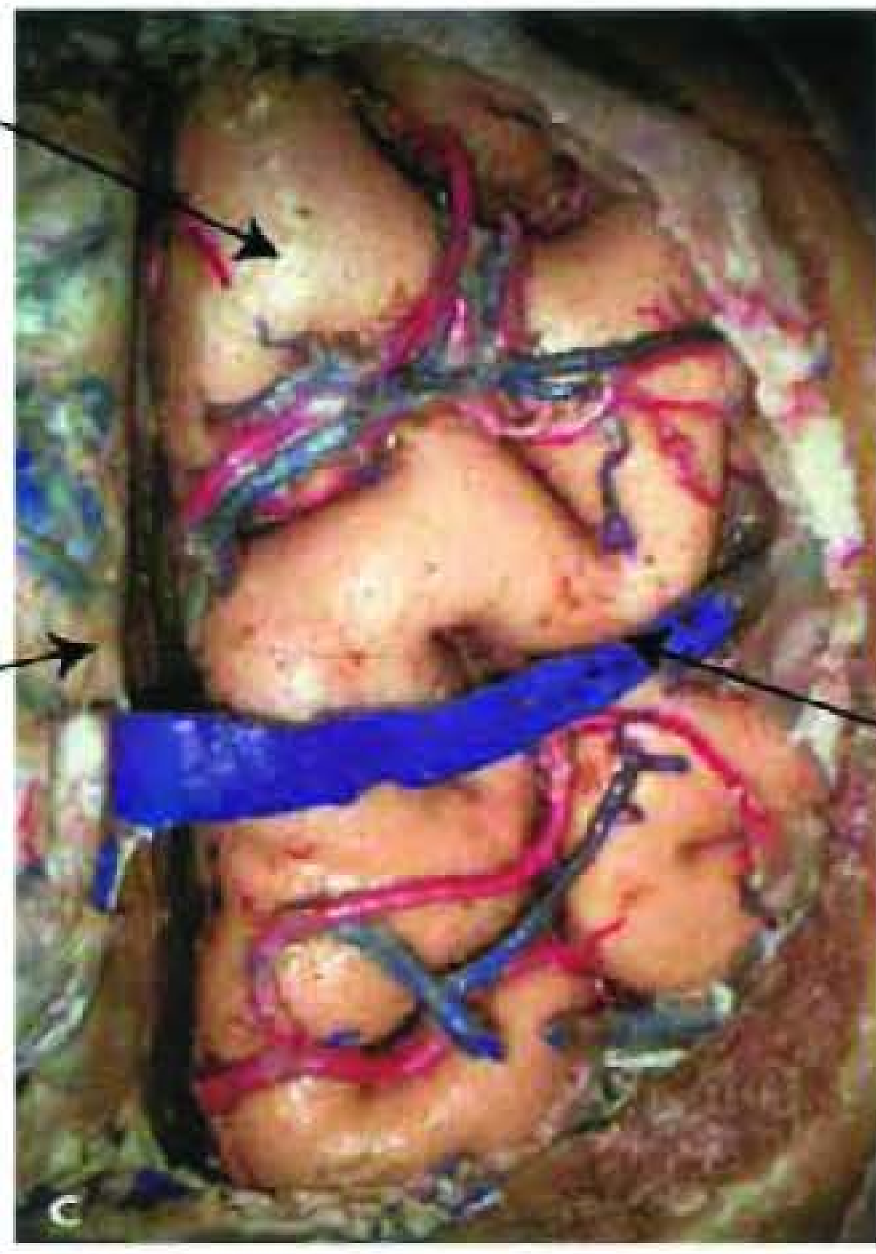


FIGURE 17–1 *(continued from page 107)* **C**: The bone flap is placed two thirds in front of and one third behind the coronal suture. The craniotomy crossed the midline. One large draining vein is seen.

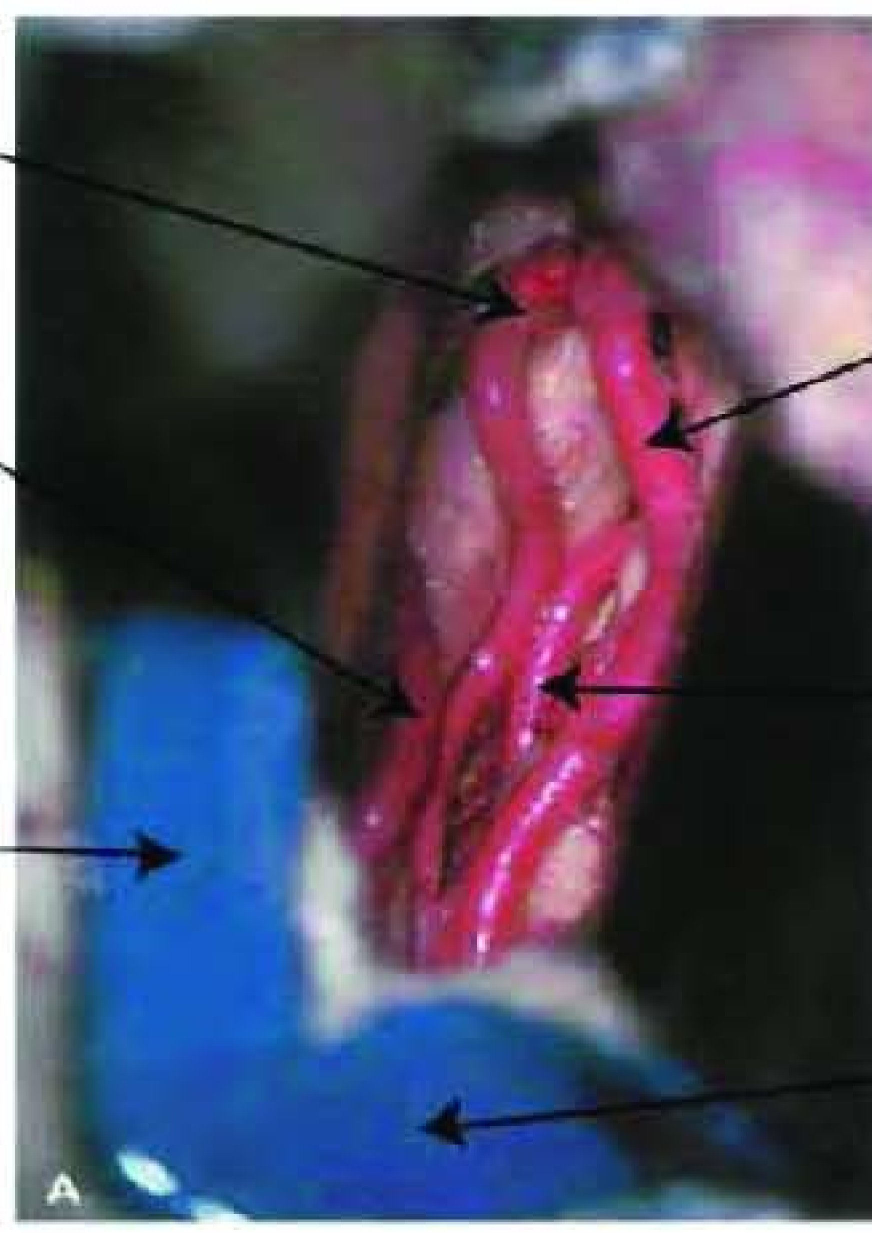
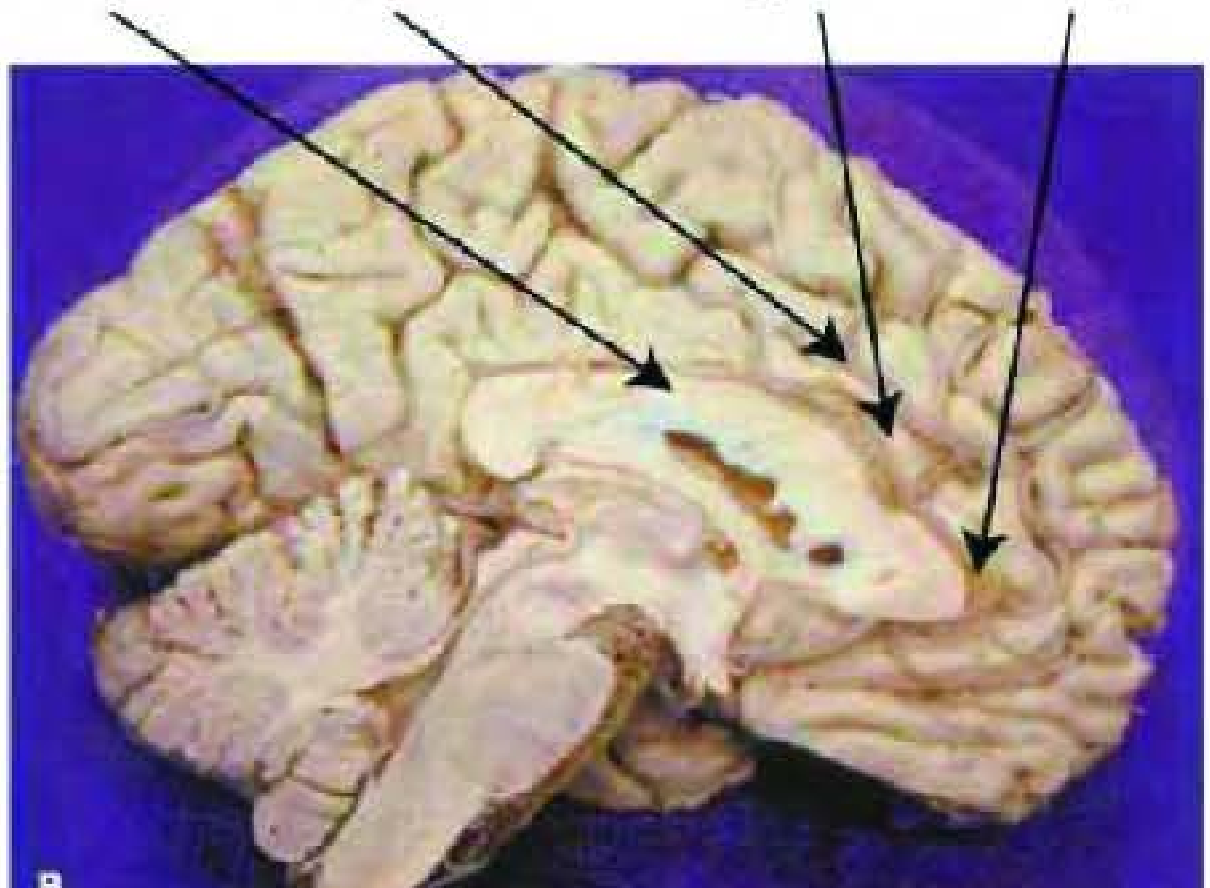
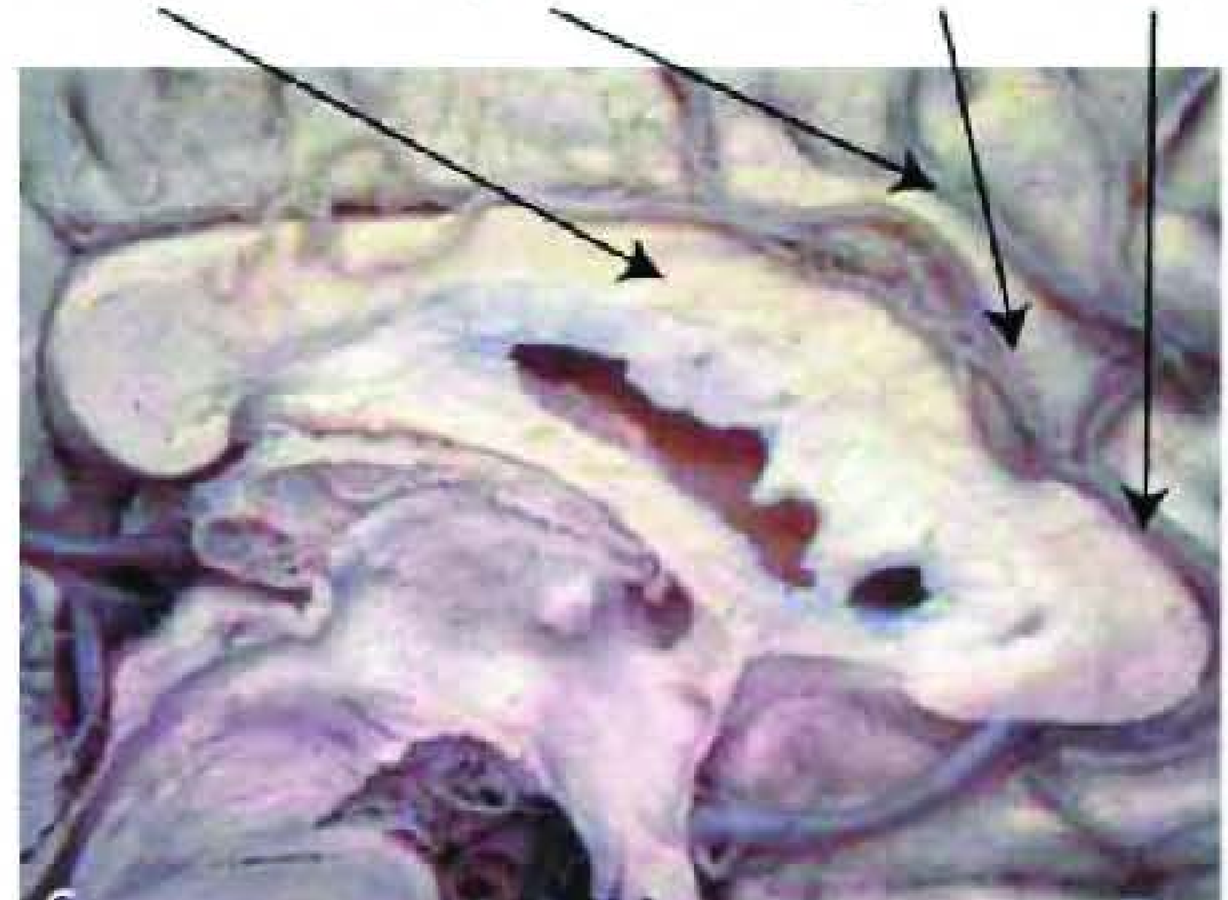


FIGURE 17–2 **A**: Paired callosomarginal and pericallosal arteries are seen. The cingulated gyrus has been separated and retracted. **B**: Mesial view of the hemisphere demonstrating the relationship of the pericallosal and callosomarginal arteries to the corpus callosum and cingulated gyrus. **C**: High-power view of the mesial hemisphere is shown. Note the relationship of the pericallosal and callosomarginal arteries to the corpus callosum and cingulated gyrus. The pericallosal arteries are deviated to one side above the corpus callosum.





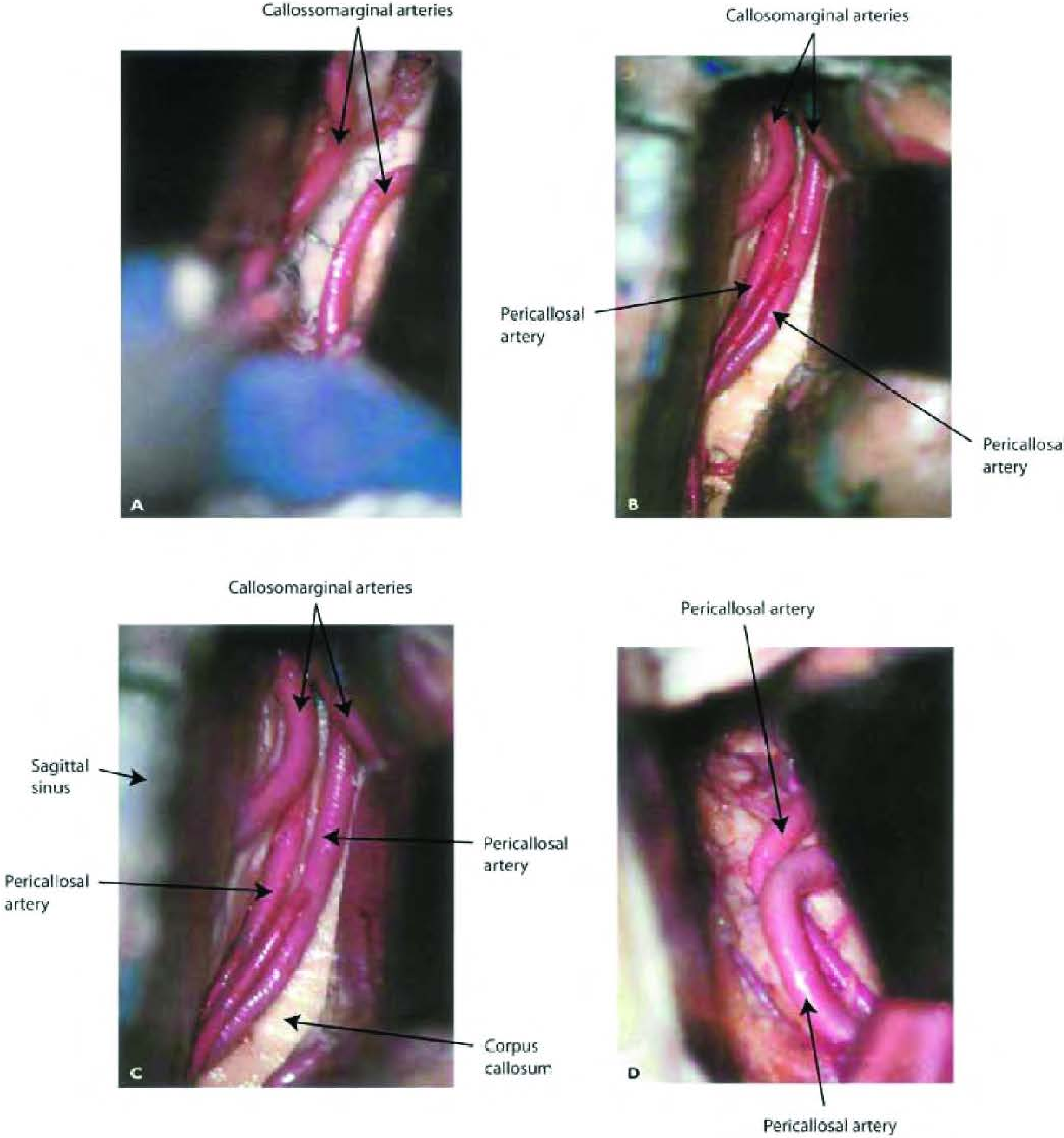


FIGURE 17–3 **A**: The callosomarginal arteries are seen into the cingulated gyrus. **B:** After separating the cingulated gyrus and retracting the callosomarginal arteries, the paired pericallosal arteries are seen. **C**: High-power view of the midline paired pericallosal arteries. **D**: The pericallosal arteries are deviated off of the midline.

artery complex. The corpus callosum is sectioned with suction and cauterization, the length of the callosotomy being about 2 to 3 cm, and the ventricular system is entered. The paired pericallosal arteries often migrate to one side or the other and are not widely separated from each other in the midsagittal plane; therefore, the callosotomy can be made lateral to these vessels (Fig. 17–4A, B).

Immediately on entering the ventricular system, inspection should be made of the surrounding structures to become oriented. The choroids plexus, anterior septal vein, and thalamostriate vein should all be identified. By following the choroid plexus or thalamostriate vein anteriorly, the foramen of Monroe can be identified. To determine which ventricle has been entered, look at the relationship between the thalamostriate vein and the choroid plexus. If the vein is to the right of the plexus, the right ventricle has been entered. If the vein is to the left of the plexus, the left ventricle has been entered. Opening the septum pellucidum provides access to the contralateral ventricular system. If, on opening the corpus callosum, no veins or choroids plexus are identified, a cavum septum pellucidum may have been entered- Review of the preoperative studies should alert the surgeon to this anatomic variance preoperatively.

Closure is done in a standard fashion with a watertight closure of the dura, followed by replacement of the bone flap. The scalp is closed in a two-layered fashion, and the skin is reapproximated.

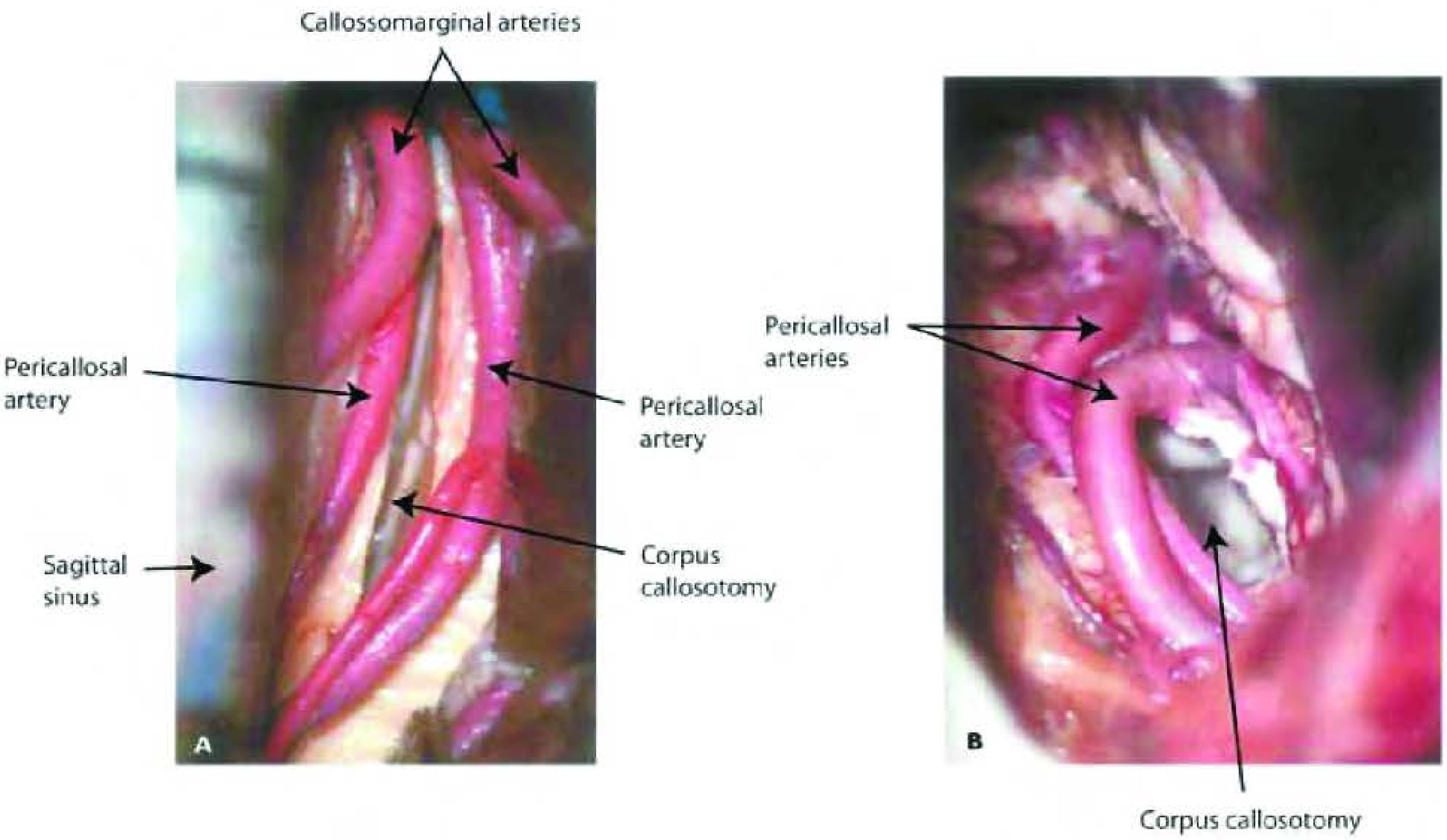


FIGURE 17–4 **A:** The corpus callosum has been opened between the midline pericallosal arteries **B**: A small corpus callosotomy is lateral to the deviated pericallosal arterius.

PITFALLS, PEARLS, CONSIDERATIONS

- Sagittal sinus injury
- Venous infarcts from taking bridging veins
- Retraction injuries to the frontal lobe, internal capsule, or thalamus
- Injury or occlusion of callosomarginal or pericallosal arteries
- Mistaking cingulated gyrus for corpus callosum
- Not recognizing a cavum septum pellucidum
- Inability to determine which ventricle is entered
- Injuries to the fornix
- Internal cerebral vein injuries

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FRONTAL LOBECTOMY

Yalcin Kocaugullar, Damirez Fossett

INDICATIONS FOR APPROACH

- Blossoming contusions
- Neoplasms
- Vascular lesions
- Seizures
- Hematomas

ANATOMY

The frontal lobes are located in front of the central sulcus and above the sylvian fissure. The medial surface is bounded by a line connecting the central sulcus to the dorsal margin of the corpus callosum posteriorly and anteriorly extends to the anterior border of the corpus callosum and floor of the frontal fossa. The inferior surface of the frontal lobe rests on the floor of the frontal fossa or the orbital plate. The frontal lobe is divided into four main gyri by the precentral sulcus, the superior frontal sulcus, and the inferior frontal sulcus. The gyri are called the precentral gyrus (primary motor cortex), the superior frontal gyrus, the middle frontal gyrus, and the inferior frontal gyrus. The inferior frontal gyrus can be divided into an orbital part, a triangular part, and an opercular part by the anterior and ascending ramus of the sylvian fissure. The motor speech area (Broca's) is located in the triangular and opercular parts of the inferior frontal gyrus on the left.

POSITIONING AND SKIN INCISION

The patient is placed supine with the head in Mayfield three-point fixation. The head is rotated about 20 to 30 degrees toward the contralateral shoulder. A shoulder roll is placed beneath the ipsilateral shoulder. A unilateral curvilinear incision or a bicoronal incision may be made (Fig. 18–1). A unilateral incision should slightly cross the midline. A bicoronal incision need only go to the superficial temporal line on the contralateral side.

SURGICAL TECHNIQUE

The facial nerve branches should be spared during reflection of the skin flap as described in Chapter 2. The temporalis muscle is reflected away from the underlying bone. The bone flap is designed to allow access to the midline, the frontal pole, and the anterior portion of the sylvian fissure. A burr hole is placed in the region of the keyhole, and a second one may be placed in the squamosal portion of the temporal bone. The bone cut should go immediately behind the coronal suture; a burr hole may be placed here if desired. The craniotomy flap is designed to go low over the supraorbital ridge and about 1 cm from the midline.

The dura is opened in a U-shaped fashion based on the sagittal sinus. The superior, middle, and inferior frontal gyri are identified. The sylvian fissure also should be visualized. Using a bipolar and suction technique, a

FIGURE 18–1 The frontotemporal skin incision is shown.

corticectomy is performed, and, in a subpial fashion, using the suction and bipolar technique, the lobectomy is performed. No more than 5 to 7 cm of the frontal lobes should be resected on the dominant hemisphere, and no more than 7 to 8 cm should be resected or the nondominant hemisphere (Fig. 18–2). The operculum should be spared. In the midline, the frontopolar artery may be bipolar coagulated; however, care should be taken to maintain patency of the pericallosal and callosomarginal arteries. If a subpial dissection is performed, these vessels should be well protected. In the same fashion, the pia should protect vessels of the sylvian fissure Veins draining into the sagittal sinus should be divided close to the brain, not close to the sinus. The ventricle may be entered, depending on how posterior the resection cavity is made (Fig. 18–3)

The dura is closed in a watertight fashion, and the bone flap is reattached with microplates. The muscle and subcutaneous tissues are reapproximated. The skin is then closed in the usual fashion.

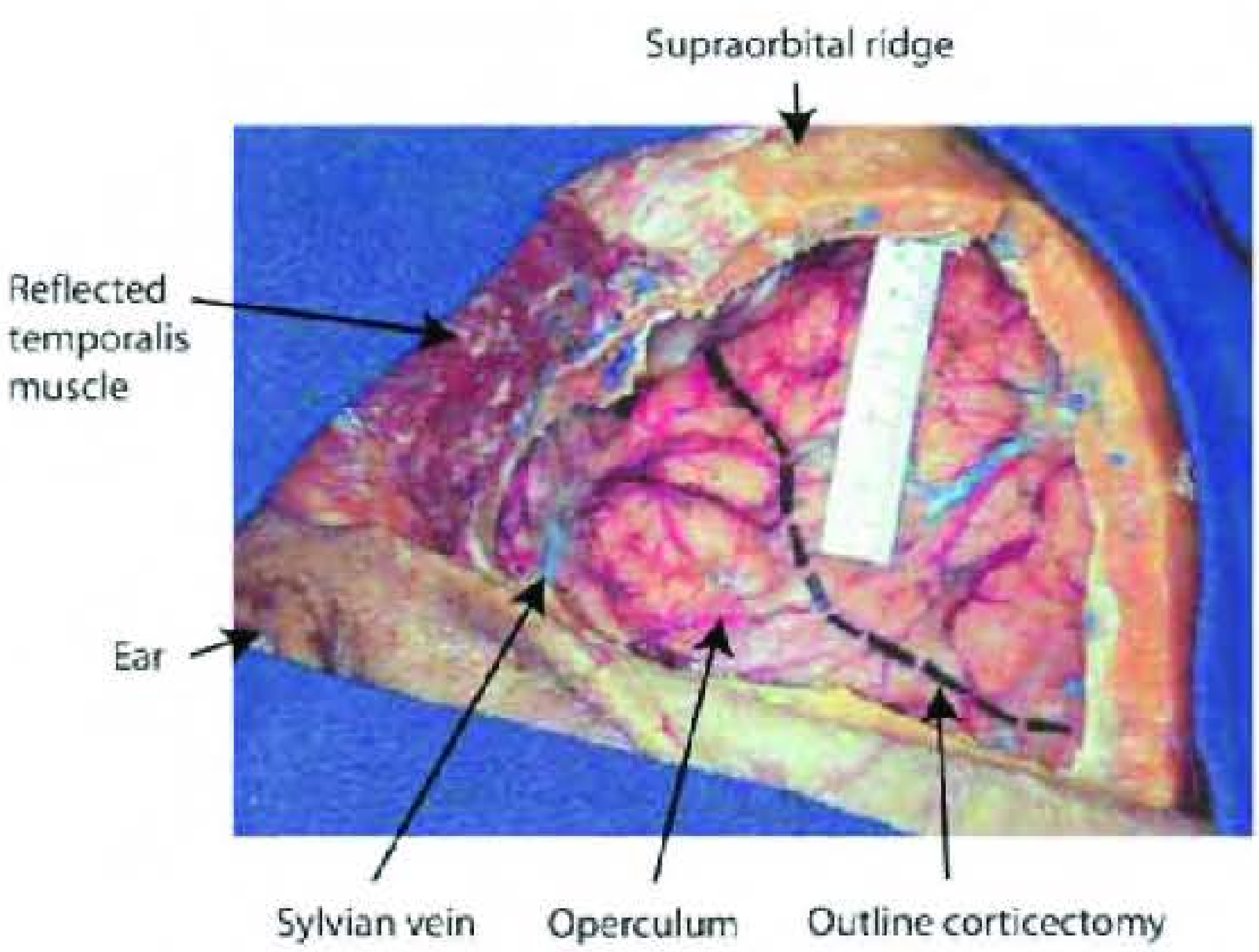

FIGURE 18–2 The corticectomy is outlined. The operculum has been spared. Interiorly, note the sylvian vein.

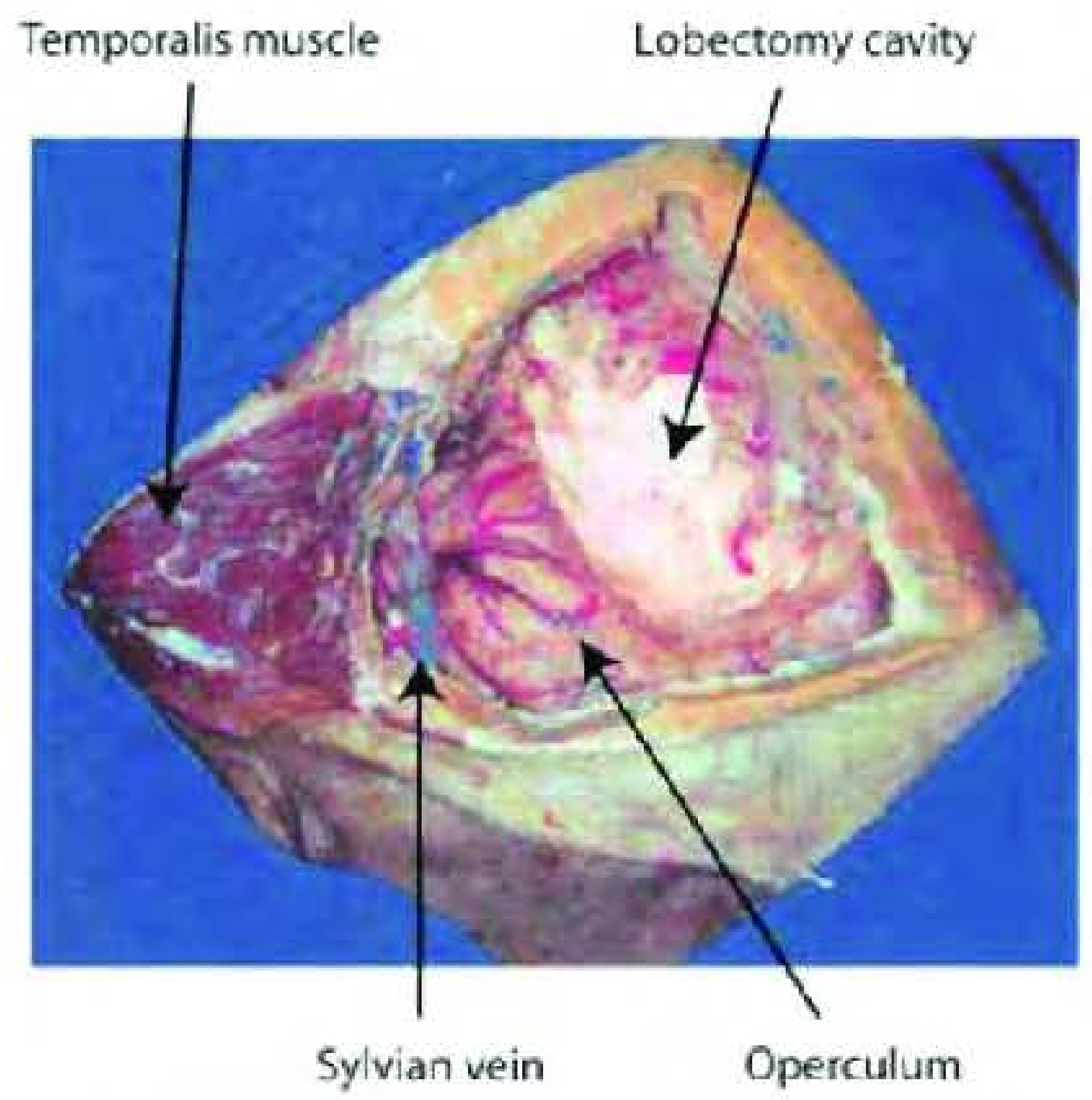

FIGURE 18–3 The lobectomy is complete. Note the sylvian vein, spared operculum, and floor of the anterior cranial fossa.

PITFALLS, PEARLS, CONSIDERATIONS

- Sinus injury
- Injury to the pericallosal and callosomarginal vessels
- Injury to sylvian fissure vessels
- Resection too large
- Postoperative epidural or subdural hematoma

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Chapter 19

Occipital Lobectomy

Yalcin Kocaogullar, Damirez Fossett

Indications for Approach

- Occipital region tumors
- Occipital vascular malformations

Anatomy

The occipital lobe occupies only a small segment of the lateral hemispheric surface. It is located behind an imaginary line, which joins the parieto-occipital sulcus with the preoccipital notch. On the medial side of the hemisphere, the occipital lobe is bounded by the parietooccipital sulcus anteriorly.

Positioning and Skin Incision

The patient is placed in rigid three-point fixation using the Mayfield head-holder in the lateral position with the head rotated 40 to 50 degrees toward the floor, the three-quarter prone, or the semisitting position. The skin incision begins in the midline in the region of the inion, courses superiorly, and curves over to the region of the squamosal suture near the ear (Fig. 19–1). The flap is reflected inferiorly, preserving the occipital artery and the greater and lesser occipital nerves.

Surgical Technique

Four burr holes are created and connected with the B1 footplated tool of the Midas Rex. The bone-flap edge approaches, but does not cross, the midline. It also approaches, but does not cross, the transverse sinus. A curvilinear dural opening is fashioned. It is then bisected such that one limb is reflected back toward the sagittal sinus, and the other limb is reflected back toward the transverse sinus (Fig. 19–2).

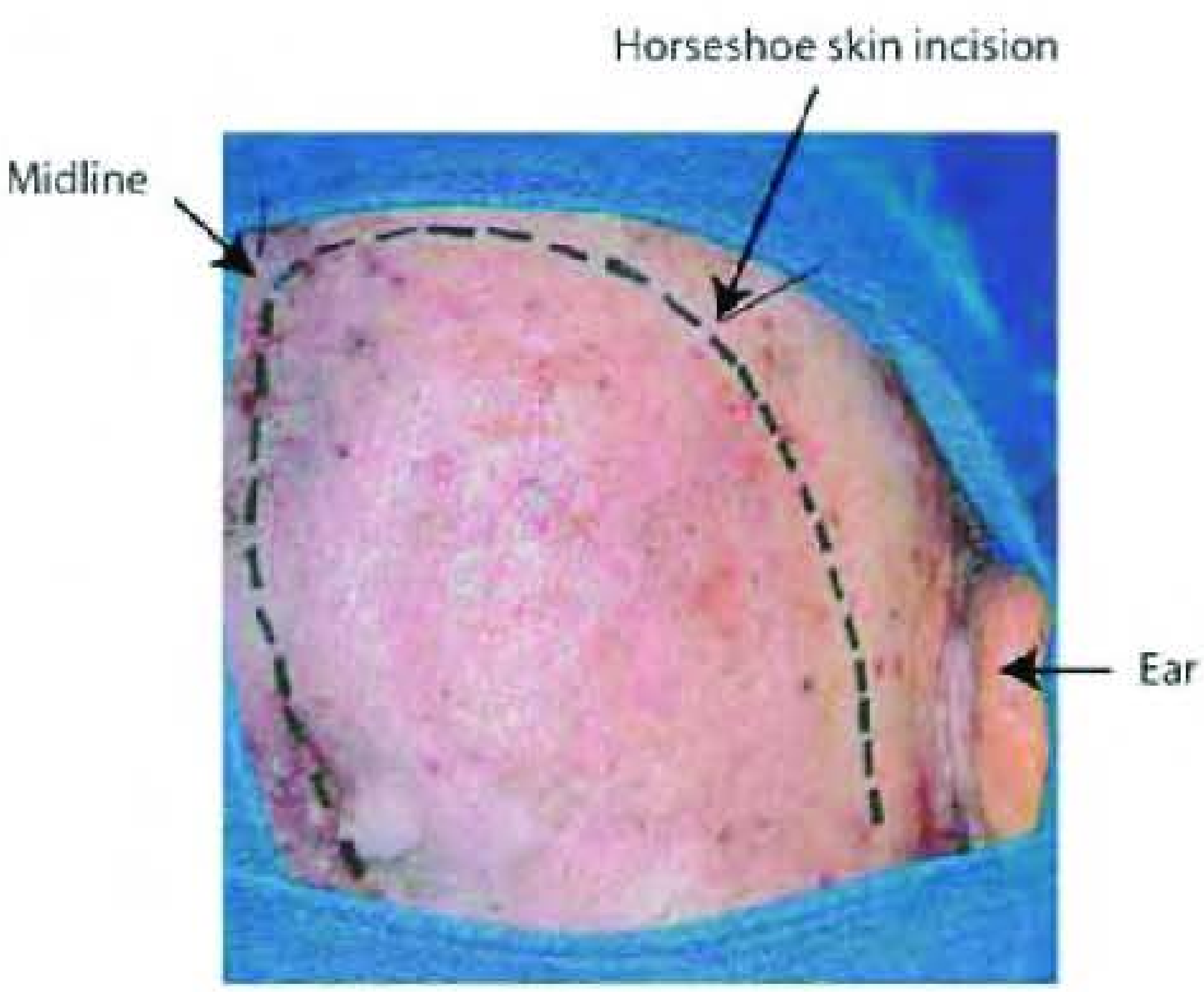

FIGURE 19–1 The skin incision is outlined for an occipital lobectomy.

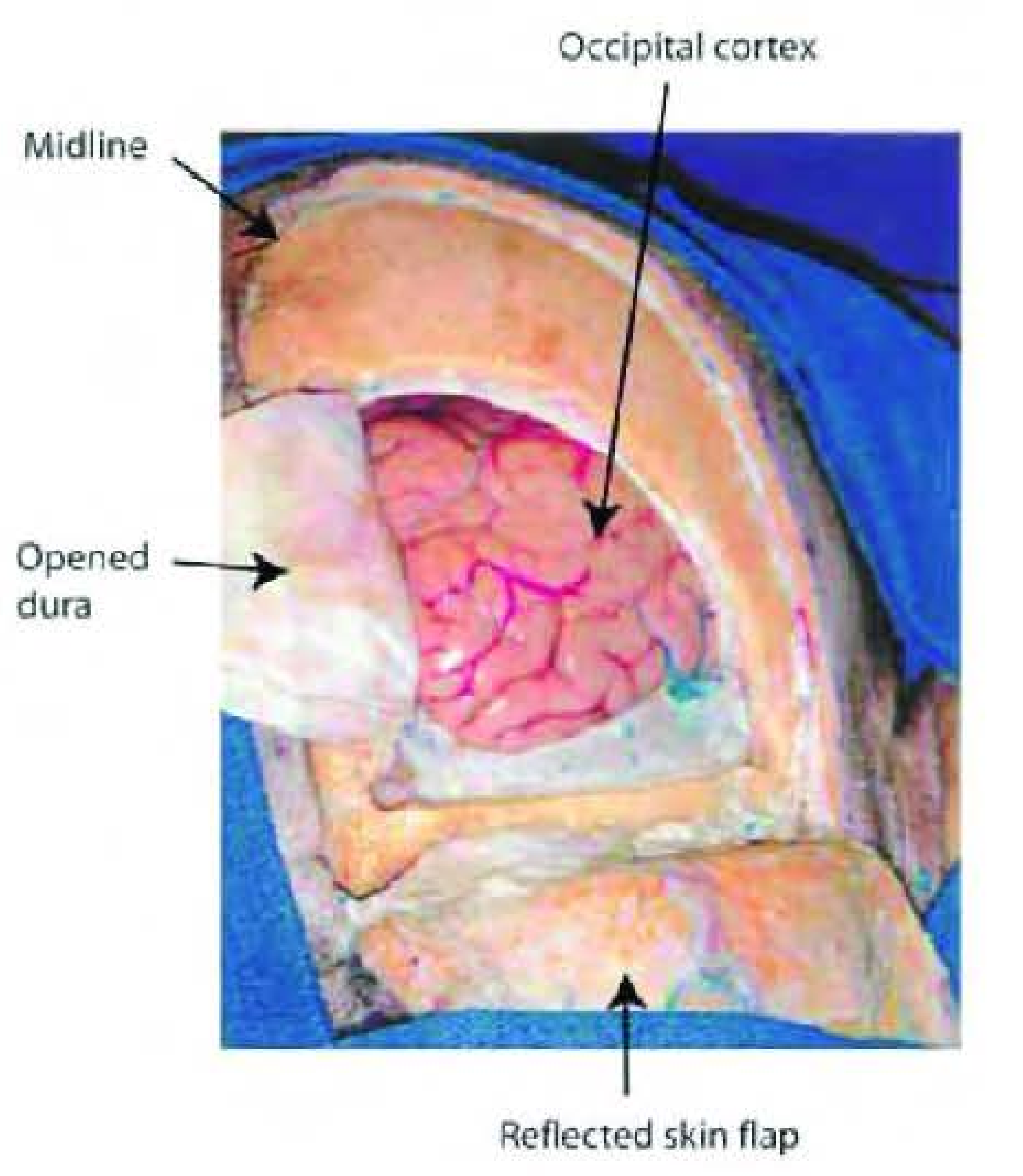

FIGURE 19–2 The dura has been opened, exposing the underlying occipital cortex.

In the dominant hemisphere, the corticectomy begins about 3.5 cm from the occipital tip on the superior cortical margin. On the nondominant hemisphere, it is begun about 7 cm from the occipital tip (Fig. 19–3). The angular gyrus must be avoided. A subpial dissection is performed (Fig. 19–4). It is possible that the occipital horn of the lateral ventricle may be entered. The posterior cerebral artery will be encountered in the region of the calcarine fissure. All draining veins to the torcula should be divided near the cortex of the brain. Once the corticectomy is complete, a watertight closure of the dura should be performed.

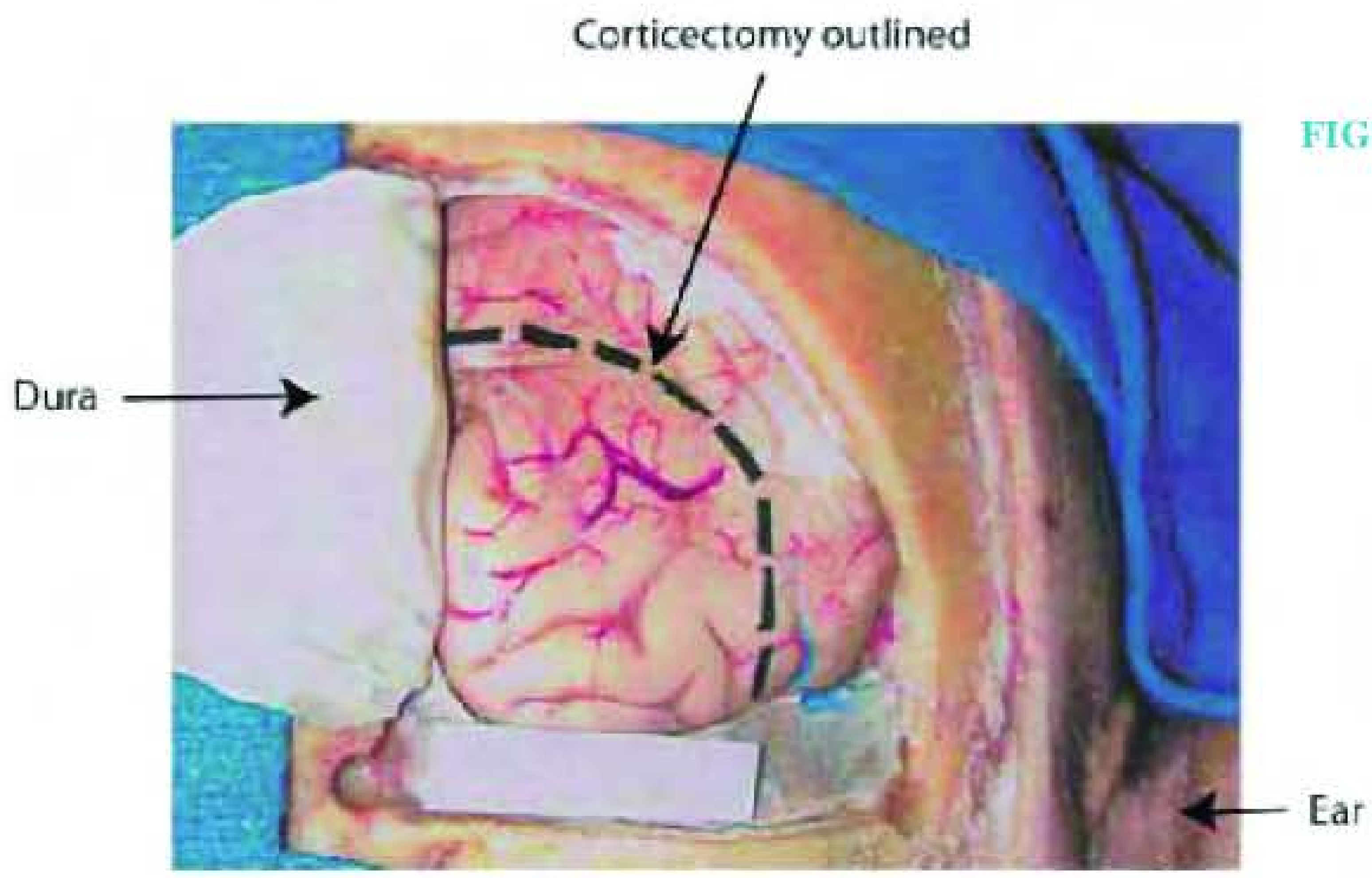

FIGURE 19–3 The occipital corticectomy is outlined.

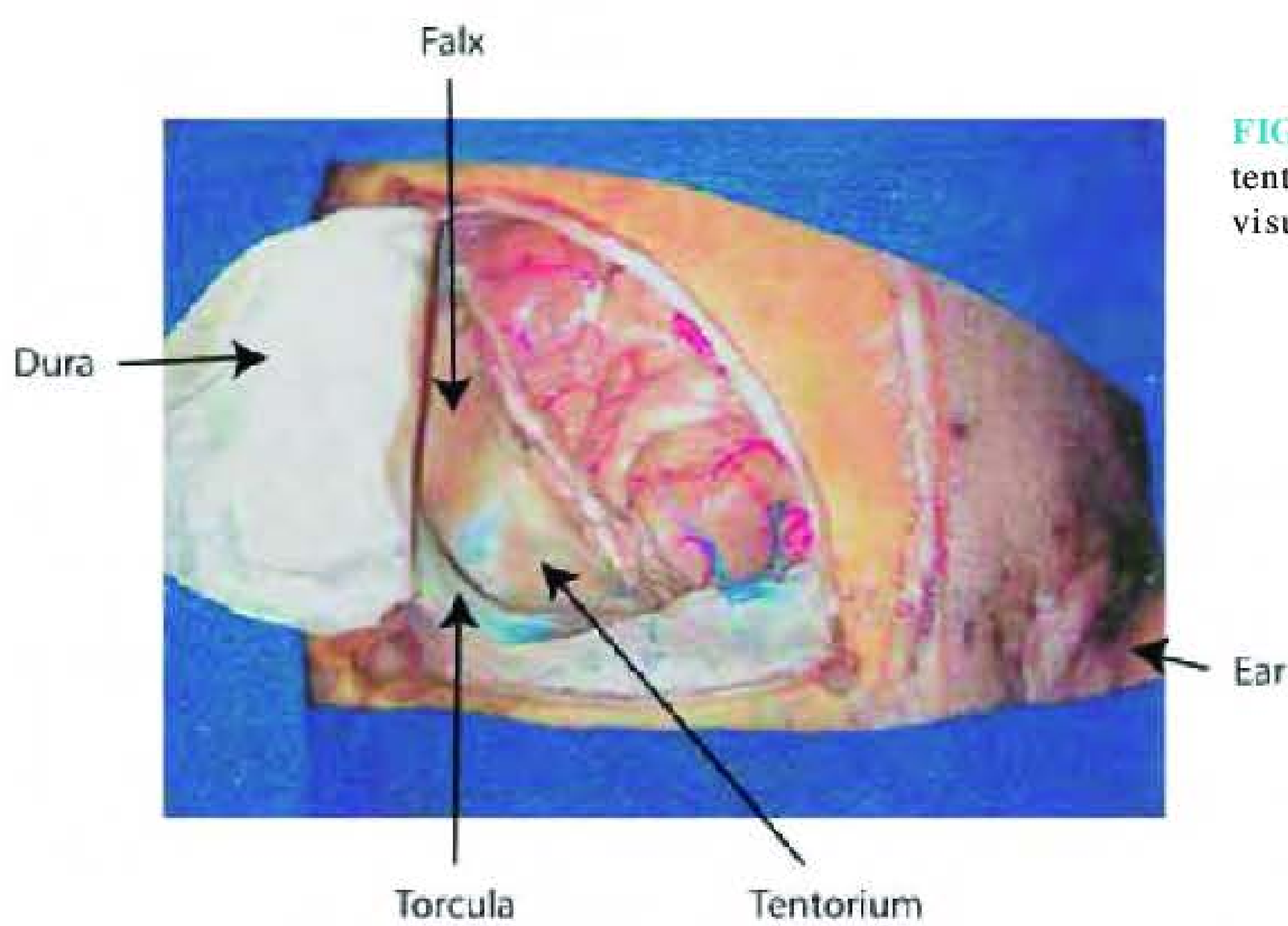

FIGURE 19–4 The occipital lobectomy is complete. The tentorium, falx, and venous drainage toward the torcula are visualized.

PITFALLS, PEARLS, CONSIDERATIONS

- Sinus injury
- Venous or arterial infarcts
- Postoperative subdural and epidural hematomas
- Resection of too much cortex

SUGGESTED READINGS

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Temporal Lobectomy for Epilepsy

Emel Avci, Ernest Senz, Anthony Caputy

Indications for Approach

- Drug-resistant epilepsy

Anatomy

The lateral surface of the temporal lobe can be divided into the superior, middle, and inferior temporal gyri by the superior and inferior temporal sulci (Fig. 20–1). The superior temporal gyrus forms the floor of the sylvian fissure. On the mesial surface of the temporal lobe, the insular cortex, lingual gyrus, and parahippocampal gyri can be identified.

The mesial temporal lobe is involved in intractable. epilepsy; therefore, the anatomy of the mesial temporal lobe becomes relevant in seizure surgery. The amygdaloid body is a large gray-matter mass that sits immediately anterior to the temporal horn of the lateral ventricle. It is continuous with the remainder of the medial surface of the temporal lobe through the uncus. The hippocampus composes the medial wall of the temporal horn of the lateral ventricle (Fig. 20–2A–D).

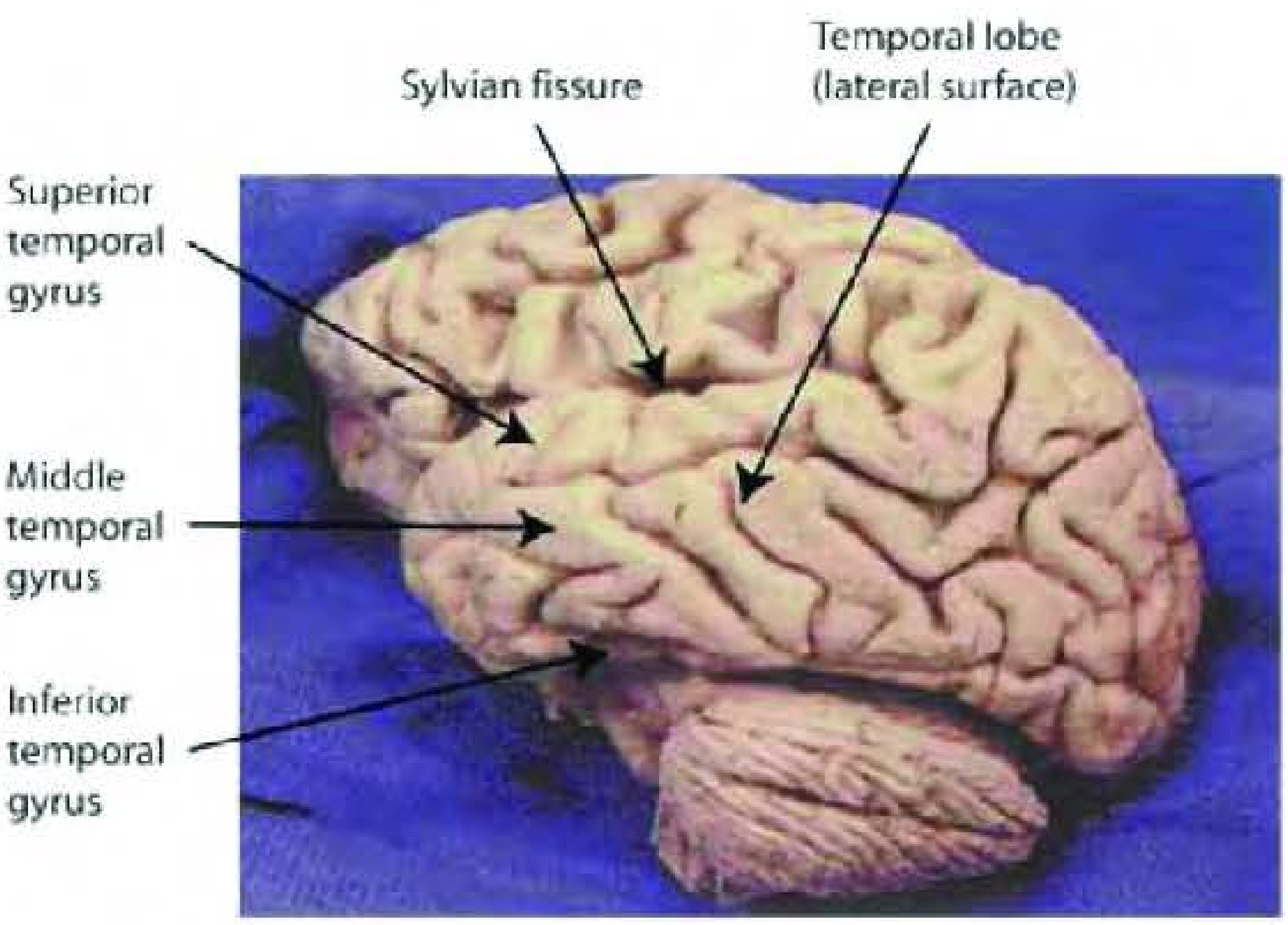
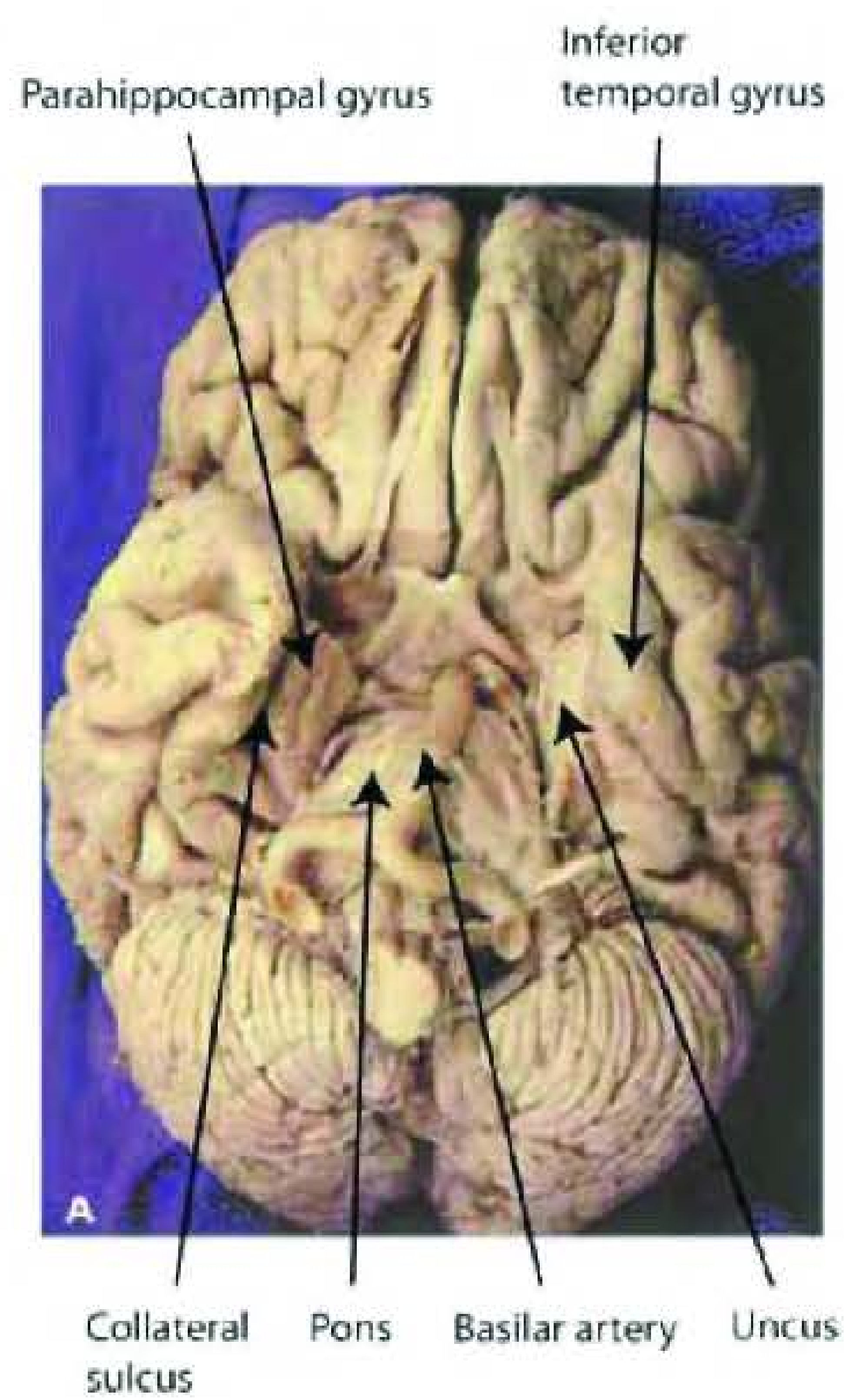


FIGURE 20–1 The lateral surface of the temporal lobe is shown.



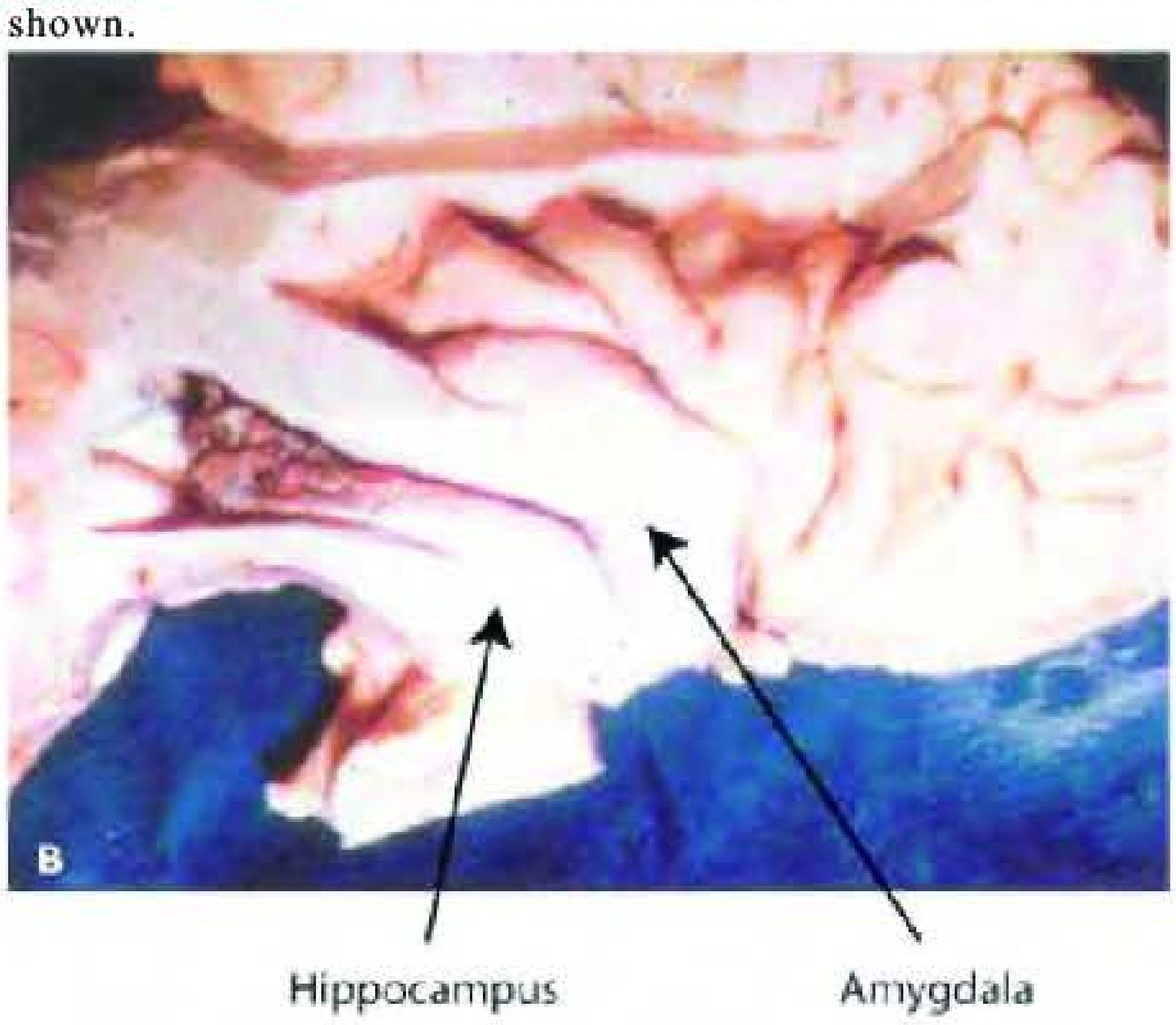
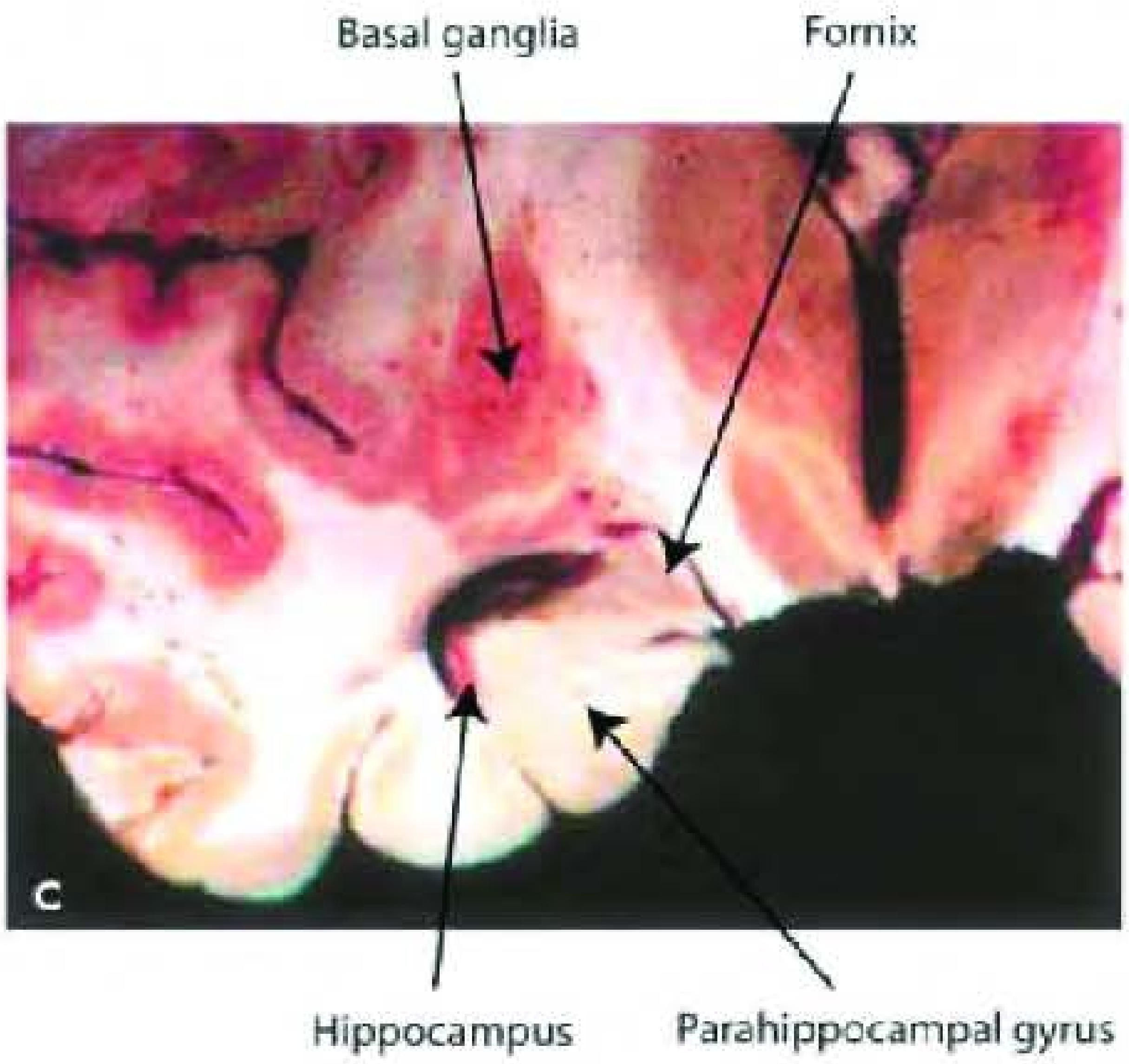


FIGURE 20–2 **A**: The mesial surface of the temporal lobe is exposed. **B:** View of the mesial hemisphere demonstrating the amygdala and hippocampus. *(continued on page 116)*



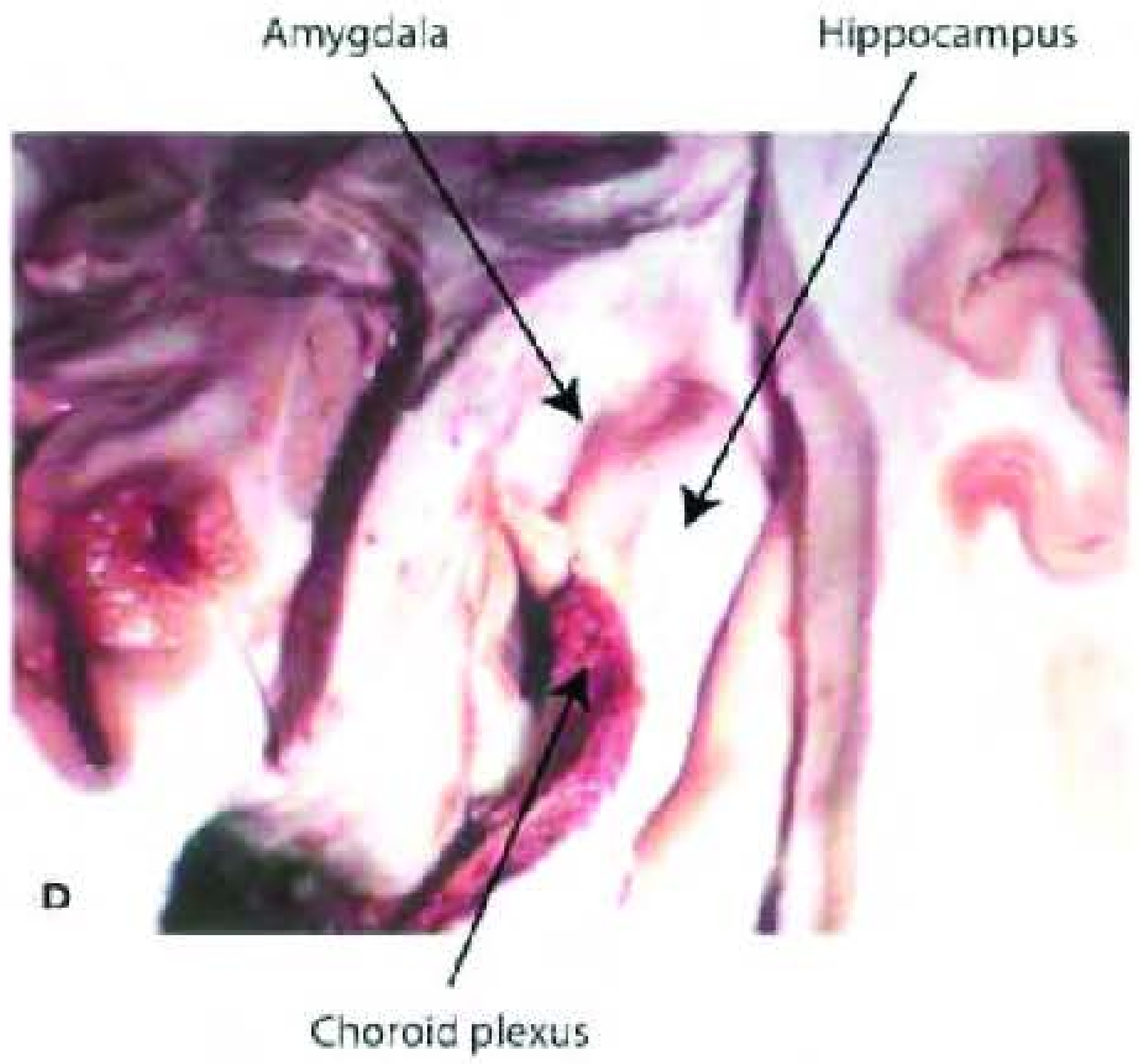


FIGURE 20–2 *(continued from page 115)* **C:** Coronal view showing the relationship of the hippocampus and parahippocampal gyrus to the temporal horn of the lateral ventricle. **D:** Axial view of the anatomy surrounding the temporal horn of the lateral ventricle.

POSITIONING AND SKIN INCISION

The patient is placed in the supine position and in Mayfield three-point fixation with the head rotated about 60 degrees and in about 30 degrees of extension. The goal is to have the frontotemporal region in a nearly horizontal plane. A shoulder roll is placed beneath the ipsilateral shoulder to facilitate optimal positioning. The standard incision is a question mark incision that begins at the region of the zygoma just anterior to the tragus of the ear (Fig. 20–3). Care is made not to extend the incision below the root of the zygoma to avoid injury to branches of the facial nerve.

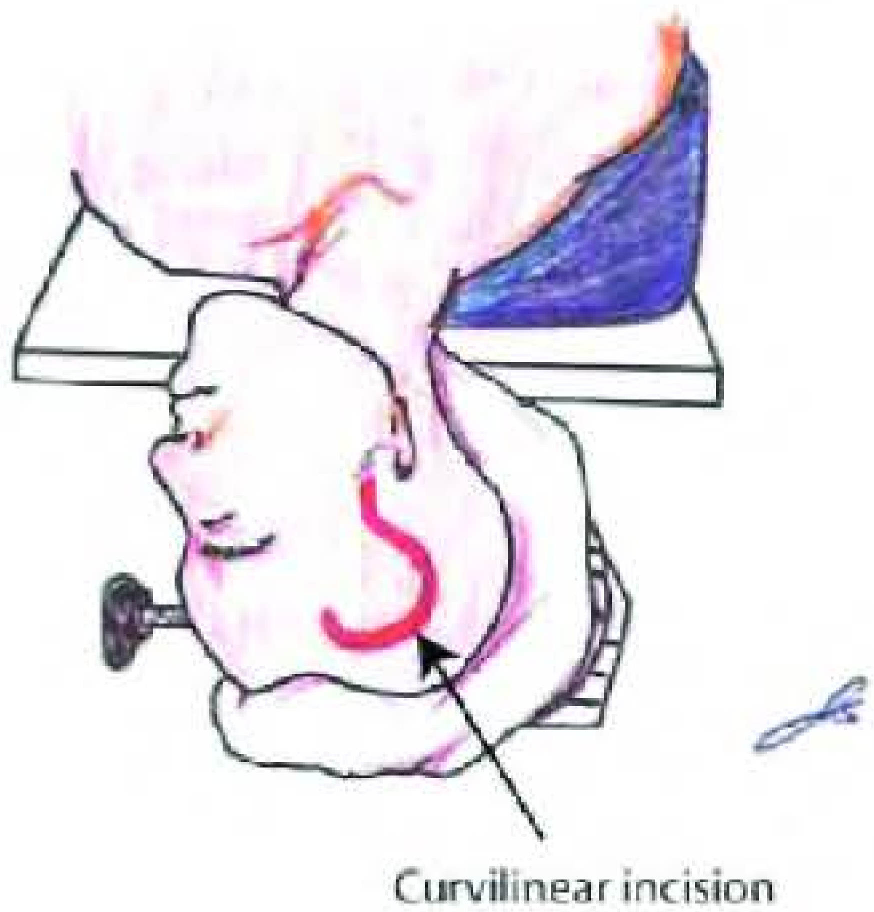


FIGURE 20–3 Illustration of the standard question mark incision.

SURGICAL TECHNIQUE

The scalp is elevated independent of the temporalis muscle. The outer fascia of the temporalis muscle is opened near the frontozygomatic area and extended in a curvilinear manner to the root of the zygoma to preserve the frontalis branch of the facial nerve. This opening in the fascia exposes the lateral portion of the zygomatic arch. Then an osteoplastic osteotomy is performed by transecting the zygomatic arch at the frontozygomatic process anleriorly and the squamozygomatic root posteriorly (Fig. 20–4A, B). The zygomatic arch then is elevated with the temporalis muscle as a separate flap. A burr hole is made in the squamosal portion of the temporal bone near the root of the zygoma. A second burr hole is made at the McCarty keyhole, and a third burr hole is made posteriorly above the superficial temporal line. A large free flap is turned, exposing the sylvian fissure, temporal lobe, and inferior gyrus of the frontal lobe. A rongeur can be used to remove any remaining bone more anteriorly to view the temporal tip and to remove any remaining bone near the floor of the middle fossa. The dura is opened in a horseshoe fashion and flapped back over the temporalis muscle. This exposes the temperal lobe as well as the inferior frontal gyrus. Intraoperative electrotorticography is used to map and define the epileptogenic areas of the temporal lobe.

Excision of the temporal lobe should be planned carefully, particularly in regard to interrupting venous and arterial blood supply. The vein of Labbé is about 4 to 6 cm from the temporal tip and care should be taken not to injure this vessel. Typically, the corticectomy spares the superior temporal gyrus and involves the middle and inferior temporal

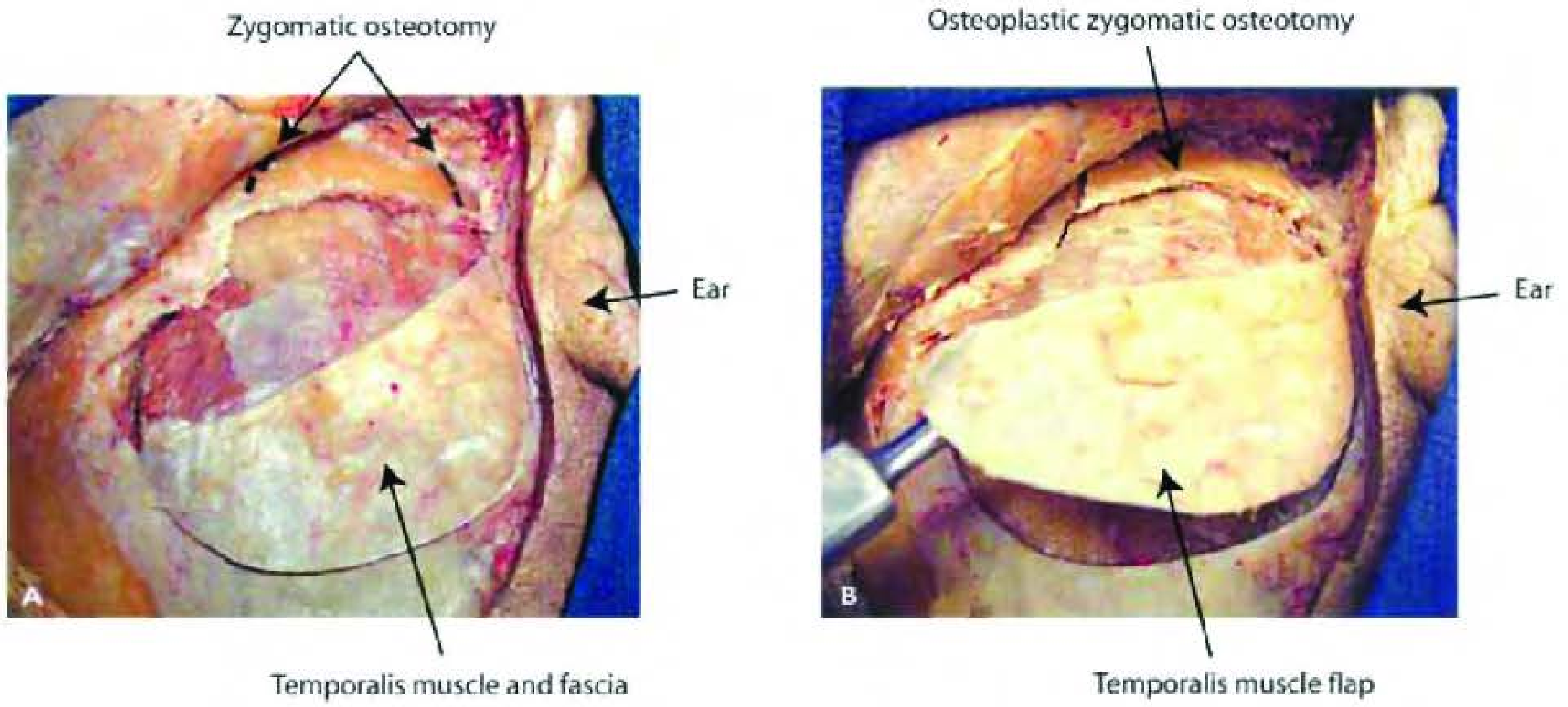


FIGURE 20–4 A: The temporalis is incised. Hash marks demonstrate the location of the osteotomy cuts. B: An osteoplastic zygomatic osteotomy flap is performed.

gyri (Fig. 20–5). The resection is *en bloc* extending about 2.0 to 2.5 cm back from the temporal pole. A dissection is performed in the white matter of the temporal lobe parallel to the cortical surface allowing the *en bloc* removal of the lateral temporal lobe (Fig. 20–6). The temporal horn will be entered

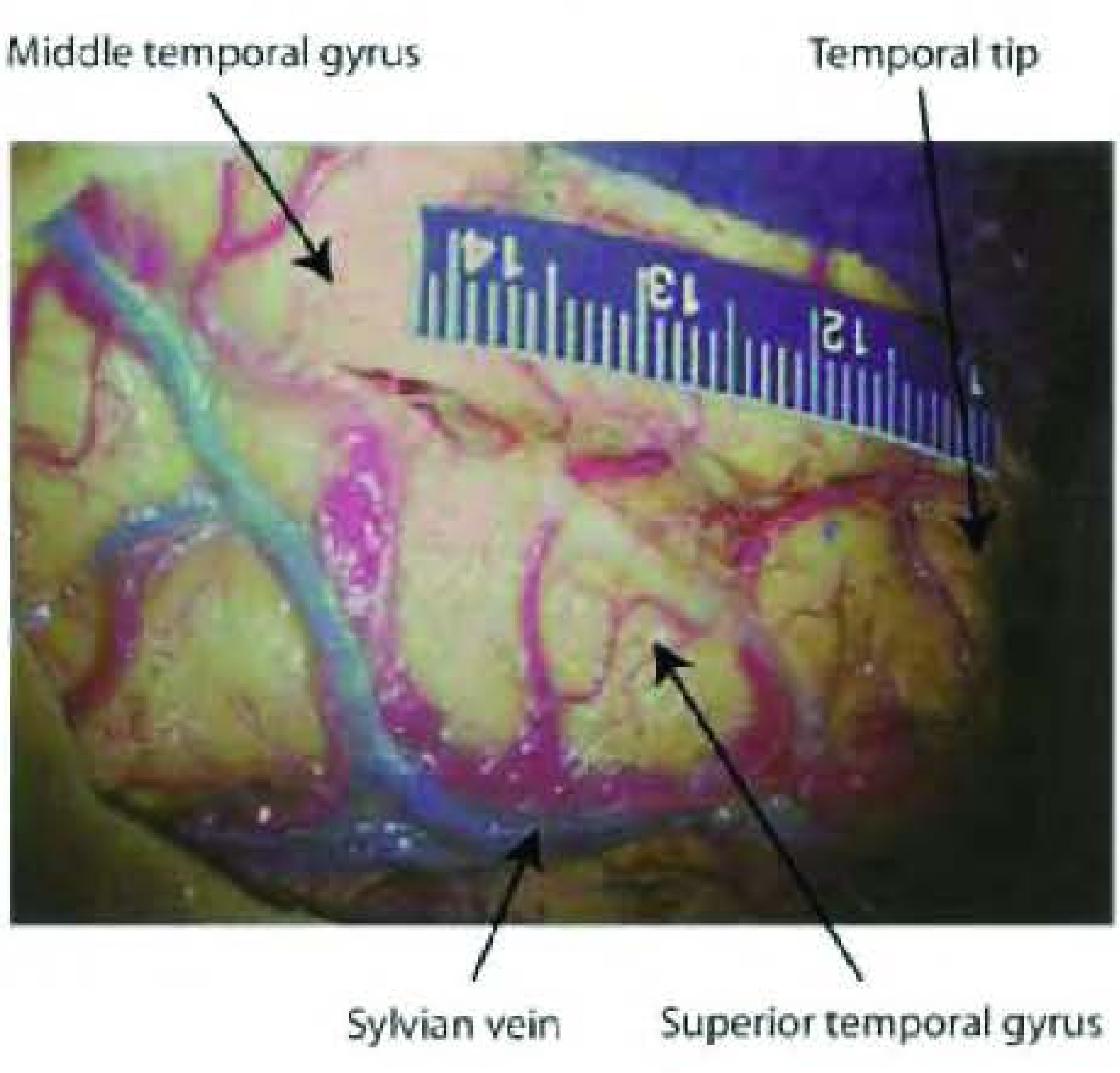


FIGURE 20–5 The sylvian vein runs in the sylvian fissure. The superior temporal sulcus is opened between the superior temporal and middle temporal gyri.

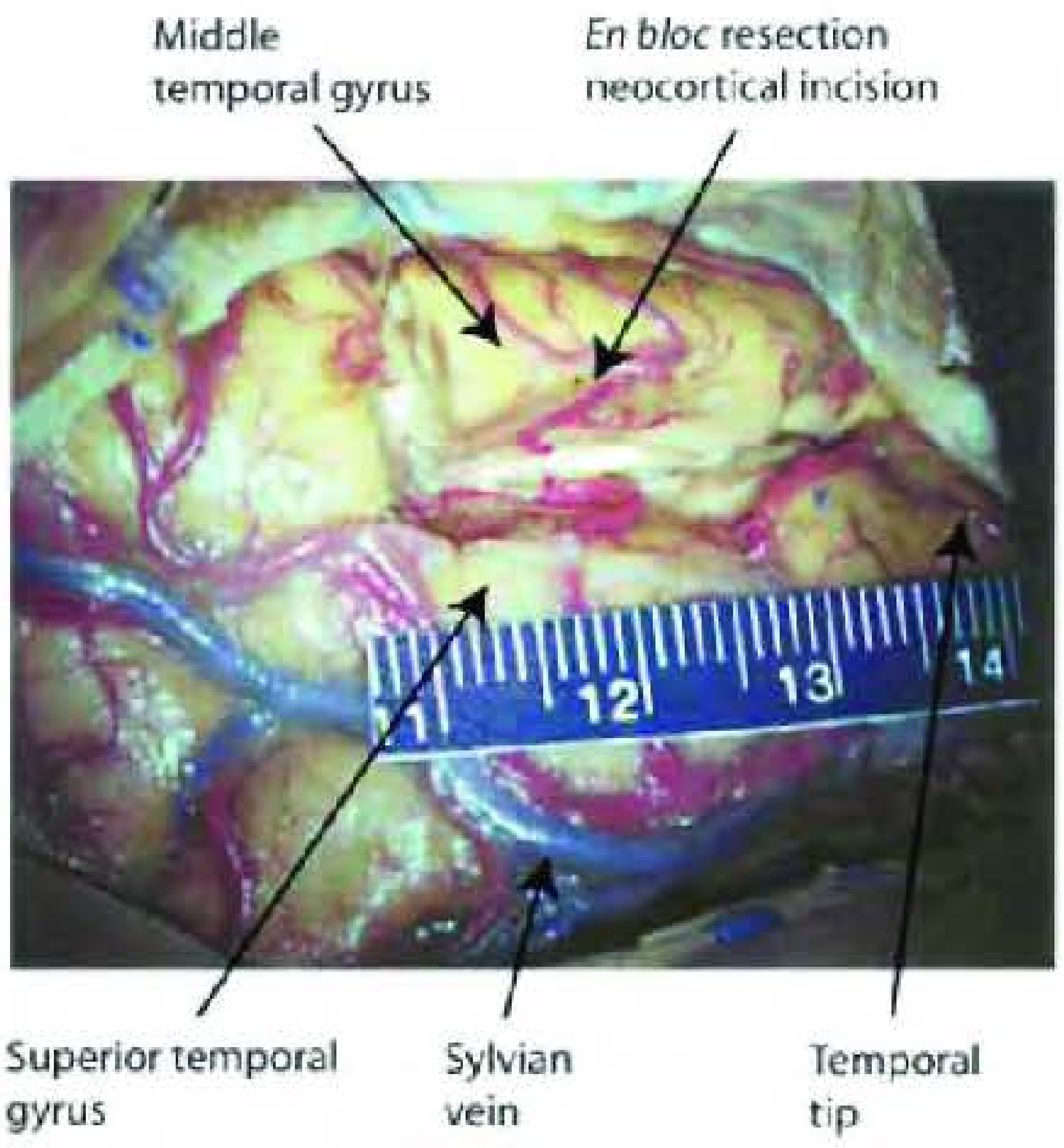


FIGURE 20–6 An *en bloc* neocortical incision for resection of the middle and inferior temporal gyri directed toward the fusiform gyrus is made.

posteriorly (Fig. 20–7). The remainder of the procedure is performed under the operating microscope. Intraoperatively, further electrocorticographic recordings are made from the hippocampus and the unresected temporal lobe.

The choroid plexus is identified in the roof of the temporal horn of the lateral ventricle (Fig. 20–8). The amygdalohippocampal structures are located Lateral to the ventricle choroid plexus. Following the roof of the ventricle, the amygdala, which forms the anterior wall of the temporal horn and the anterior part of its roof, is cut in a lateral direction toward the arachnoid of the lesser wing of the sphenoid. With suction, a subpial resection of the amygdala is performed to allow visualization of the tentorial edge and the incisura. The third nerve can be identified coursing close to the tentorial edge (Fig. 20–9). An *en bloc* resection of the head of the hippocampus, which forms the floor of the temporal horn and its medial walls, then is performed in a subpial fashion. The choroidal point, which is defined as the point where the anterior choroidal artery can be seen entering the temporal horn of the ventricle, is the posterior limit of the dissection. Typically, 3.0 cm of hippocampus is resected. After resection of these mesial structures, the posterior cerebral artery, the anterior choroidal artery, the third nerve, the tentorial edge, and the anterolateral surface of the brainstem can be visualized through the cisternal arachnoid layer (Figs. 20–10–20–12). After adequate hemostasis is achieved, the dura is closed in a watertight fashion, and the bone flap and zygomatic arch are reattached. The muscle, subcutaneous tissues, and skin are closed in the usual fashion.

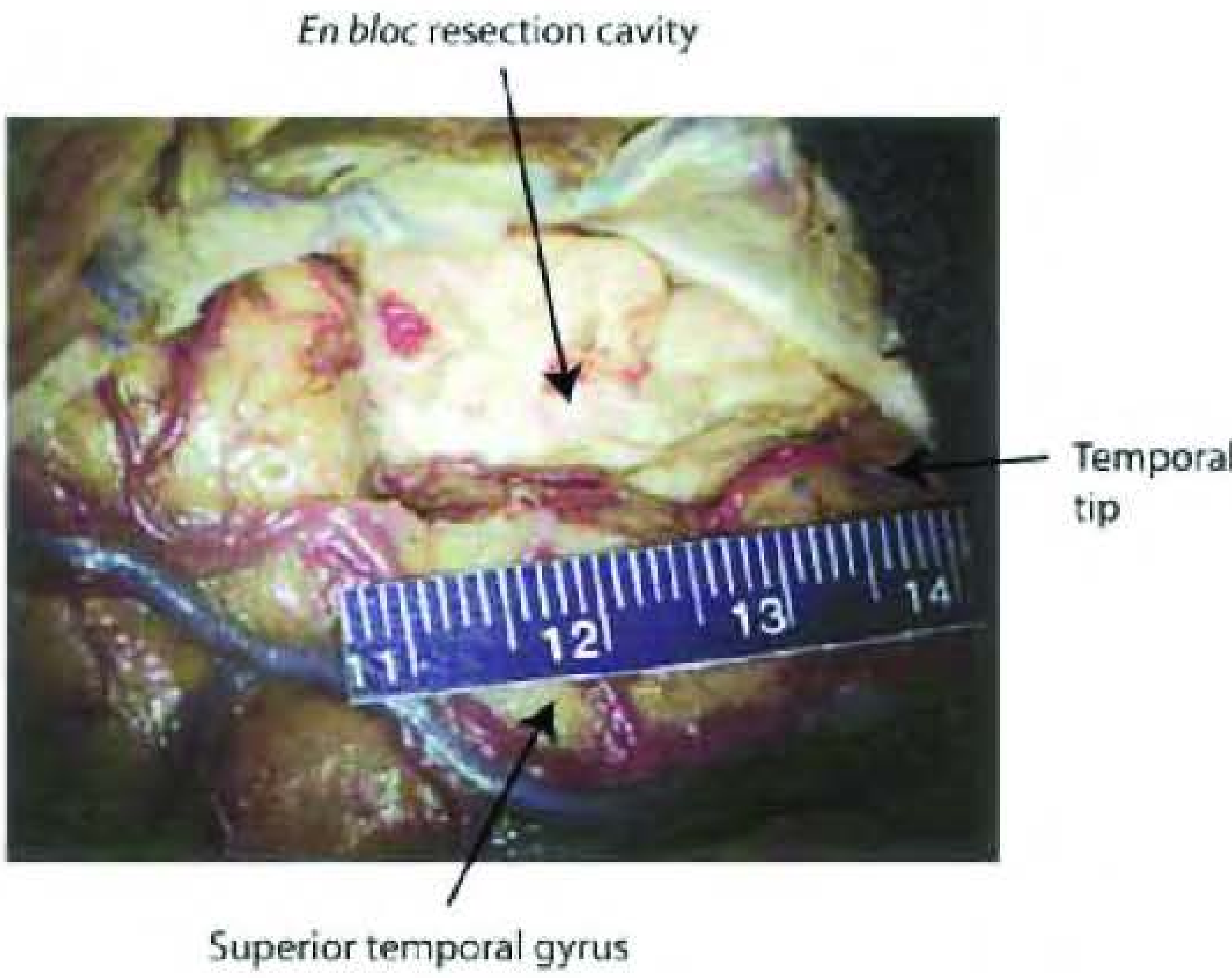


FIGURE 20–7 An *en bloc* resection of the middle and inferior temporal gyri has been performed.

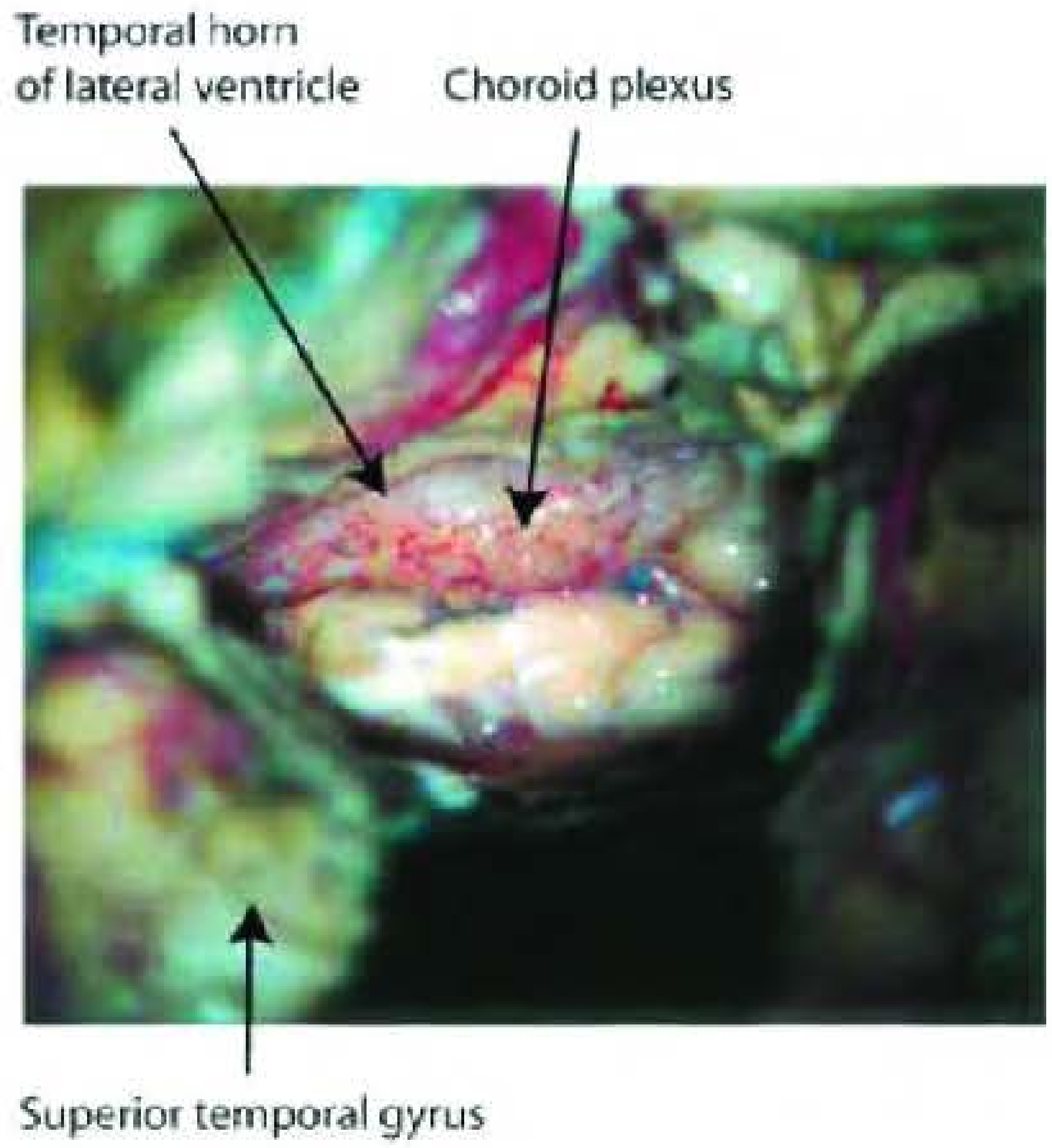


FIGURE 20–8 With elevation of the superior temporat gyrus, the choroid plexus in the roof of the temporal horn of the lateral ventricle is exposed.

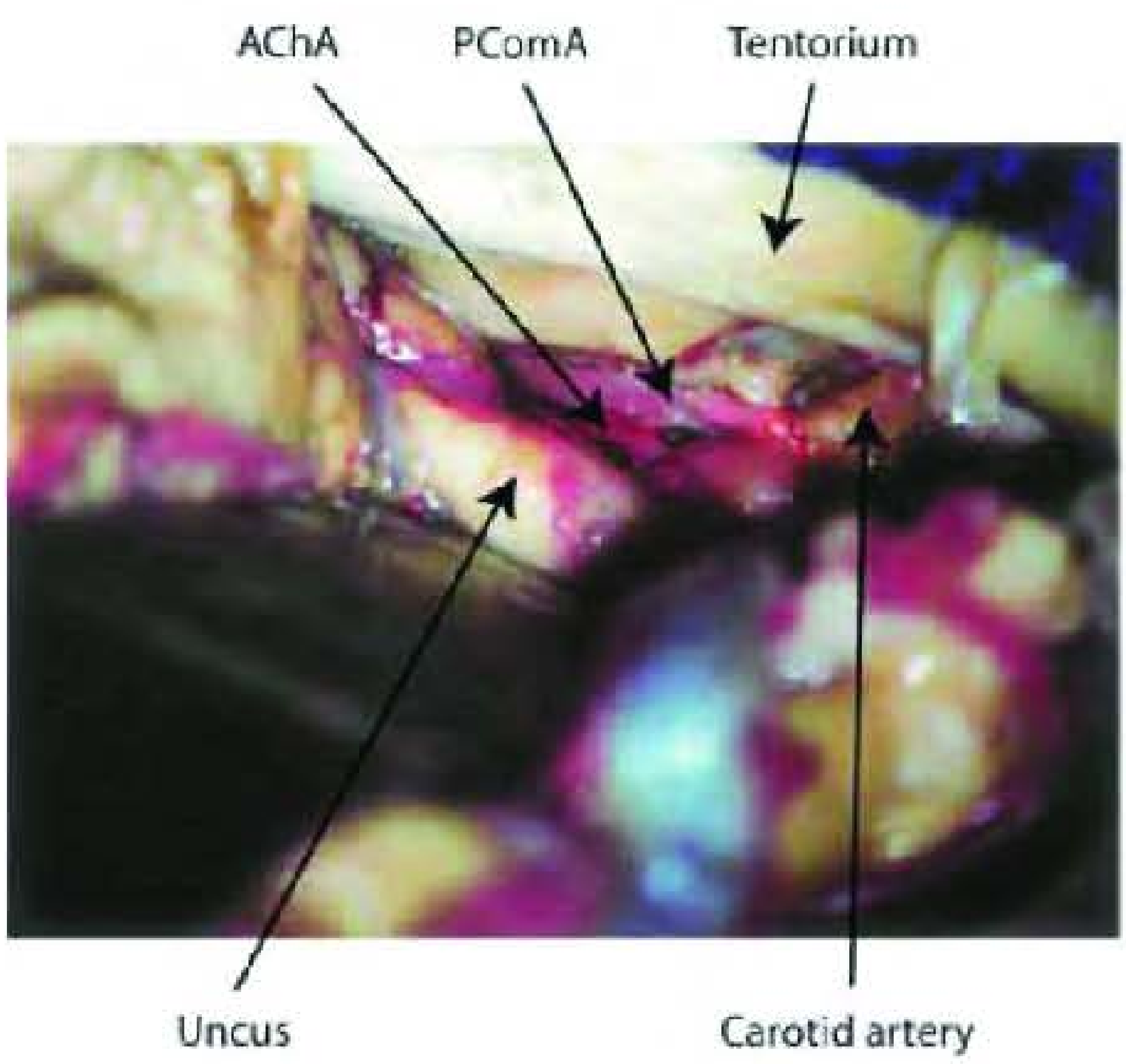


FIGURE 20–9 The uncus is seen just beneath the retractor blade. The carotid artery, posterior communicating artery (PComA), and anterior choroidal artery (AChA) are seen. The third nerve is seen by the tentorium.

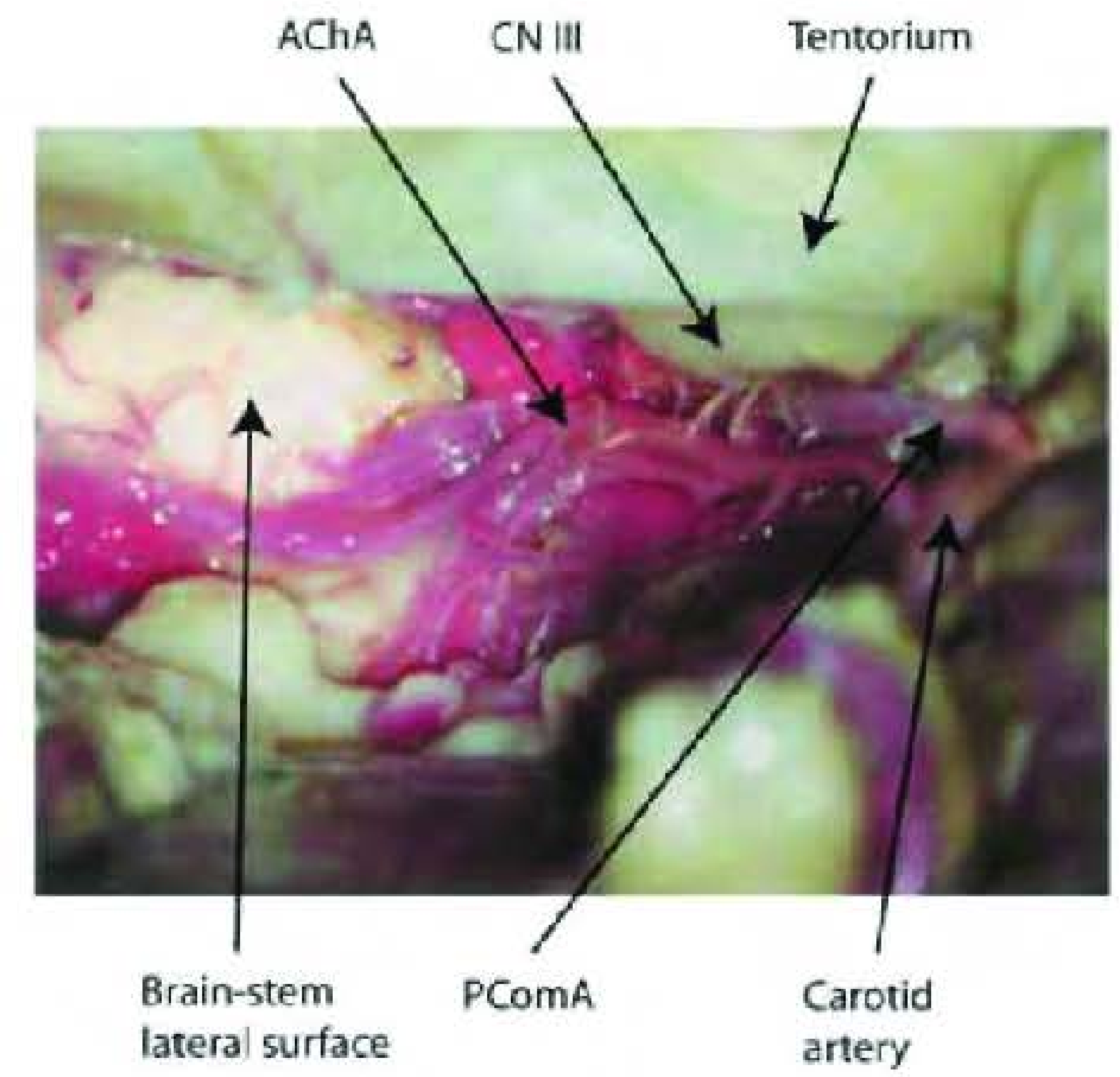


FIGURE 20–10 At the end of the resection, the contents of the ambient cistern are exposed. The internal carotid artery, posterior communicating artery (PComA), and anterior choroidal artery (AChA) are seen. The lateral surface of the brainstem is visualized. CN III, third cranial nerve.

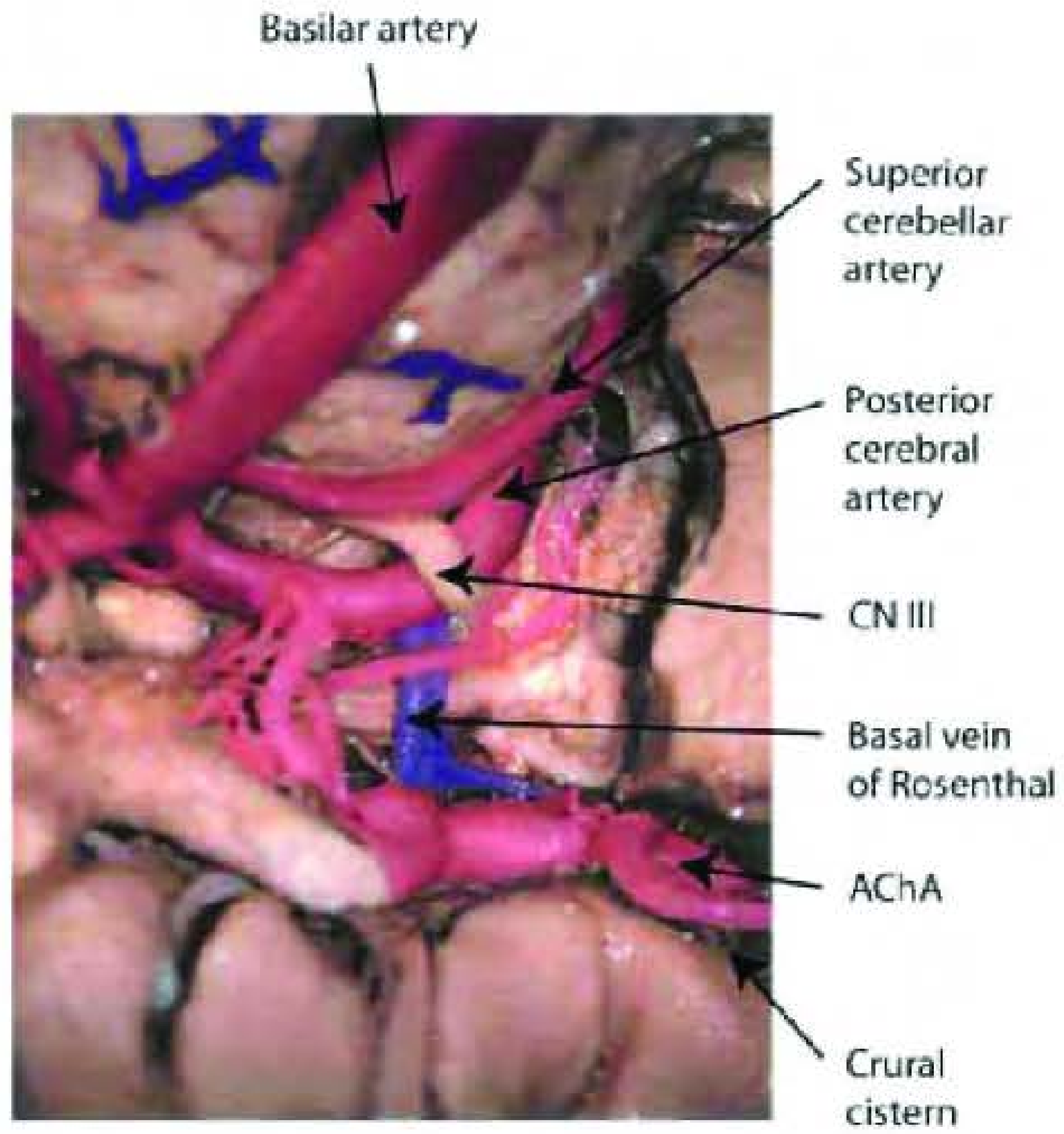


FIGURE 20–11 Anatomic dissection showing the full course of the anterior choroidal artery (AChA) rounding the uncus in the crural cistern. The basilar artery, superior cerebellar artery, third nerve, and basal vein of Rosenthal are also visualized. CN III, third cranial nerve.

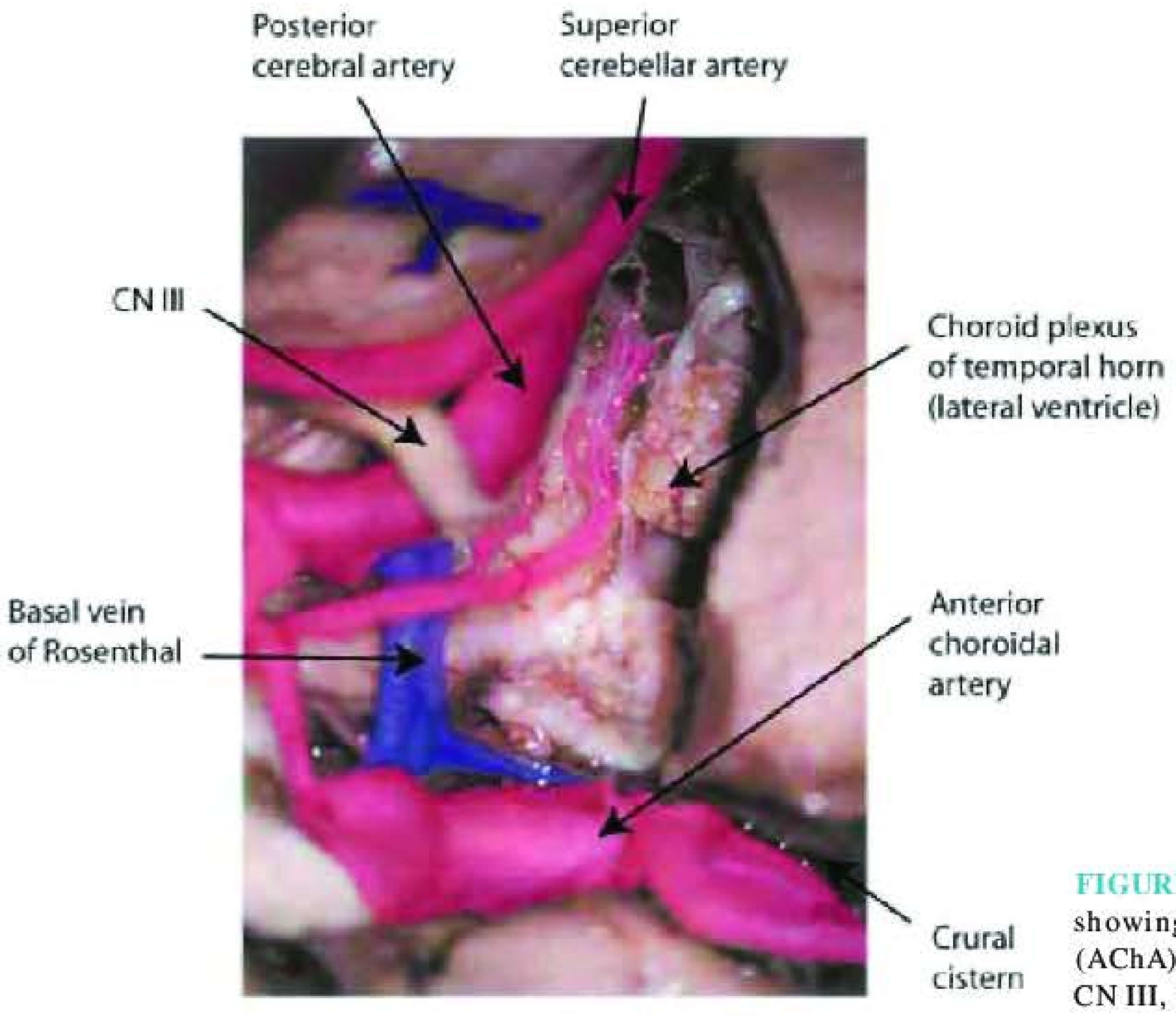


FIGURE 20–12 Higher-power anatomic dissection showing the entrance of the anterior choroidal artery (AChA) into the temporal horn of the lateral ventricle. CN III, third cranial nerve.

PITFALLS, PEARLS, CONSIDERATIONS

- Vascular injury: hemiparesis
- Injury to the optic radiations: superior quadrantanopia
- Injury to the third and fourth nerves
- Brainstem injury
- Retraction injury

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PART II

SPINAL APPROACHES

Vertebral Column Anatomy

Emel Avci, Yalcin Kocaogullar, Damirez Fossett

The spinal column consists of 33 vertebrae and an intervening fibrocartilaginous disc between each vertebra. The vertebrae interarticulate through facet joints, and the multiple motion segments are held together by ligaments. There are 7 cervical, 12 thoracic, 5 lumbar, 5 fused sacral, and 4 coccygeal vertebrates.

The typical vertebral segment consists of a body and a dorsal vertebral arch with several processes. The outer shell of the body is composed of hard cortical bone; the inner surface is made of soft cancellous bone. The upper and lower surfaces of the vertebral bodies are concave and are bound together by the fibrocartilaginous disc.

The dorsal arch is composed of the paired pedicles, the paired lamina, the spinous processes, the transverse processes, and the facet joints. The pedicles attach anteriorly to each vertebral body and are in continuity with the more posterior facet joints, lamina, and spinous process. There is both an inferior and a superior notch on the pedicle. When two adjacent vertebrae articulate, these notches make up the bony neuroforamen (Fig. 21–1). The spinous processes arise in the midline from the union of the laminae. The transverse processes arise laterally (Fig. 21–2). In the cervical area, the transverse processes are more central and arise from the vertebral body; the thoracic and lumbar transverse processes

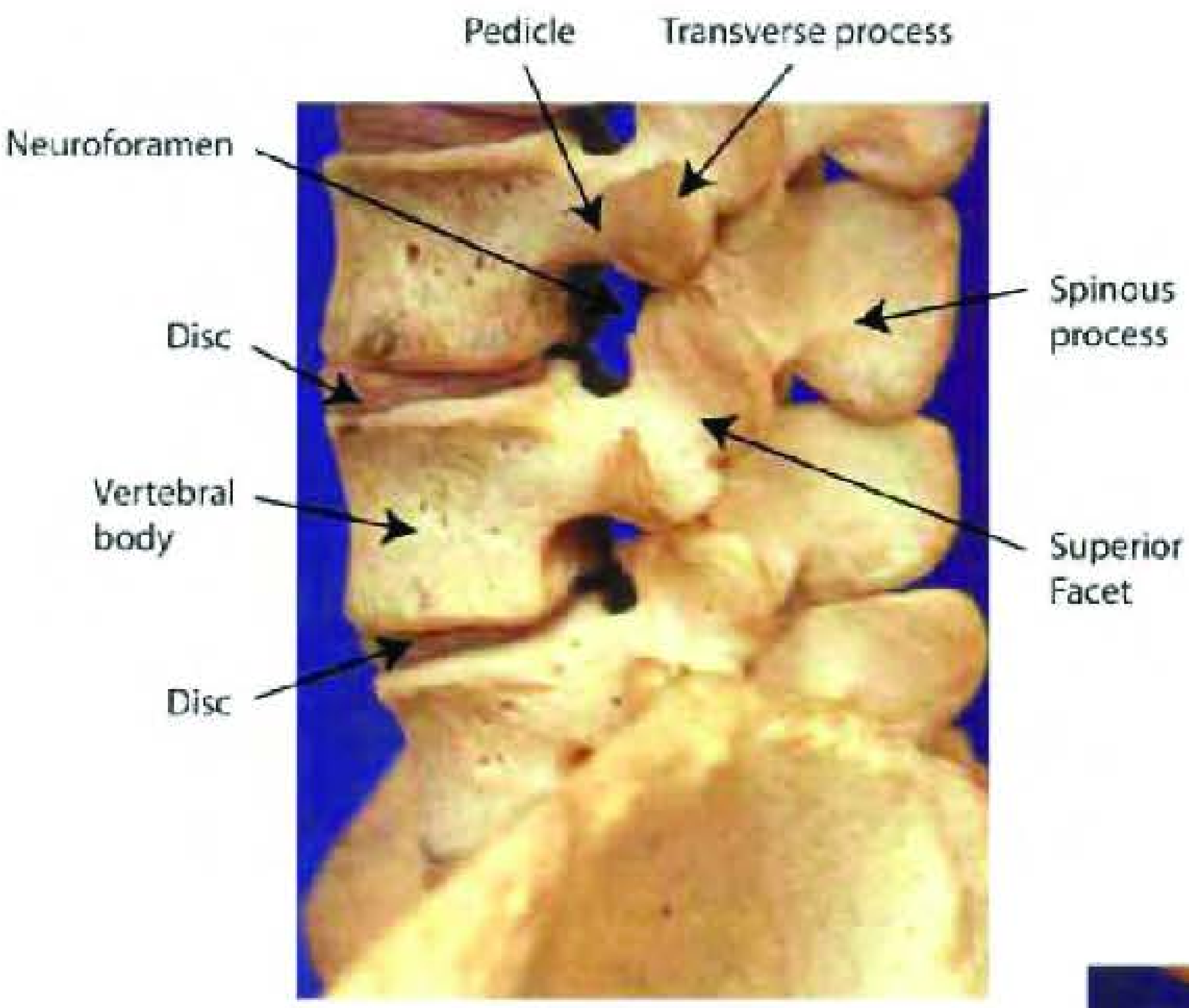

FIGURE 21–1 The basic architecture of a spinal vertebral segment. The vertebral bodies are separated by a disc. Each vertebral segment interarticulates with the one above and below at the facet joints. The spinal cord passes through the central canal, and the nerve roots exit through the neuroforamen.

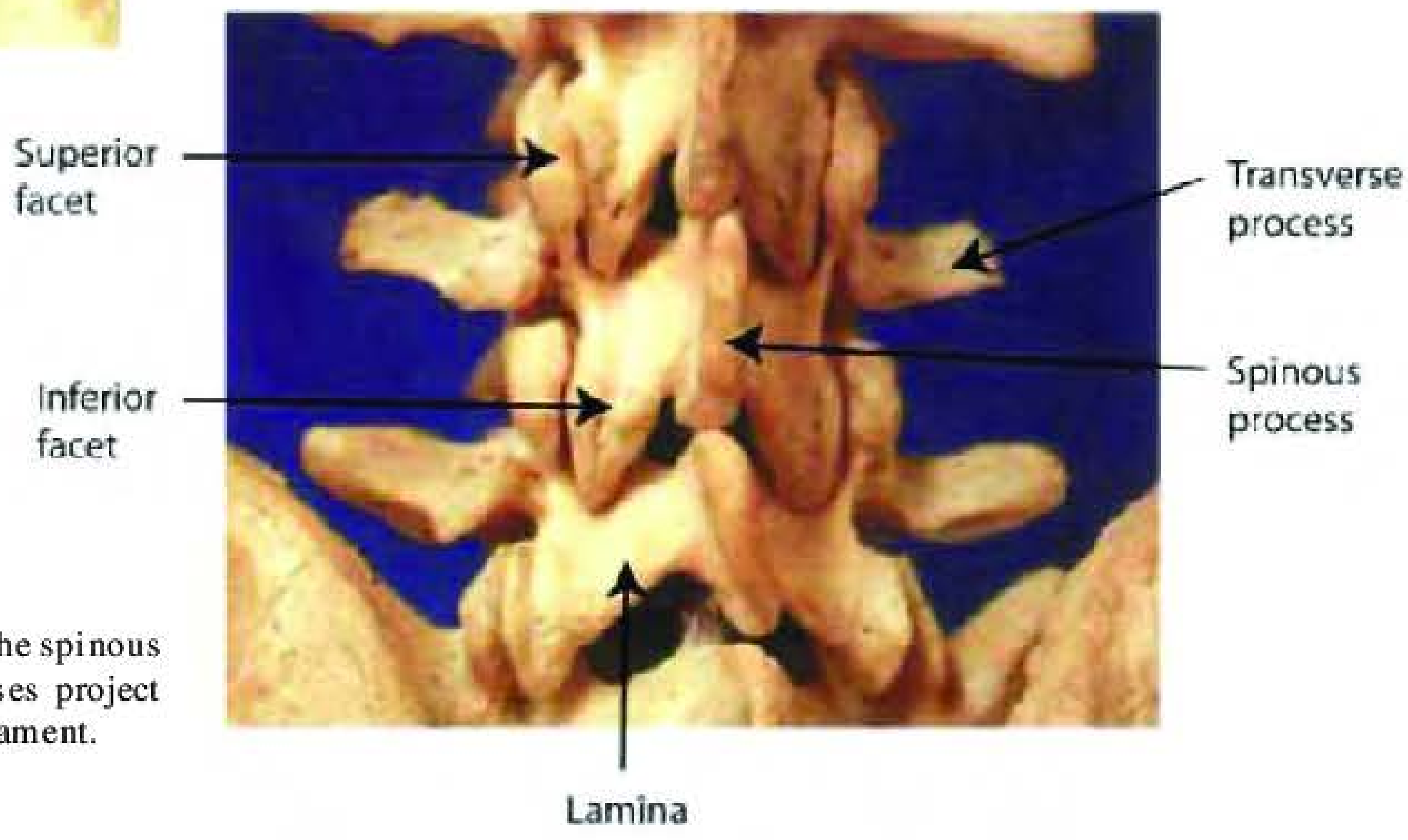

FIGURE 21–2 The posterior arch is composed of the spinous process, lamina, and facet joints. Transverse processes project laterally and are attachment sites for muscle and ligament.

arise from the junction of the pars interarticularis and the pedicle. Muscles and ligaments attach to the spinous and transverse processes. Two adjacent vertebral bodies interarticulate at facet joints. A facet joint is composed of the inferior articular processes of the vertebral body above and the superior articular processes of the segment below.

An intervertebral disc space exists between every vertebral body from the C2–3 level to the L5–S1 level. The disc is formed by a fibrous outer layer known as the *annulus fibrosus* and a central softer, pulpy, elastic central core known as the *nucleus pulposus*. The nucleus has a large water content and may desiccate with aging.

The ligaments, which are composed of elastin and collagen, connect adjacent vertebral bodies. The two major ligaments of the spinal axis are the anterior longitudinal and posterior longitudinal ligaments. The anterior longitudinal ligament begins at the occiput as the atlantooccipital membrane and continues down to the sacrum. The ligament is thickest over the concave portions of the vertebral bodies. The posterior longitudinal ligament, like the anterior ligament, traverses the entire length of the spine. At C2 it is the tectorial membrane. This ligament adheres closely to the disc annul us but only marginally to the vertebral bodies. Additional ligaments span individual motion segments. The ligamentum flavum connects lamina to lamina and is found from the C2–3 region to the L5–S1 region. It arises from the ventral surface of the caudal lamina and attaches to the dorsal border of the adjacent rostral lamina. It is discontinuous in the mid vertebral region and in the midline. The interspinous and supraspinous ligaments connect adjacent spinous processes. The interspinuns ligament attaches from the base to the tip of each spinous process. It starts at the C2–3 level and terminates at the L5–S1 level. The supraspinous ligament begins at the C7 spinous process and continues to the L5–S1 region. The intertransverse ligaments connect adjacent transverse processes. At the occipital–cervical junction, with its intricate range of movement, additional ligamentous connections are defined. In the upper cervical spine, ligaments attach the occiput to C2. The anterior longitudinal ligament is the anterior atlanto-occipital membrane from C1 to the occiput. The apical ligament arises from the tip of the odontoid process and extends to the basion. The alar ligaments run between the occipital condyles and the rostra lateral aspect of the odontoid process. The cruciate ligament has ascending, descending, and transverse bands that run dorsal to the odontoid and attach at the medial tubercle of each lateral mass of C1. The tectorial membrane begins at the basiocciput and becomes continuous with the posterior longitudinal ligament. The posterior atlanto-occlpital membrane connects the rostral aspect of the dorsal arch of C1 to the occiput.

The muscles of the spine can be divided into superficial, intermediate, and deep groups. Many different muscle groups compose the paraspinal musculature in the cervical, thoracic, and lumbar regions. Some muscle groups span more than one segment of the spine. The attachments of the muscle groups is to the many processes and protuberances associated with the bony axial skeleton.

CERVICAL SPINE

The cervical vertebrae are the smallest of the axial skeleton. They are wider in their transverse than their anteroposterior (AP) diameter. The size increases from C3 to C7. The spinous processes from C3 to C6 are short and bifid. The C2 spinous process is broad, large, and bifid. The C7 spinous process is long and not usually bifid. The ring of C1 does not have a spinous process. The pedicles of the cervical vertebrae are short. They arise about midway between the rostral and caudal surfaces of the body. The laminae join the pedicles at the facet joints and are overlapping with adjacent levels. The transverse processes contain a transverse foramen from C1 to C6 through which courses the vertebral artery. Occasionally, C7 contains a small transverse foramen, but the vertebral artery does not travel through it. The pars in the cervical spine is called the *lateral mass*. The superior and inferior facets arise from the lateral masses. The cervical facets are aligned with an almost coronal orientation (Fig. 21–3).

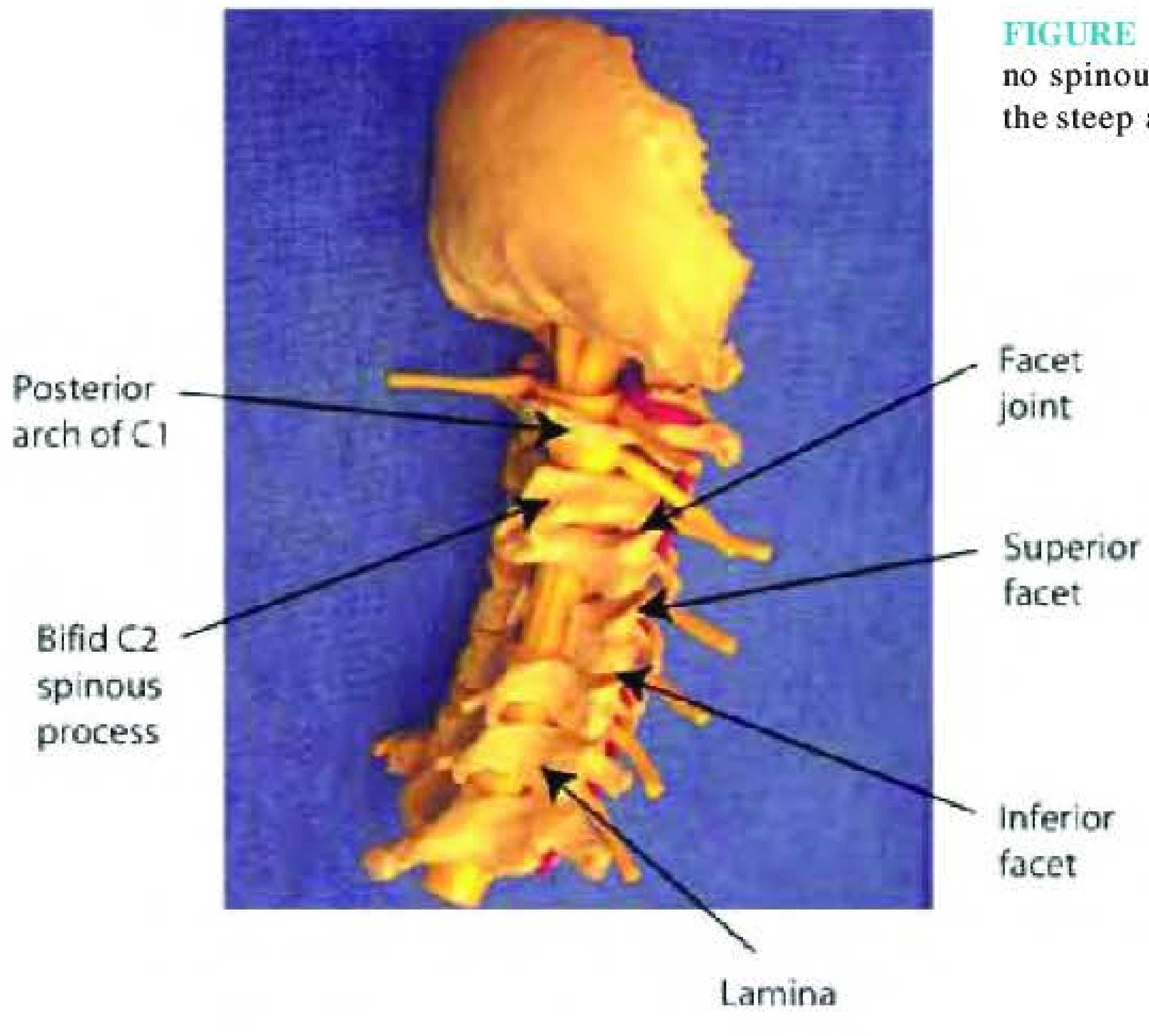

FIGURE 21–3 Posterolateral view of a model cervical spine. C1 has no spinous process. The C7 process is the only nonbifid process. Note the steep alignment of the facet joints.

The first cervical vertebra (atlas) is ring shaped and has no vertebral body. It is composed of two lateral masses and a posterior and an anterior arch, each containing a tubercle. There is no spinous process. The facet surfaces of C1 are oriented horizontally; the superior surfaces articulate with the occipital condyles. The second cervical vertebra (axis) has as its distinguishing feature, the odontoid process, which projects upward posterior to and articulating with the anterior arch of C1. The dens is held in position by the transverse ligaments, which run between the lateral masses of C1 and the dens. The superior articular processes receive the inferior articulating processes of the atlas allowing for rotatory movement (Fig. 21–4).

The C1 nerve root emerges over the top of the C1 vertebra. Therefore, all the other cervical roots also exit above their respective vertebra. The C8 nerve root exits above T1. In the cervical region, the spinal cord has a normal anatomic enlargement, and the bony canal is therefore relatively narrow.

THORACIC SPINE

The thoracic vertebrae are more pear-shaped and are larger than the cervical vertebrae but not as large as the lumbar ones. The most distinguishing characteristic is that at each level a rib articulates bilaterally through a costal facet located on each side at the junction of the pedicle with the vertebral body and through a costal facet found on the transverse process.

The thoracic vertebrae have transition zones where the T1 through T4 bodies having some features of cervical vertebral bodes and where the T8 through T12 bodies have some features of the lumbar vertebral bodies (Fig. 21–5). The spinous processes of the thoracic vertebrae are long and slender, with the spinous processes of the middle level vertebrae located directly over the dorsal arch of the body below. The spinous processes of T1, T2, T11, and T12 are horizontal; the spinous processes of T3, T4, T9, and T10 are oblique. Thoracic lamina are broad, sloping, and overlap like shingles on a roof.

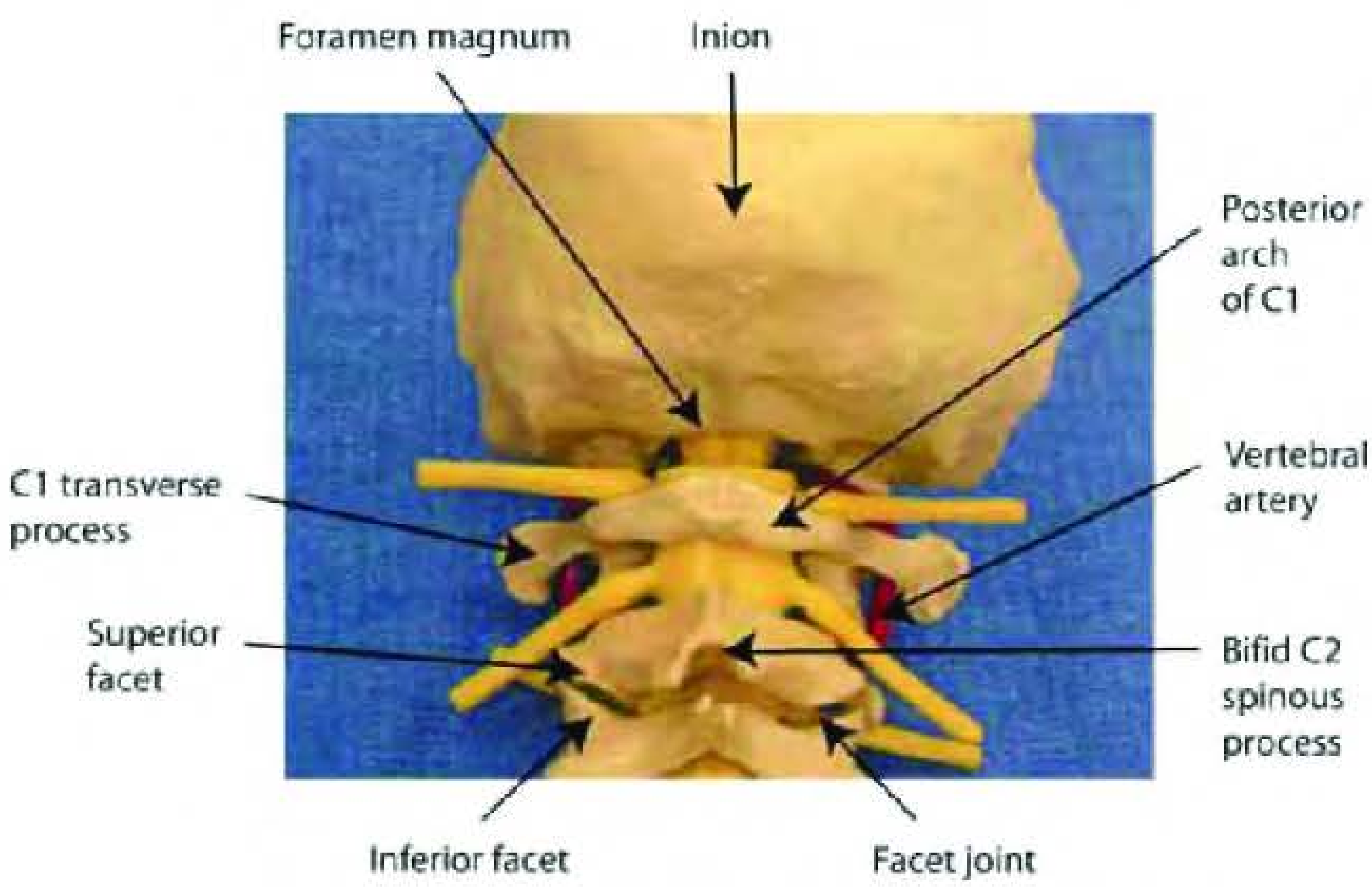

FIGURE 21–4 C1 has no vertebral body and is composed of a ring of bono that articulates superiorly with the occipital condyles and interiorly with the lateral mass of C2. C1 also has no spinous process.

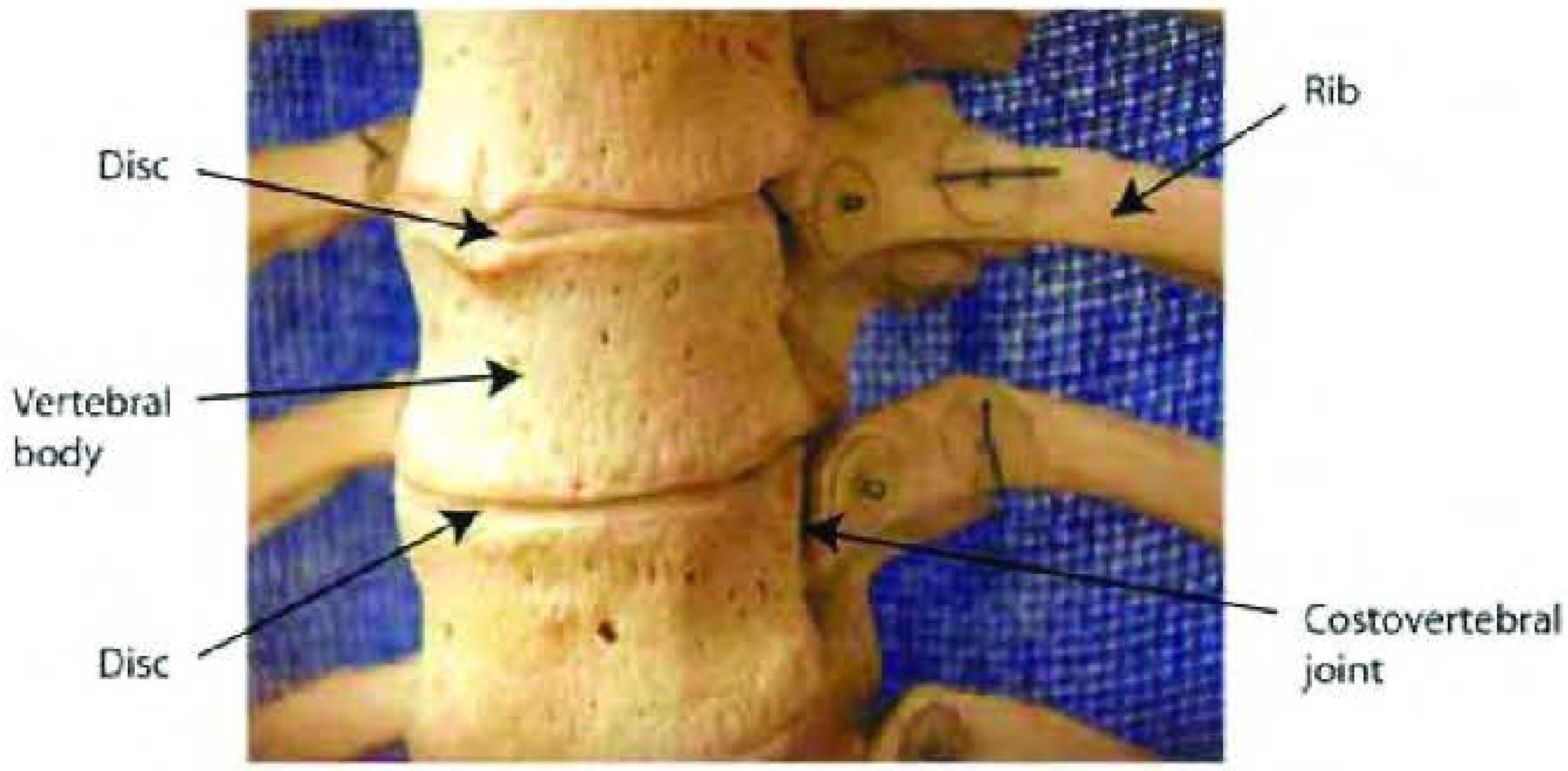

FIGURE 21–5 The thoracic spine has an extra joint by virtue of its junction with the rib cage. The costovertebral joints are situated high on the vertebral body.

The interarticulating facets of the thoracic segments are oriented in a coronal plain (Fig. 21–6).

LUMBAR SPINE

The lumbar vertebra) bodies are the largest and progressively increase in size with each caudal segment (Fig. 21–7). Like the cervical vertebrae, the lumbar vertebrae are larger in the transverse diameter than the anterior-posterior diameter. The lamina are broad, wide, and do not overlap. The spinous processes are long and horizontal; the transverse processes are thin (Fig. 21–8).

The spinal cord ends opposite the L1–2 level. Because there are seven cervical vertebrae and eight cervical roots, each lumbar nerve root, like the thoracic nerve roots, exits under the pedicle of the vertebral segment; that is, the L4 nerve root exits under the L4 pedicle. The discs exit very high in the neuroforamen so that it is possible that a prolapsed disc may damage the root that is passing from the segment above, and not the root exiting at the same level. Therefore, an L4–5 disc herniation will likely affect the L5 root unless it is a far lateral disc herniation in which case it might affect the already exited L4 root. Centrally located disc herniations may affect any or every root from its level caudally. The cataclysmic compression of multiple nerve roots *of* the cauda equina by a single level of compression in the lower lumbar spine has been termed the *cauda equina syndrome.*

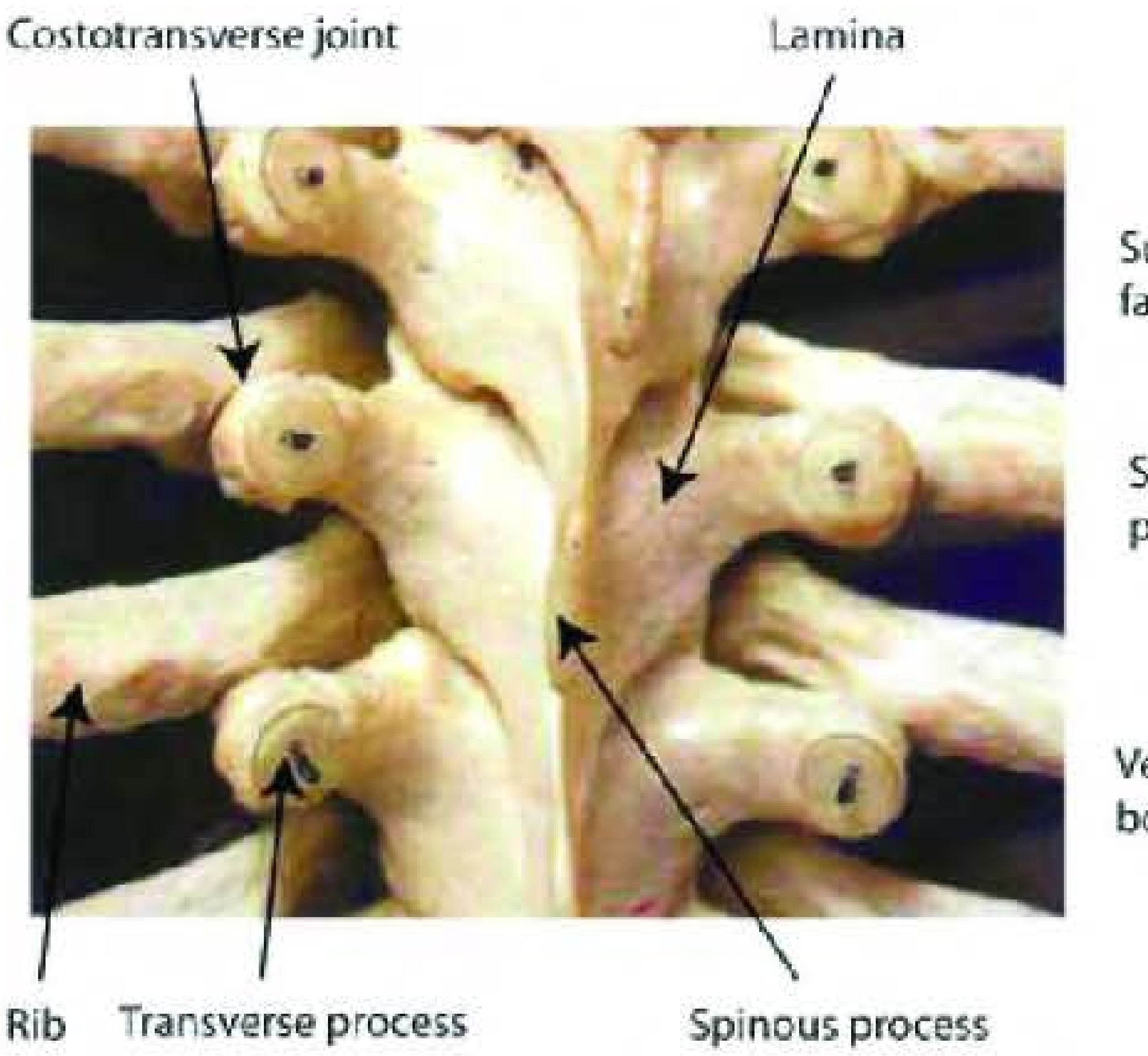

FIGURE 21–6 The pedicles for thoracic vertebrae are situated high on the vertebral body. The spinous process of the segment above overlies the body and posterior arch of the segment below.

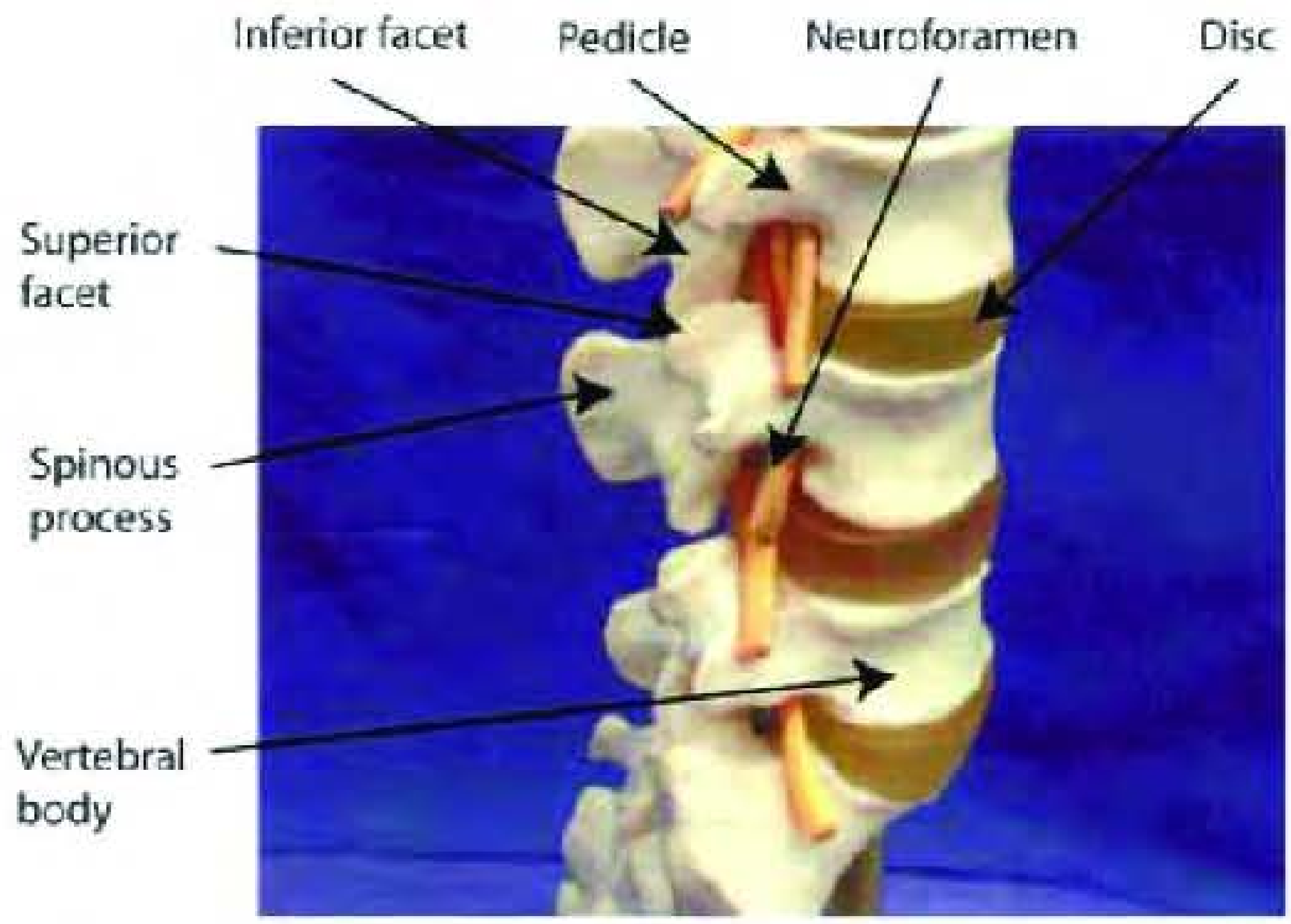

FIGURE 21–7 The lumbar vertebrae are the largest vertebrae.

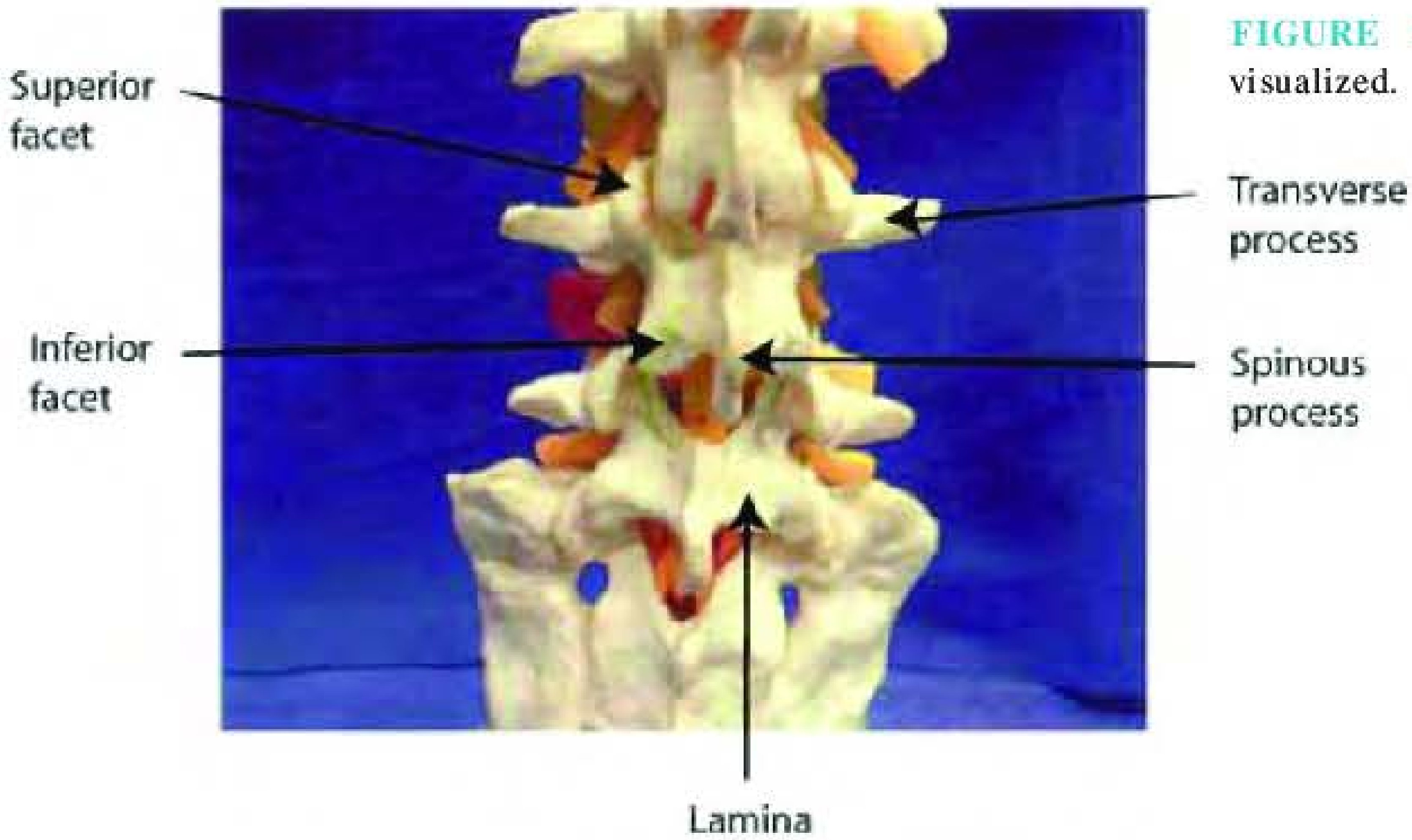

FIGURE 21–8 The interacticulating facet joints are well visualized.

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Chapter 22

Transoral Approach to the Upper Cervical Spine

Carlos Acevedo, Anthony Caputy

Indications for Approach

- Dens fractures and pseudoarthroses
- Tumors of the upper cervical spine and lower clivus
- Os odontoideum
- Cranial settling
- Rheumatoid pannus

Positioning and Skin Incision

The patient is placed supine with the head held in rigid three-point fixation with the Mayfield head holder. The patient should be in slight Trendelenburg with the neck in gentle extension. The final operative position is confirmed by radiography or fluoroscopy. A self-retaining retractor is placed to retract the uvula and soft palate as well as to depress the tongue for adequate visualization (Fig. 22–1). Intubation may be transoral or transnasal, or a tracheostomy may be performed.

Surgical Technique

Under the operating microscope, the posterior pharyngeal wall is incised in the midline (Figs. 22–2 and 22–3). The incision may extend from the anterior tubercle of the arch of C1 to the level of C2 or C3. A subperiosteal dissection is made of the pharyngeal muscles, and they are retracted laterally to expose the underlying longus colli muscles on either side of the anterior longitudinal ligament (Fig. 22–4). The longus colli muscles are reflected laterally by subperiosteal dissection and placed under the retractor blades to allow visualization of the anterior longitudinal ligament

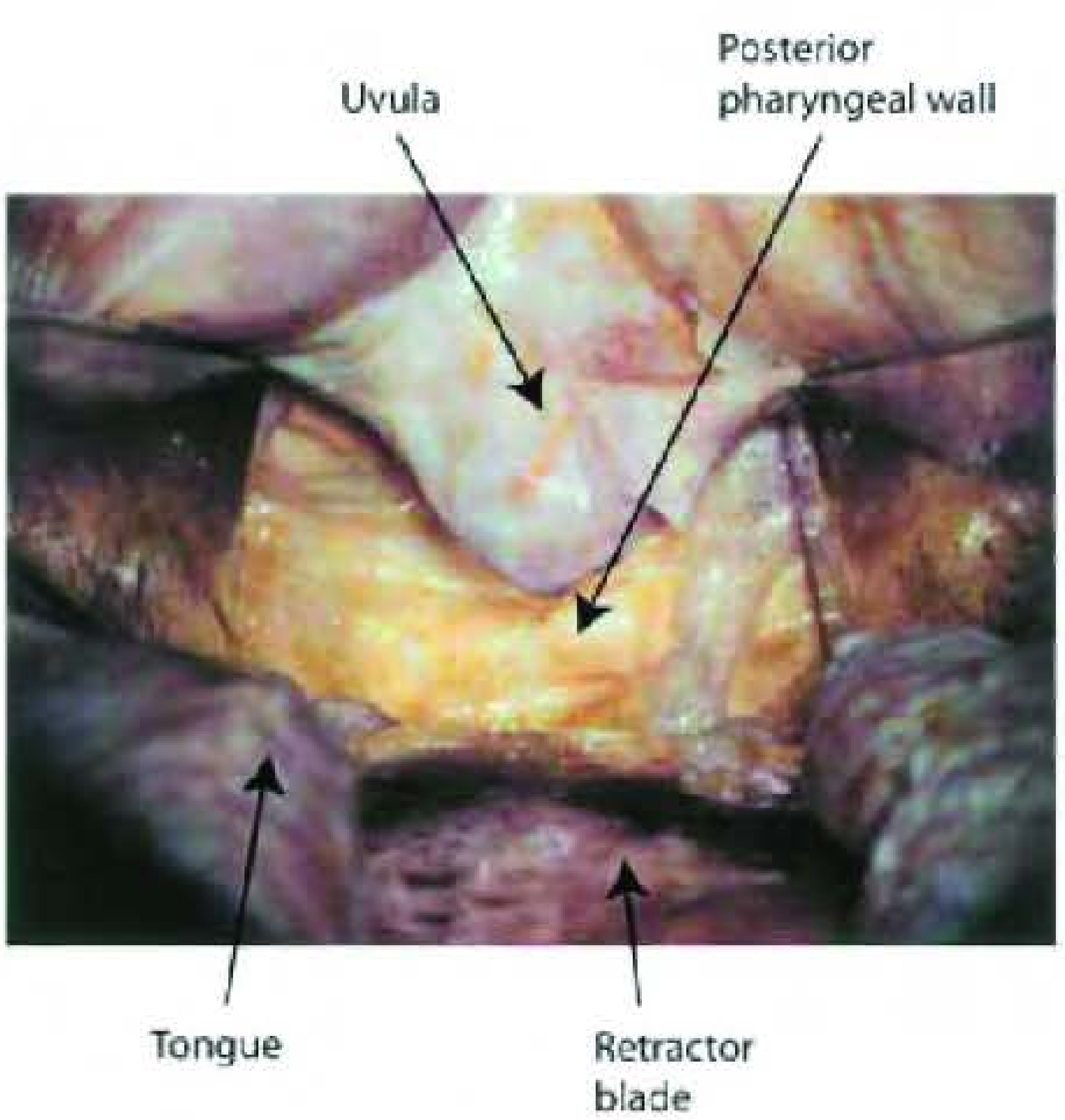

FIGURE 22–1 Self-retaining retractor is in place, exposing the uvula, soft palate, and posterior wall of the pharynx.

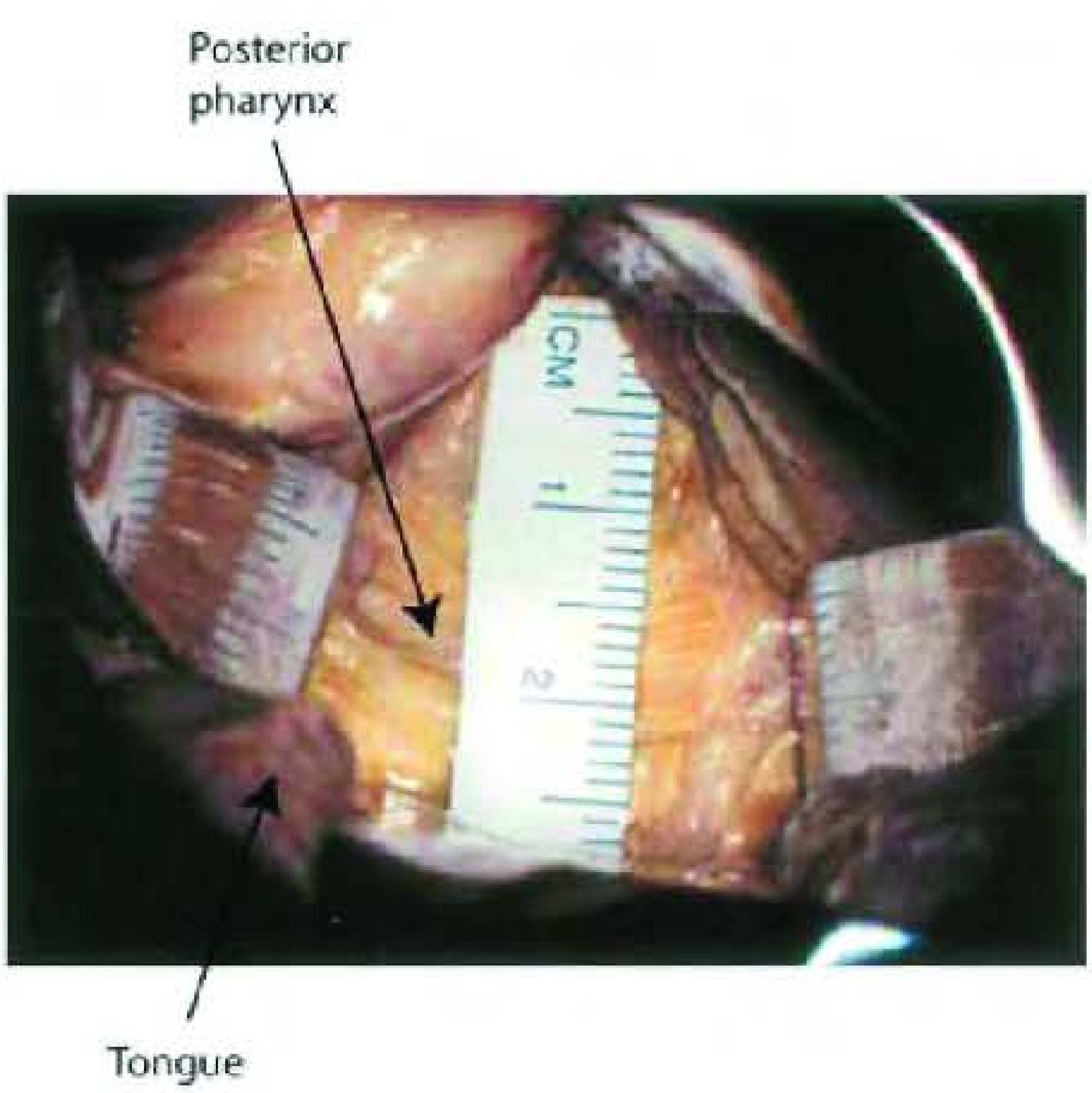

FIGURE 22–2 A working distance of 2.5 cm is easily obtained through this approach without incising the soft palate.

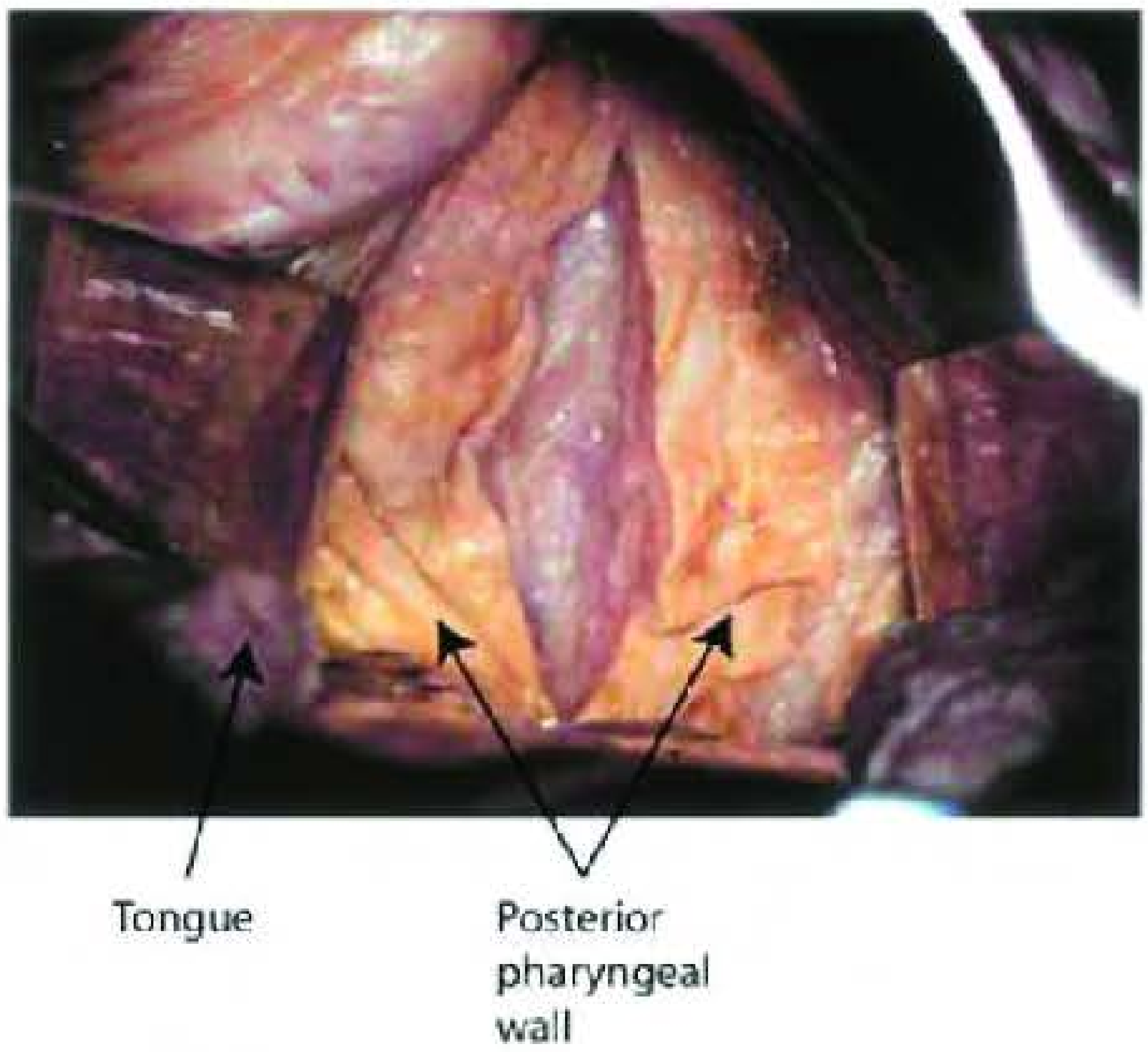

FIGURE 22–3 The posterior wall of the pharynx is incised in the midline.

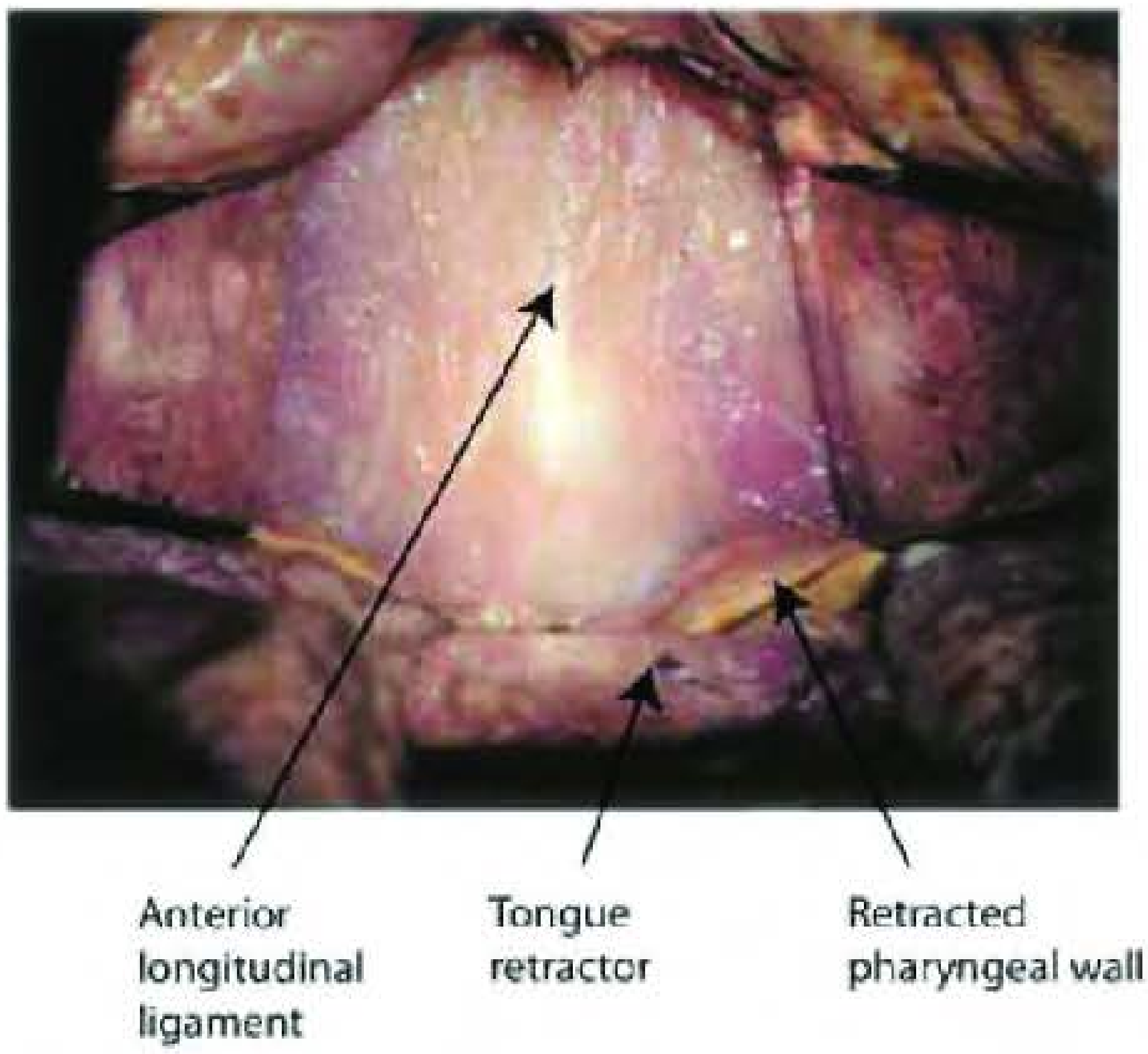

FIGURE 22–4 The midline anterior longitudinal ligament is visualized.

(Fig. 22–5). The anterior longitudinal ligament is resected, exposing the tubercle of the arch of C1, the bodies of C2 and C3, as well as the C2–3 disc space (Fig. 22–6). Lateral exposure should not exceed more than 1 cm from the midline at the C2 and C3 levels because the vertebral artery is at risk with further lateral dissection. At the level of the arch of C1, exposure laterally should not exceed more than 2 cm from the midline. The risk of entering the retromandibular fossa is higher if the dissection is carried lateral to the lateral masses of C1. Injuries to the lower cranial nerves, particularly the ninth and twelfth nerves, also may occur.

Once the bony exposure is obtained, the C2–3 disc space may be entered easily for a C2–3 discectomy. Using a high-speed air drill, the vertebral body of C2 may be removed (Fig. 22–7). For dens resection, part of the arch of C1 may be removed. The transverse and apical ligaments that attach to the dens from laterally and superiorly must be cut to resect the dens and allow visualization of the posterior longitudinal ligament and, subsequently, the dura (Figs. 22–8–22–10). The transverse ligaments are attached to the lateral masses of C1 in the region of the interarticular joint spaces.

After resection of the dens, a Valsalva may be performed to ensure no evidence of a cerebrospinal fluid leak. The wound may be closed in one or two layers using an absorbable suture.

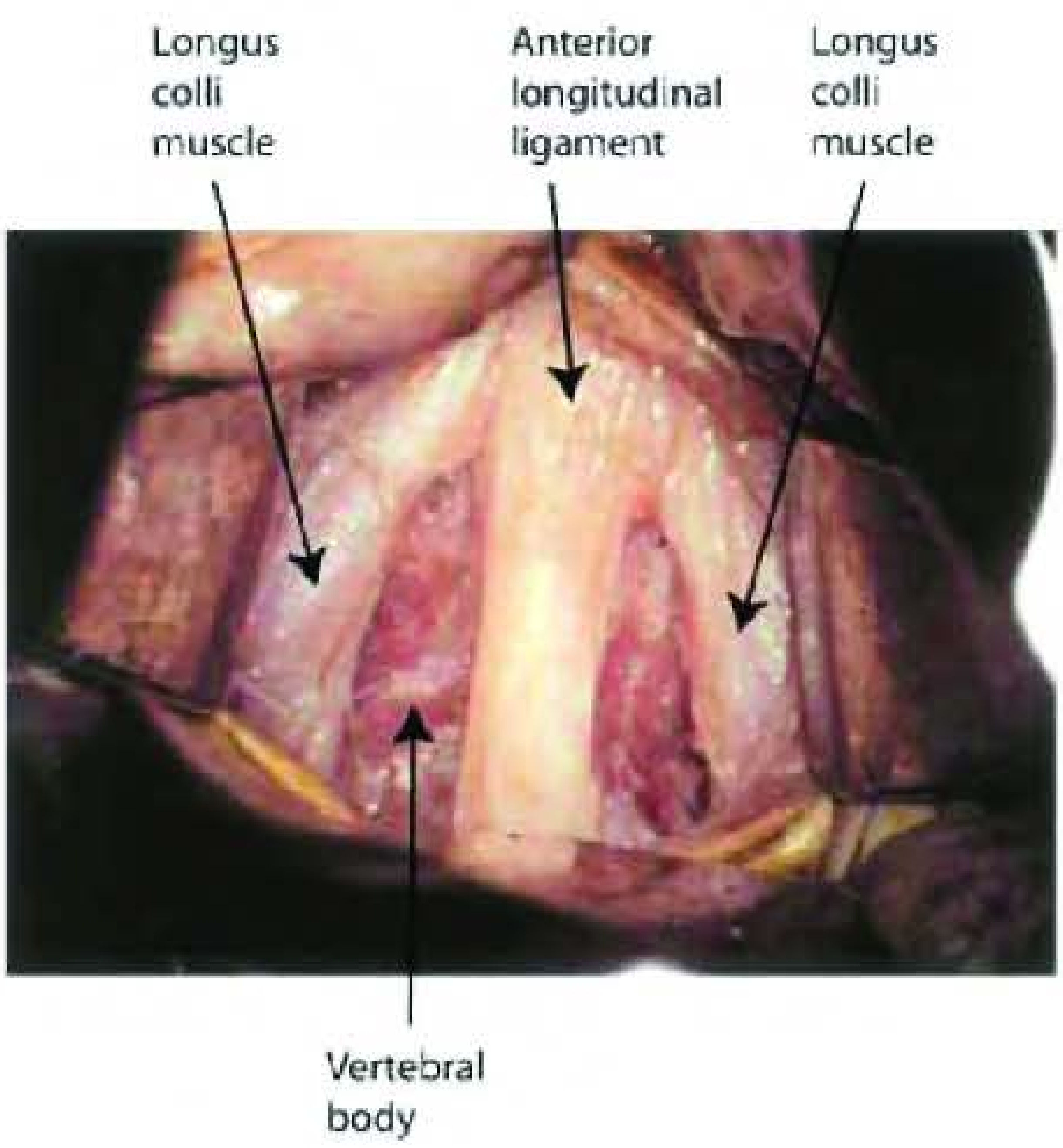

FIGURE 22–5 Subperiosteal dissection of the longus colli muscles away from the anterior longitudinal ligament and underlying vertebral body.

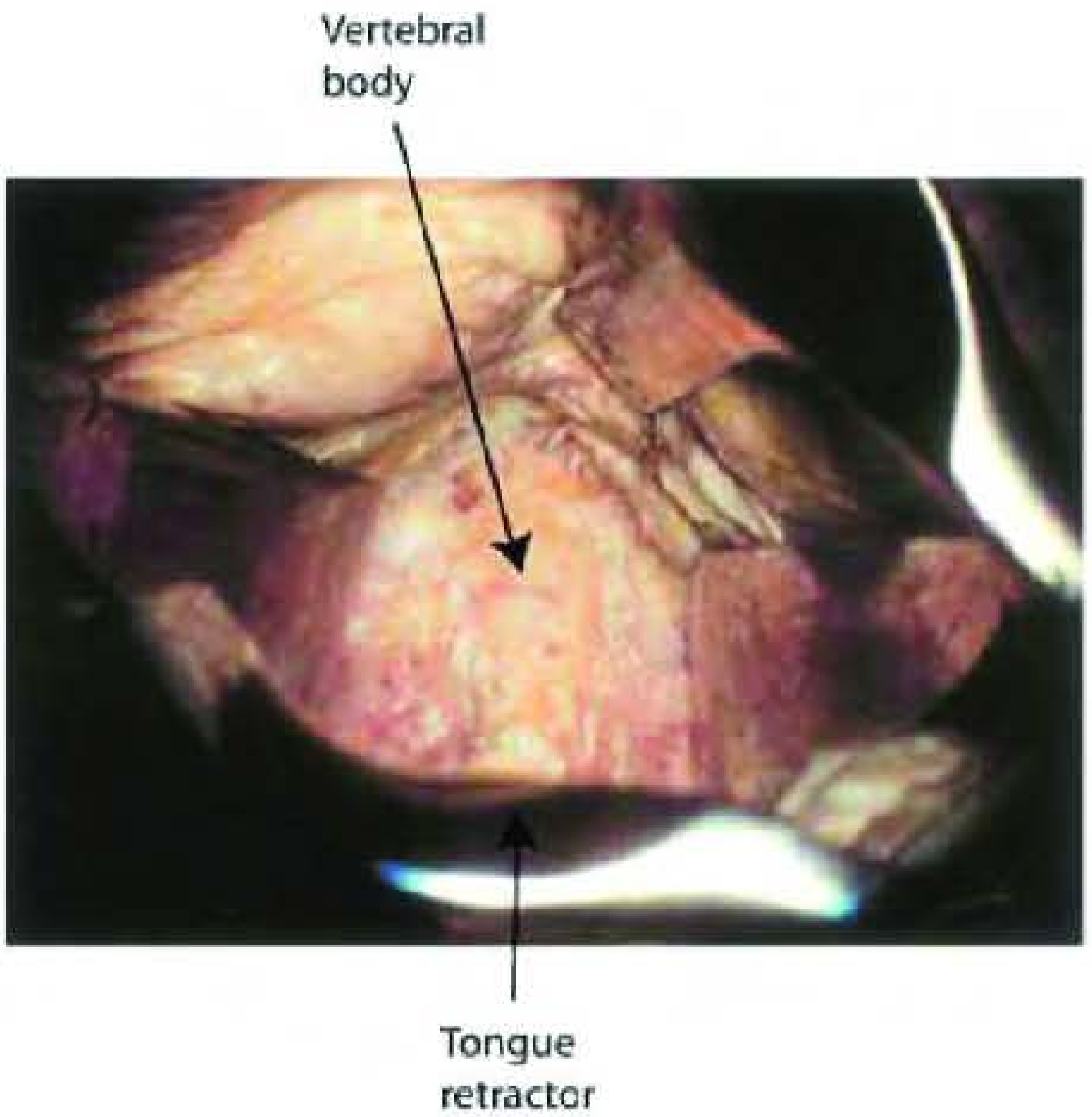

FIGURE 22–6 Resection of the anterior longitudinal ligament and lateral retraction of the longus colli muscles.

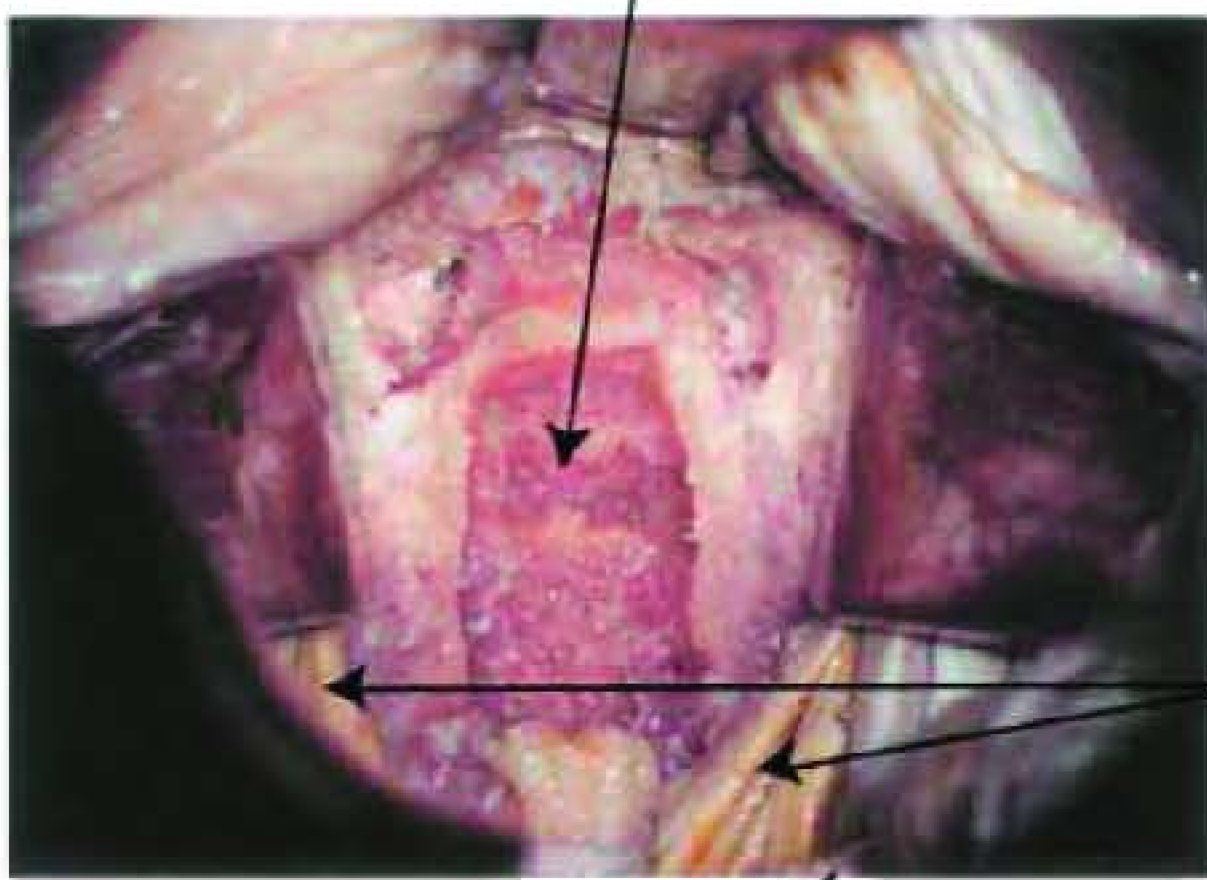

FIGURE 22–7 A C2 and C3 corpeetomy from the base of the dens to the C3–4 juncture has been performed.

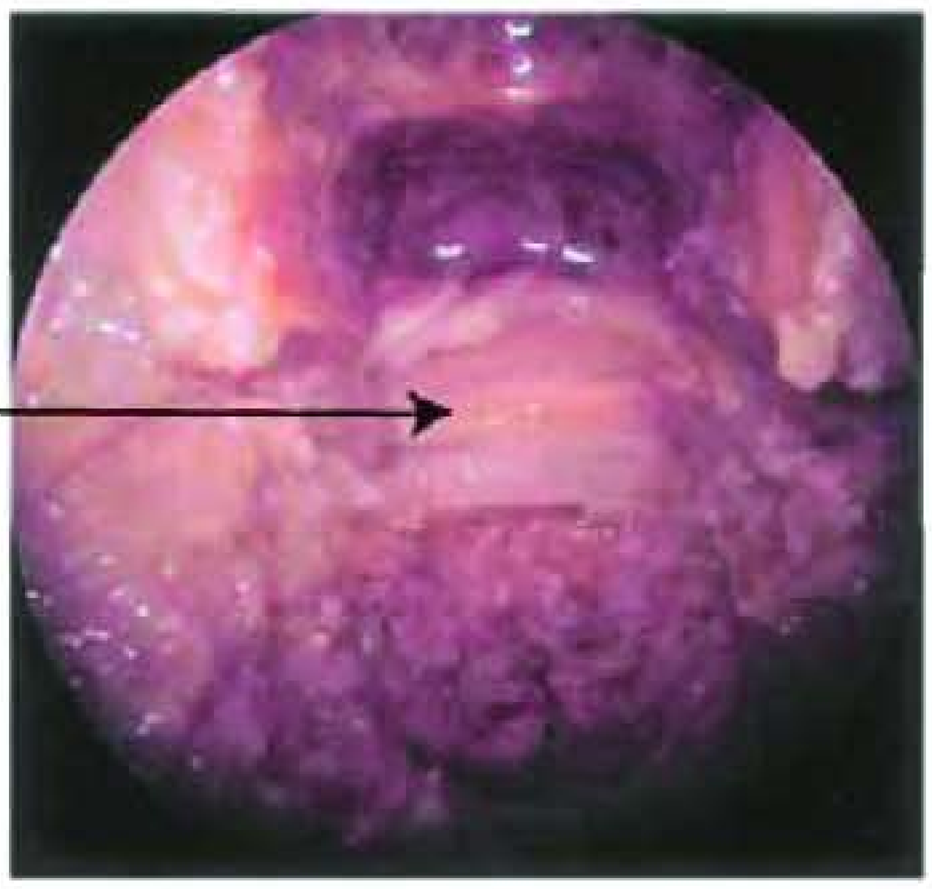

FIGURE 22–8 The odontoid has been resected reveealing the underlying transverse ligament.

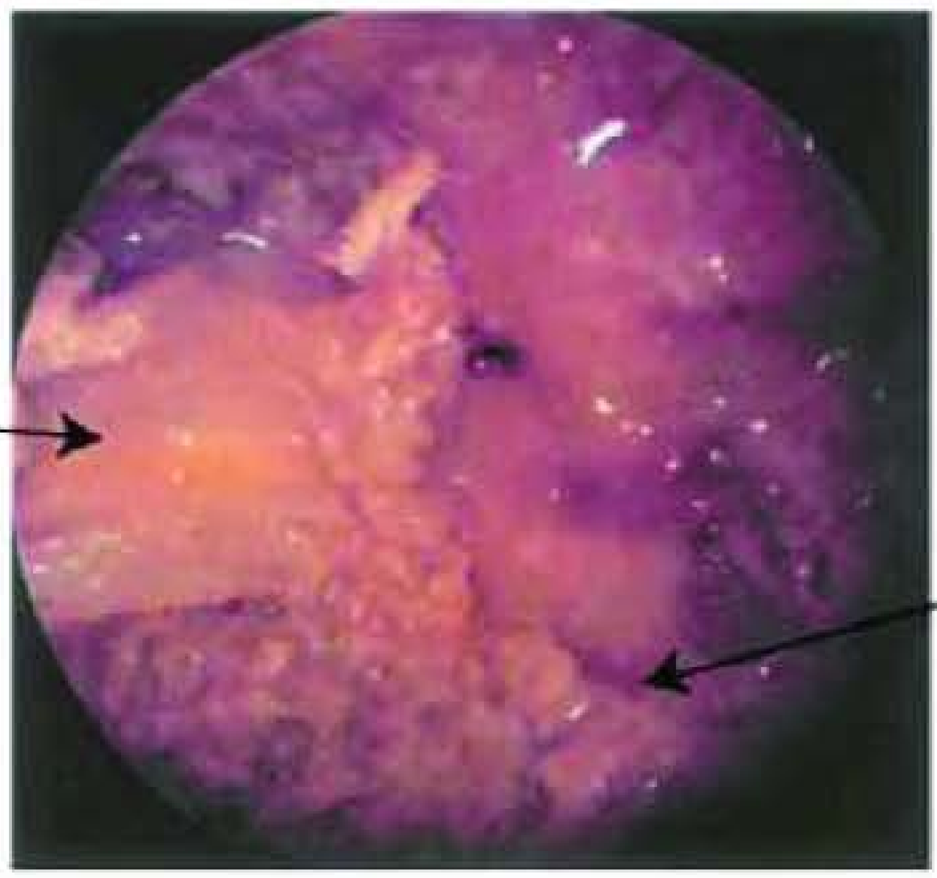

FIGURE 22–9 The lateral mass of the atlas is identified. The lateral attachment of the transverse ligament and the C1–2 articulating facet can be seen.

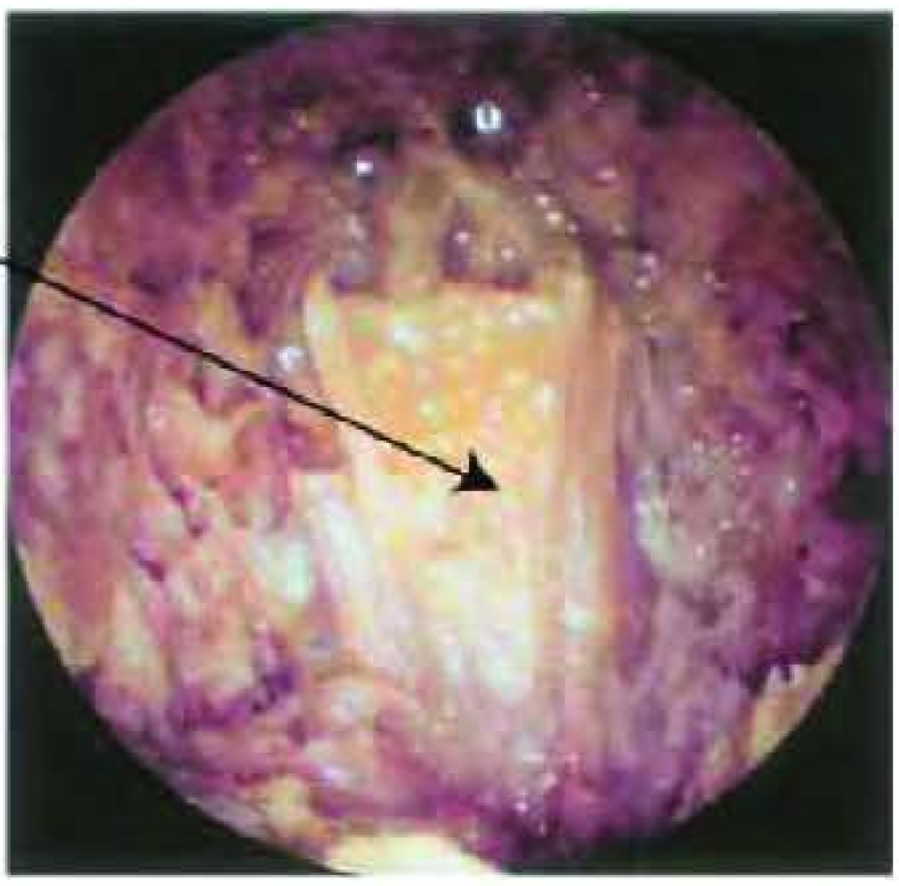

FIGURE 22–10 The upper cervical dura is visualized after resection of the transverse ligament.

PITFALLS, PEARLS, CONSIDERATIONS

- Vertebral artery injury
- Injury to cranial nerves IX and XII
- Wound infection and dehiscence
- Upper spinal cord and lower brainstem injury
- Anterior spinal artery injury

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Chapter 23

ANTERIOR APPROACH TO THE CERVICAL SPINE

Emel Avci, Ernest Senz, Anthony Caputy

INDICATIONS FOR APPROACH

- Cervical spondylosis
- Cervical spine fractures
- Anterior bony or spinal neoplasms
- Carotid endarterecotomy

POSITIONING AND SKIN INCISION

The patient is placed in the supine position with the head placed on a horseshoe or donut, with or without Gardner-Wells traction, depending on the clinical circumstances. A Halter chin strap may be used for distraction and extension during anterior cervical discectomies not associated with spinal instability. For high cervical pathology, the head may he rotated slightly to the contralateral side. The shoulders should be taped to the foot of the bed to facilitate imaging down to the C7–T1 region. Care must be taken to avoid over-pulling the shoulders because brachial plexus stretch injuries could result. The elbows should be padded to minimize the risk of an ulnar neuropathy.

A transverse skin incision gives excellent cosmetic results; however, for multilevel pathology and vascular disease, a longitudinal incision may be more beneficial (Fig. 23–1). Transverse skin incisions must be positioned appropriately and can be approximated with the use of palpable landmarks. The C3–4 region is at the level of the hyoid bone. The C4–5 region is at the level of the thyroid cartilage. The C5–6 region is at the level of the cricothyroid membrane and the C6–7 region is generally two fingerbreadths above the clavicle.

FIGURE 23–1 A transverse skin incision is depicted. A transverse incision at the level of the hyoid bone approximates the C3–4 level; at the level of the thyroid cartilage, it approximates the C4–5 level, and at the level of the cricothyroid membrane, it approximates the C5–6 level. Two fingerbreadths above the clavicle approximates C6–7.

SURGICAL TECHNIQUE

CERVICAL COMPRESSION

The transverse skin incision is generally centered on the anterior border of the sternocleidomastoid muscle and is generally made in a skin crease for cosmesis. The underlying platysma is identified and transected, and a subplatysmal dissection plane is developed superiorly and interiorly (Fig. 23–2). A plane medial to the anterior border of the sternocleidomastoid muscle is exploited most easily using the surgeon's forefinger. The trachea, esophagus, and thyroid will be displaced medially, and the carotid sheath containing the artery, jugular vein, and vagus nerve will be displaced laterally- Superior, middle, or inferior thyroid vessels may cross the field and require ligation and sectioning. The recurrent laryngeal nerve must be identified and spared.

Hand-held retractors are introduced into the wound, and the anterior cervical fascia is identified. After incising the anterior cervical fascia, the anterior longitudinal ligament and longus colli muscles are identified (Fig. 23–3). The longus colli muscles are dissected free of the underlying bone and displaced laterally with a self-retaining retractor. Localization of the visualized disc spaces is confirmed radiographically (Fig. 23–4).

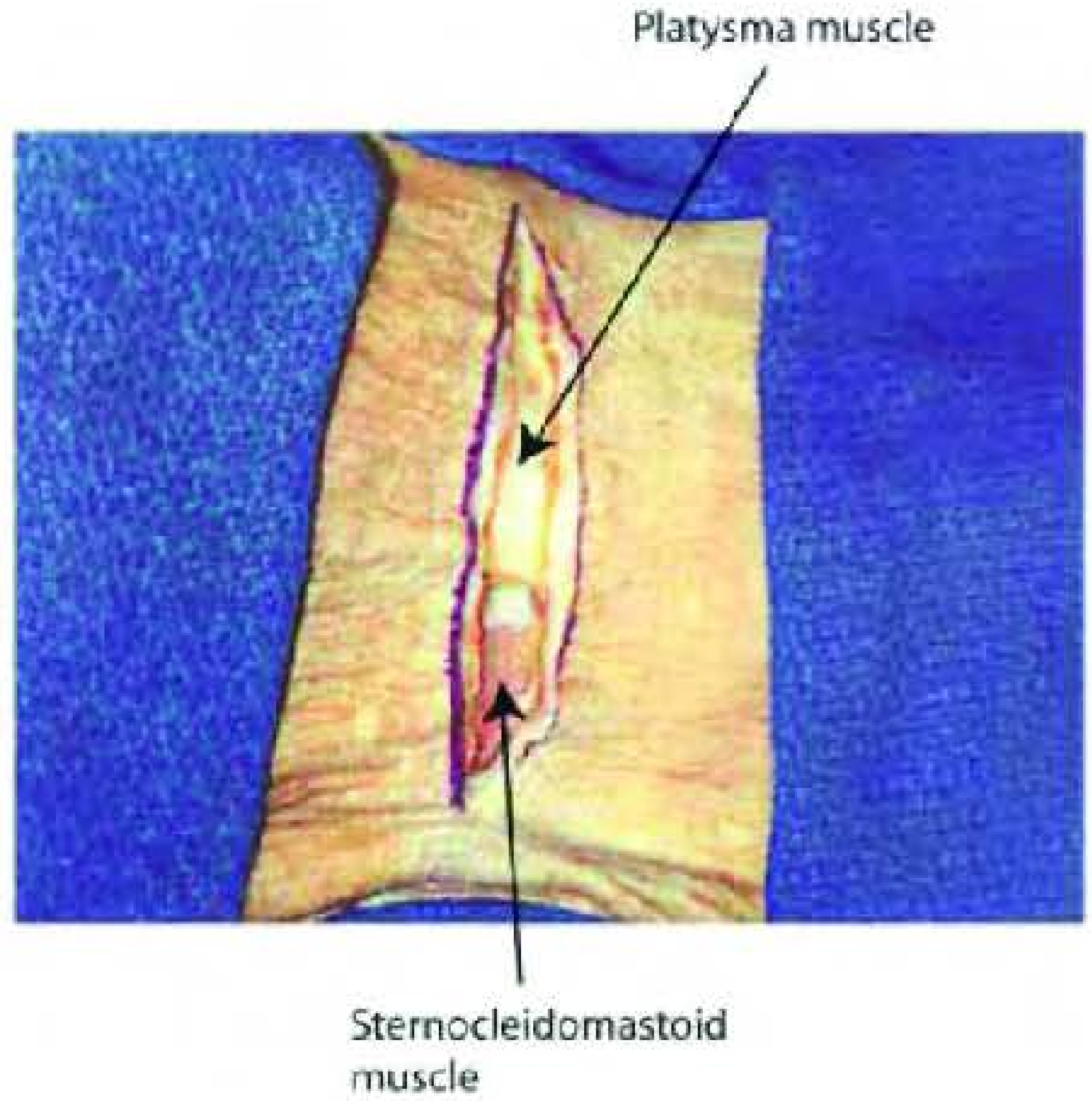


FIGURE 23–2 A transverse incision exposes the underlying thin platysma and the anterior bonder of the sternocleidomastoid muscle. The plane to be developed is just medial to the anterior bonder of the sternocleidomastoid muscle.

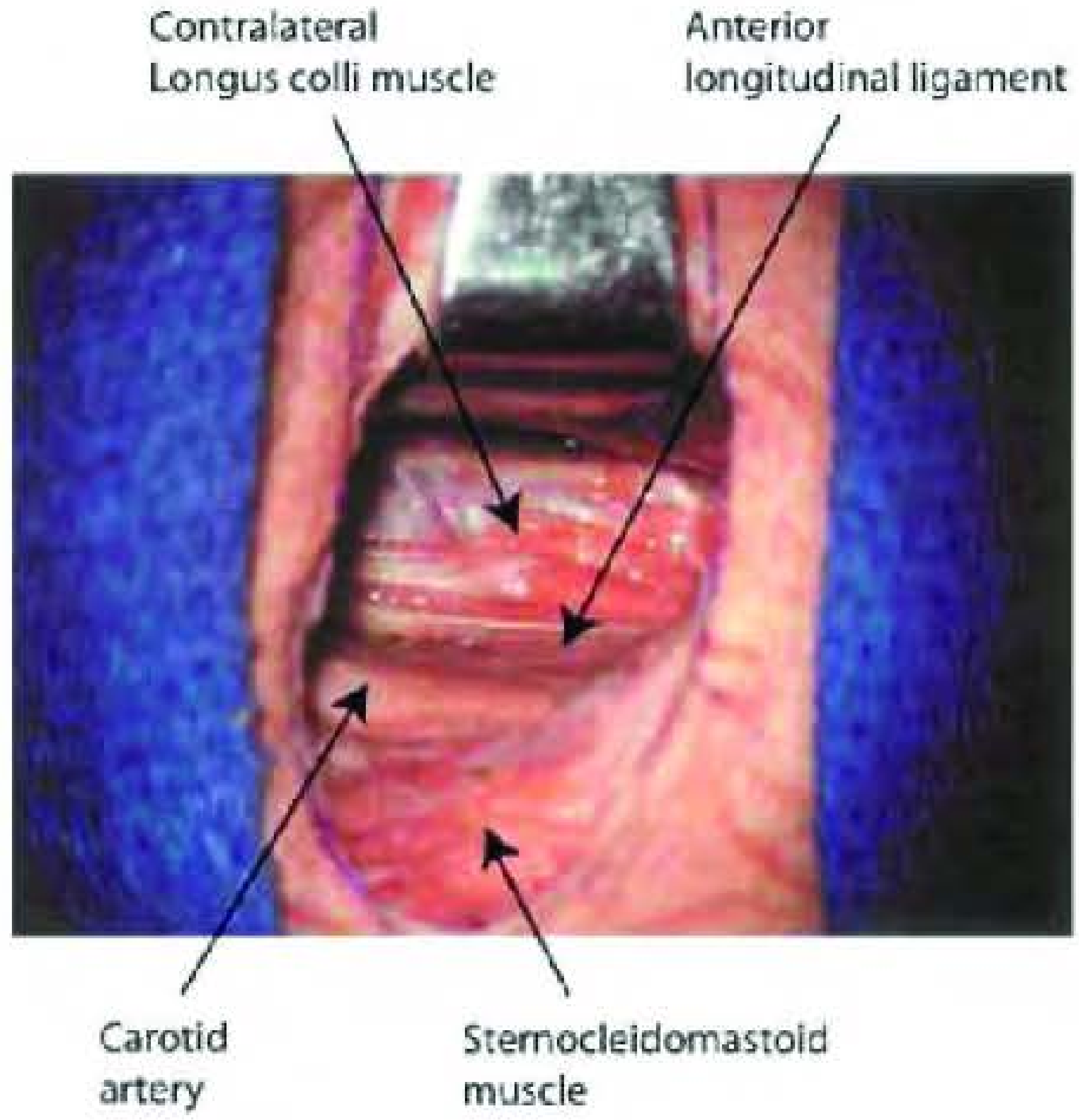


FIGURE 23–3 Retraction of the midline structures. The longus colli muscles and the anterior longitudinal ligament overlying the vertebral bodies and disc spaces are exposed in the depths.

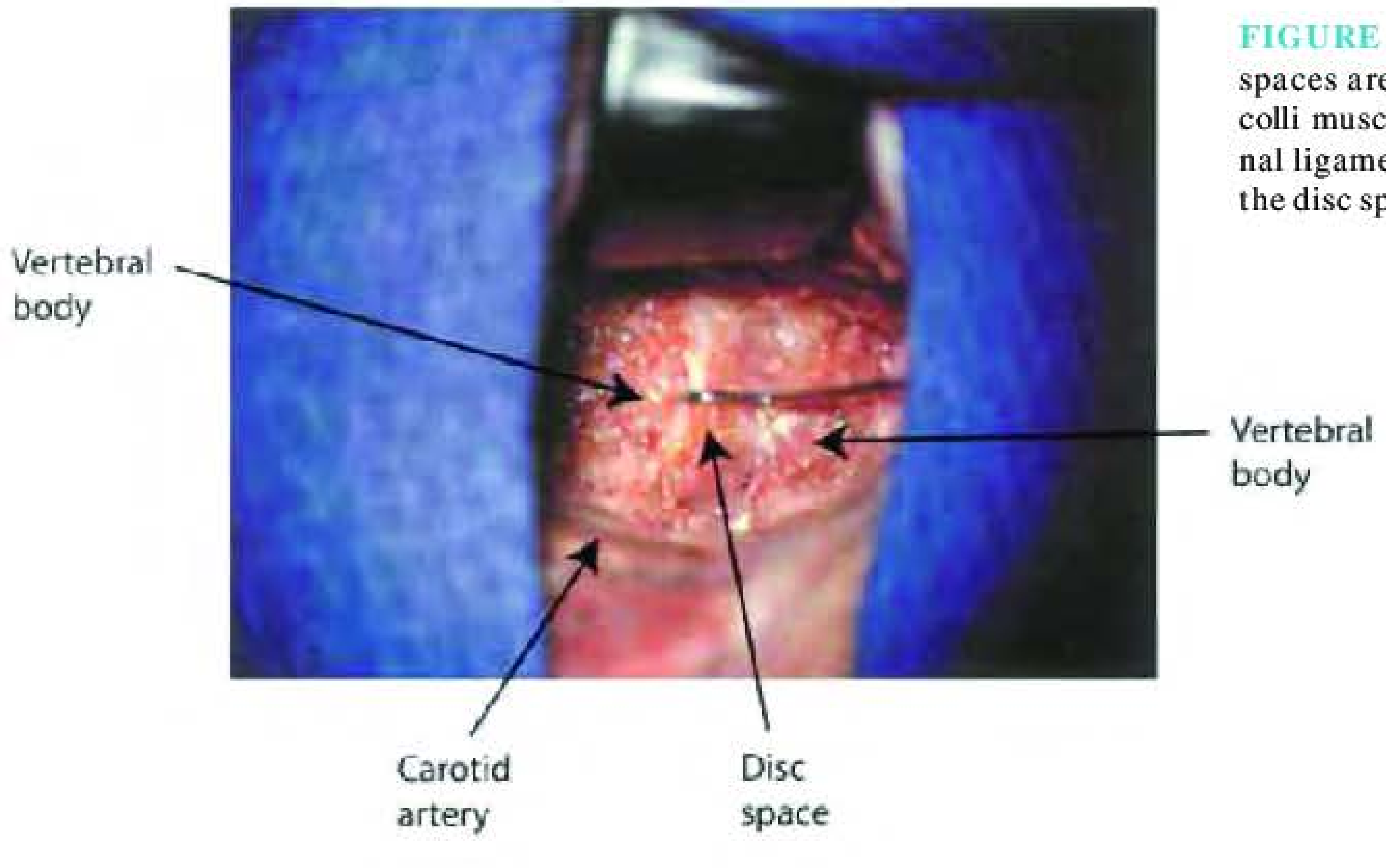


FIGURE 23–4 The vertebral bodies and disc spaces are visualized after reflection of the longus colli muscles and incision of the anterior longitudinal ligament. A localizing needle has been placed in the disc space for radiographic verification of level.

The annul us fibrosus is incised in a rectangular fashion, and the disc is removed (Fig. 23–5). This may be done with the aid of the operating microscope. Using a high-speed air drill, posterior osteophytes can be removed. In certain cases, the drill may facilitate a vertebral corpectomy. Once the annul us is incised and the process of disc removal has begun, some element of distraction is usually applied to the vertebral segments involved. Interbody spreaders, Caspar screw distractors and halter-weight traction are all acceptable methods of traction to widen the disc space further. Once all disc material has been removed, the posterior longitudinal ligament should be identified and opened using a blunt nerve hook and a Kerrison no. 1 or 2 (Fig. 23–6). Using a no. 1 or 2 Kerrison, foraminotomies can be performed bilaterally to visualize and decompress exiting nerve roots (Figs. 23–7 and 23–8). The cervical dura can be easily visualized and inspected to identify any further compression.

An appropriate tricortical graft may be fasitioned from the iliac crest to wedge into the discectomy site if an interbody fusion is planned. For long-segment vertebrectomies, fibular or rib structural grafts, or cages filled with bone can be inserted for fusion. Anterior cervical plating can be performed with adequate exposure superiorly and interiorly. Distraction should be removed prior to plating.

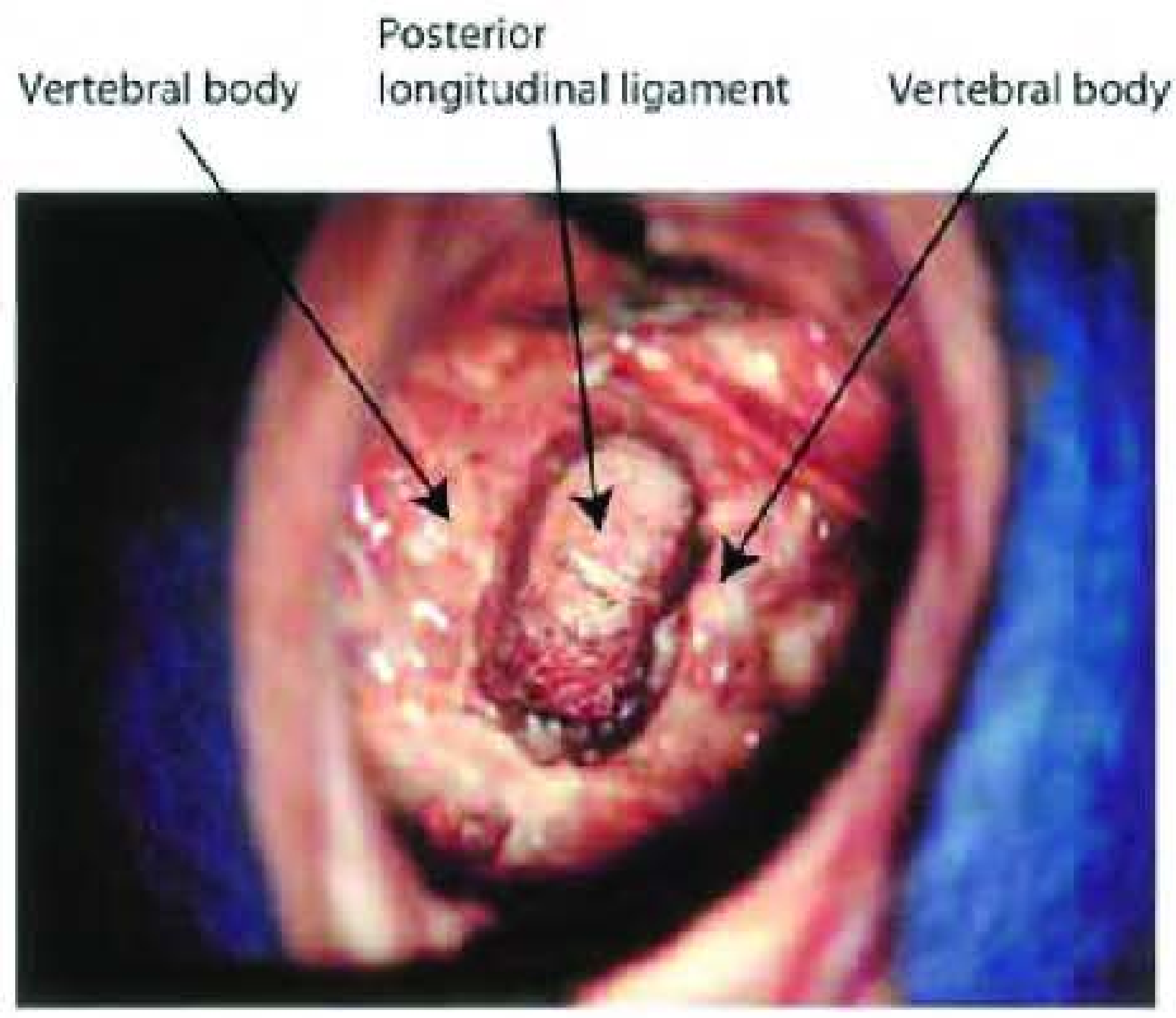


FIGURE 23–5 The annulus has been incised and the disc excised, exposing the posterior longitudinal ligament.

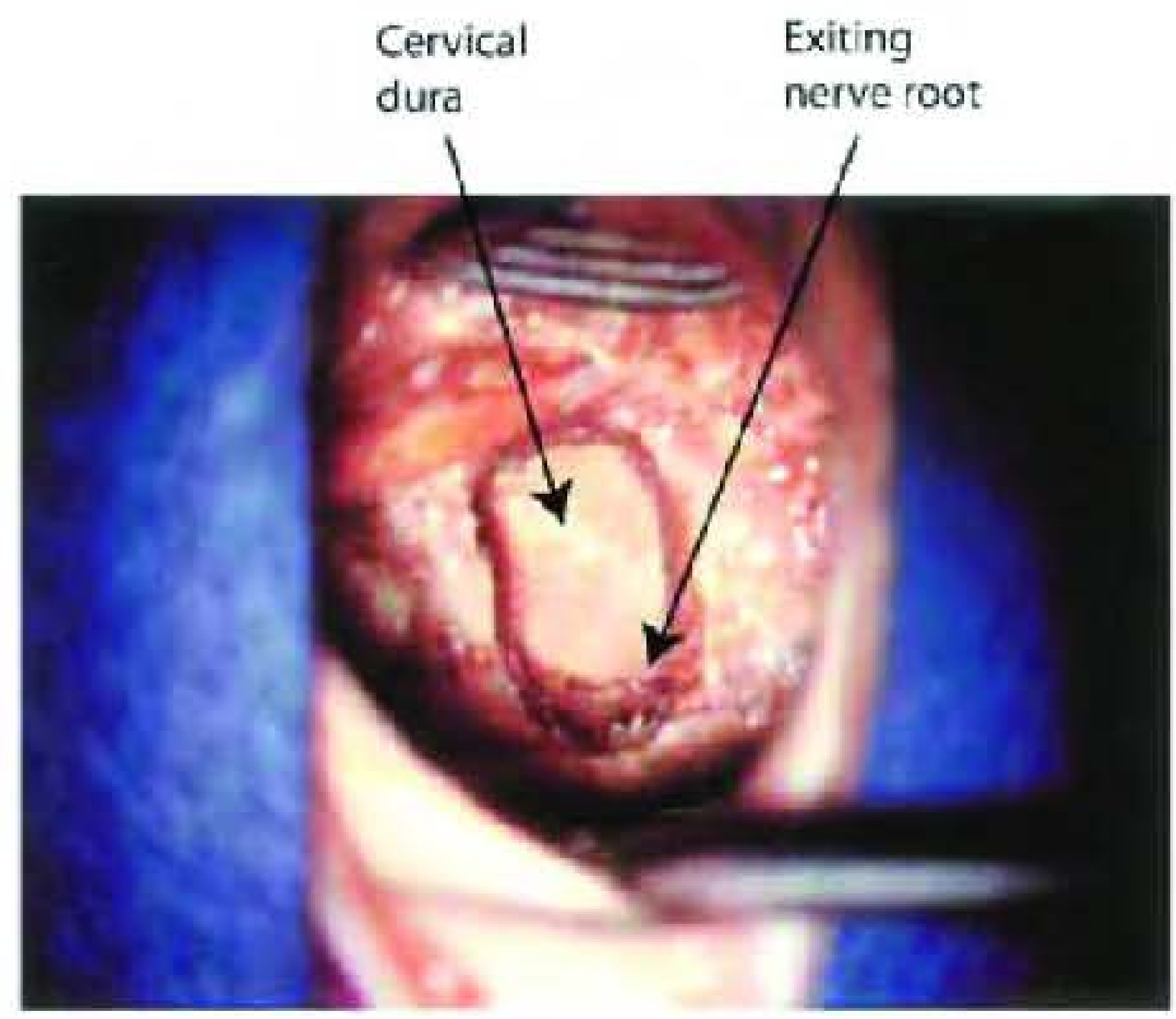


FIGURE 23–6 The posterior longitudinal ligament has been resected, exposing the epidural compartment. A foraminatomy has been performed to allow visualization of the exiting nerve root.

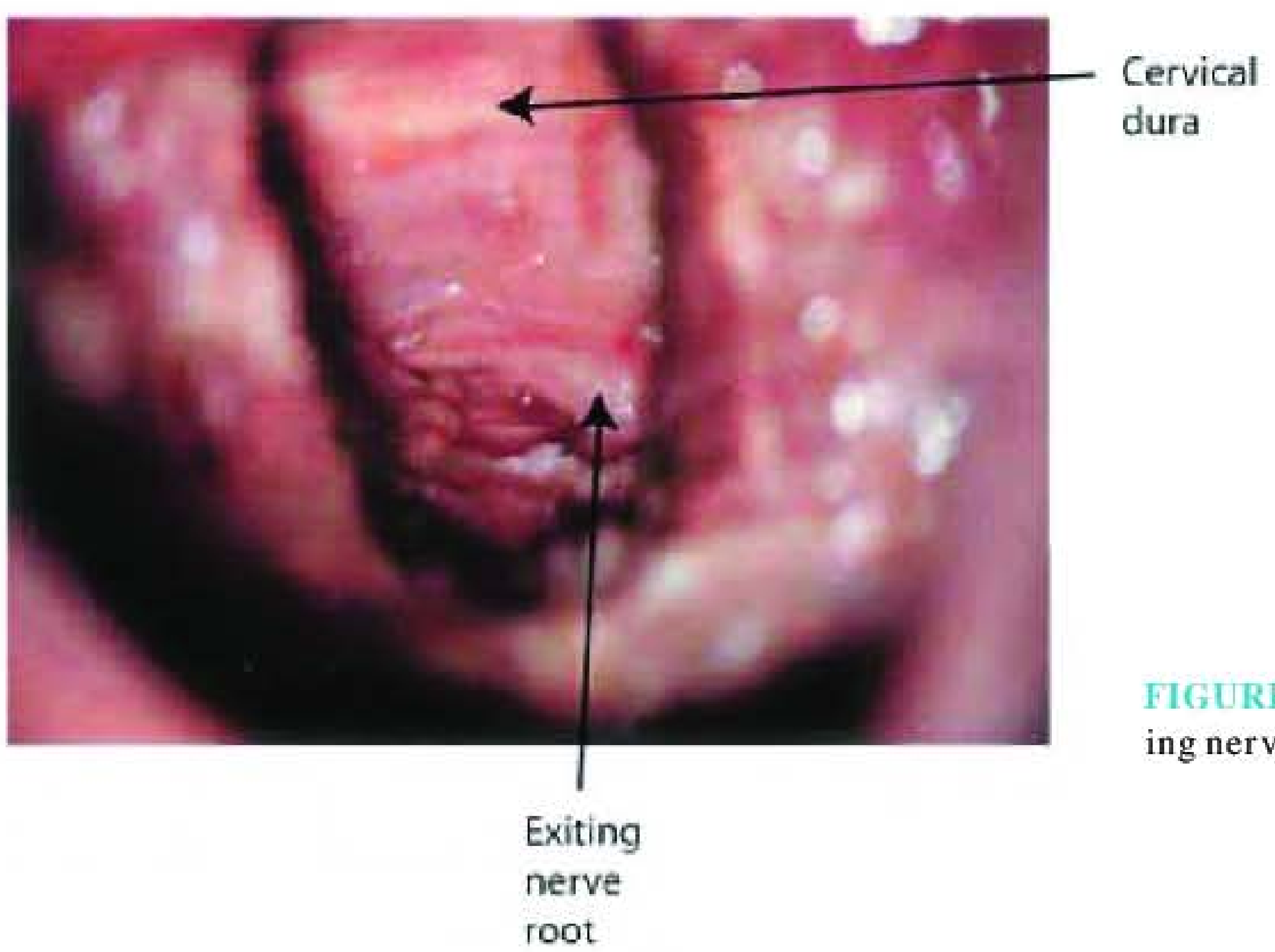


FIGURE 23–7 High-power view of the cervical dura and exiting nerve root.

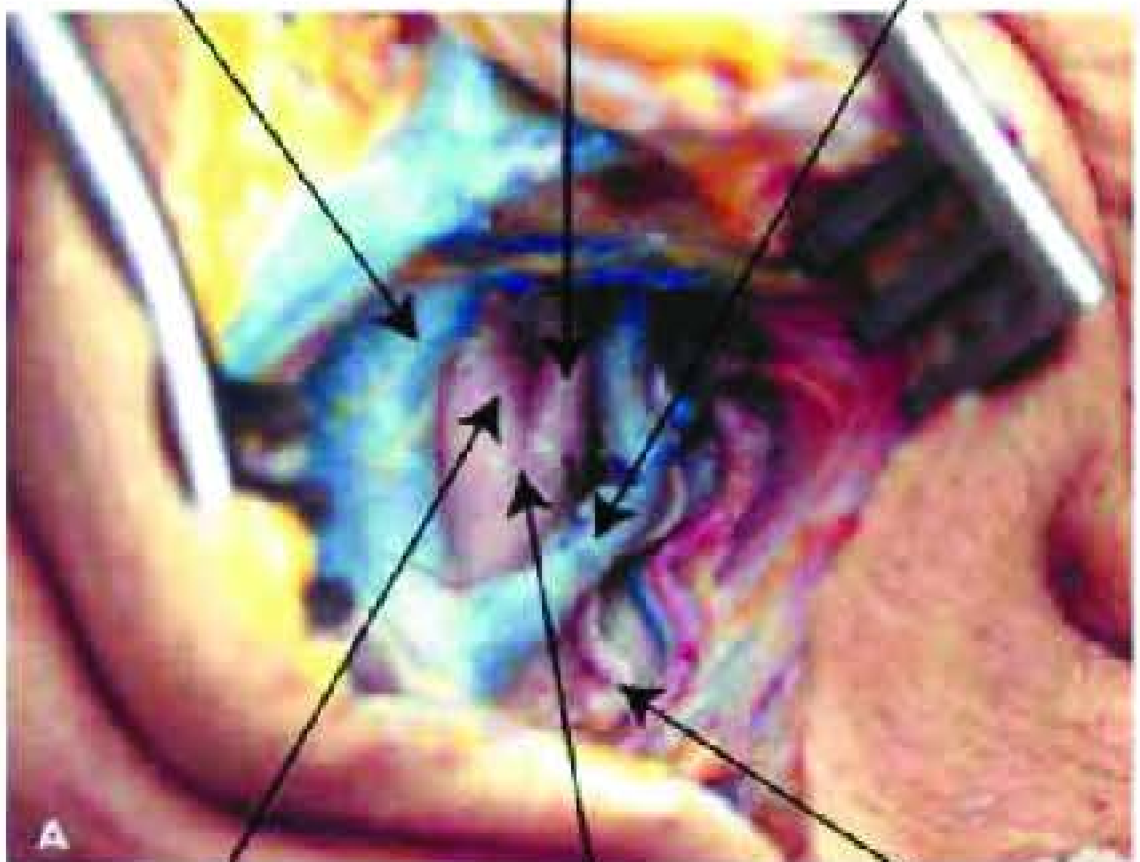
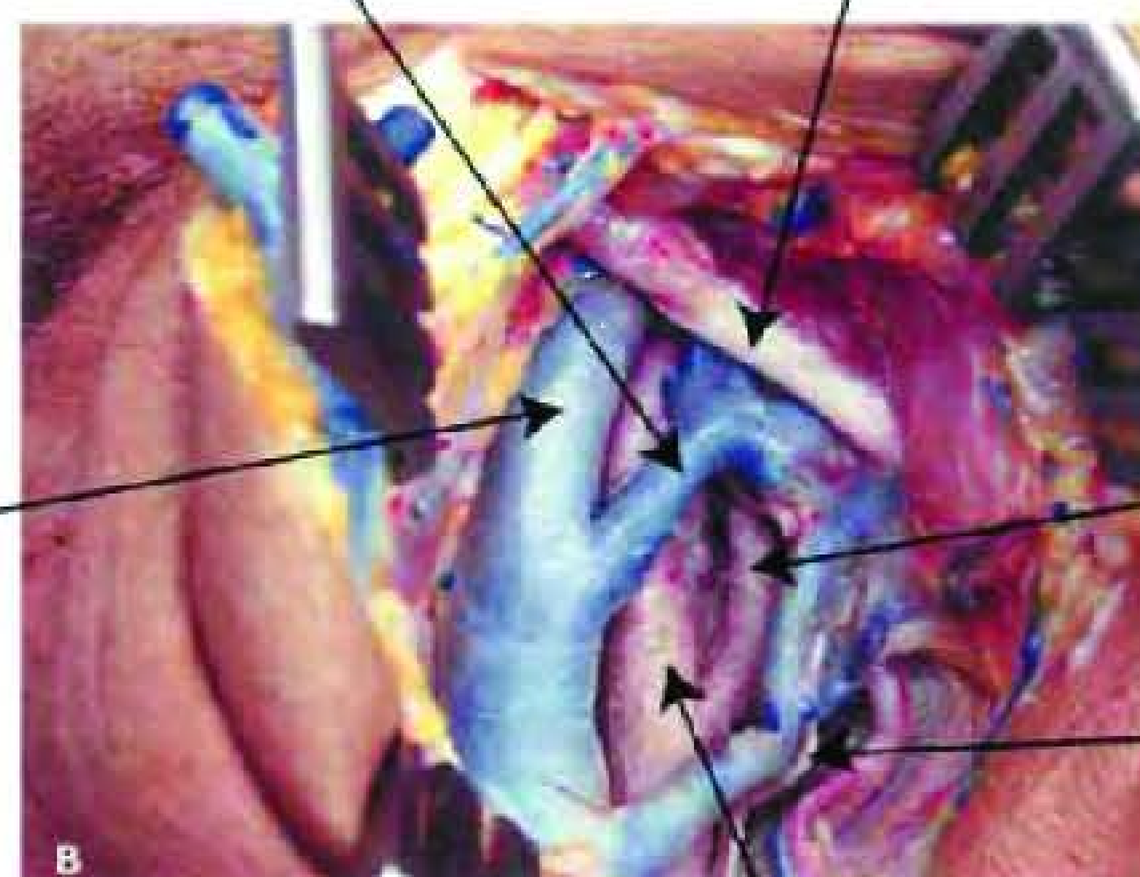


FIGURE 23–8 **A**: The internal and external jugular vein and the carotid bifurcation are seen. **B**: The posterior belly of the digastric muscle has been reflected. The internal jugular vein, the racial vein, the internal and external carotid arteries, and the ansa cervicalis are seen.



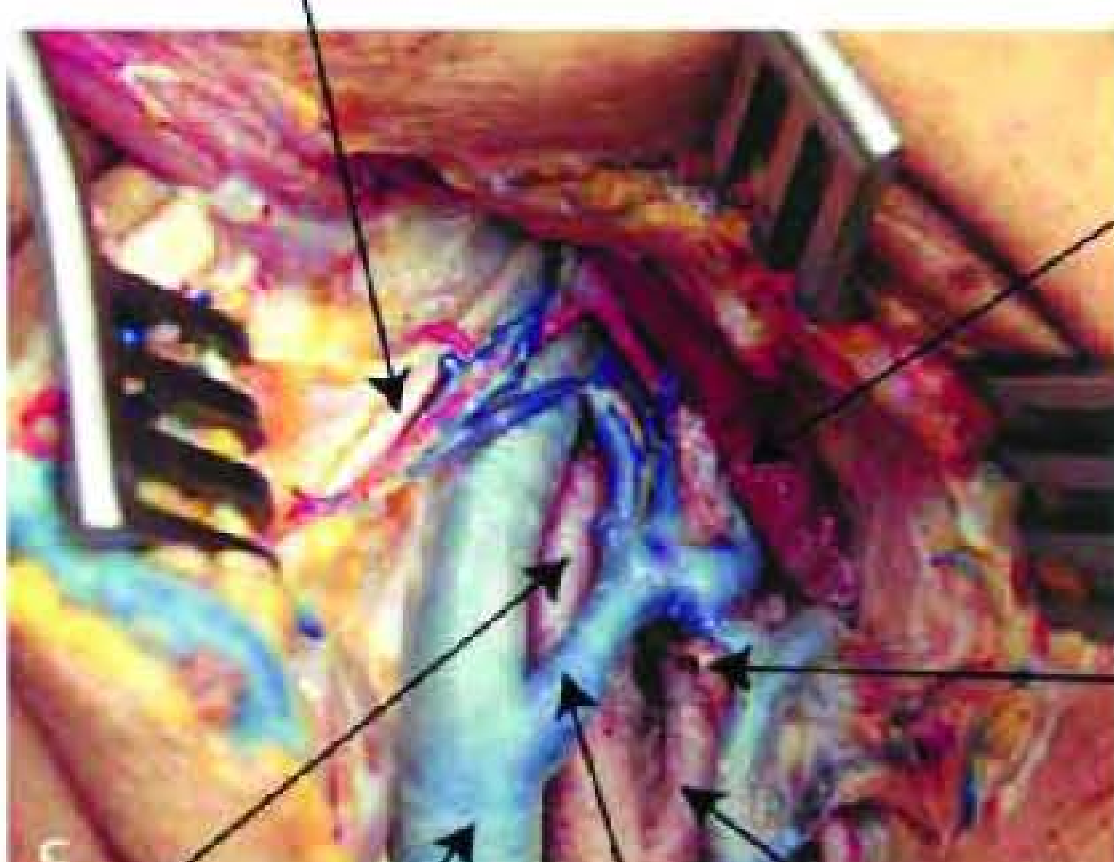
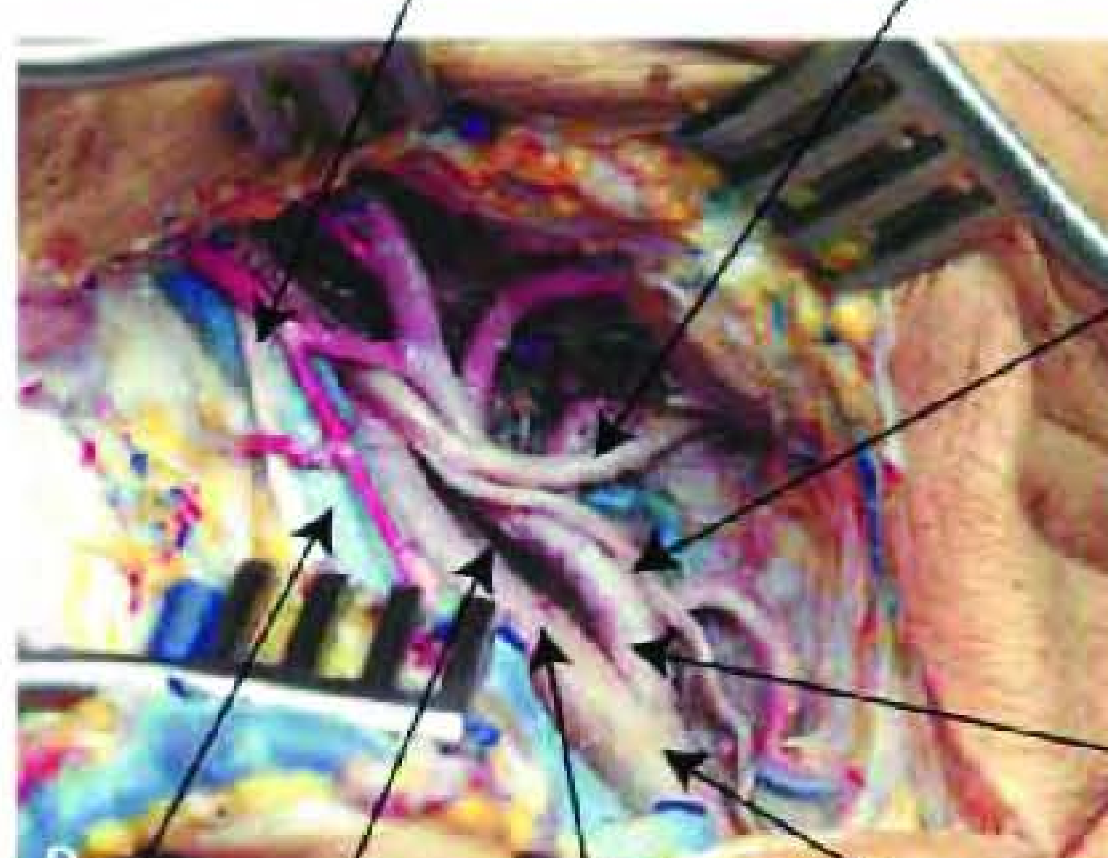


FIGURE 23–8 **C**: The common facial and internal jugular veins overlie the internal carotid artery. The ansa can be seen coursing under the facial vein, and the spinal accessory nerve is seen just lateral to the jugular vein. **D**: The hypoglossal nerve and Ansa are seen crossing the external Carotid artery. The vagus nerve is seen just under the internal carotid artery. The spinal accessory nerve is just lateral to the internal jugular vein. Note there are no branches from the cervical internal carotid artery but many branches from the cervical external carotid artery.



CAROTID ENDARTERECTOMY

A longitudinal incision is typically used for carotid endarterectomy. The dissection is a slower, more meticulous dissection because heparinization is part of the operative procedure, and the formation of a postoperative hematoma can produce significant morbidity.

The carotid must not be manipulated because portions of the plaque may become dislodged and create emboli by such manipulation. Salient cervical anatomy that must be identified during the dissection includes the hypoglossal nerve (which will course across the bifurcation), the ansa hypoglossus (which, in the event that the hypoglossal nerve cannot be found, can be followed superiorly to identify the twelfth nerve), the digastric muscle (which may require division), and the vagus nerve (Fig. 23–8A–D). The hypoglossal nerve may require mobilization to obtain access to the external carotid artery (ECA) and the internal carotid artery (ICA) above the bifurcation. The digastrics may require sectioning, or the styloid process on occasion may need to be resected for a high carotid bulb. The parotid gland located superiorly should be avoided to preserve facial function.

Once the common carotid artery (CCA), ECA, and ICA are isolated, the patient is given 5000 U of intravenous heparin. The ECA is occluded first, followed by the CCA and finally the ICA. An arteriotomy is performed over the ICA and CCA, and the plaque is dissected starting from the CCA interiorly, going to the ICA or ECA superiorly. A shunt is used if there are electroencephalographs changes or if there is a change in the neurologic examination if the procedure was performed in an awake patient. Once the plague is dissected free, the vessel lumen is inspected for loose plaque remnants and the vessel is closed either primarily or with a patch graft. An ICA back-bleed should be done before putting in the final stitch to clear debris. The temporary vascular clamps then are removed; the ECA is opened first, followed by the CCA. This allows any residual debris to be shunted up the ECA. The ICA is opened last.

PITFALLS, PEARLS, CONSIDERATIONS

- Vascular injuries: dehiscence, tears, vertebral arteries
- Injury to neural structures: cranial nerves, recurrent laryngeal nerve
- Esophageal tears
- Cerebrospinal fluid leak
- Spinal cord injury
- Hematoma formation with airway compromise
- Stroke
- Graft extrusion

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Chapter 24

Posterior Cervical Approach

Damirez Fossett, Anthony Caputy

Indications for Approach

- Nerve root decompression
- Cervical spondylosis and stenosis
- Cervical spine fractures
- Cervical spine intramedullary tumors and vascular lesions
- Spinal cord biopsies

Positioning and Skin Incision

The patient is placed in the prone position. The head can be fixed in three-point fixation using the Mayfield head holder, or it can be placed in a horseshoe with the eyes well padded to make sure there is no pressure on the globes. The horseshoe with Gardner-Wells tongs is more suitable than three-point fixation for cervical spine fractures. The use of tongs provides traction and external stabilization of the cervical spine. Radiographs are taken to ensure appropriate alignment

Generally, a midline skin incision is used (Fig. 24–1). It may extend as high as the inion if C1 or C2 needs to be visualized, and it may extend several centimeters caudally to expose the lower cervical segments. Occasionally, a paramedian incision can be used for endoscopic foraminotomies.

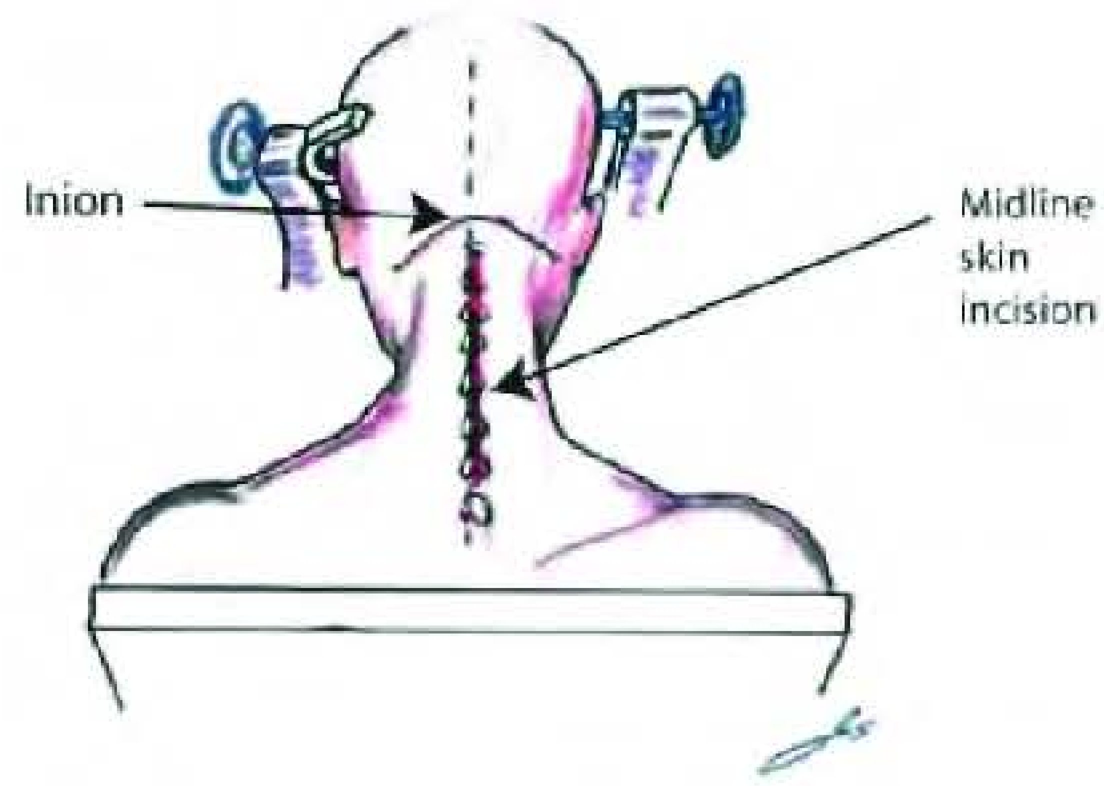

FIGURE 24–1 Midline skin incision.

Surgical Technique

The skin incision is carried through the subcutaneous tissues and splits the dorsal cervical fascia. Staying in the midline allows visualization of a midline raphe between the para spinal muscles (Fig. 24–2). If this midline raphe is followed, the muscle bundles can be separated in an avascular fashion down to the level of the spinous processes (Fig. 24–3).

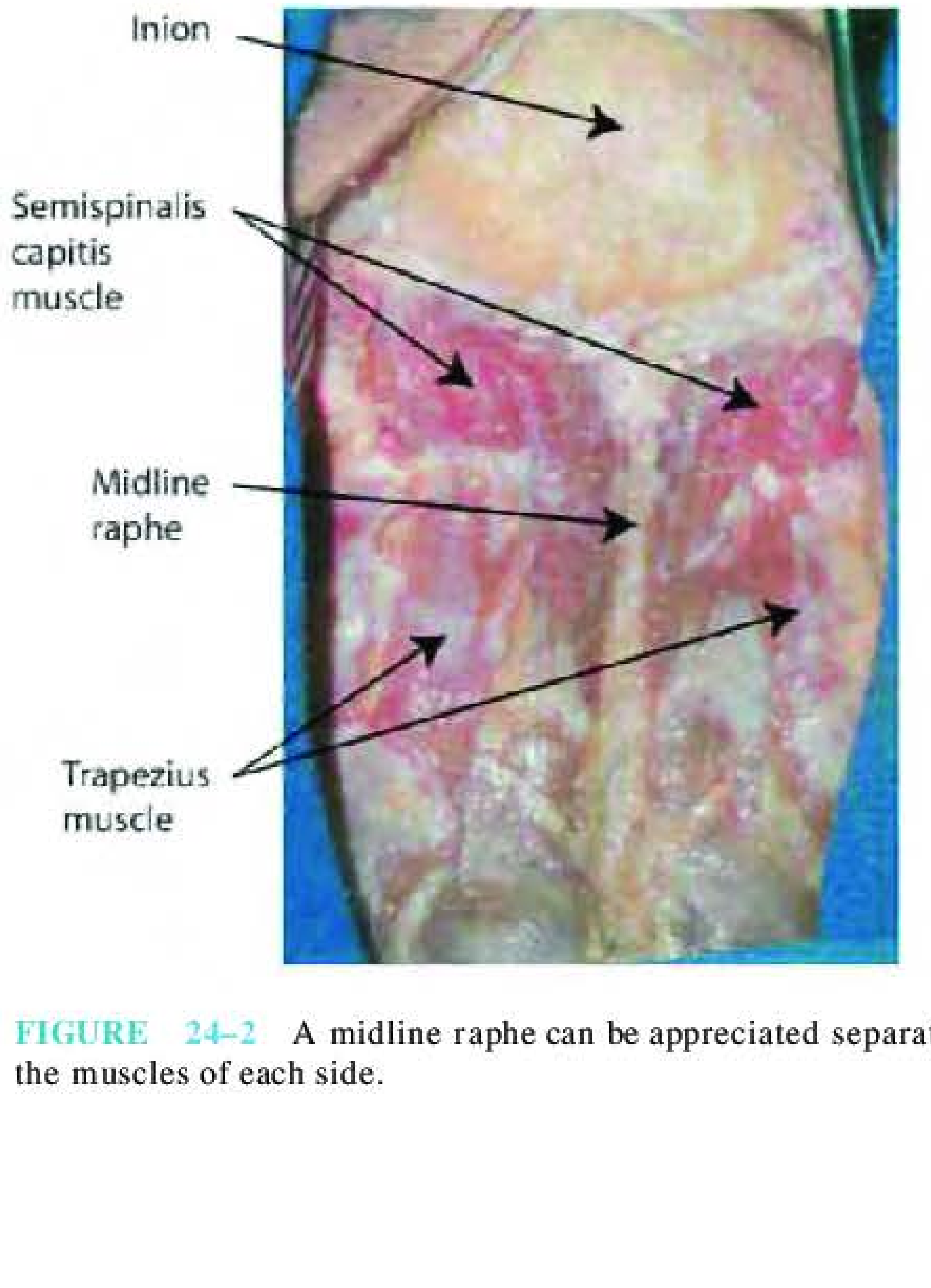

FIGURE 24–2 A midline raphe can be appreciated separating the muscles of each side.

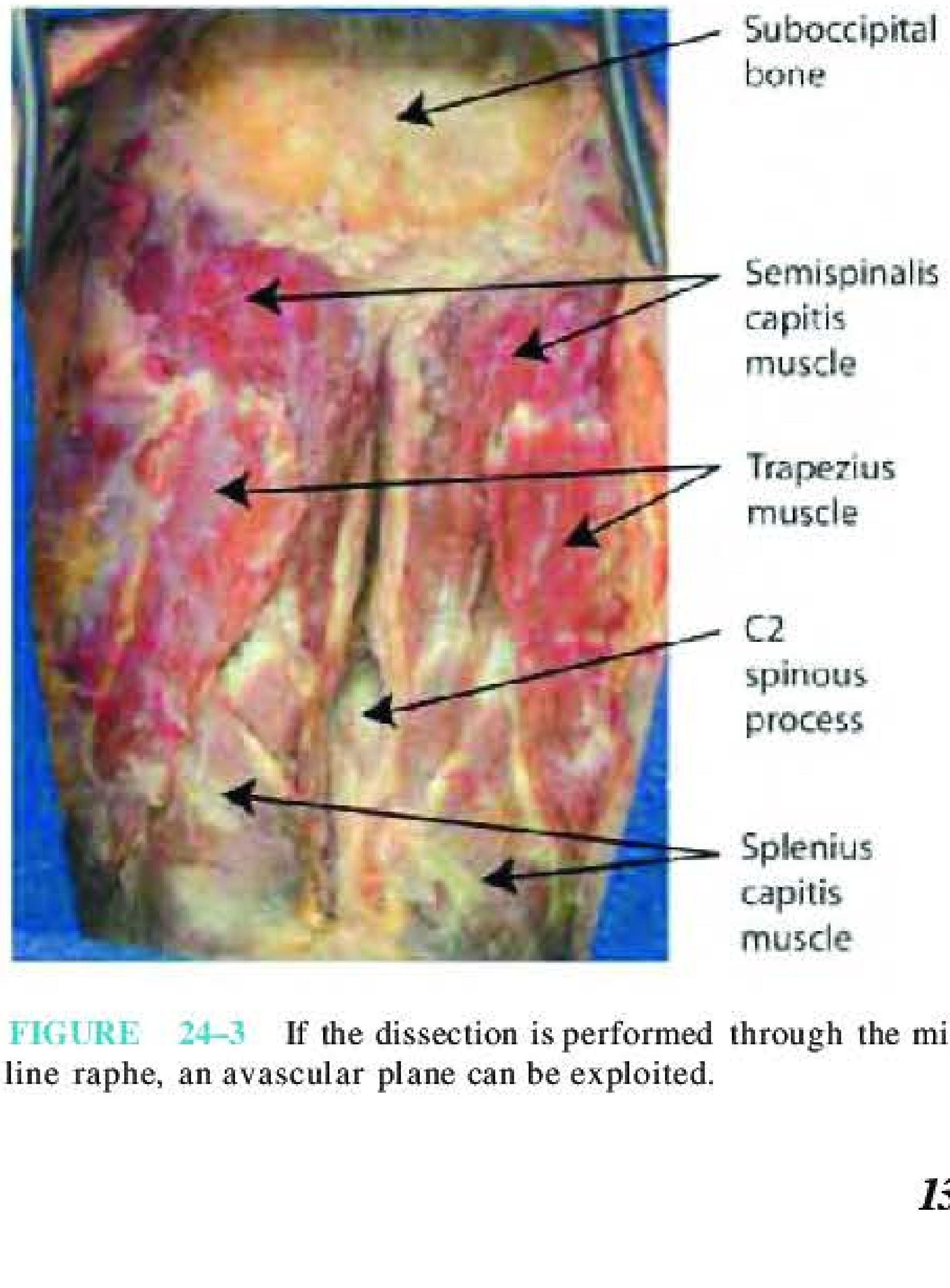

FIGURE 24–3 If the dissection is performed through the midline raphe, an avascular plane can be exploited.

CERVICAL FORAMINOTOMY

The paraspinal muscles are reflected away from the spinous processes and underlying hemilamina in a subperiosteal fashion. A localizing radiograph is taken to confirm location. A hemilaminectomy may be performed if necessary; otherwise, attention can be focused on the facet joint. A Williams or cerebellar retractor can be used to maintain exposure. Once the appropriate facet joint is identified, either a high-speed drill or a no. 1 Kerrison rongeur can be used to remove the medial third of the facet joint. The neural foramen can be identified, and the exiting nerve root decompressed as it exits the foramen (Fig. 24–4). Soft disc in the nerve root axilla can be teased free and removed via a foraminotomy by gentle retraction of the nerve root and use of a blunt nerve hook. Transverse bands must be identified and transected to relieve root compression.

CERVICAL LAMINECTOMY

The paraspinal muscles are reflected away from the spinous processes and underlying lamina bilaterally in a subperiosteal fashion (Fig. 24–5). The laminectomy can he performed using a Leksell and Kerrison rongeurs (Fig. 24–6). In a safer fashion, the laminectomy can be performed by drilling a trough bilaterally at the lamina-facet junction with the C1 or MS tools of

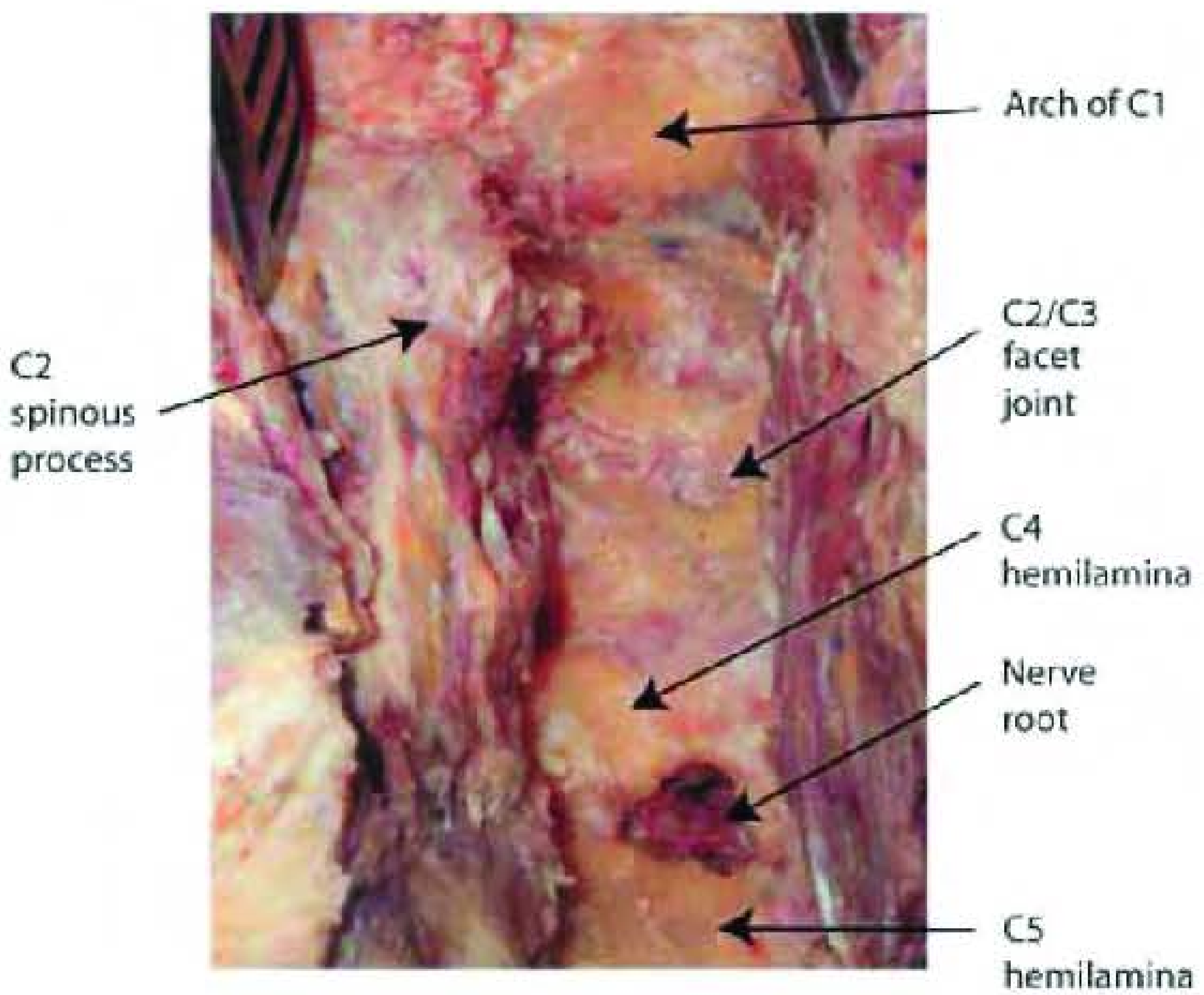

FIGURE 24–4 After reflection of the muscles on one side, a keyhole foraminotomy has been performed and the exiting nerve root visualized.

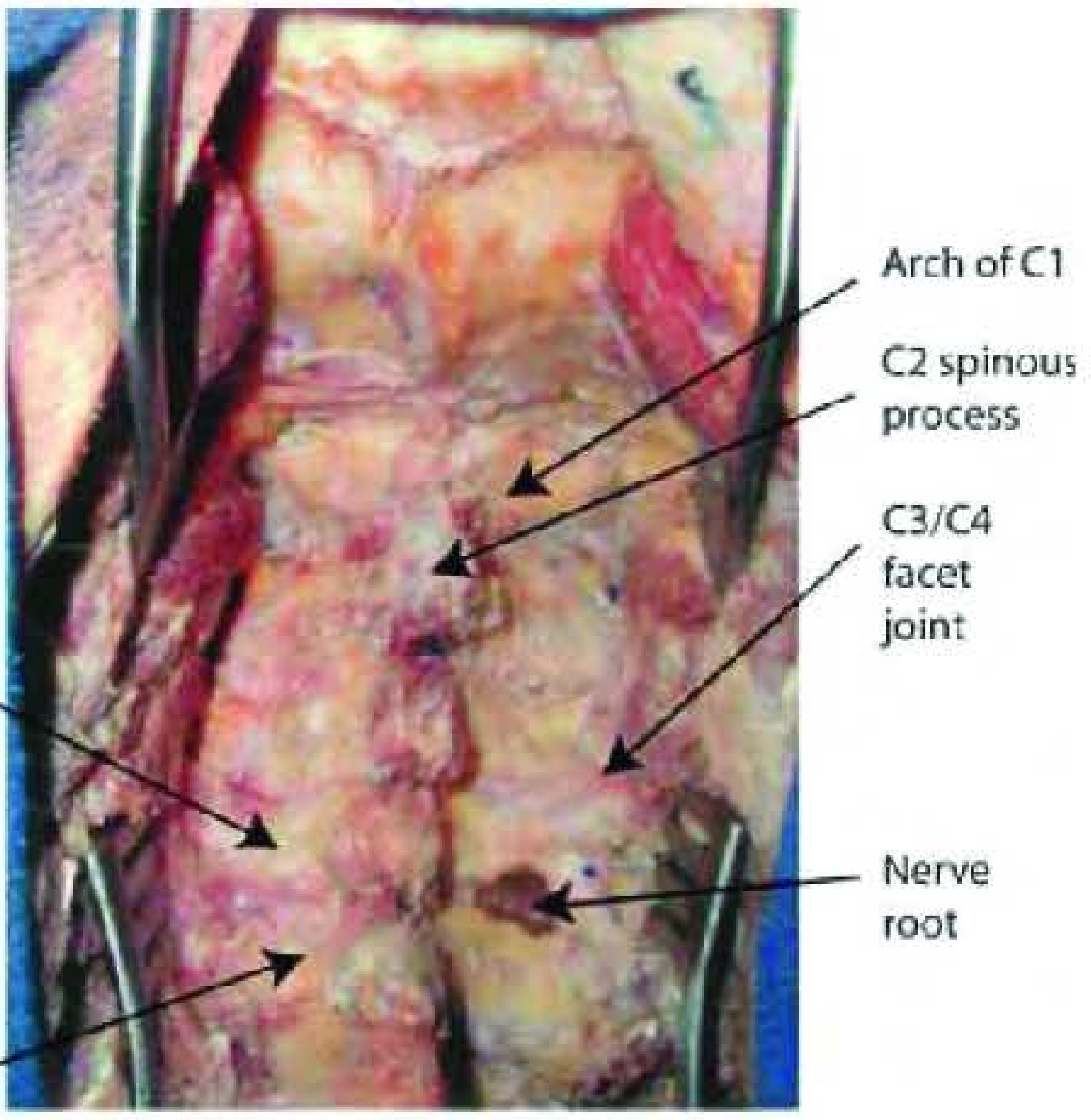

FIGURE 24–5 The muscles have been reflected bilaterally in a subperiosteal fashion to expose the underlying lamina and facet joints.

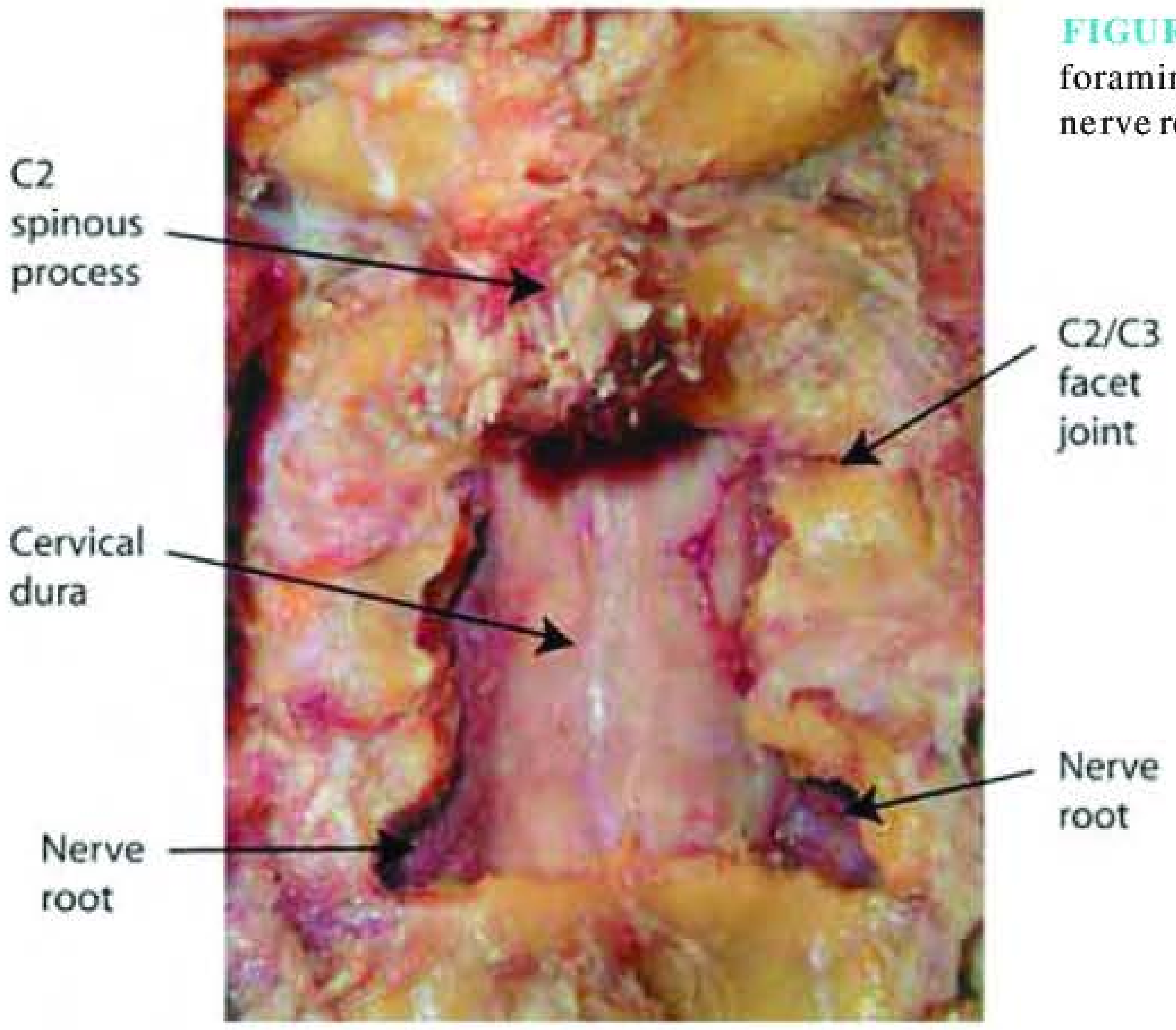

FIGURE 24–6 A posterior cervical laminectomy and bilateral foraminotomies have been performed. The dura has been exposed and nerve roots can be seen exiting the neuroforamen bilaterally.

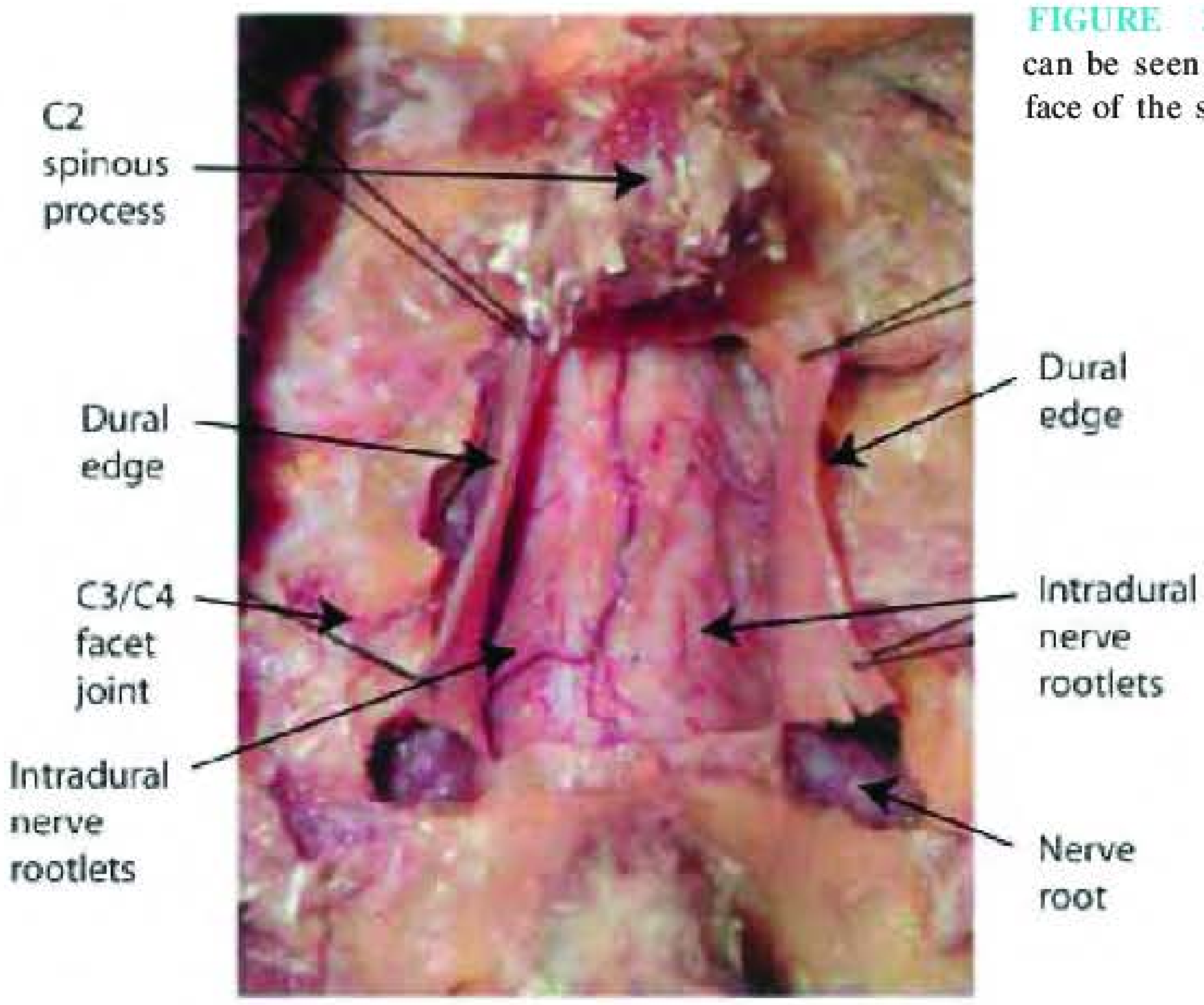

FIGURE 24–7 The dura has been opened in the midline. Rootlets can be seen exiting toward the neuroforamen on the dorsolateral surface of the spinal cord.

the Midas and then using a no. 1 Kerrison to open the trough. The spinous process and lamina then can be removed *en bloc.* This method is safer because it eliminates the need to pass the foot plate of the Kerrison beneath the bone, risking dural compression or blunt trauma. Care must be taken to remove no more than one third to one half of the facet joint, or the stability of the spinal segment may become compromised. After bone removal, a Kerrison can be used to remove the yellow ligament. Foraminotomies then can be performed at all necessary levels.

For the resection of intradural lesions, the dura can be opened in the midline. On the dorsal surface of the cord, cervical rootlets can be seen exiting through the neural foramen (Fig. 24–7). Dura must be dosed in a watertight fashion, and grafts may be used to provide an expanded subdural space. The paraspinal muscles are reapproximated, and the skin is closed in a multi layered fashion.

PITFALLS, PEARLS, CONSIDERATIONS

- Avoid taking too much of the facet; stability may become an issue
- Radiographic confirmation of level is a necessity
- Avoid blunt trauma to the thecal sac and spinal cord when using Kerrison rongeurs
- Stay in the midline raphe during the opening to have a bloodless opening
- Do not work in a deep hole; lengthen the incision

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Chapter 25

POSTERIOR APPROACH TO THE THORACIC SPINE

Ernest Senz, Damirez Fossett, Anthony Caputy

INDICATIONS FOR APPROACH

- Thoracic cord tumors and vascular lesions
- Epidural infections
- Thoracic spine trauma; decompression and stabilization
- Thoracic disc herniations
- Scoliosis procedures
- Vertebral body or pedicular biopsy

POSITIONING AND SKIN INCISION

The patient is placed in the prone position on chest tolls or a radiolucent frame on a radiolucent operating table. For upper thoracic approaches, the neck is moderately flexed and the arms are positioned at the patient's sides with the shoulders depressed. For middle and lower thoracic procedures, the arms can be positioned either at the sides or abducted at the shoulders and flexed at the elbows. The head can he rested on a donut or placed on a horseshoe head rest. Attention should be given to padding the eyes to avoid pressure on the globes. Appropriate padding should be placed to avoid peripheral nerve compression.

The skin incision is a midline incision (Fig. 25–1). A localizing radiograph should be taken to aid in planning the placement of the incision.

SURGICAL TECHNIQUE

THORACIC LAMINECTOMY

The skin incision is carried through the subcutaneous tissue to expose the dorsal thoracolumbar fascia (Fig. 25–2). The fascia is incised bilaterally, and the paraspinal muscles reflected

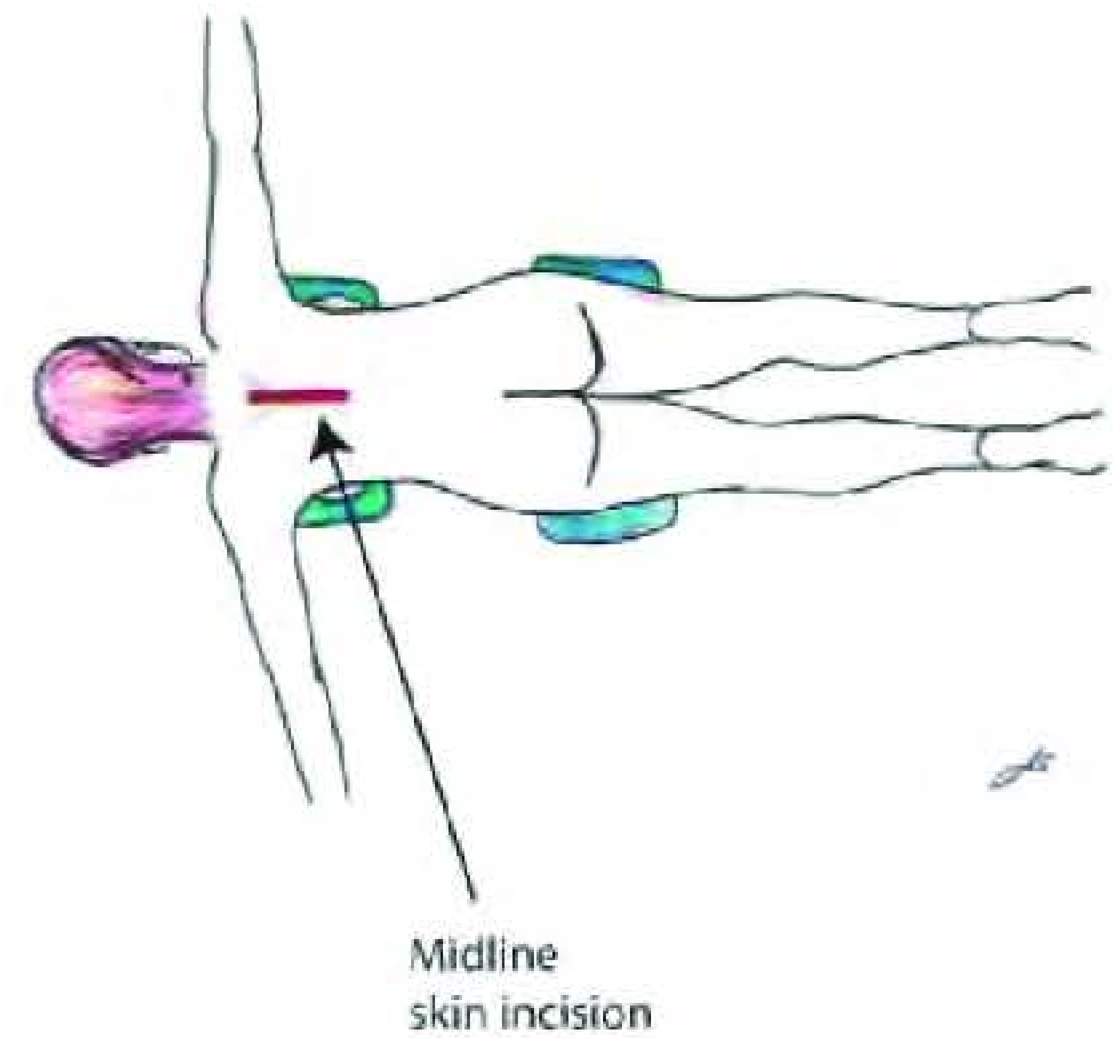

FIGURE 25–1 A midline incision is made after placing the patient prone.

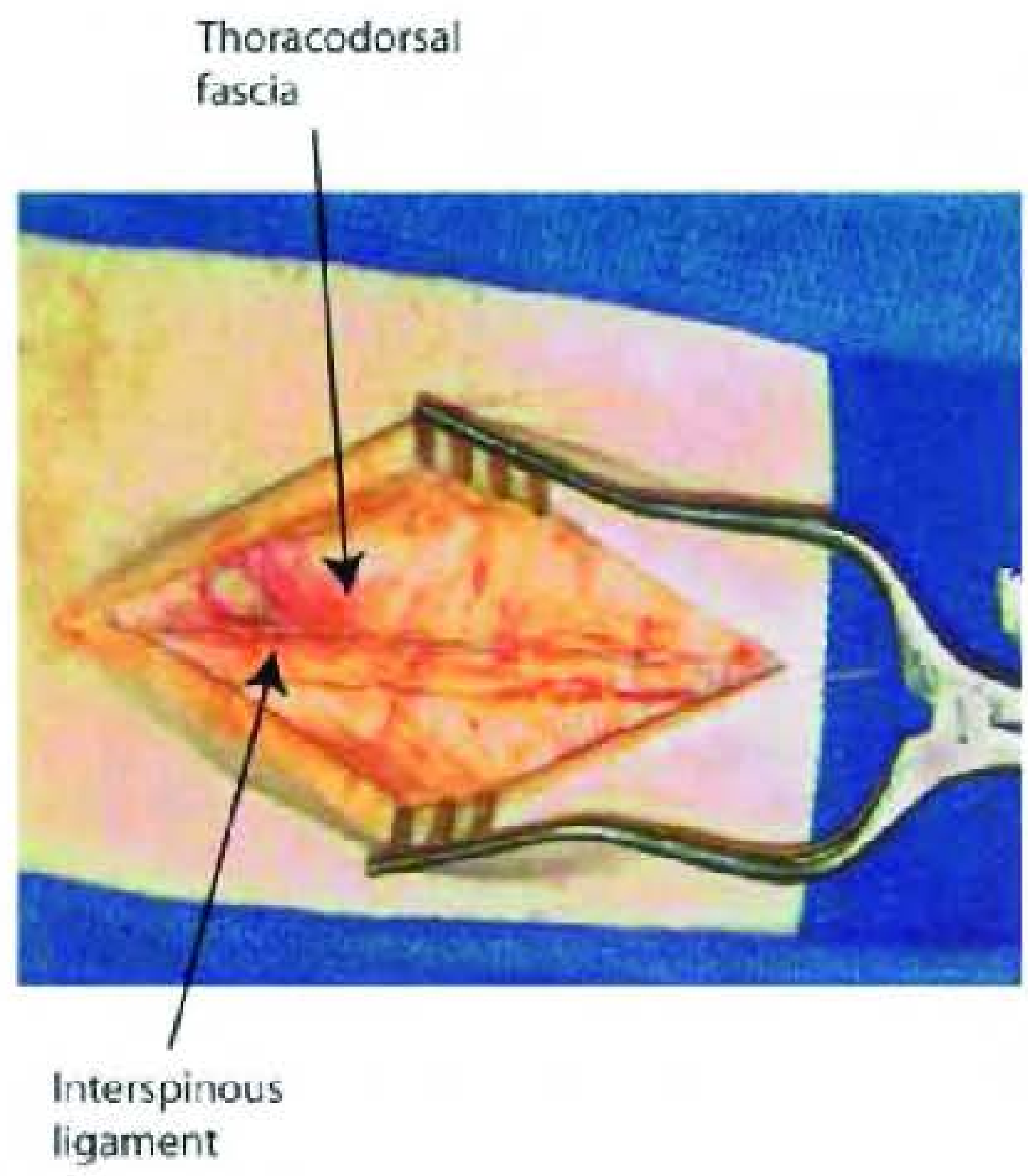

FIGURE 25–2 The thoracodorsal fascia attaches to the supraspinous ligament in the midline.

in a subperiosteal fashion away from the underlying lamina and spinous processes to expose the facet joints (Fig. 25–3). The muscles are held retracted with cerebellar retractors.

The spinous processes may be removed with a Leksell after a localizing radiograph is taken. The laminectomy is performed using a Leksell and Kerrison rongeurs for bone and yellow ligament removal (Fig. 25–4). Alternatively, the laminectomy also can be performed by using the C1 or M8 tools of Midas to drill a trough at the lamina-facet function. A no. 1 Kerrison punch then can be used to detach the lamina from the facet joint. The spinous process and lamina then may be removed *en bloc* using scissors to detach bone from the yellow ligament. The ligament then is removed with a Kerrison rongeur.

INTRADURAL DISSECTION

For intradural pathology, a tenting stitch may be placed in the dura to elevate it gently (Fig. 25–5). With an arachnoid knife or no. 15 blade, the dura is opened in the midline under microscopic vision. Care should be taken to leave the outer arachnoid layer intact as the inner pia-arachnoid layer may aid in the dissection of a tumor. The outer arachnoid is opened off the midline after the dural edges have been retracted with 4.0 Neurolon or 5.0 Prolene sutures The pia-arachnoid is opened in an avascular region and the surgical pathology resected. Laterally, the motor and sensory roots can be seen leaving through the neural foramen (Fig. 25–6).

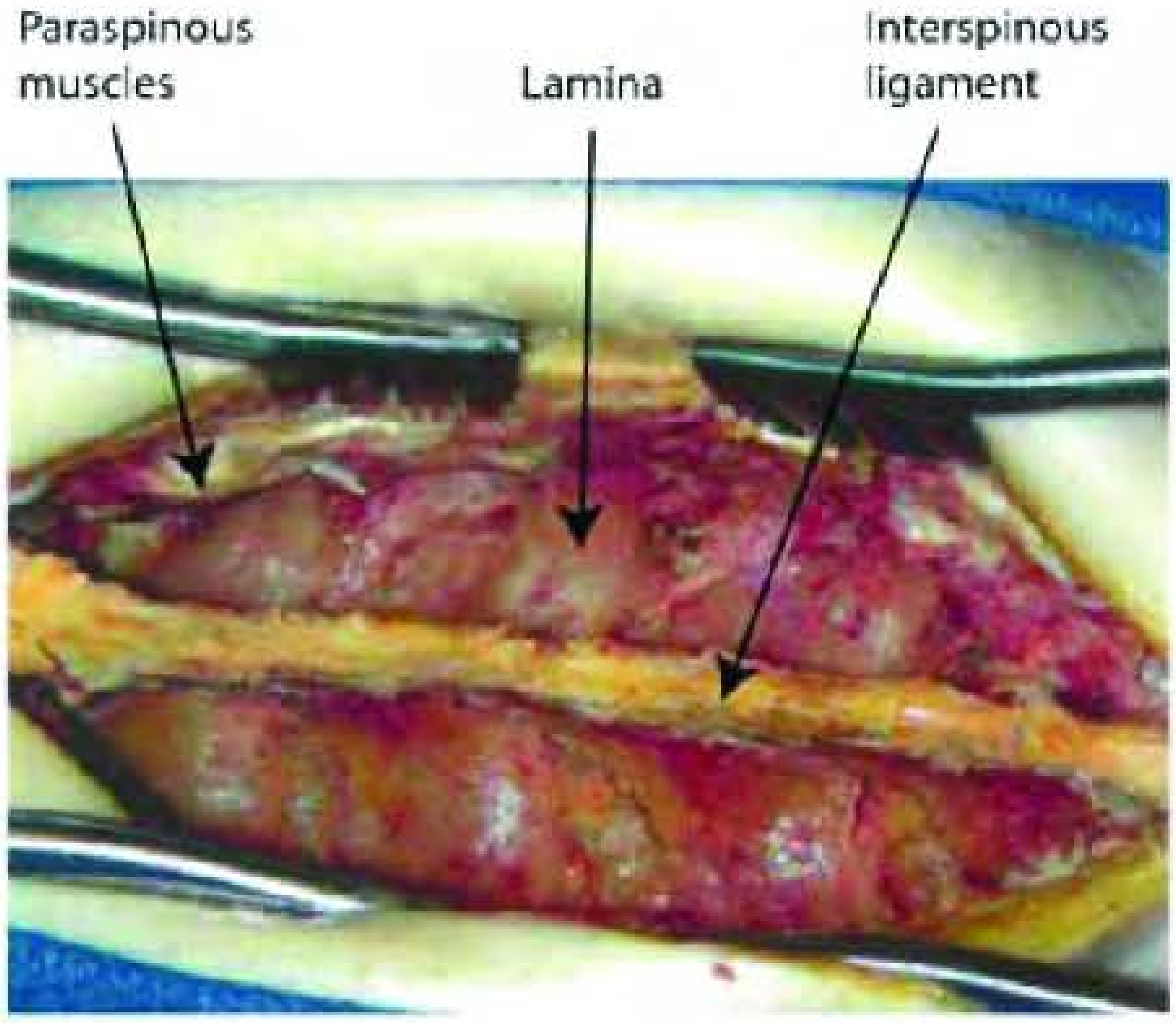

FIGURE 25–3 A subperiosteal dissection of the paraspinous muscles allows visualization of the spinous processes and bilateral lamina.

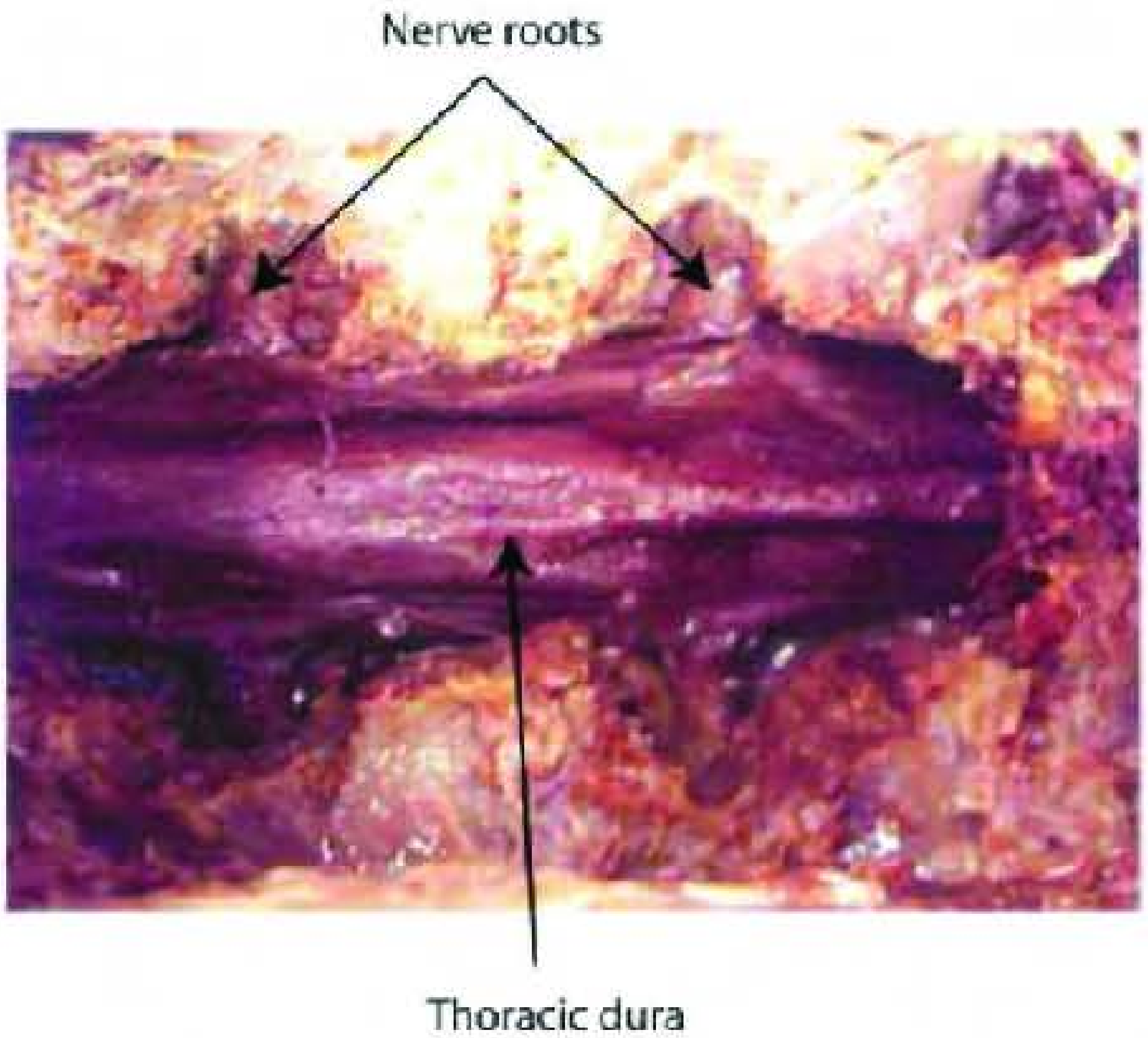

FIGURE 25–4 After performing a laminectomy, the dura and exiting nerve roots are visualized bilaterally.

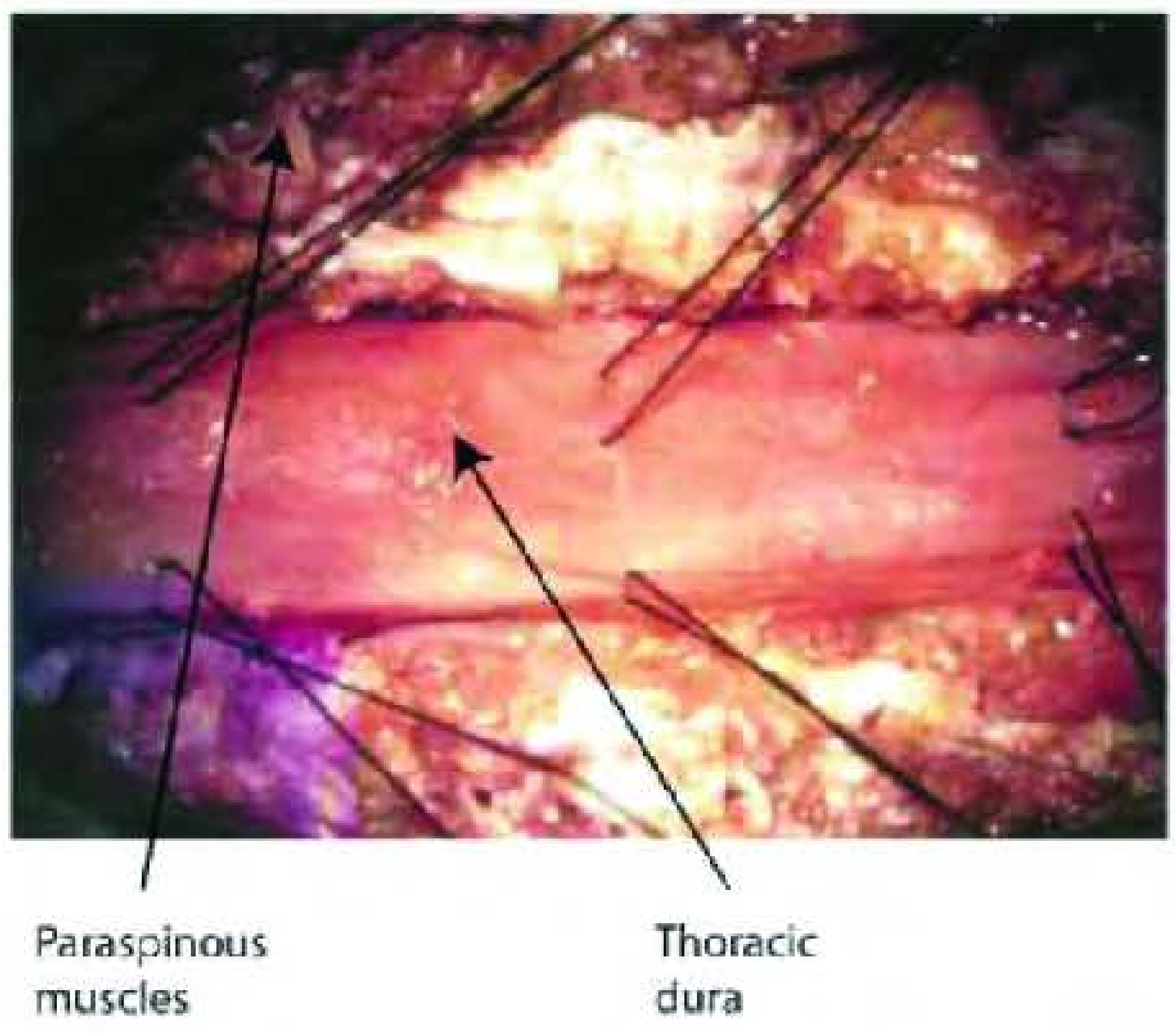

FIGURE 25–5 The dura is tented with stitches to prepare for opening.

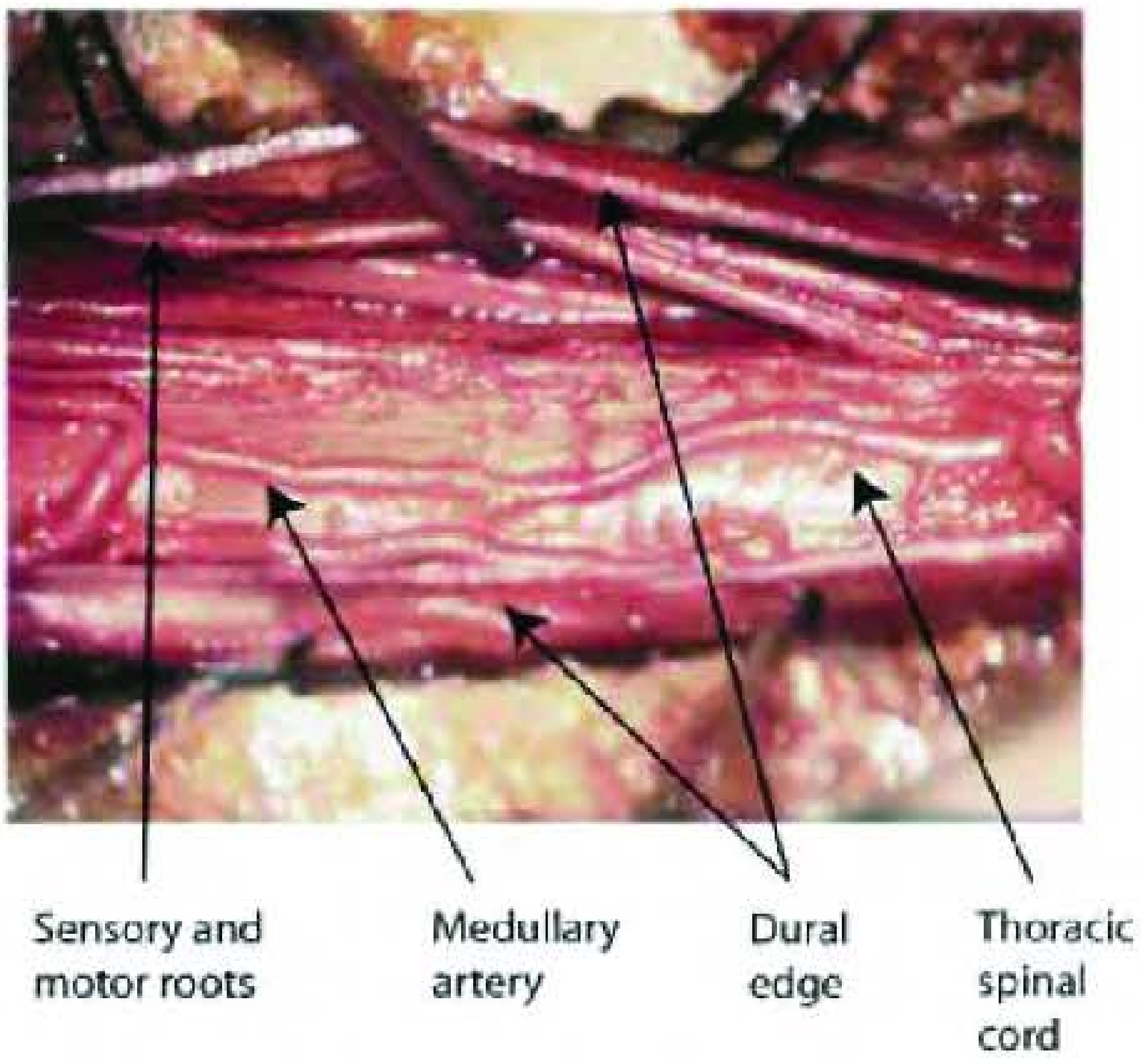

FIGURE 25–6 The dura is opened to expose the thoracic spinal cord. The sensory and motor nerve roots can be seen exiting from the same neuroforamen.

TRANS PEDICULAR APPROACH

The skin incision and dissection of the paraspinous muscles is the same technique as described for a standard thoracic laminectomy. The muscles, however, must be reflected far enough laterally to visualize the lateral tip of the transverse processes. Typically, the procedure is done unilaterally. Using a rongeur, a hemilaminectomy may be performed if the procedure is for a decompression. If a biopsy is the goal, a hemilaminectomy may not be required. The facet joint, medial transverse process, and pedicle then can be removed using a high-speed drill (Figs. 25–7 and 25–8). Care is taken not to injure the rib, enter the pleura, or injure the dura of the spinal cord or exiting nerve root.

Once the posterolateral and pedicle bone removal is accomplished, the structures anterior to the spinal cord can be accessed, including the disc space, central and paracentral osteophytes, and anterior vertebral body pathology.

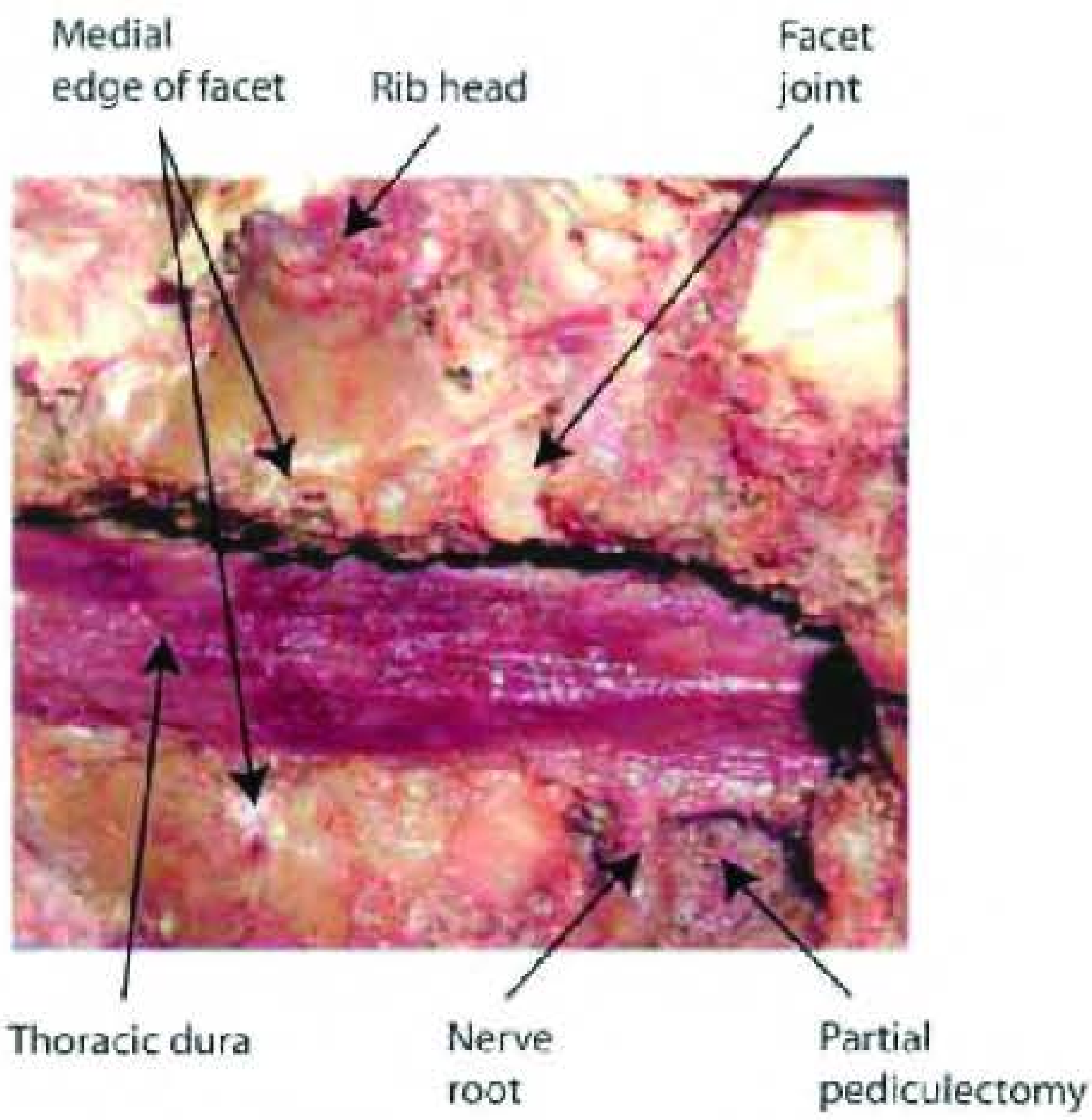

FIGURE 25–7 The facet and medial transverse process have been removed and a partial resection of the pedicle has been performed. The exiting nerve root is visualized.

PITFALLS, PEARLS, CONSIDERATIONS

- Radiographic confirmation of level is extremely important
- Do not dissect muscles too far lateral because to do so risks pleural injury and pneumothorax
- Avoid blunt trauma to the spinal cord when using rongeurs
- Open dura in the midline; leave pia–arachnoid intact
- Use a watertight dural closure
- Intradural work should be done under the microscope
- Anterior pathology that crosses the midline cannot be resected
- Anterior strut grafts cannot be placed
- Transpedicular drilling risks injury to the thoracic cord and to the pleura

This approach is not suitable for pathology that crosses the midline because direct visualization is limited. An anterior strut graft cannot be adequately placed for stabilization with this approach.

For biopsies, the pedicle can be localized by visualizing a plane running horizontally through the midportion of the transverse processes intersecting a plane through the midportion of the facet joint. The pedicle angles 10 degrees in a posterolateral-to-anteromedial direction. A high-speed drill is used to create a small cortical window, and a Craig biopsy needle is inserted to obtain a biopsy from the vertebral body.

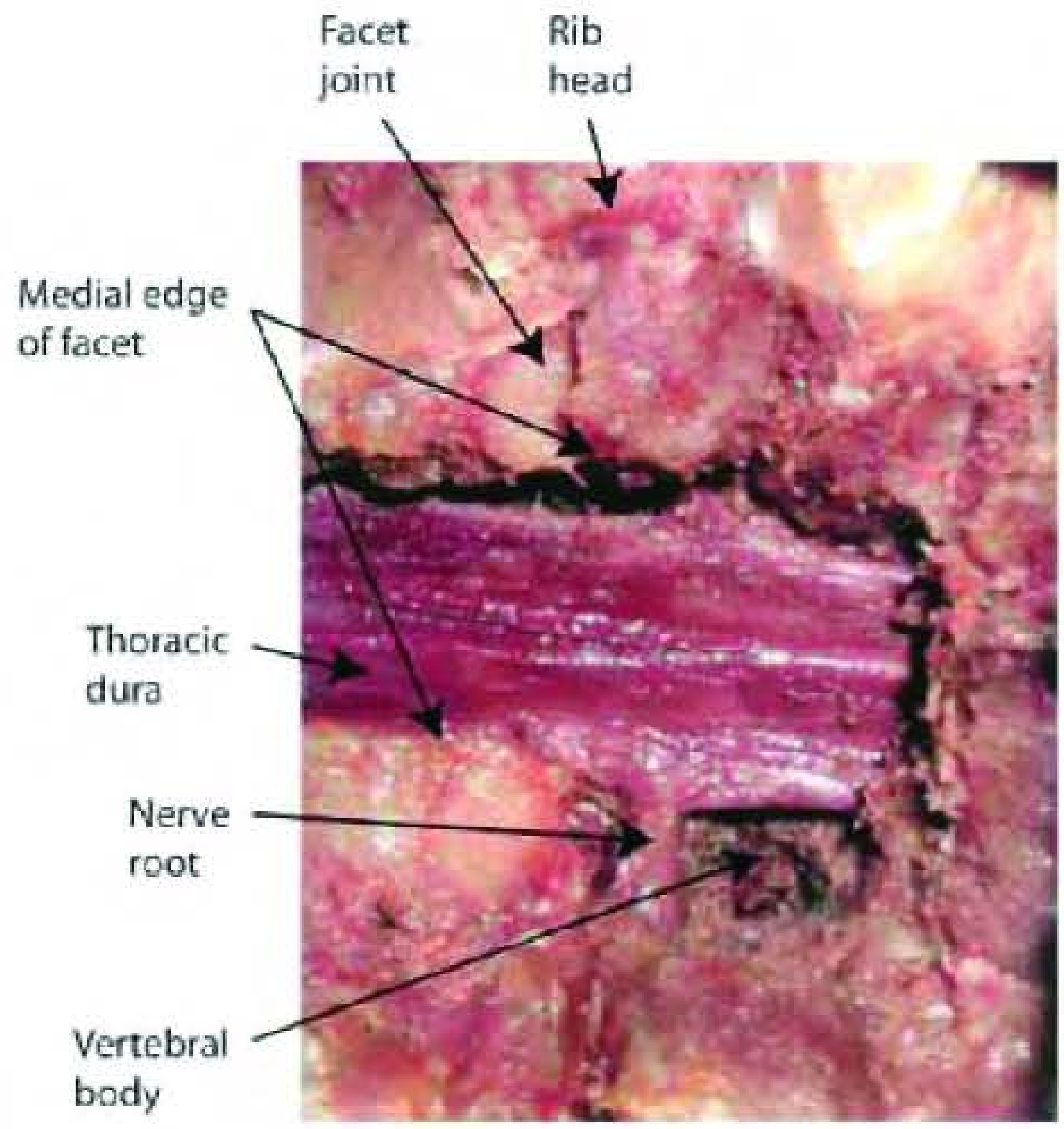

FIGURE 25–8 The pedicle has been fully resected and the vertebral body anterolateral to the thecal sac is in view. The exiting nerve root is visualized.

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Chapter 26

DORSOLATERAL APPROACHES TO THE THORACIC SPINE

Ernest Senz, Damirez Fossett, Anthony Caputy

INDICATIONS FOR APPROACH

- Anterolateral decompression for compressive neoplasms
- Thoracic Fractures
- Thoracic disc herniations

POSITIONING AND SKIN INCISION

The patient is placed in the prone position on chest rolls. Unequal-sized rolls sometimes are used with the larger one placed under the upside of the exposure and the smaller one under the downside. The table will be rotated from side to side during the procedure for visualization; so the patient must be well secured to the table. The head is placed in a horseshoe or, more commonly, on a donut. Attention should be given to padding the eyes to avoid pressure on the globes. Appropriate padding should be placed to avoid peripheral nerve compression.

The skin incision for a costotransversectomy can be a paramedian straight or curvilinear incision. The curvilinear incision generally has proximal and distal tips about 3 cm from the midline with its midpoint about 5 to 7 mm from the midline. The lateral extracavitary approach is performed generally with a larger midline incision or with a T-shaped skin incision over the rib to be resected. This T-shaped incision can be used for the costotransversectomy approach as well (Fig. 26–1).

Generally speaking, to expose a vertebral body, the corresponding rib and the rib below should be resected. For example, removal of the seventh rib leads to the T7 vertebral body, exposes the T6–7 disc space, and exposes the T7 pedicle under which the T7 nerve root passes.

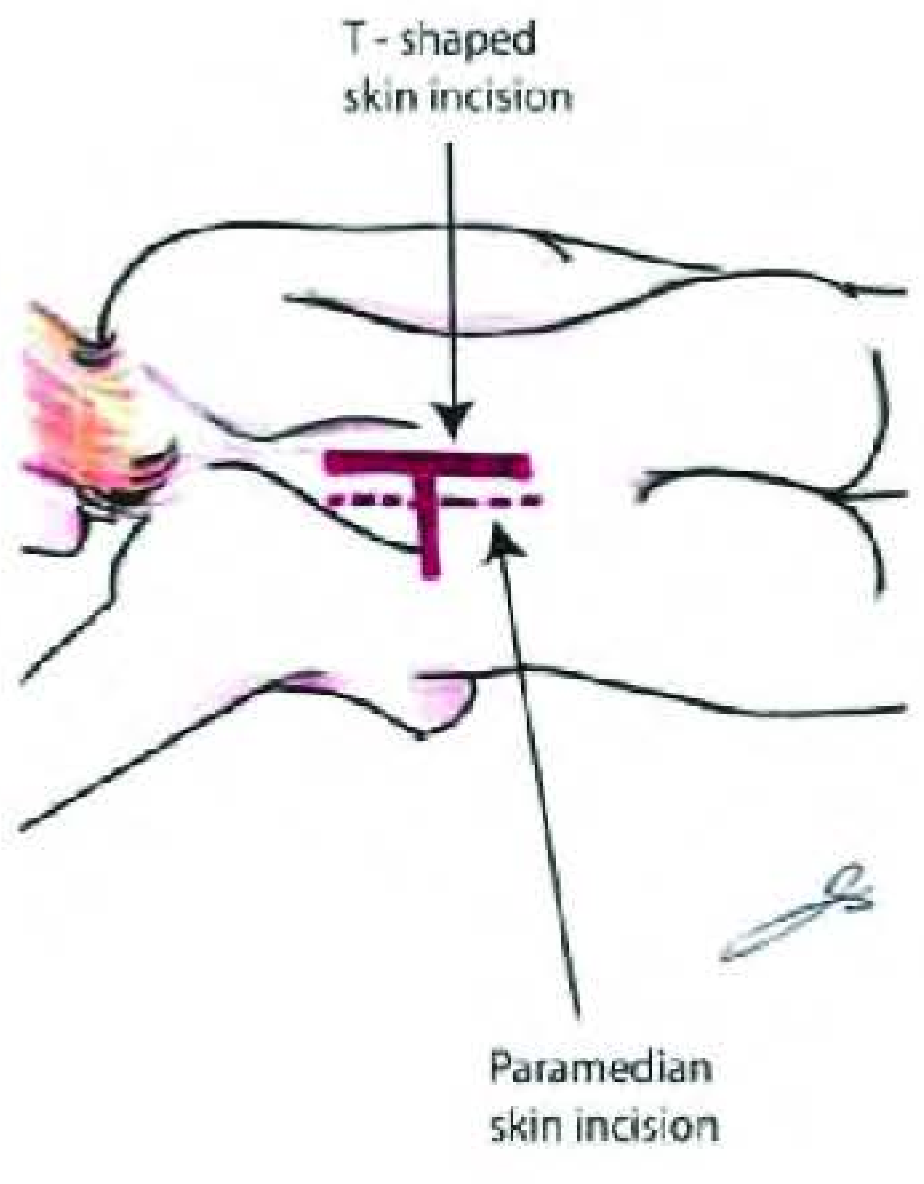

FIGURE 26–1 A paramedian or T-shaped incision is used to approach the dorsolateral thoracic spine.

Surgical Technique

Costotransversectomy

Under the skin flap, the trapezius muscle is identified. The underlying muscles are identified and dissected medially in a subperiosteal fashion. The dissection will expose the rib–transverse process articulation, facet joint, and lamina (Figs. 26–2 and 26–3). The perichondrium then is dissected off the rib, and the neurovascular bundle is identified and protected. The rib is transected 6 cm from the rib head. The pleura is swept away from the overlying rib, and the rib is transected medially. Removal of the rib head exposes the disc space above. Removal of the transverse process exposes the pedicle and vertebral body (Fig. 26–4). The neurovascular bundle leads to the neural foramen located under the pedicle. The pedicle can be resected, a laminectomy performed, or an anterior corpectomy performed, depending on the nature of the pathology (Figs. 26–5 and 26–6). Removal of epidural fat allows excellent exposure of the dorsal, lateral, and anterolateral dura. An anterior strut graft can be placed, if indicated. The wound then can be closed in a multilayered fashion.

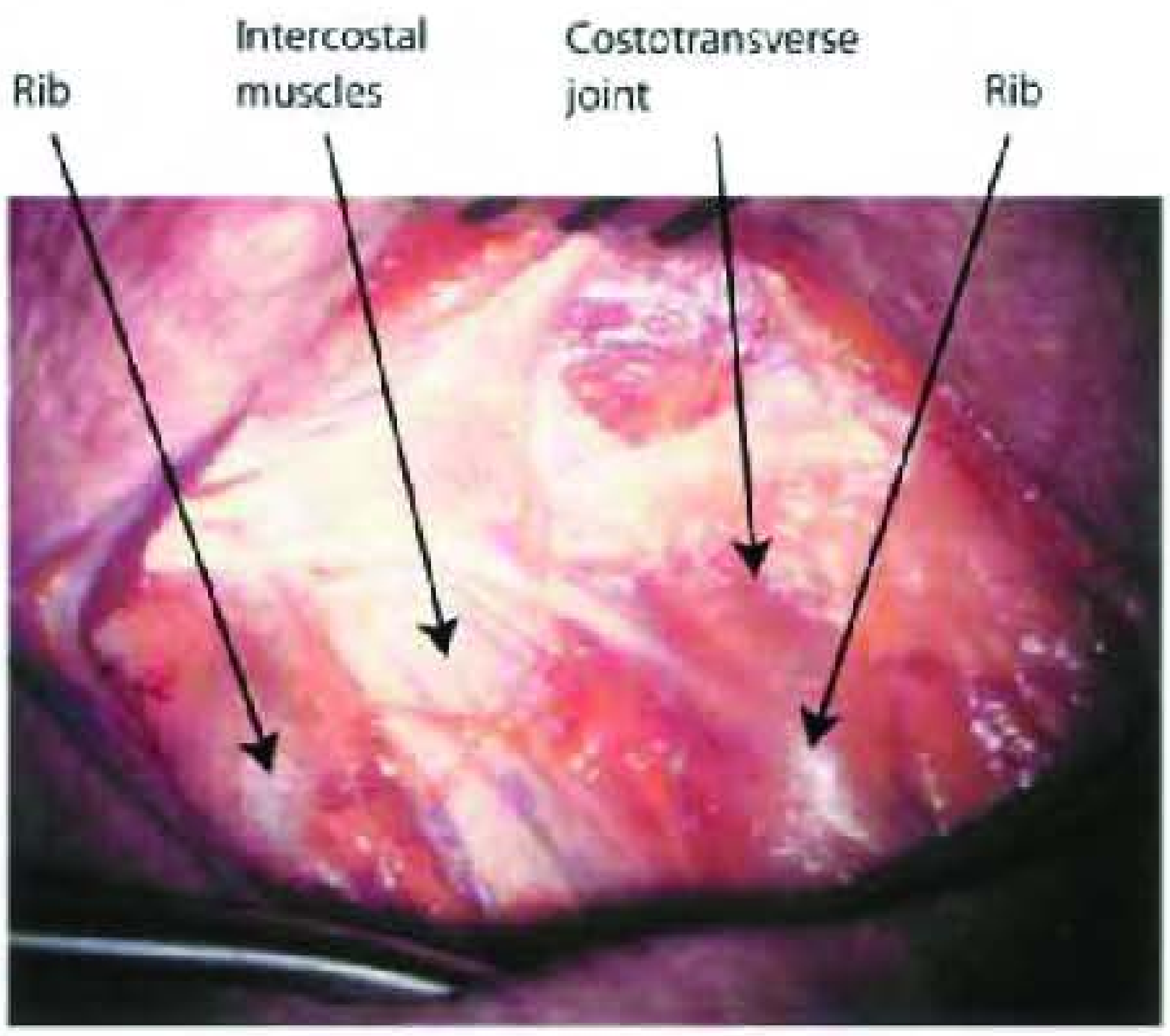

FIGURE 26–2 Subperiosteal dissection and medial reflection of the paraspinal muscles reveal the underlying costotransverse joint.

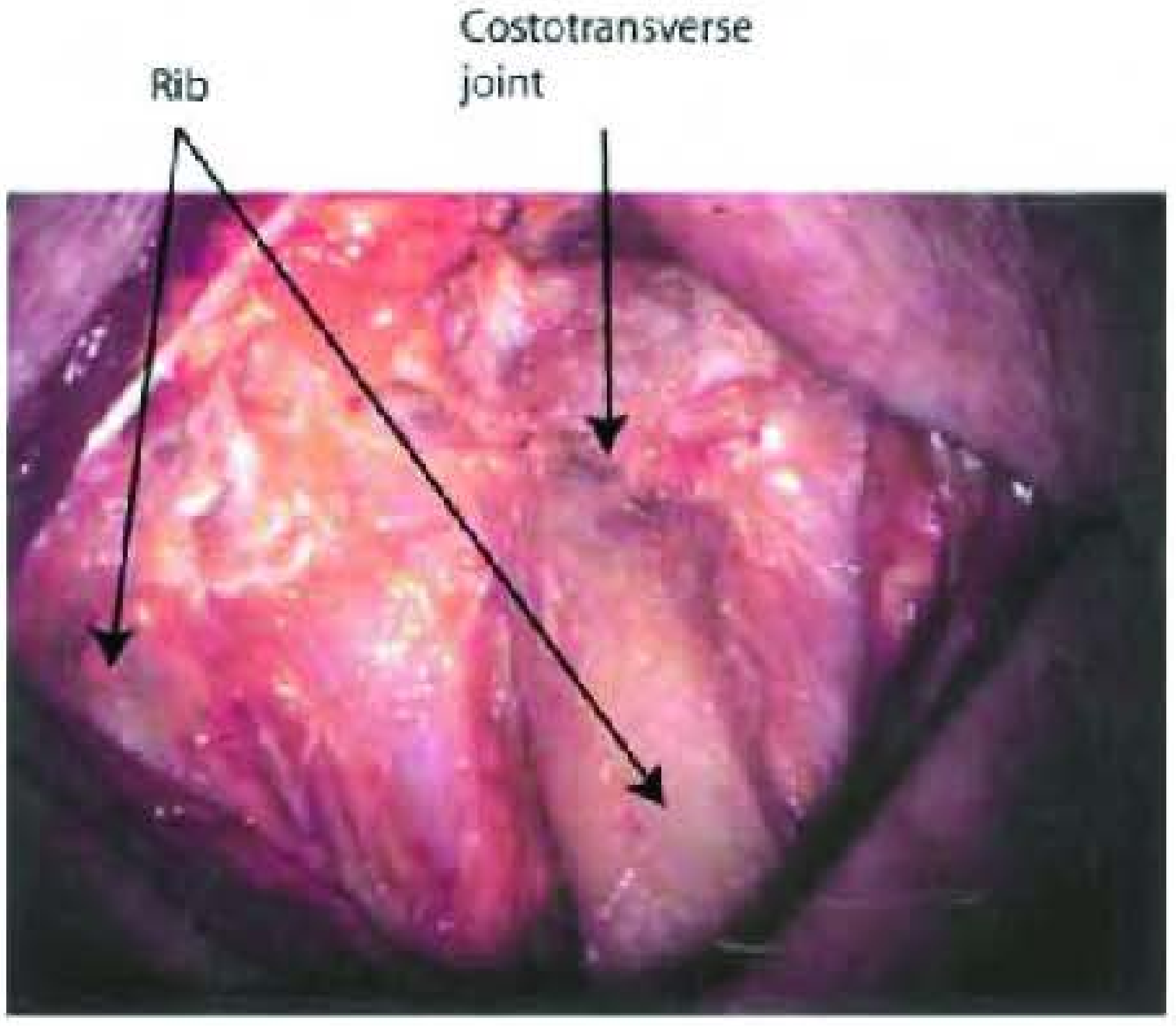

FIGURE 26–3 The perichondrium has been stripped from the rib and the intercostal muscles have been resected. The costotransverse joint is clearly visualized.

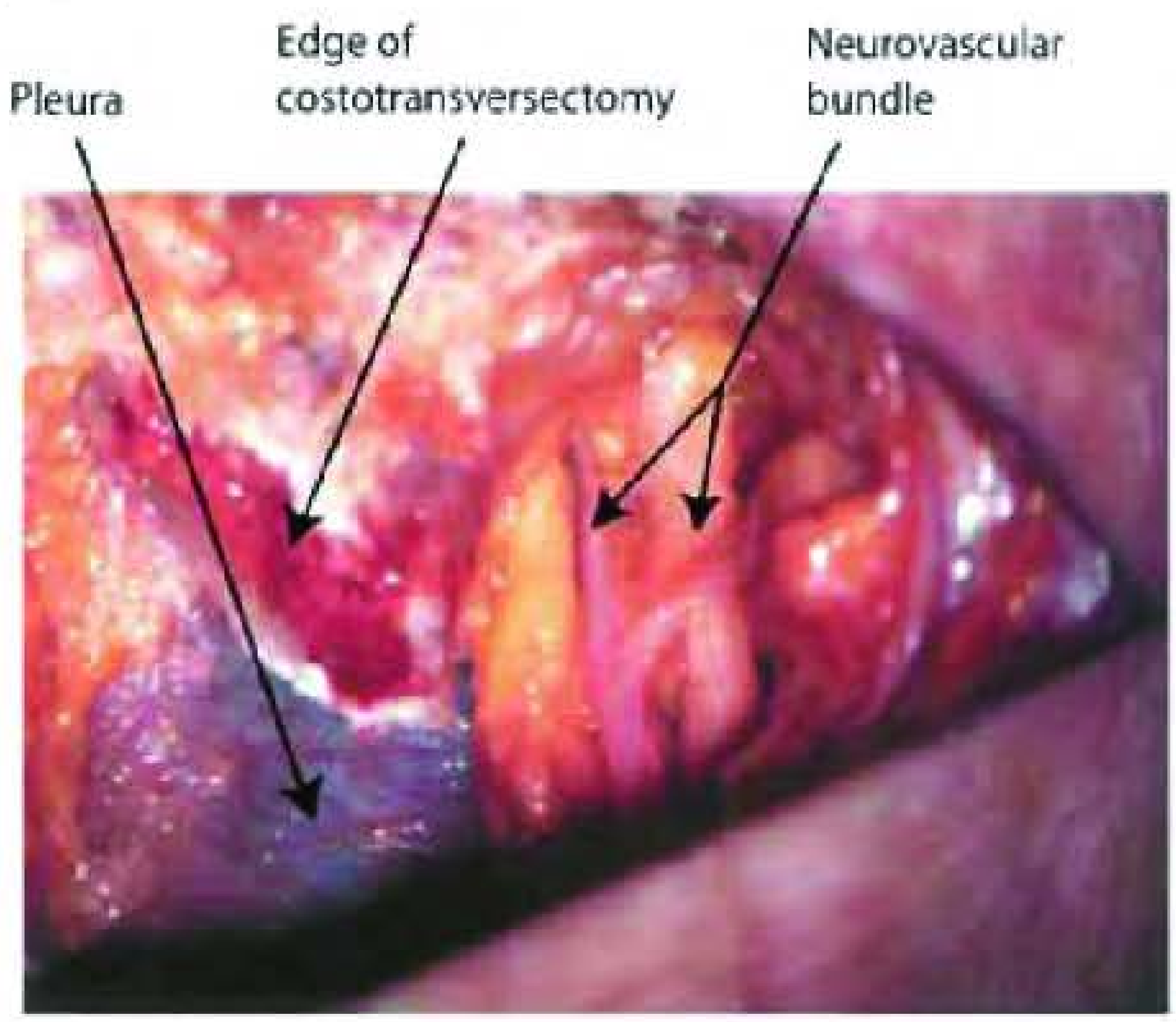

FIGURE 26–4 A costotransversectomy has been performed. The pedicle is seen as is the neurovascular bundle exiting the neural foramen. Beneath the pleura is the anterolateral aspect of the vertebral body.

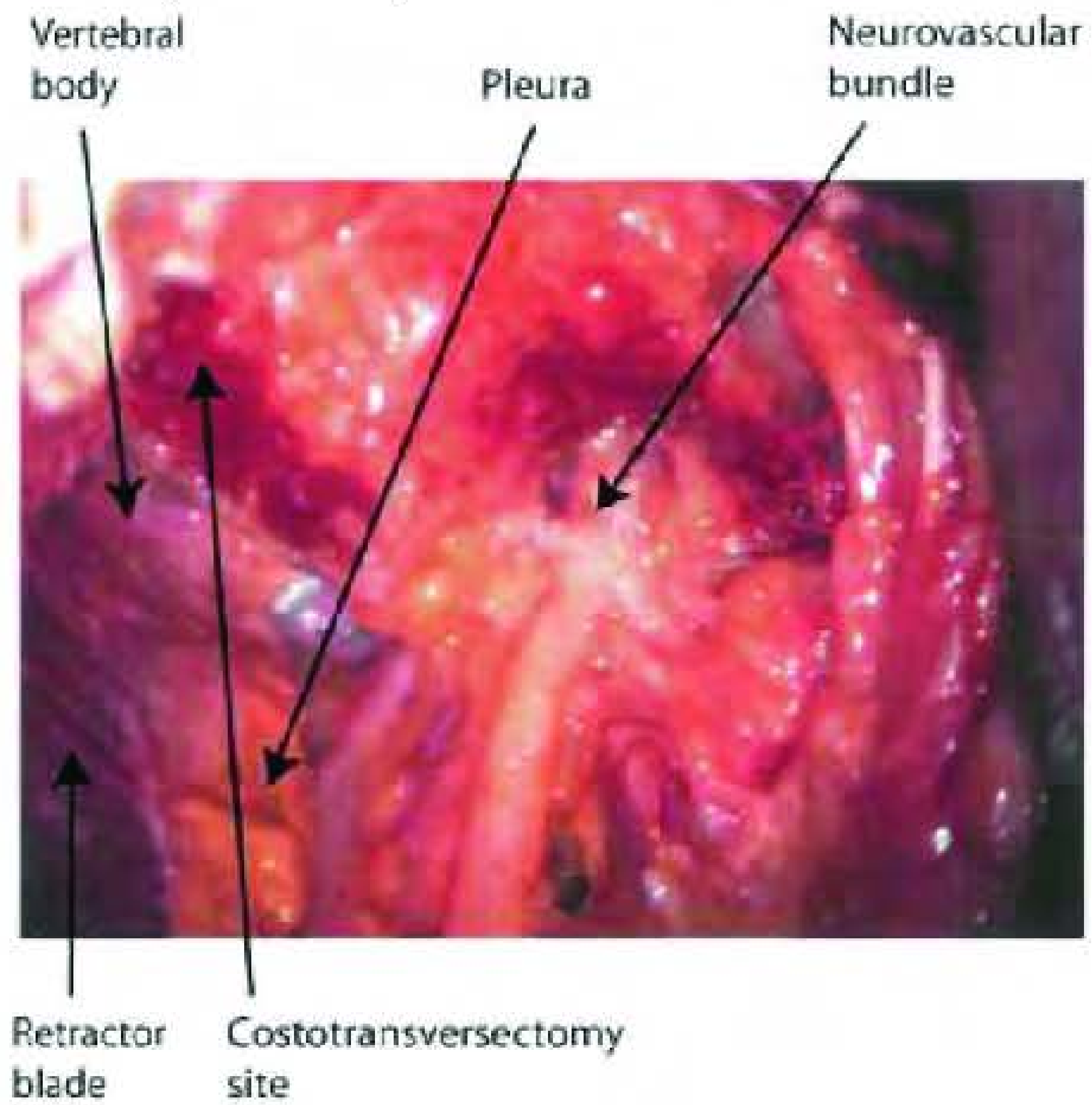

FIGURE 26–5 The pleura has been reflected to visualize the anterolateral aspect of the vertebral body. A pediculectomy has been performed, exposing the ganglion of the nerve root with the dorsal and ventral rami. The hemilamina remains intact.

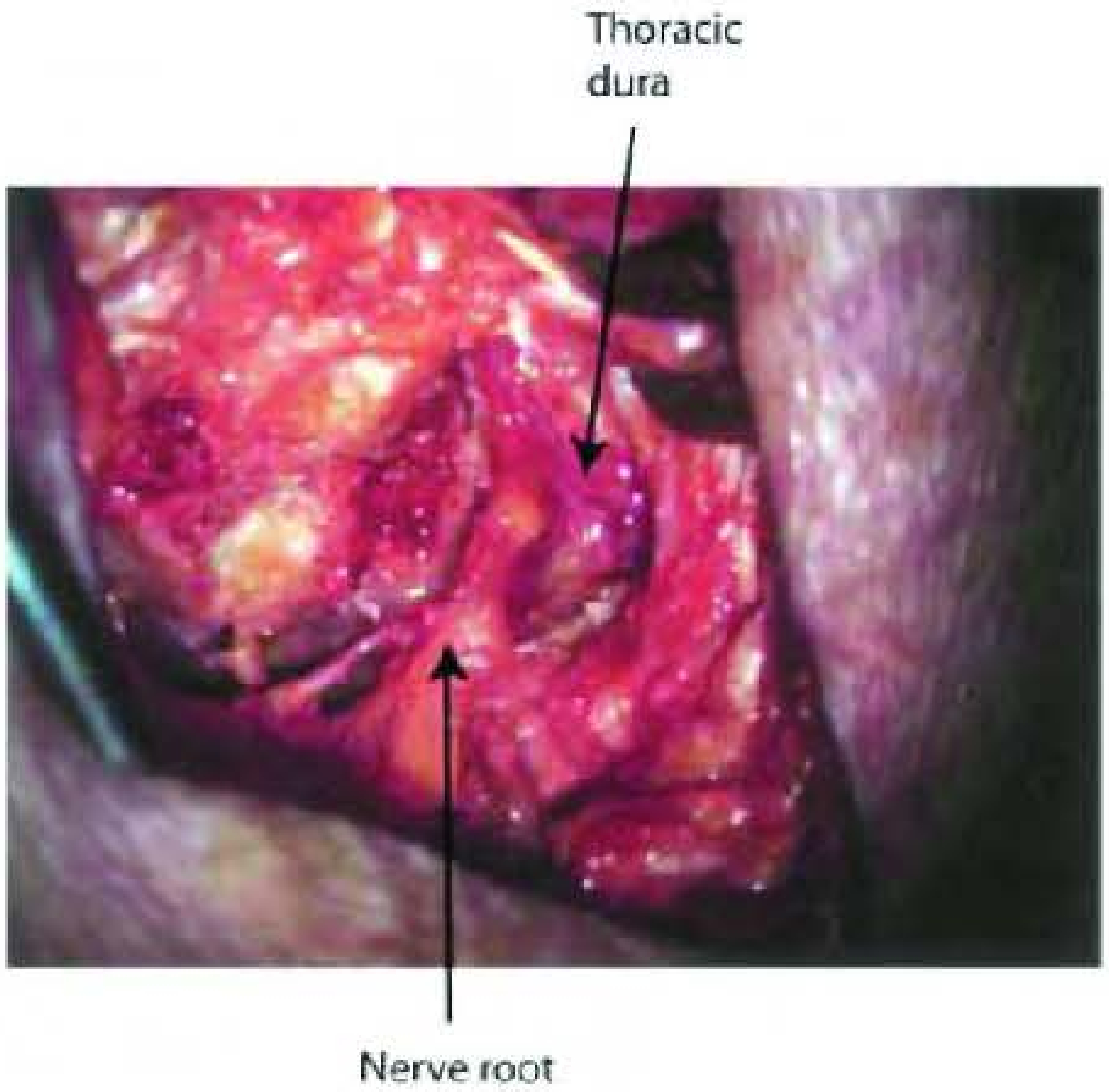

FIGURE 26–6 A hemilaminectomy has been performed, exposing the underlying thoracic dura.

LATERAL EXTRACAVITARY APPROACH

The midline incision used for this approach allows for both anterior and posterior stabilization of the thoracic spine as well as resection of a full range of pathology- The incision should span from three levels above to three levels below the region of interest. The muscles are dissected from the midline laterally to expose the spinous process, lamina, facets, costotransverse junction, and rib at each level. To expose a vertebral body, the corresponding rib, costotransverse articulation, and the one below generally are removed after stripping away the perichondrium, sweeping away the pleura, and identifying and ligating the intervening intercostal vessels and nerves. The neurovascular bundle is followed to the vertebral foramen. The sympathetic chain will be encountered and displaced ventrally in a subperiosteal fashion. The vertebral body and pedicle then can be visualized. Removal of the pedical and anterior vertebral body allows excellent access to the ventrolateral aspect of the spinal canal and dura (Figs. 26–7 and 26–8).

Anterior and posterior stabilization can be achieved by placement of an anterior strut graft and anterior plating or by using posterior instrumentation. The wound is closed in a multilayered fashion.

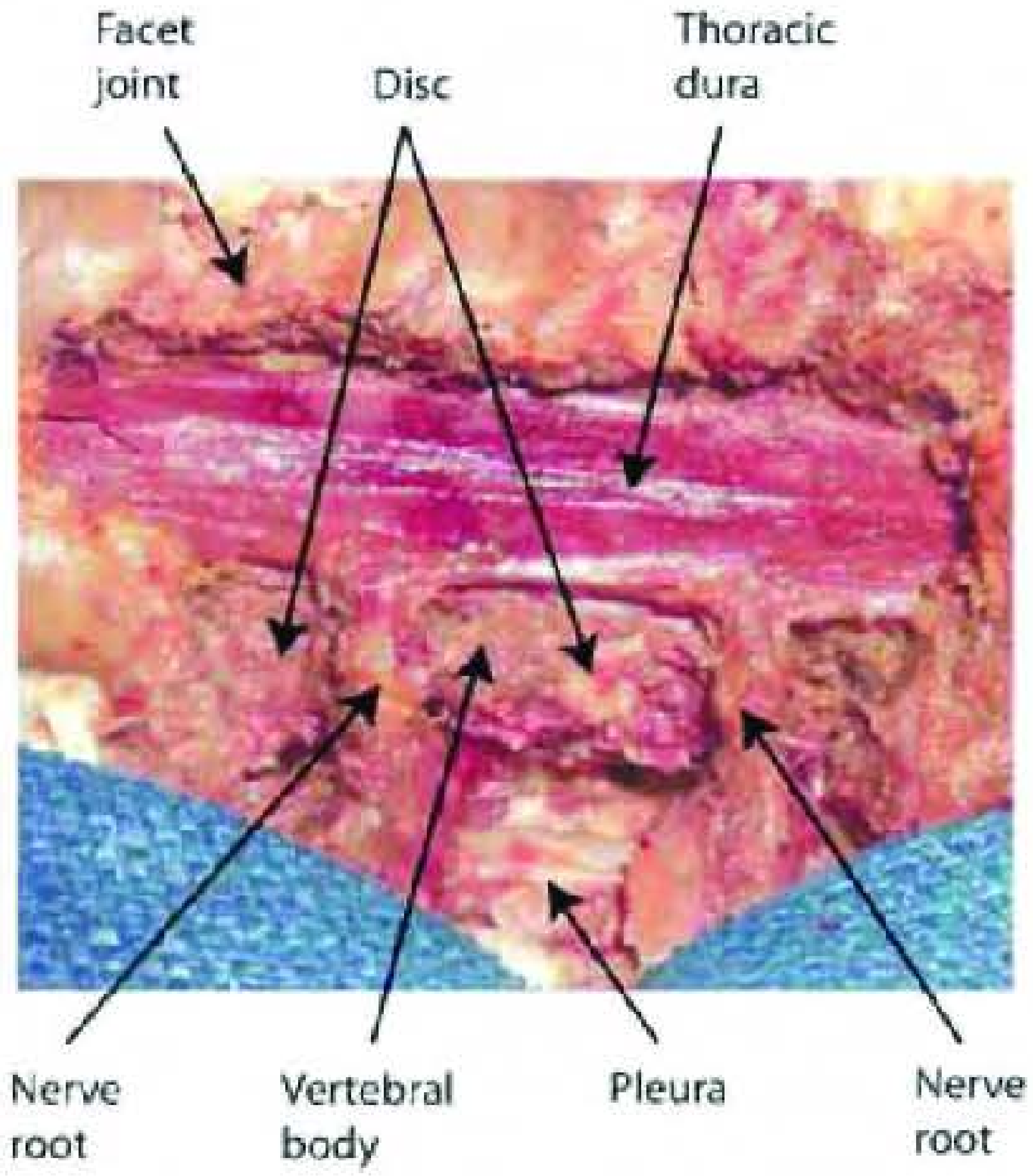

FIGURE 26–7 An anatomic slide showing a thoracic laminectomy along with resection of the facets, pedicles, transverse processes, and ribs at two levels, to expose the exiting nerve roots, the vertebral bodies, and discs ventrolateral to the thecal sac. This anatomy is seen in the extracavitary approach.

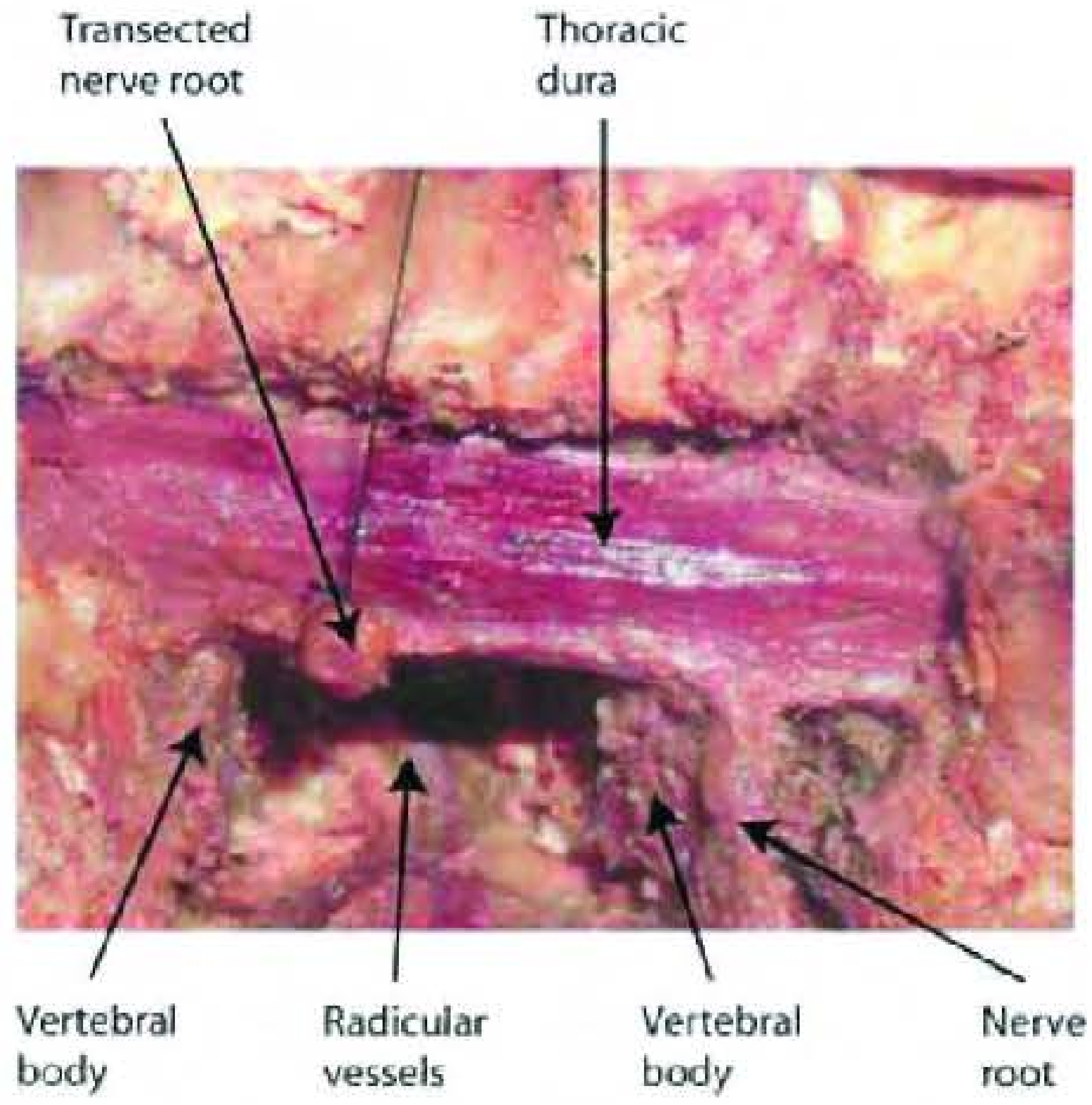

FIGURE 26–8 An anatomic slide showing resection of two discs and the intervening vertebral body through a lateral extracavitary approach, A laminectomy has been performed. One nerve root has been resected. Mote the vascular bundle on the pleural surface running toward the aorta.

PITFALLS, PEARLS, CONSIDERATIONS

- Pneumothorax
- Dural tear or cord injury
- Radiographic confirmation of level is needed
- Limited visualization of ventral dural sac

SUGGESTED READINGS

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Ventrolateral Approach to the Thoracic Spine

Ernest Senz, Damirez Fossett, Anthony Caputy

Indications for Approach

- Anterior thoracic spine neoplasms
- Anterior thoracic spine infections
- Anterior thoracic cord compression

Positioning and Skin Incision

Double-lumen endotracheal intubation must be accomplished to allow independent ventilation of both lungs. The patient is placed in the lateral decubitus position for surgery. The right lateral decubitus position is used for lesions from T2–T6, and the left lateral decubitus position is used for lesions from T6–T11. An axillary roll is placed under the downside, and the table is tilted forward about 15 degrees. The upper ipsilateral extremity is anteriorly extended so that the inferior scapular border rotates anteriorly.

The skin incision overlies the rib to be removed. It begins about 4 cm away from the dorsal midline and extends to the midaxillary line. In the lower thoracic spine, the incision should parallel the rib one segment above the pathologic level (Fig. 27–1).

Surgical Technique

After the skin incision, the latissimus dorsi and serratus anterior muscles are transected (Fig. 27–2). A subperiosteal dissection is performed along the rib, and it is resected from the posterior axillary line to the costotransverse ligament. Beneath the rib lies the endothoracic fascia, to which is

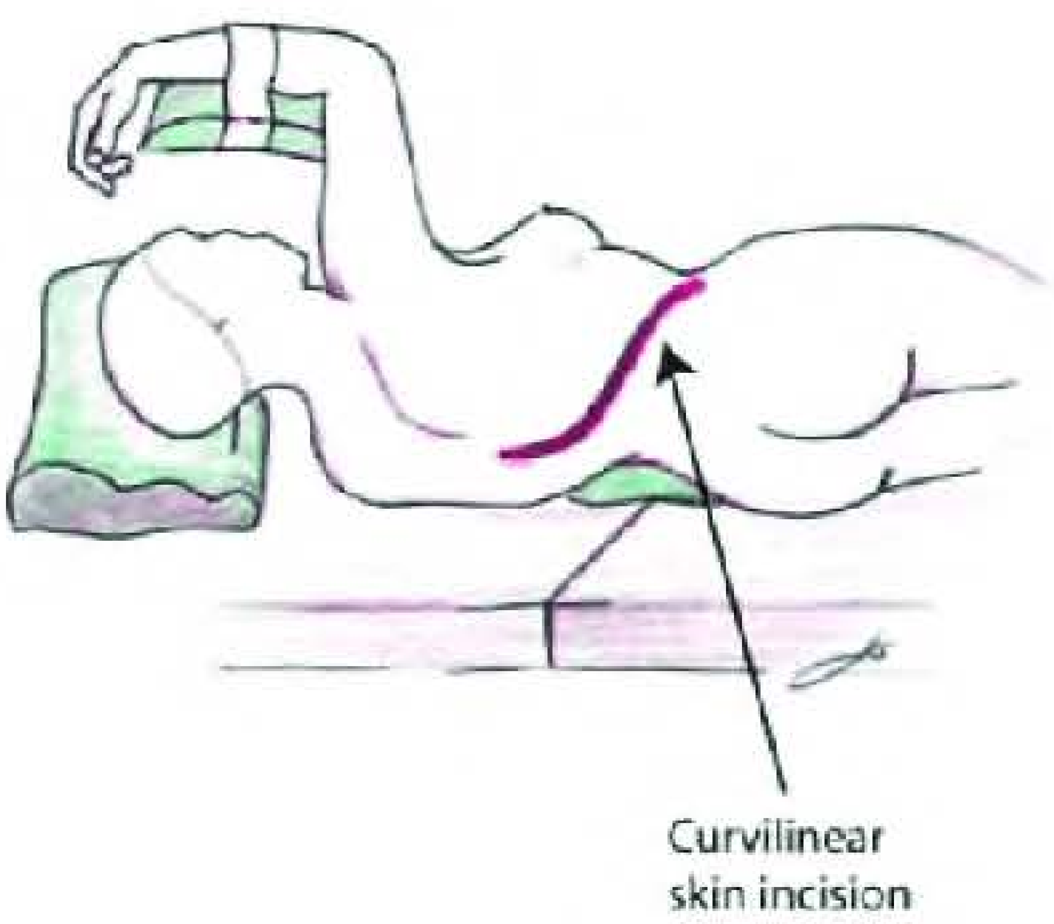

FIGURE 27–1 Illustration showing positioning and curvilinear skin Incision for ventral thoracic approaches.

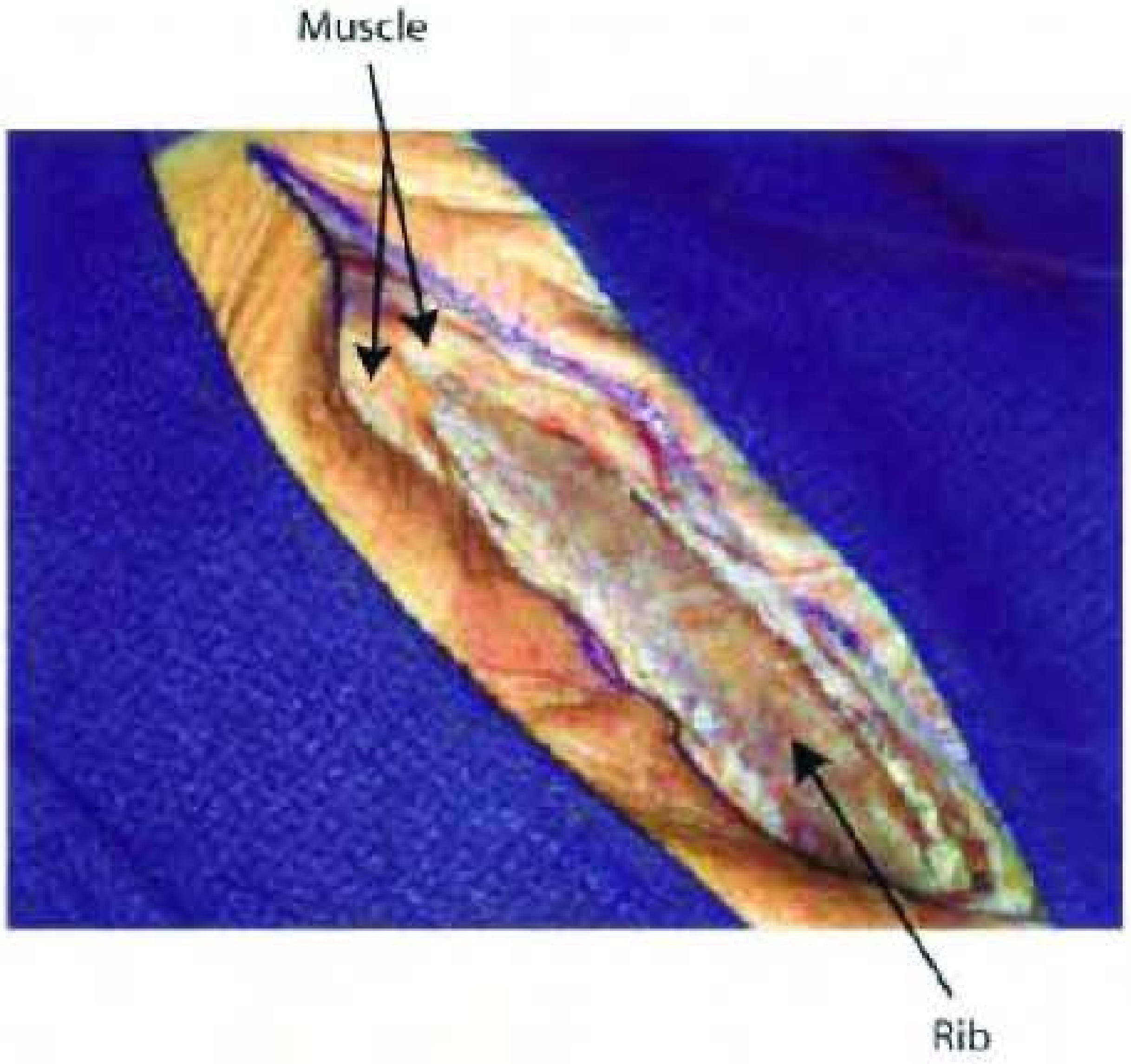

FIGURE 27–2 After muscle transection, the underlying rib can be visualized.

attached the parietal pleura (Fig. 27–3). The endothoracic fascia is incised, and the parietal pleura is bluntly and widely separated from the fascia. A segment of rib can be harvested to be used as graft later in the procedure.

With the pleura opened, the lung is collapsed, and the intrathoracic rib heads and spinal column are exposed. The pathologic level may be identified by inspection, but it must be confirmed radiographically. Following identification of the level of interest, the pleura overlying the rib head and adjacent vertebral bodies is opened. The rib head is resected and removed from the costovertebral articulation. The rib is further resected down to the costotransverse articulation. The joint is removed, thus exposing the pedicle, which will be drilled away (Figs. 27–4 and 27–5). The

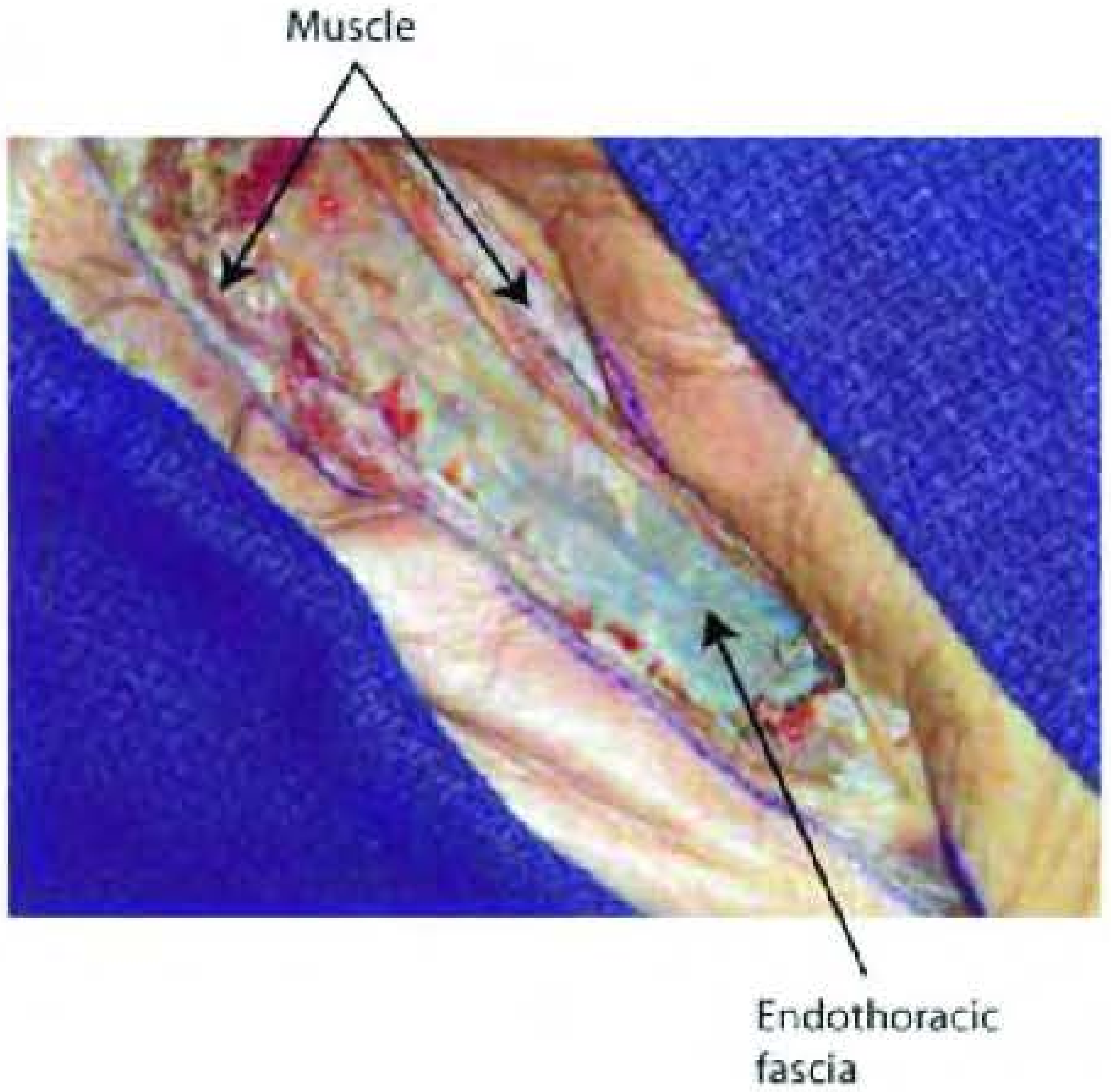

FIGURE 27–3 The rib is resected after a subperiosteal dissection, and the underlying endothoracic fascia is visualized.

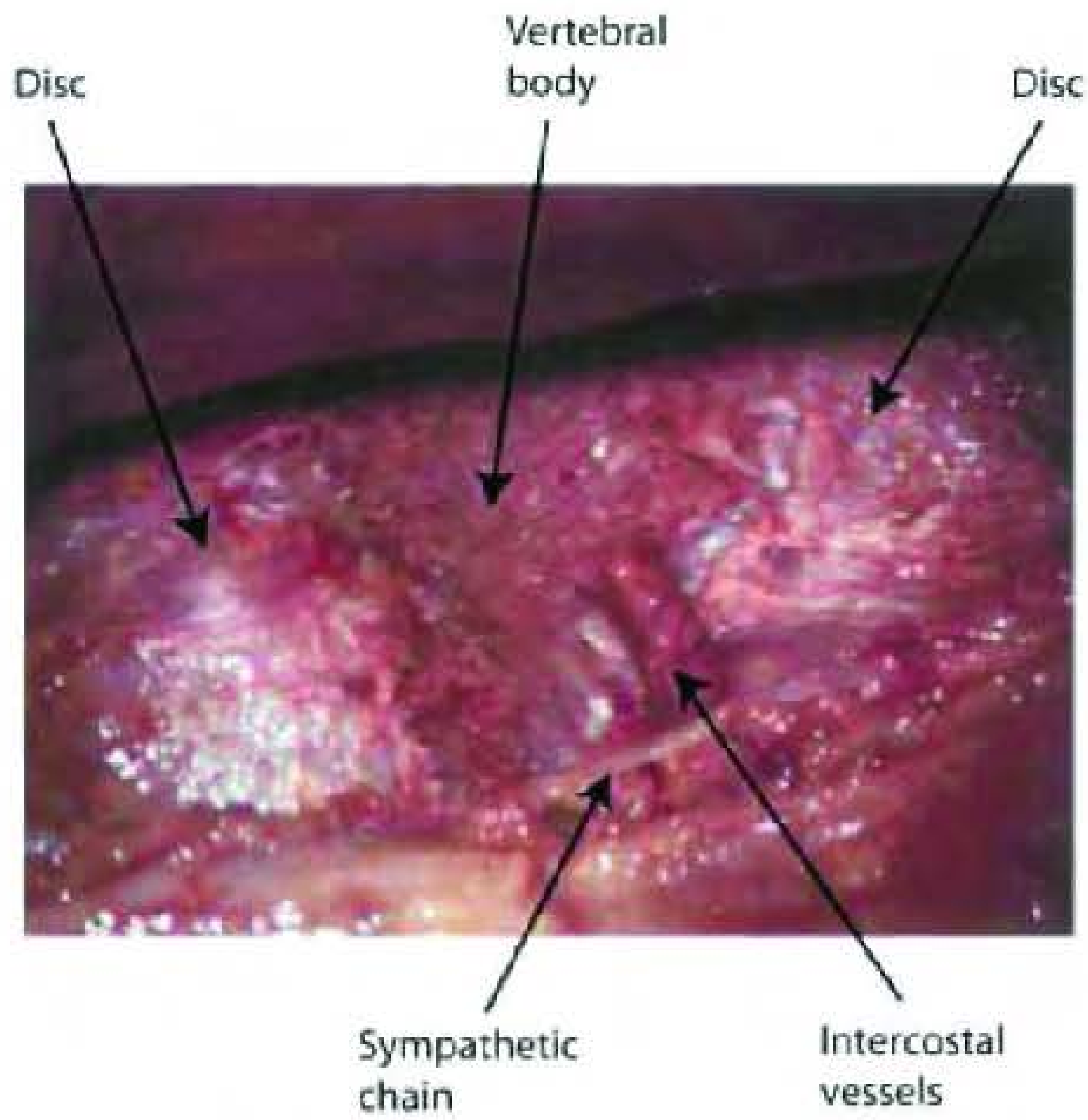

FIGURE 27–4 The pleura has been retracted medially to expose the underlying disc spaces, vertebral body, mid vertebral intercostal vessels, and the sympathetic chain.

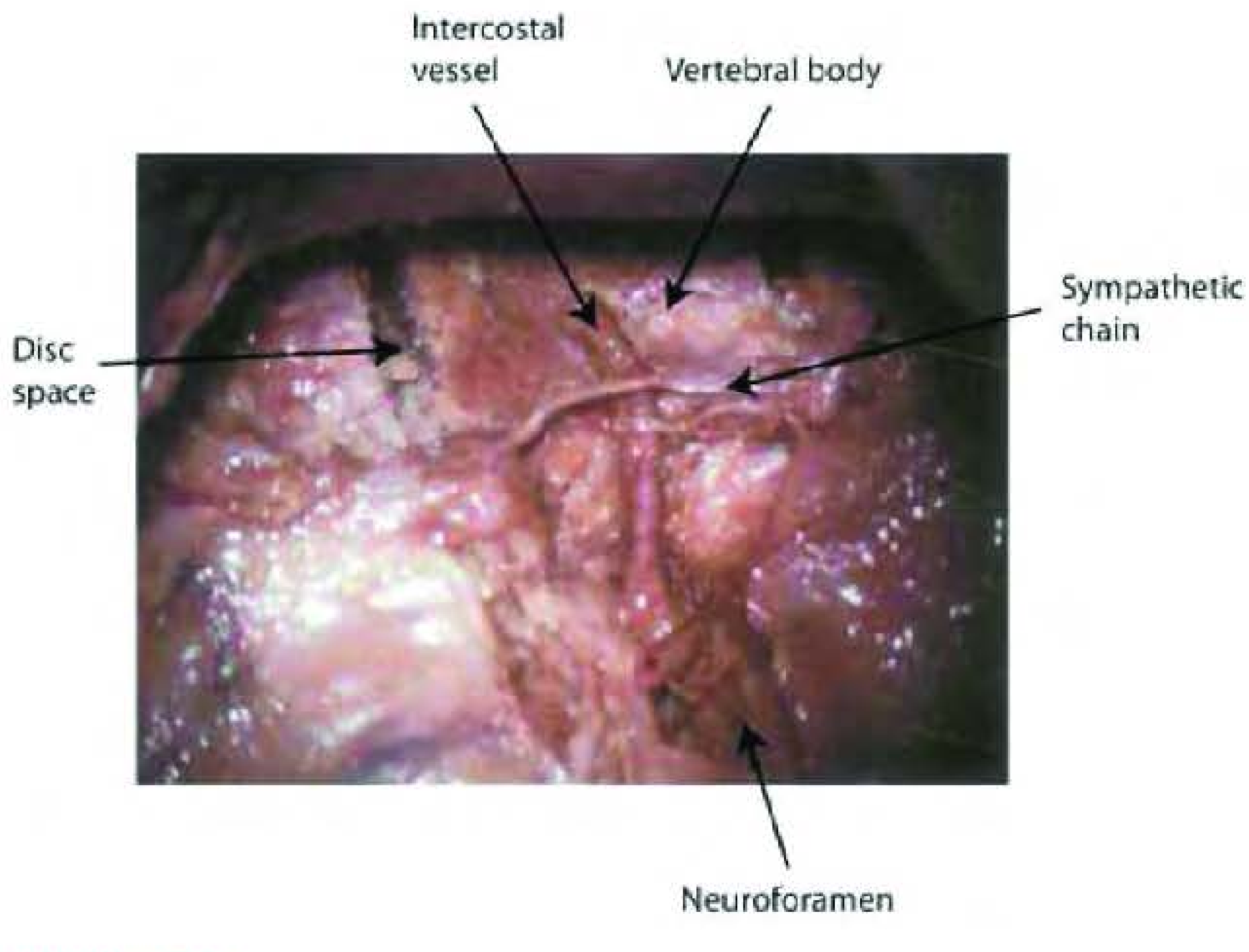

FIGURE 27–5 The discs have been excised and the pedicle removed to show the contents of the neuroforamen.

intersegmental vessels are seen at the midvertebra I body level. These vessels should be ligated and transected. The disc space then is sharply incised laterally, and the disc is removed. The vertebral body then can be drilled away with a high-speed drill. From one pedicle to the other is a depth of about 3.0 to 3.5 cm for complete anterior decompression. The extent of the dissection will depend on the nature of the pathology. The exposure is complete when the posterior longitudinal ligament is identified. Decompression is complete when the dura is visualized (Figs. 27–6 and 27–7). For an anterior stabilization procedure, a resection of two ribs and a more extensive dissection are generally required.

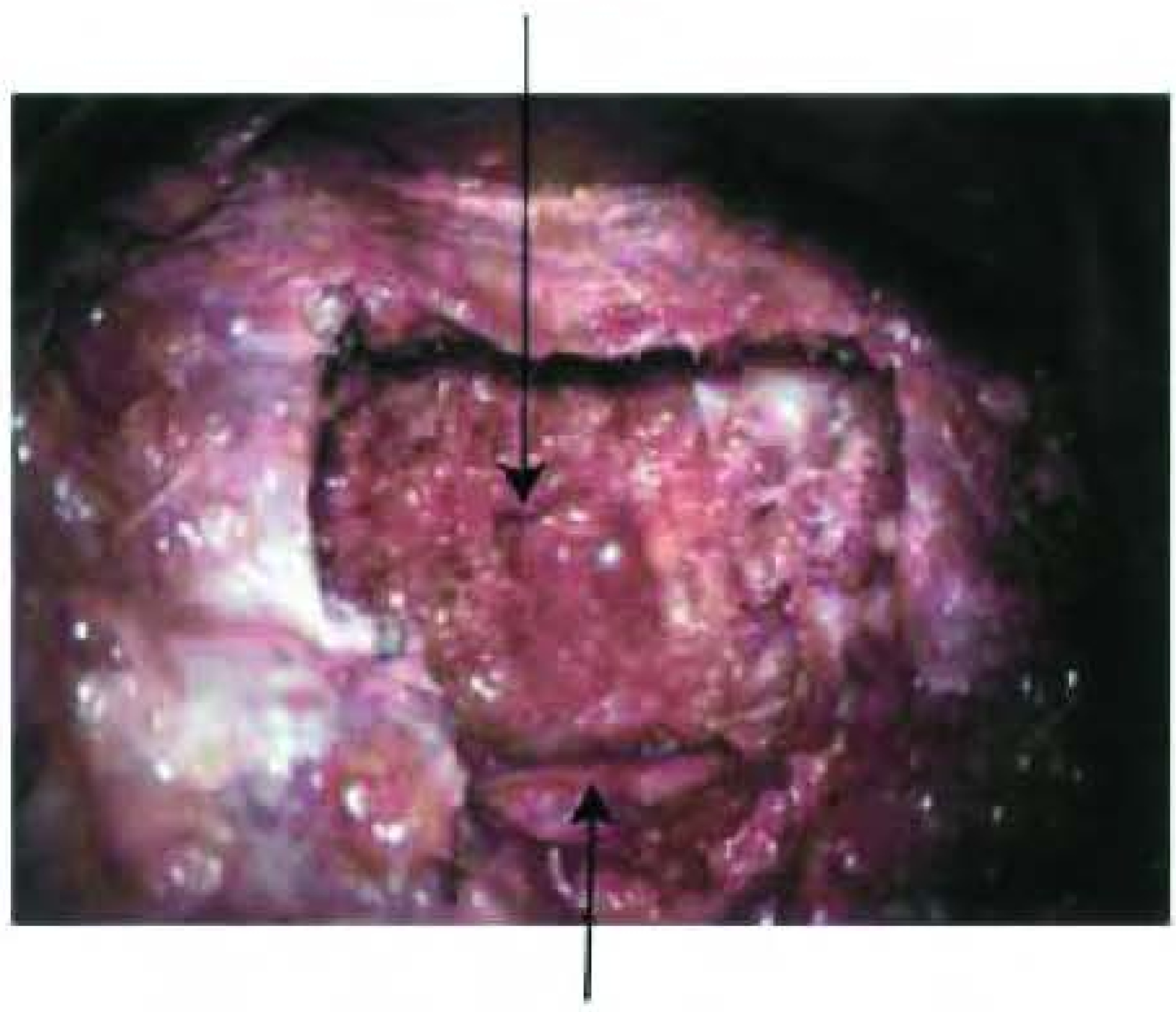

FIGURE 27–6 A vertebrectomy has been performed and the anterior dural sac exposed. The segment is now ready for graft placement.

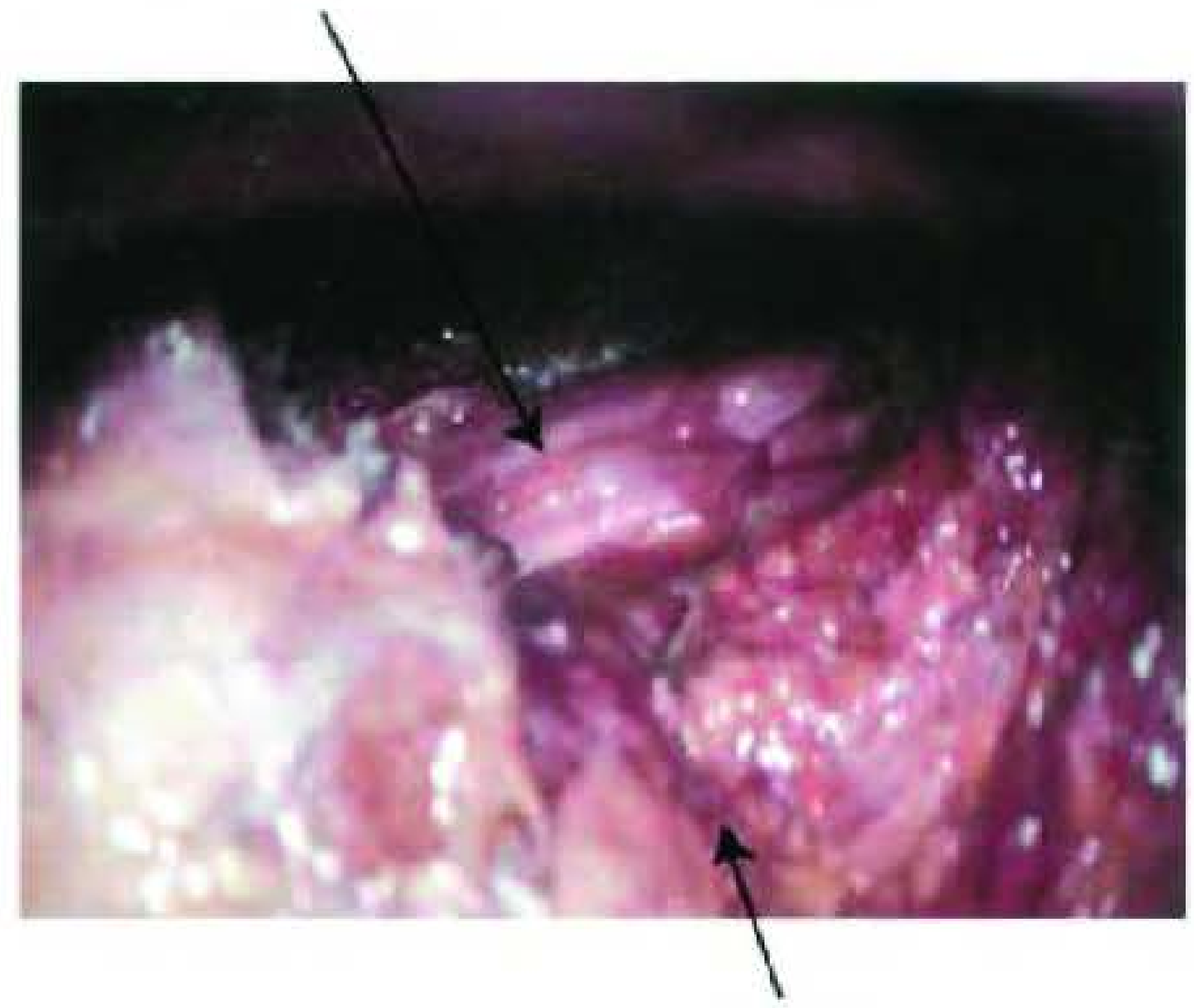

FIGURE 27–7 High-power view of the anterior dural sac and editing nerve root.

PITFALLS, PEARLS, CONSIDERATIONS

- Double-lumen endotracheal tube
- Radiographic confirmation of level
- Pneumothorax

SUGGESTED READINGS

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LUMBAR LAMINECTOMY AND DISCECTOMY

Ernest Senz, Damirez Fossett, Anthony Caputy

INDICATIONS FOR APPROACH

- Lumbar stenosis
- Lateral recess stenosis
- Herniated lumbar disc
- Intradural tumors
- Extradural compressive lesions

POSITIONING AND SKIN INCISION

Lumbar dorsal procedures can be performed with the patient in either the lateral or prone position. In the prone position, the patient is placed on either chest rolls, a Wilson or Andrew frame, or a Cloward saddle. Attention should be given to padding the eyes to avoid pressure on the globes. Appropriate padding should be placed to avoid peripheral nerve compression. A midline skin incision is performed (Fig. 28–1).

SURGICAL TECHNIQUE

LUMBAR DISCECTOMY

After the skin incision is made, the dissection is carried through the subcutaneous tissue to the level of the lumbodorsal fascia. For a unilateral disc herniation, the lumbodorsal fascia need only be opened on the side ipsilateral to the herniation. Once the fascia is opened, the paraspinal muscles are reflected in a subperiosteal fashion away from the underlying spinous process and hemilamina (Fig. 28–2). The muscles are usually reflected laterally to the facet joints- A localizing radiograph should be taken to confirm the level.

A Taylor retractor or other self-retaining retractor is placed behind the facet joint to maintain lateral retraction of the paraspinal muscles. With a curette, the ligamentum flavum is separated from the overlying hemilamina. A hemilaminectomy is performed using first a Leksell and then Kerrison rongeurs. Alternatively, a high-speed drill can be

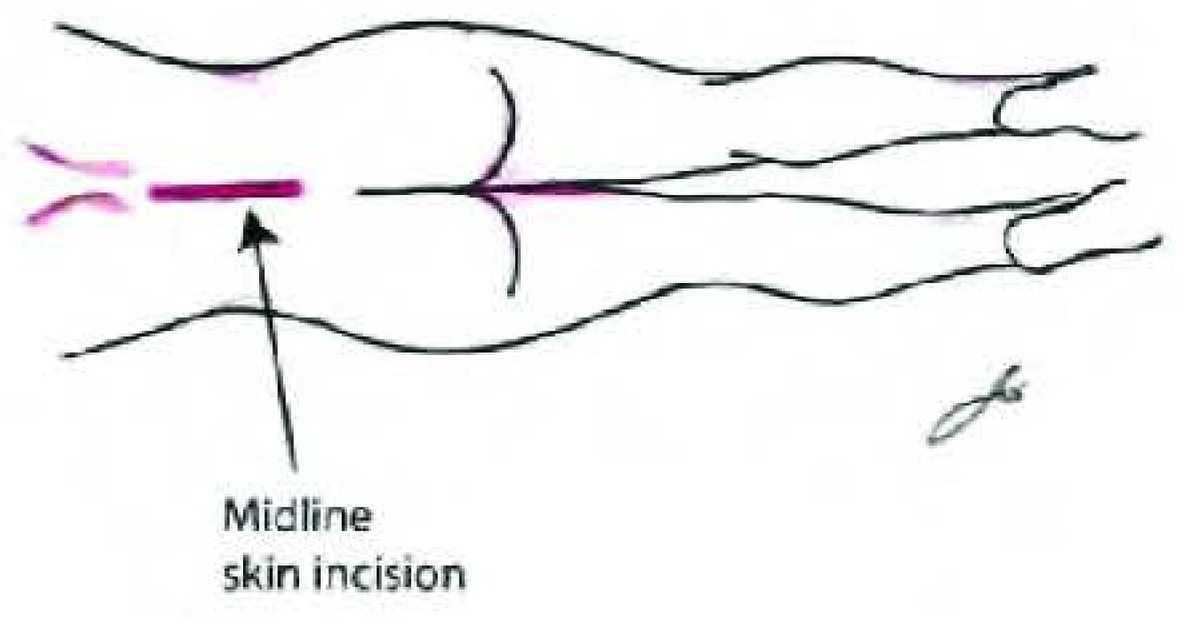

FIGURE 28–1 Illustration of the midline skin incision. The patient may be in either the prone or lateral position.

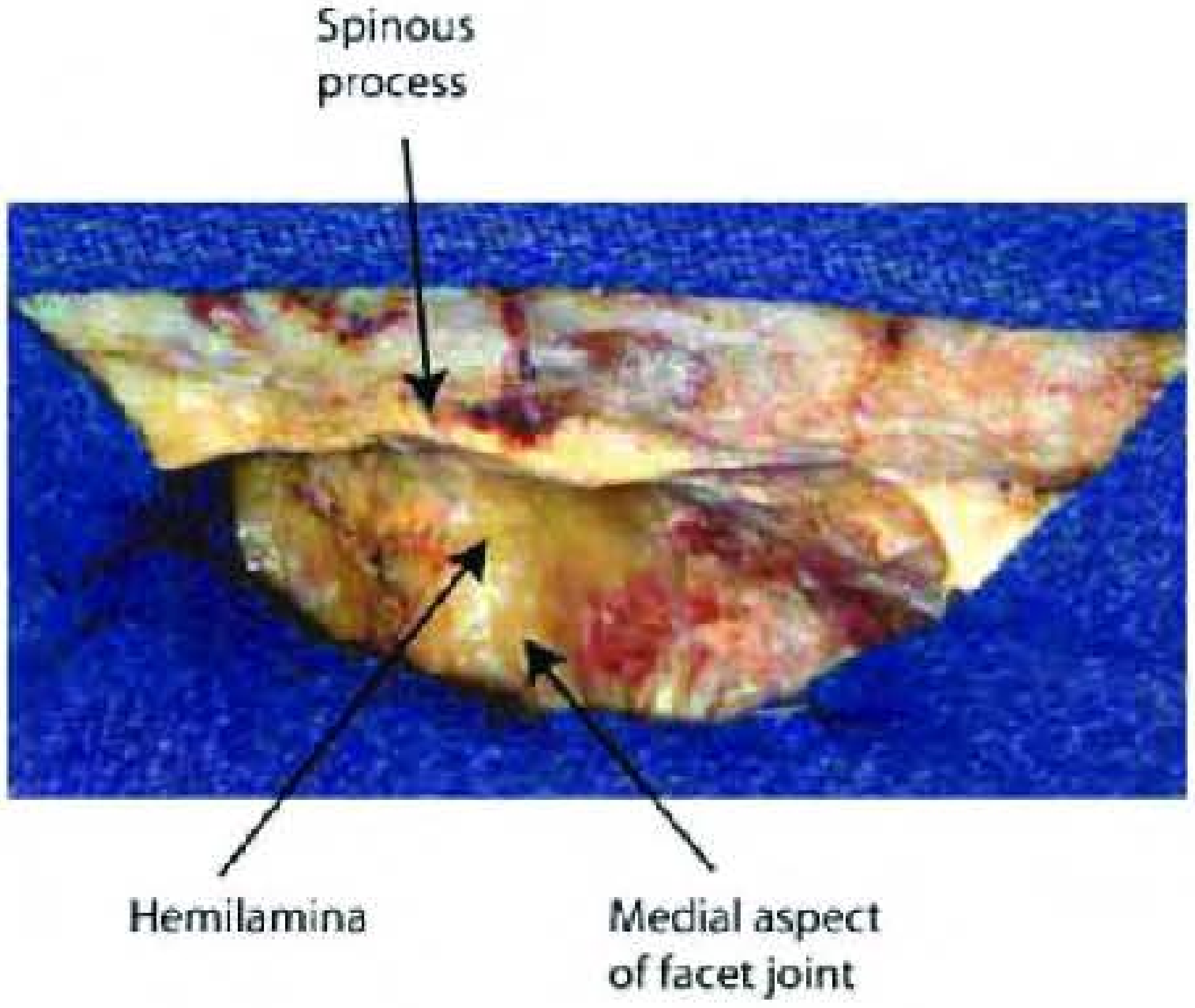

FIGURE 28–2 Lateral retraction of the paraspinal muscles reveals the underlying hemilamina and facet joint.

used. The endpoint of bone removal should be the rostral extent of the ligamentum flavum. Using a Kerrison rongeur, the yellow ligament can be excised; which exposes the underlying dural sac (Fig. 28–3). With the Kerrison, a foraminotomy and medial facetectomy can be performed to expose the underlying nerve root adequately (Fig. 28–4A, B).

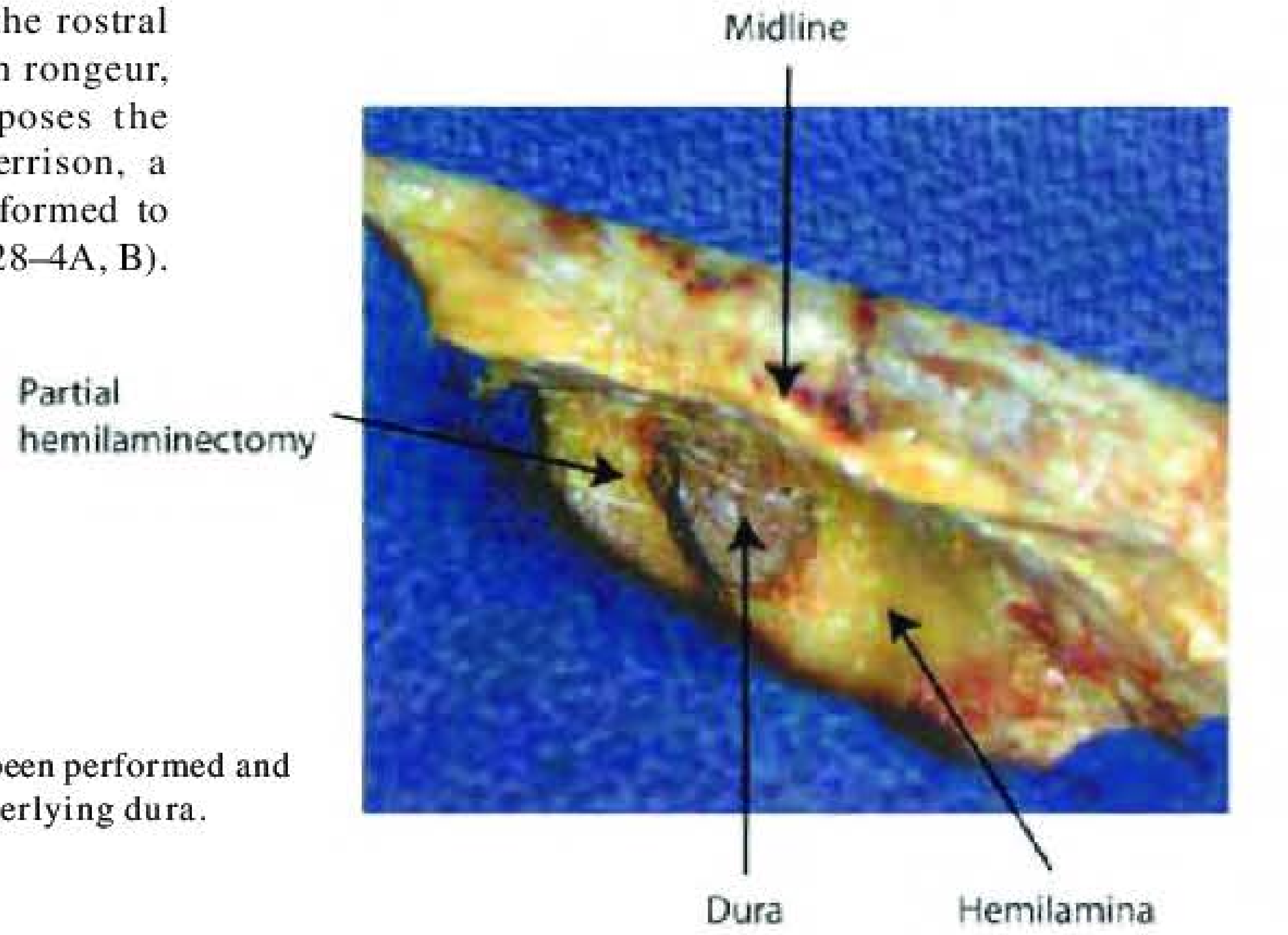

FIGURE 28–3 A partial hemilaminectomy has been performed and the ligamentum flavum resected revealing the underlying dura.

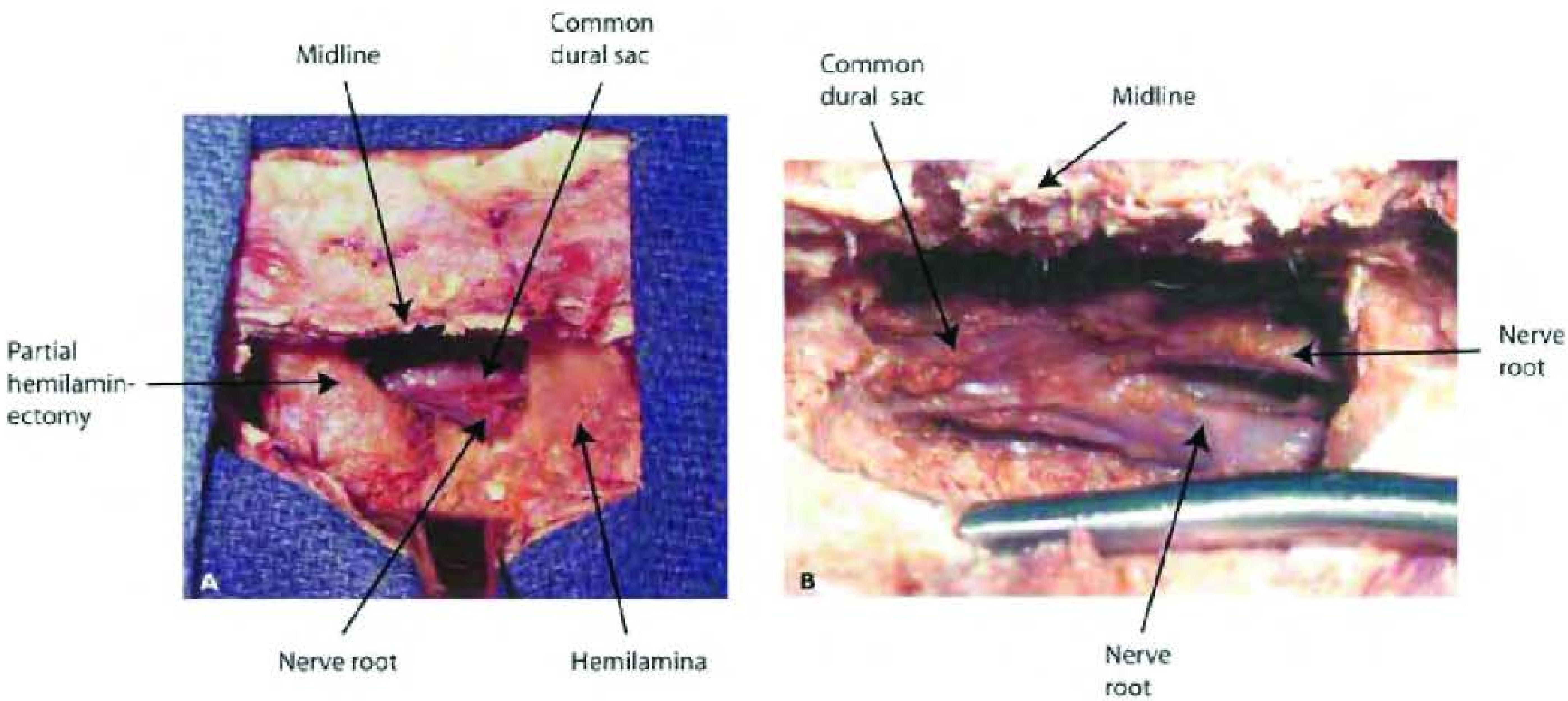

FIGURE 28–4 **A**: A foraminotomy has been performed exposing the exiting nerve root. **B**: A more extensive foraminotomy shows exiling nerve roots.

A Love nerve root retractor is used to retract the nerve root medially, thereby exposing the disc space The space is entered with a no. 15 blade. Using a series of pituitary rongeurs, disc material is removed from the disc space. It is important to palpate with a Woodson or blunt nerve hook in the subligamentous regions and to inspect out the neuroforamen to look for free disc fragments and to ensure that the exiting nerve root is fully decompressed. Once the root is free, bone edges should be inspected to ensure that there are no sharp spicules that could puncture the dura. The wound then can be closed in a multilayered fashion starting with the lumbodorsal fascia.

LUMBAR LAMINECTOMY

After the skin incision is carried to the level of the lumbodorsal fascia, the fascia is opened in the midline and the paraspinal muscles reflected in a subperiosteal fashion away from the spinous processes and lamina bilaterally. Radiographic confirmation of the level is made. For a simple decompression, exposure to the facet joints is all that is required. For a posterolateral fusion, the transverse processes are exposed. Self-retaining retractors are placed in the wound to maintain exposure.

With a Leksell and Kerrison rongeurs, the spinous processes and lamina are removed exposing the common dural sac and exiting nerve roots (Fig. 28–5). Alternatively, a trough can be drilled at the facet-laminar junction; with a thin Kerrison, the lamina and spinous processes can be removed *en bloc*. This technique is also used for laminoplasty. Medial facetectomies and foraminotomies are then performed. The yellow ligament is removed both in the midline and in the Lateral recesses to ensure an adequate decompression. The pedicle can be palpated with a Woodson or blunt nerve hook, and with palpation out the neuroforamen, the nerve can be shown to be well decompressed. A discectomy is performed if needed.

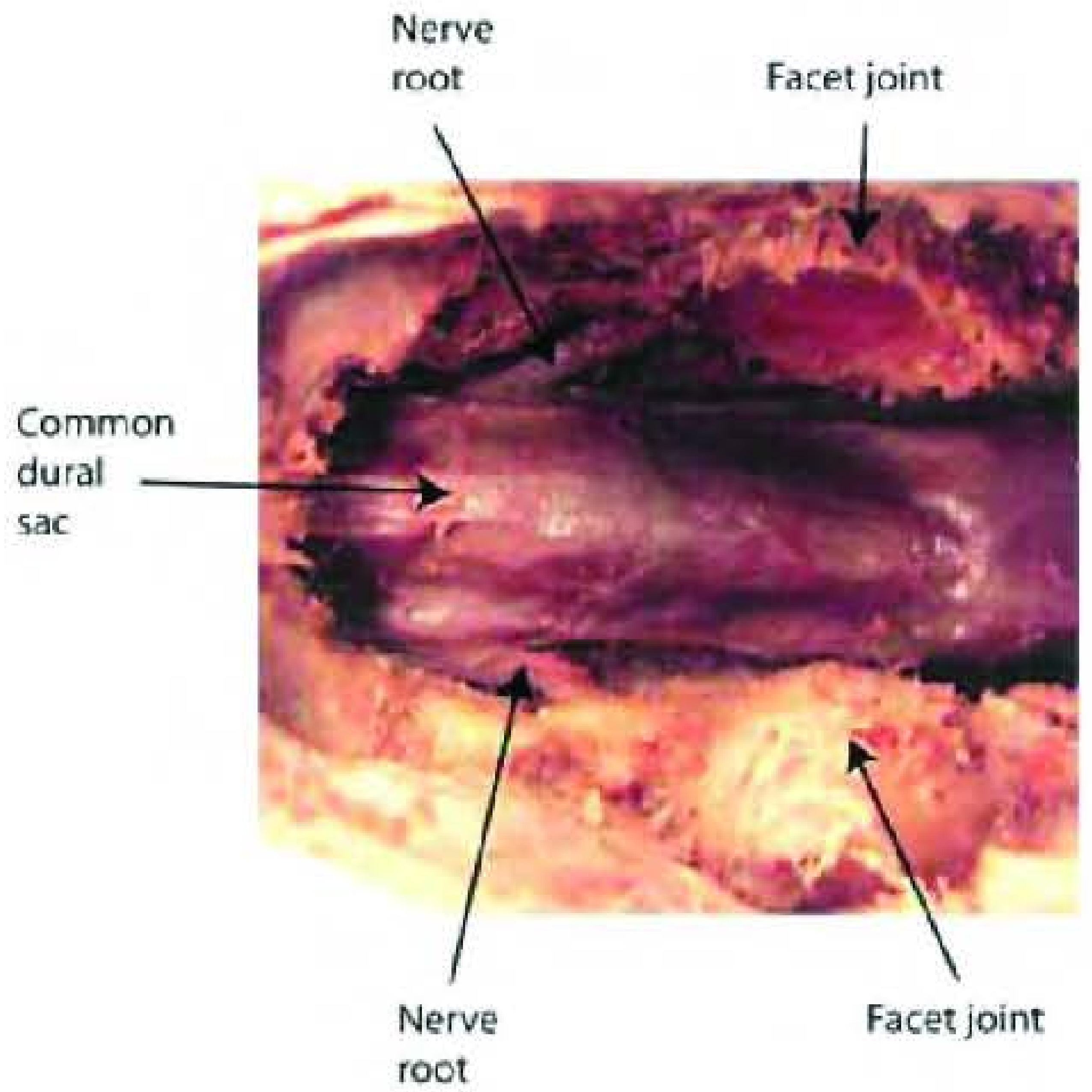

FIGURE 28–5 A total laminectomy has been performed. The exiting nerve roots can be seen bilaterally. A medial facetectomy has been performed on one side to demonstrate the added decompression and exposure of the nerve that can be achieved with this additional bone removal.

INTRADURAL LESIONS

For intradural tumor resection, traction stitches are placed in the dura to tent it up, and the dura is incised in the midline with an arachnoid knife or no. 15 Made. The dura is opened further with a knife and groove director or with a dural scissor. Stay stitches are placed to maintain lateral traction on the dural edges. In the upper lumbar spine, the conus medullaris will be visualized (Fig. 28–6). In the lower lumbar spine, the nerve roots of the cauda equina and the filum terminate are seen (Fig. 28–7). Tumors may be dissected free of the involved neural structures and resected without injury to the lower spinal cord or exiting nerve roots. The dura should be closed in a watertight fashion As with all posterior spinal procedures, the wound is closed in a multi layered fashion beginning with the lumbodorsal fascia.

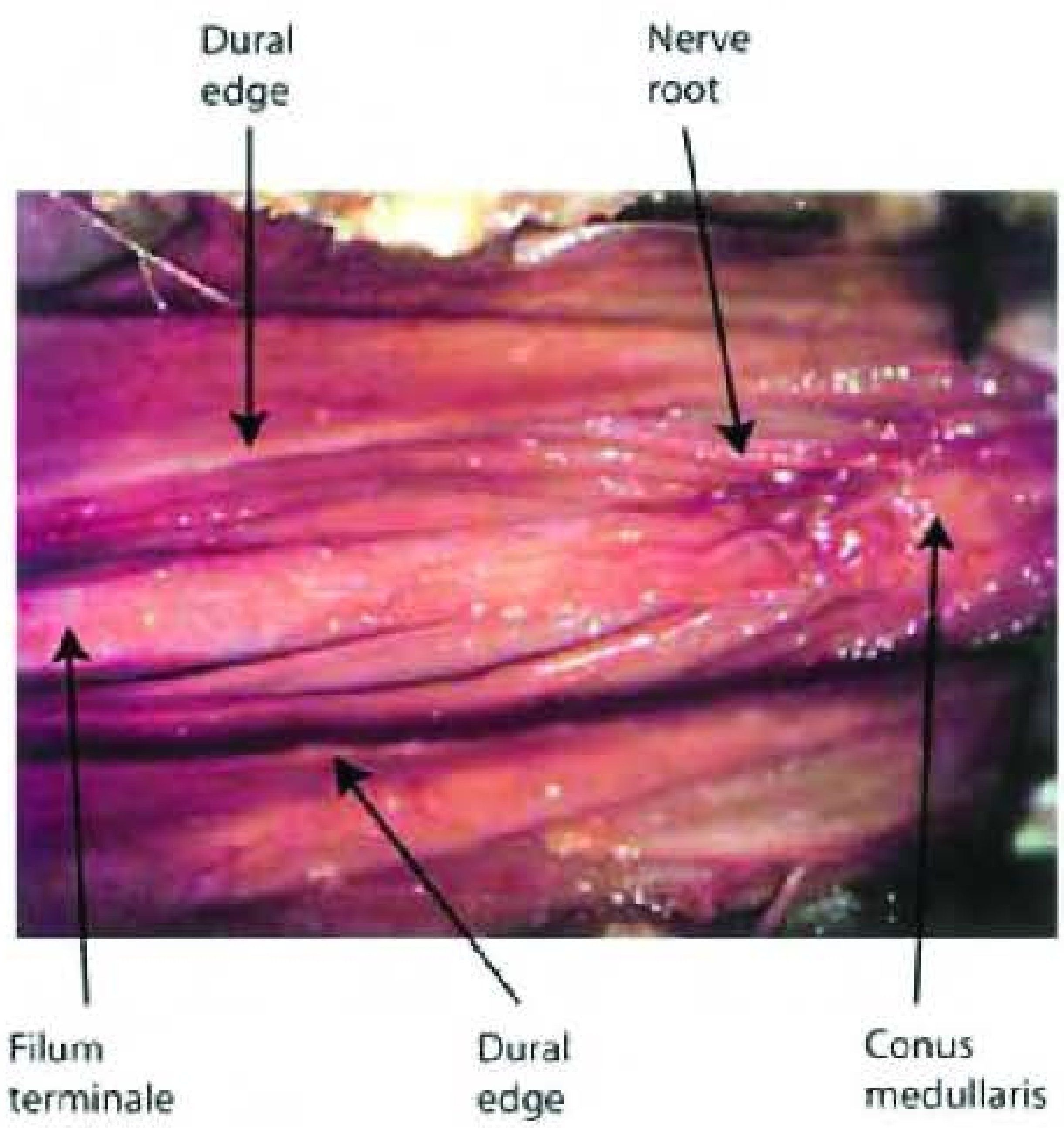

FIGURE 28–6 In the upper lumbar spine, the conus medullaris is exposed after opening the dura.

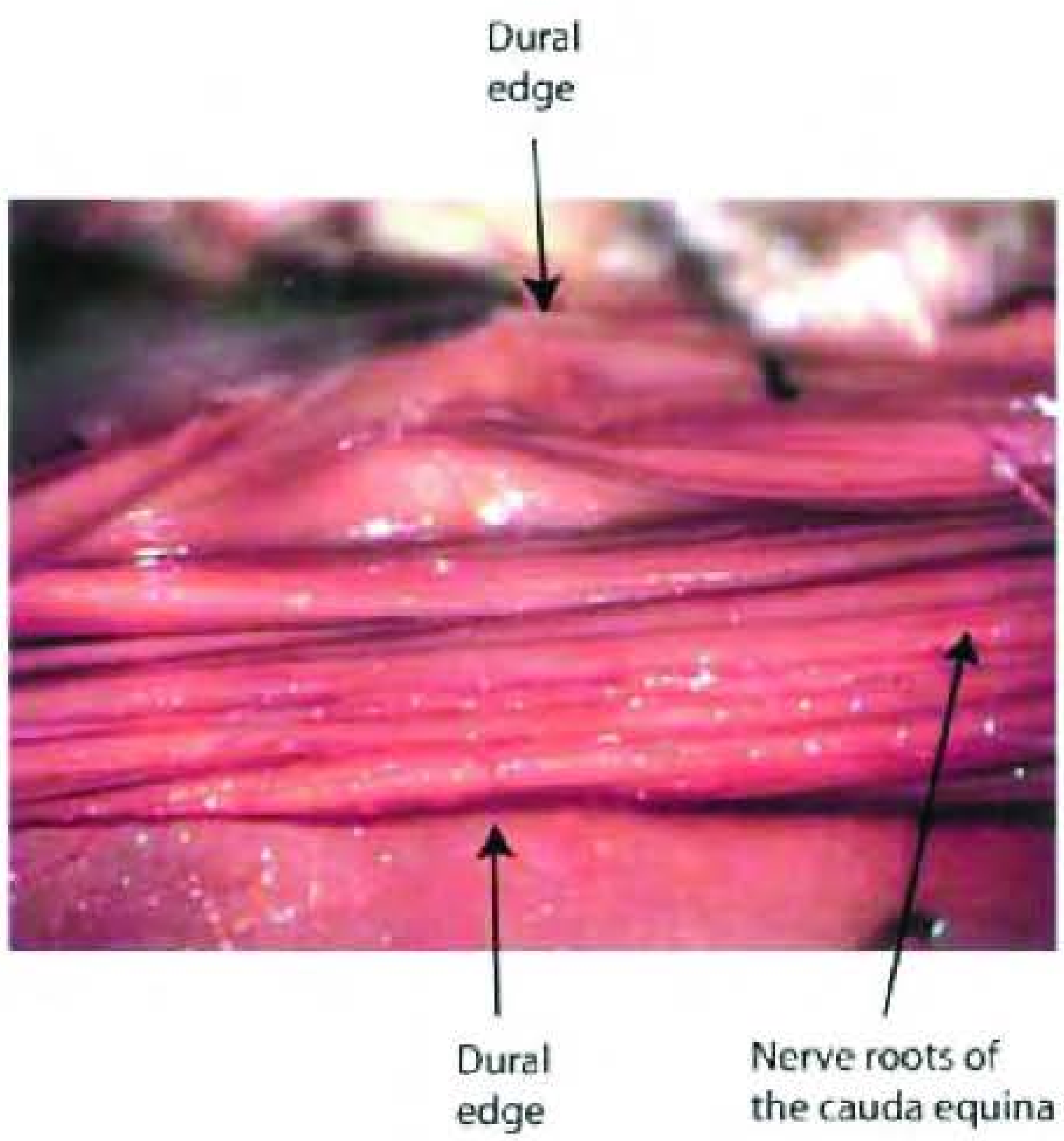

FIGURE 28–7 In the lower lumbar region, nerve roots of the cauda equina are visualized. A nerve root can be seen exiting the common dural sac.

PITFALLS, PEARLS, CONSIDERATIONS

- Avoid dural lacerations; these should be repaired primarily if possible
- Confirm level with lateral radiographs
- Avoid removing too much of the facet joint unless a fusion has been planned or discussed
- Large or centrally placed discs may require a total laminectomy
- High-speed drills risk nerve root injury or dural laceration

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FAR LATERAL LUMBAR DISCECTOMY

Ernest Senz, Damirez Fossett, Anthony Captity

INDICATIONS FOR APPROACH

- Foraminal or extraforaminal disc herniations

POSITIONING AND SKIN INCISION

The patient usually is placed in the prone position on chest rolls, a Wilson or Andrews frame, or a Cloward saddle. Attention should be given to padding the eyes to avoid pressure on the globes. Appropriate padding should he placed to avoid peripheral nerve compression. The appropriate level is located radiographically by placing spinal needles down to the facet joints above and below the level of interest. A paramedian skin incision is made about 3 cm from the midline to join the two needles (Fig. 29–1).

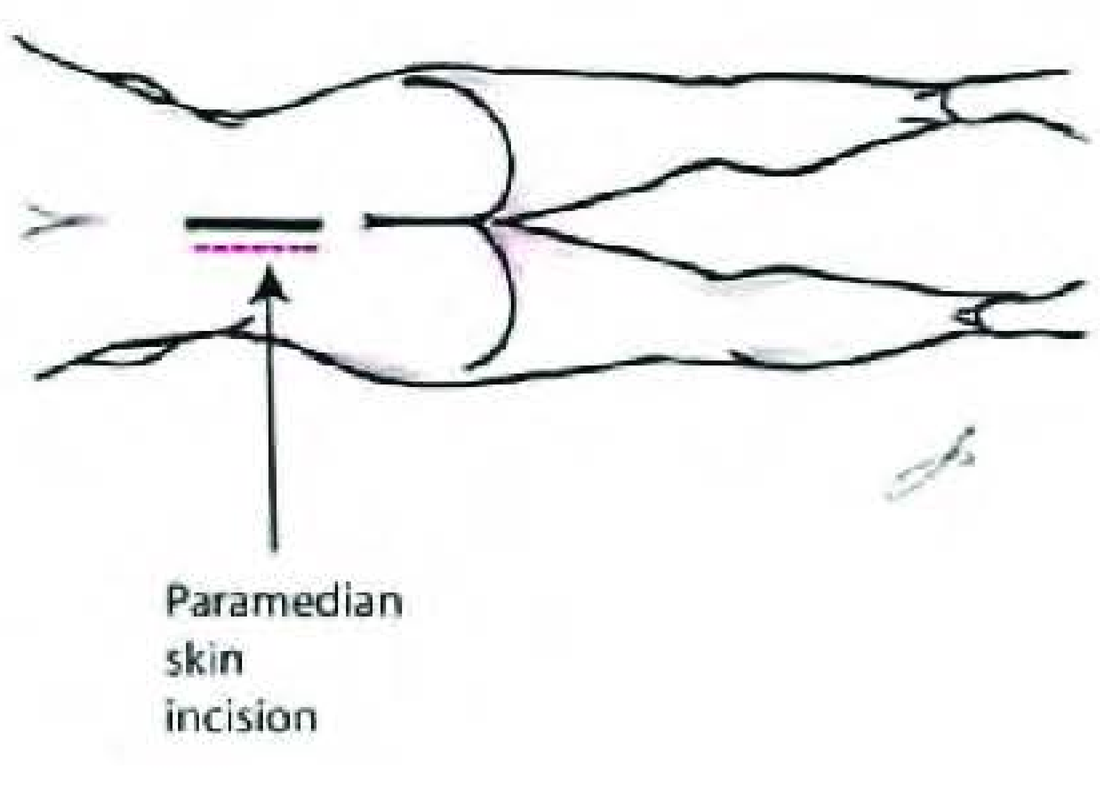

FIGURE 29–1 Illustration showing a paraspinal incision 3 cm away from the midline.

SURGICAL TECHNIQUE

After incising the subcutaneous tissue, the multifidus muscle can be identified medially and the longissimus muscle laterally (Fig. 29–2). Blunt dissection in the groove between these two muscles allows palpation and visualization of the transverse processes. A subperiosteal dissection of the muscles away from the transverse processes is performed, and another localizing radiograph is obtained. The transverse process–facet joint junction must be clearly identified because this joint indicates the position of the underlying pedicle. The compressed nerve root lies just under the pedicle.

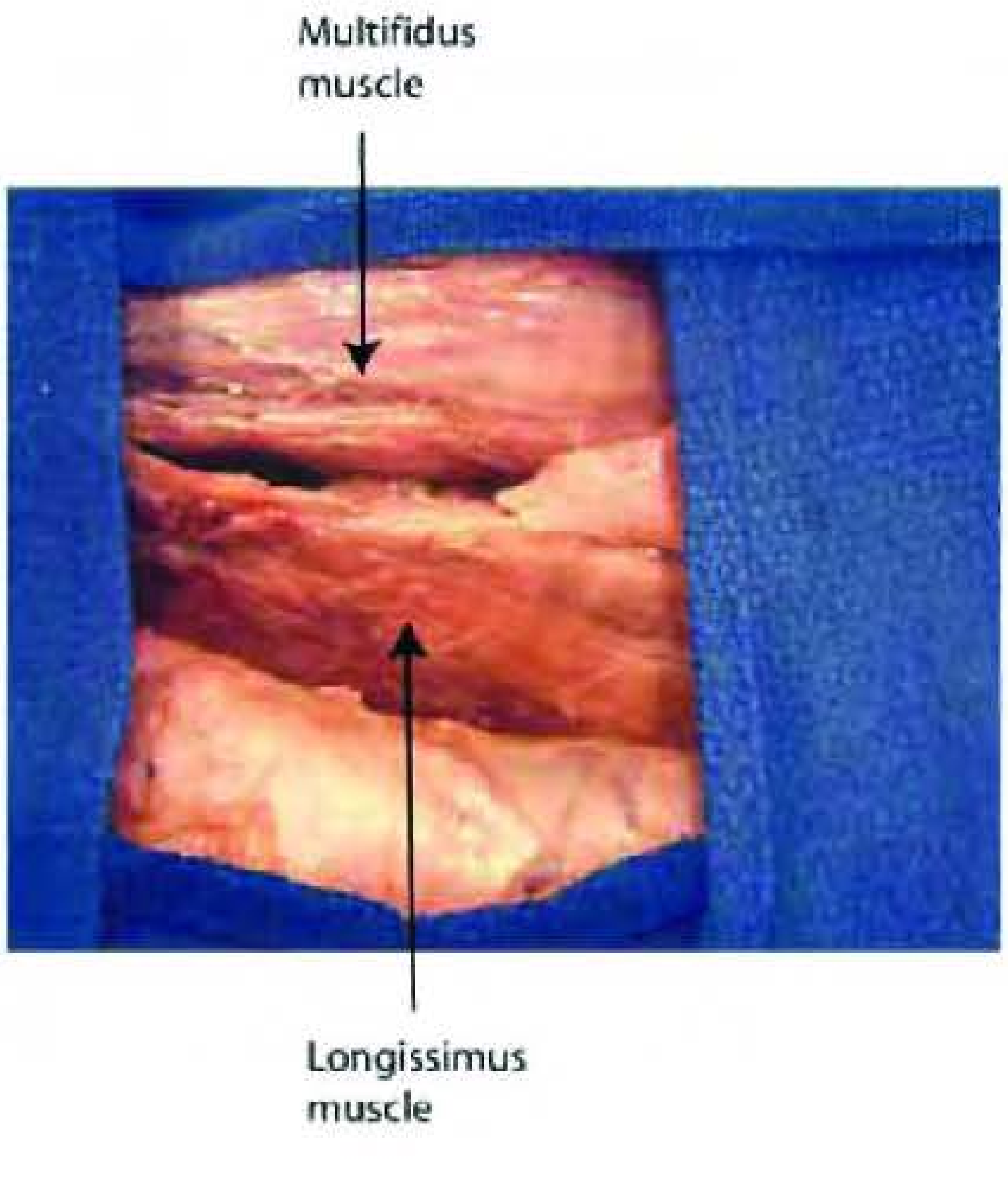

FIGURE 29–2 After reflection of the lumbodorsal fascia, the multifidus muscle is exposed medially, and the longissimus muscle laterally.

Small intertransverse muscle fibers join adjacent transverse processes (Fig. 29–3). Under these muscle fibers lies the intertransverse fascia. The muscle fibers should be opened, and, on incising the fascia, fat and the underlying nerve root will be identifiable (Fig. 29–4). Under the operating microscope, a partial resection of the transverse process-facet junction is performed. The neuroforamen then is exposed, and the relationship between the axilla of the nerve root and the disc can be appreciated (Fig. 29–5). Disc material is removed with a pituitary forceps, and exploration is done to remove any additional free fragments.

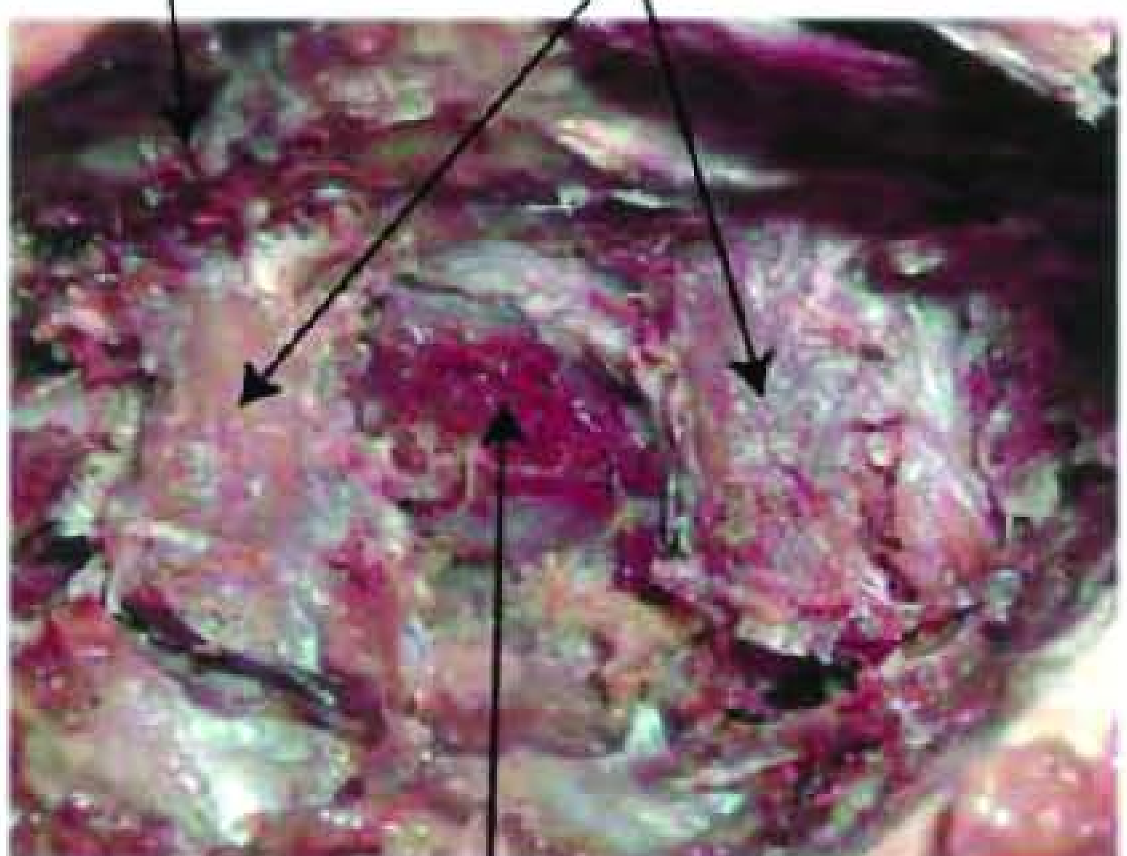

FIGURE 29–3 Developing the plane between multifidus and longissimus allows visualization of the transverse processes with the interposing intertransverse muscle.

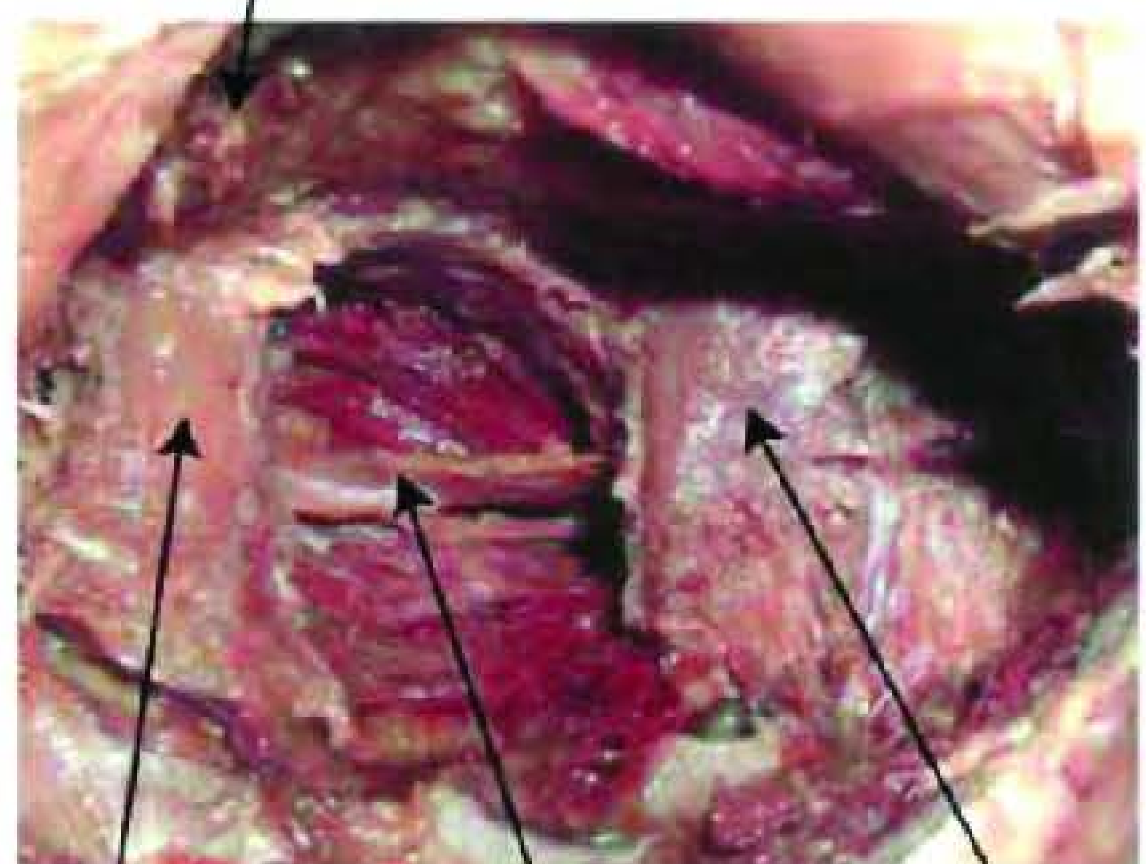

FIGURE 29–4 The exiting nerve root can be visualized after opening the intertransverse fascia.

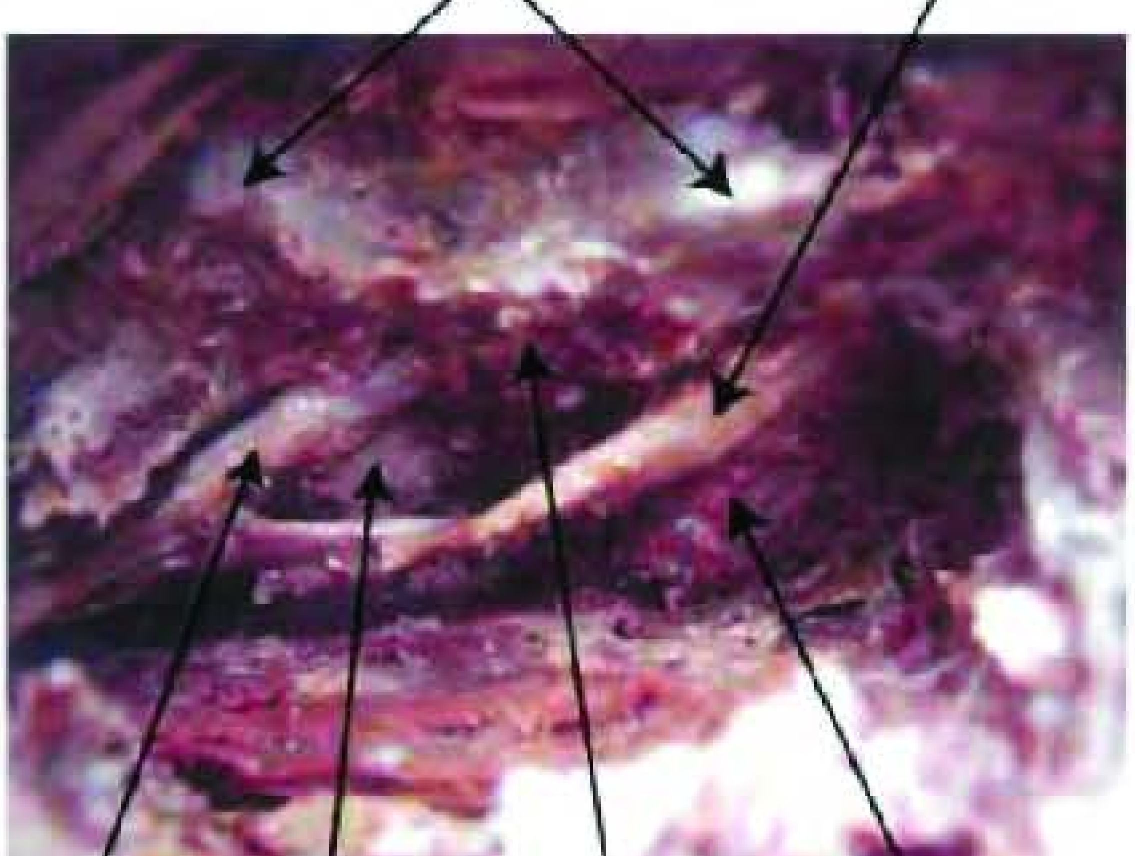

FIGURE 29–5 The superior transverse process has been completely resected in order to allow visualization of the disc and to expose the disc-axilla relationship. The lower nerve root and disc are also visualized. Note that a far lateral disc herniation will impinge on the superior nerve root.

PITFALLS, PEARLS, CONSIDERATIONS

- Find the right paramedian plane
- Localize the facet joints radiographically prior to making the skin incision
- Do not inadvertently injure the nerve root between the transverse processes

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Retroperitoneal Approach to the Lumbar Spine

Ernest Senz, Anthony Caputy

Indications for Approach

- L2–5 anterior tumors, infections, fractures causing thecal sac or nerve root compression

Positioning and Skin Incision

The patient is placed in the lateral decubitus position with the operating table "broken" to open the space between the ribs as well as to open the angle between the rib cage and the iliac crest. This also allows the abdominal viscera to migrate cephalad out of the surgical field of interest. The approach is generally made from the left because there is no need for liver retraction, and it is easier to deal with the aorta and iliac vessels than with the vena cava. The skin incision begins at the dorsal midline and extends at least to the midaxillary line. The incision generally begins at the level of the eleventh or twelfth rib and ends just above the umbilicus to expose L2, under the eleventh or twelfth rib to expose L3, and about half the distance between the umbilicus and the symphysis pubis to expose L4–5 (Fig. 30–1).

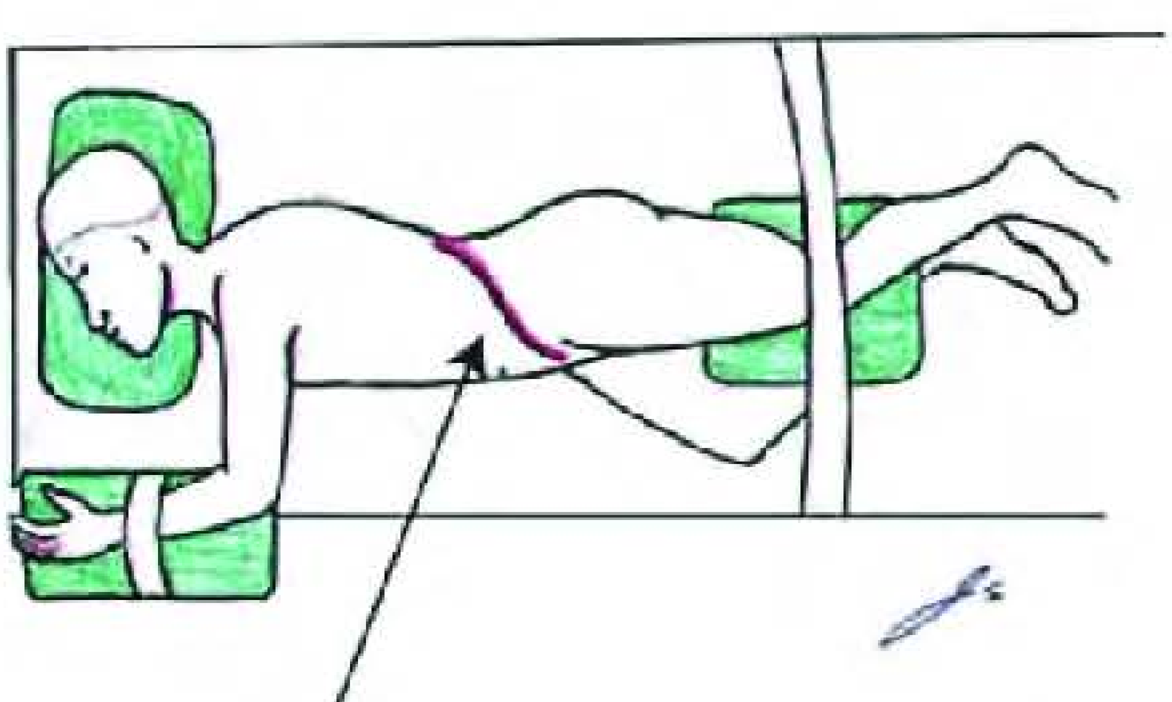

FIGURE 30–1 Alternative skin incisions for the retroperitoneal approach begin in the dorsal midline. They end at, above, or below the umbilicus, depending on the level of surgical pathology.

Surgical Technique

In line with the skin incision, the latissimus dorsi, external and internal obliques, and transverse muscles are transected. The transversalis fascia running beneath these muscle layers is identified and opened in a similar fashion to enter the retroperitoneal space. The peritoneum is dissected bluntly from the abdominal wall in all directions and then from lateral to medial in the direction of the vertebral bodies. The quadralus lumborum and psoas muscles should be identified along with the kidney and, in the retroperitoneal fat the ureter (Fig. 30–2). The lumbar spine is identified

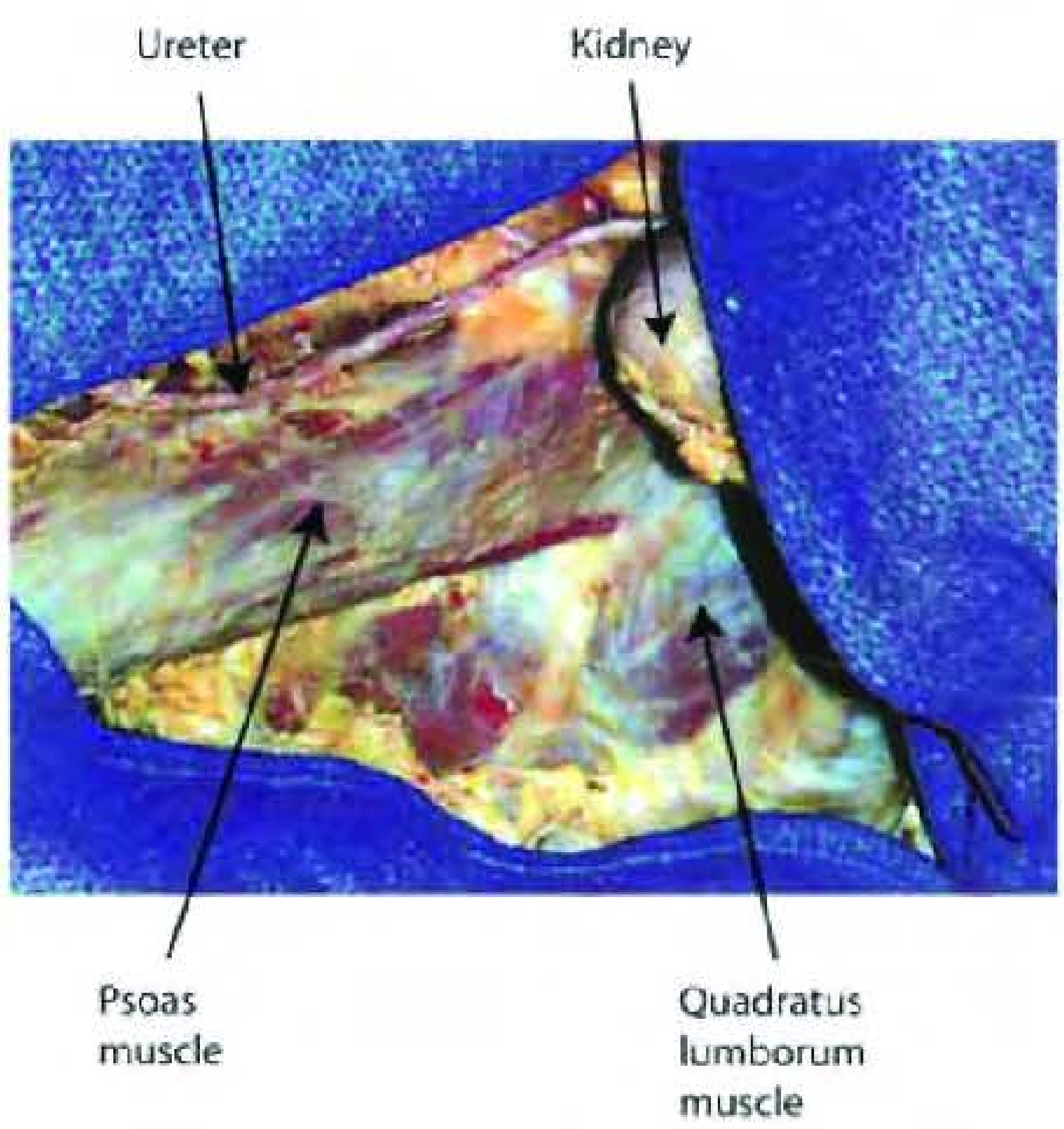

FIGURE 30–2 The contents of the retroperitoneal space are exposed. Embedded in fat and fascia are the ureter, lower pole of the kidney, psoas muscle medially, and quadratus lumborum muscle laterally.

immediately medial to the psoas muscle. The sympathetic chain can be identified between the psoas muscle and the vertebral column (Fig. 30–3).

The segmental vessels are found at the midportion of each vertebral body. These must be identified, isolated, and ligated so that the aorta can he mobilized medially to expose the vertebral bodies. The psoas muscle is reflected laterally. This will bring into view the vertebral column. The anterior longitudinal ligament is identified and separated from the underlying vertebral bodies, and a localizing radiograph is taken to confirm the correct level (Fig. 30–4).

The disc spaces can be incised and disc material removed to define the upper and lower limits of the vertebral segment (Fig. 30–5). A vertebrectomy is performed

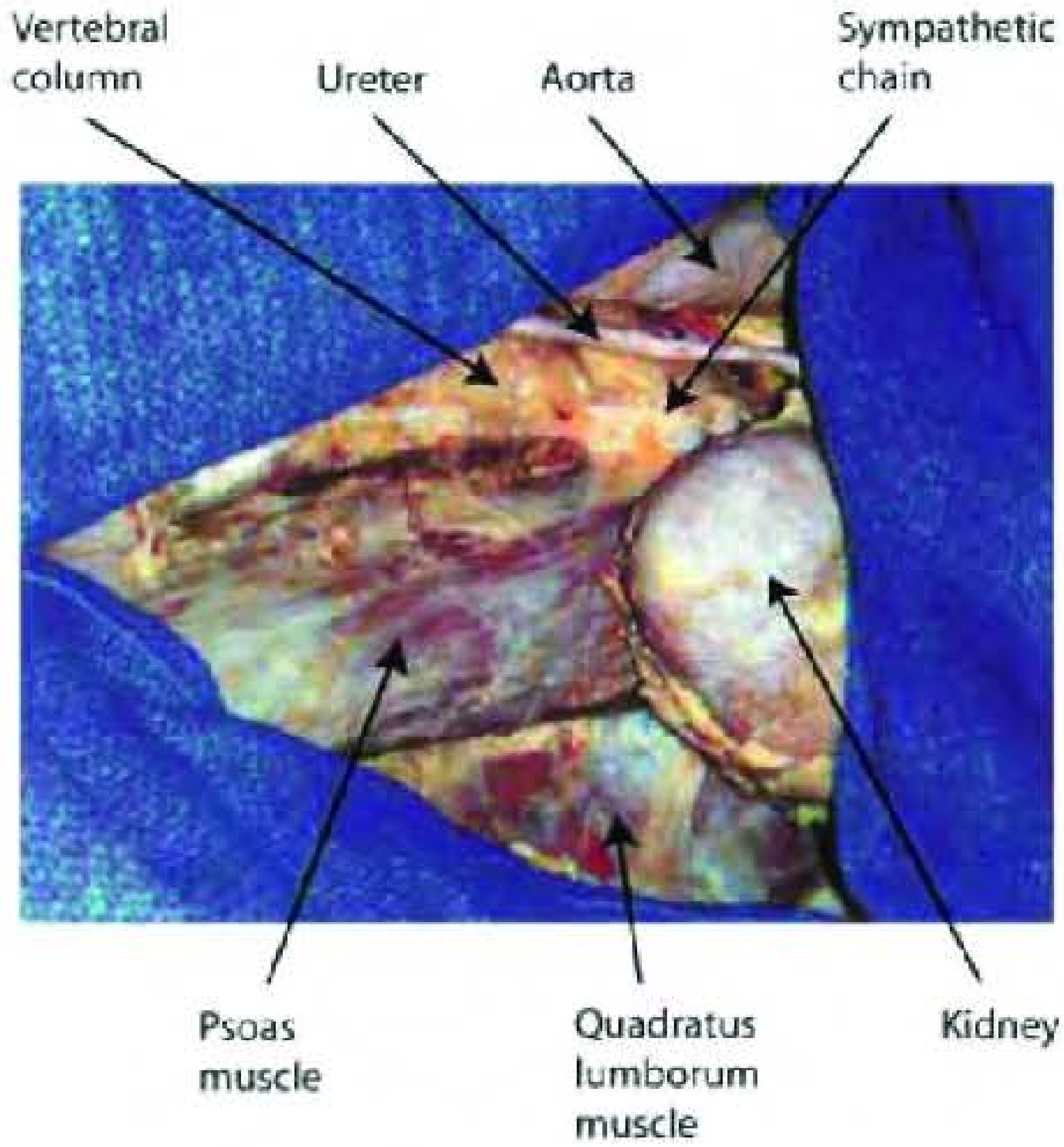

FIGURE 30–3 Further reflection of the peritoneum exposes the aorta anterior to the vertebral column as well as the ureter. The psoas muscle covers the lateral portion of the vertebral body.

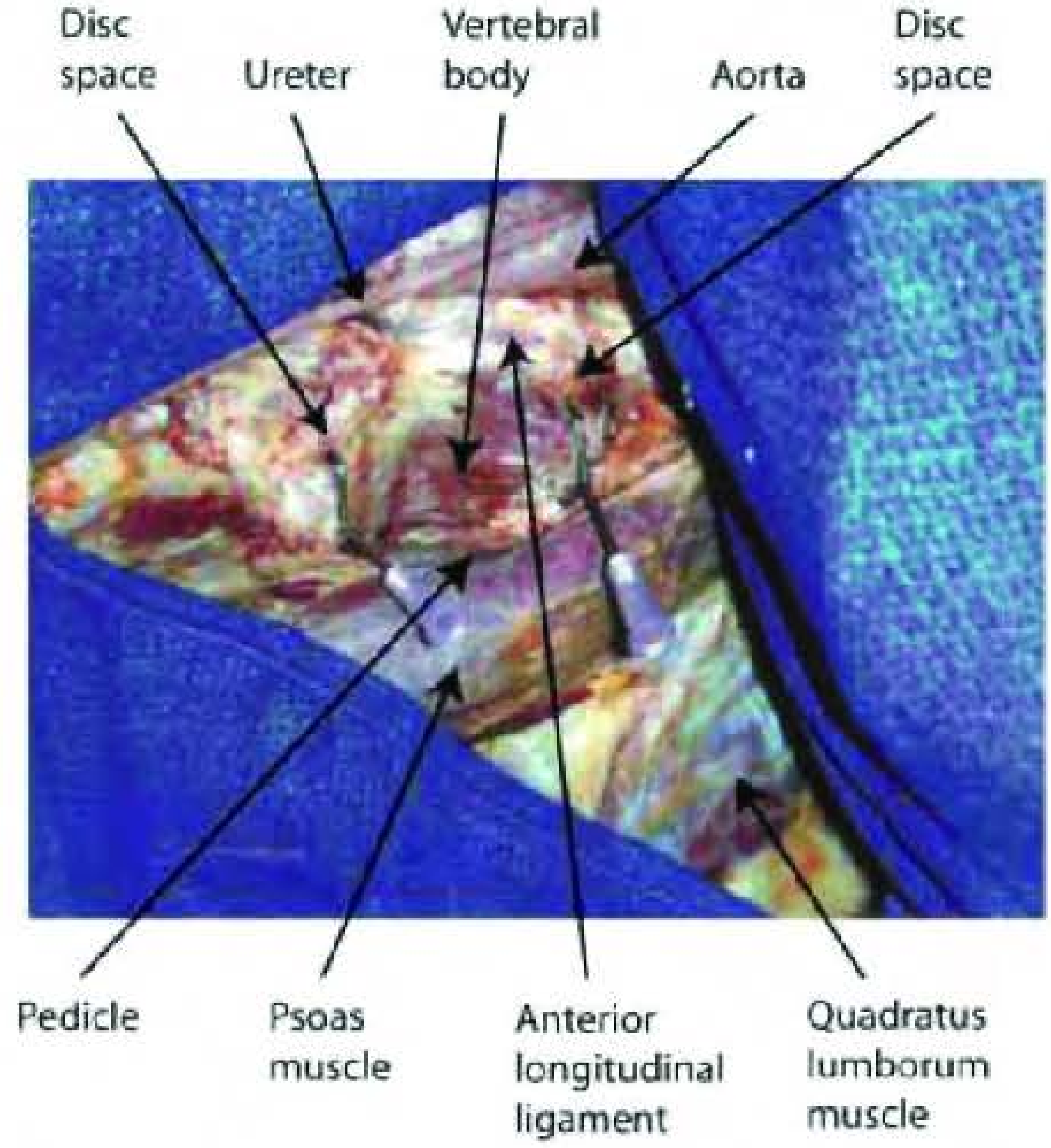

FIGURE 30–4 Lateral reflection of the psoas muscle allows visualization of the disc spaces and lateral surface of the vertebral bodies. Needles are placed in the disc spaces for radiographic verification of location. The aorta and ureter are anterior to the anterior longitudinal ligament.

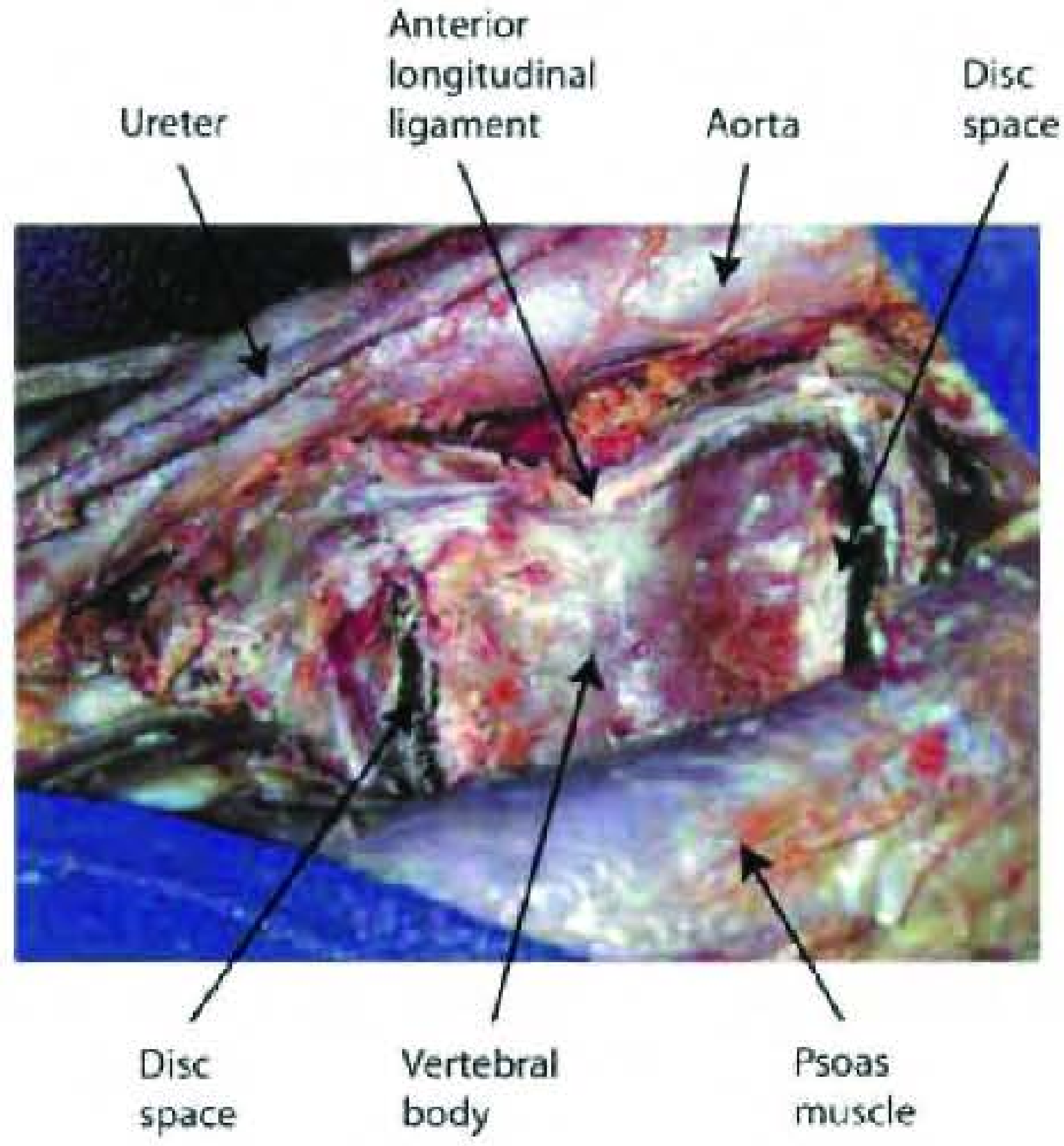

FIGURE 30–5 High-power view showing the aorta and ureter anterior to the anterior longitudinal ligament. The discs have been excised. The vertebral body is defined.

using a high-speed air drill (Fig. 30–6). The posterior longitudinal ligament is resected, and the lumbar dura and exiting nerve roots are exposed and decompressed (Fig. 30–7). After stabilization of the lumbar spine with a cage packed with bone graft and a plate, or strut grafts and a plate, the wound is closed in a multilayered fashion.

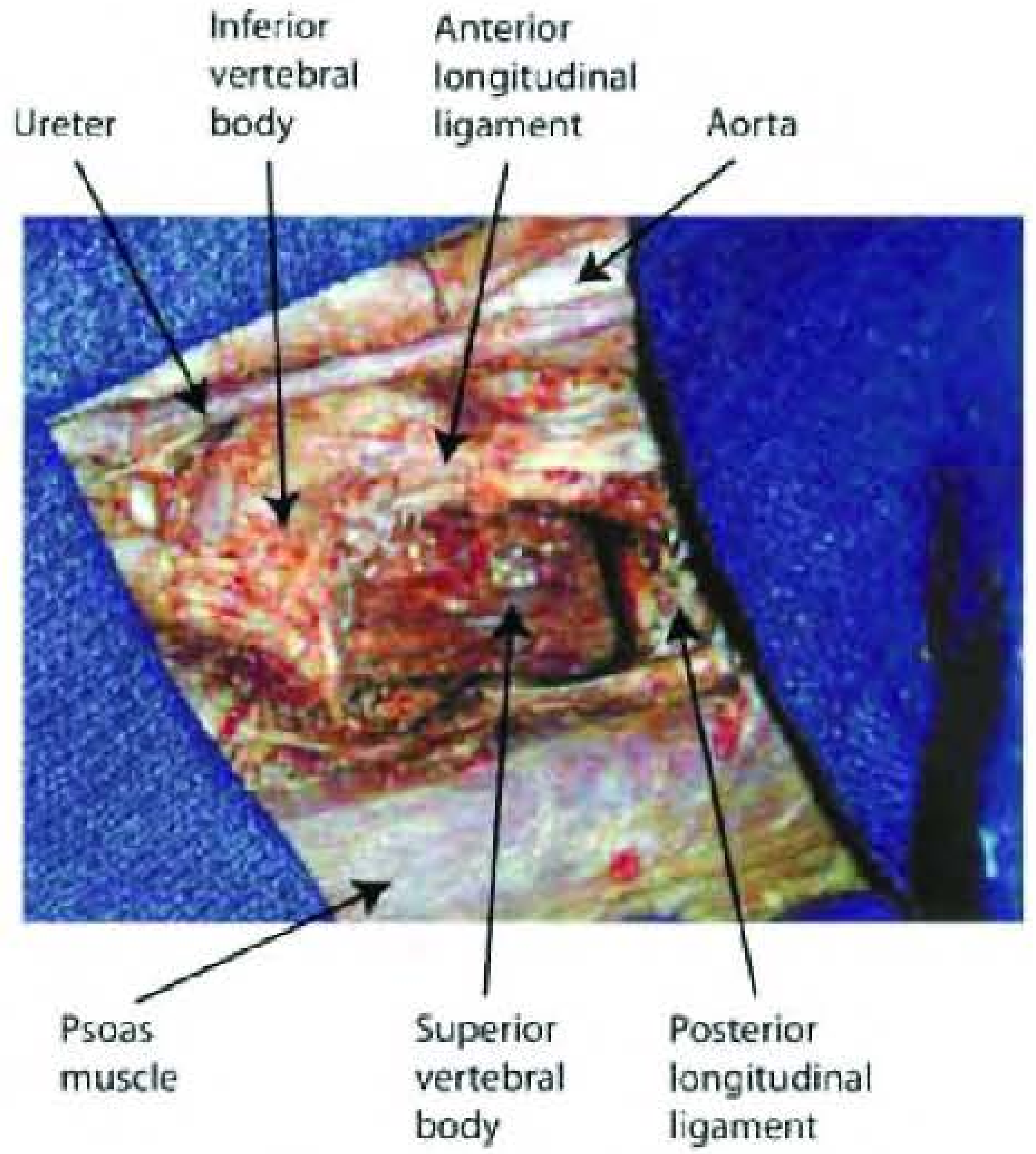

FIGURE 30–6 A vertebrectomy has been performed. The anterior and posterior longitudinal ligaments define the limits of the vertebrectomy.

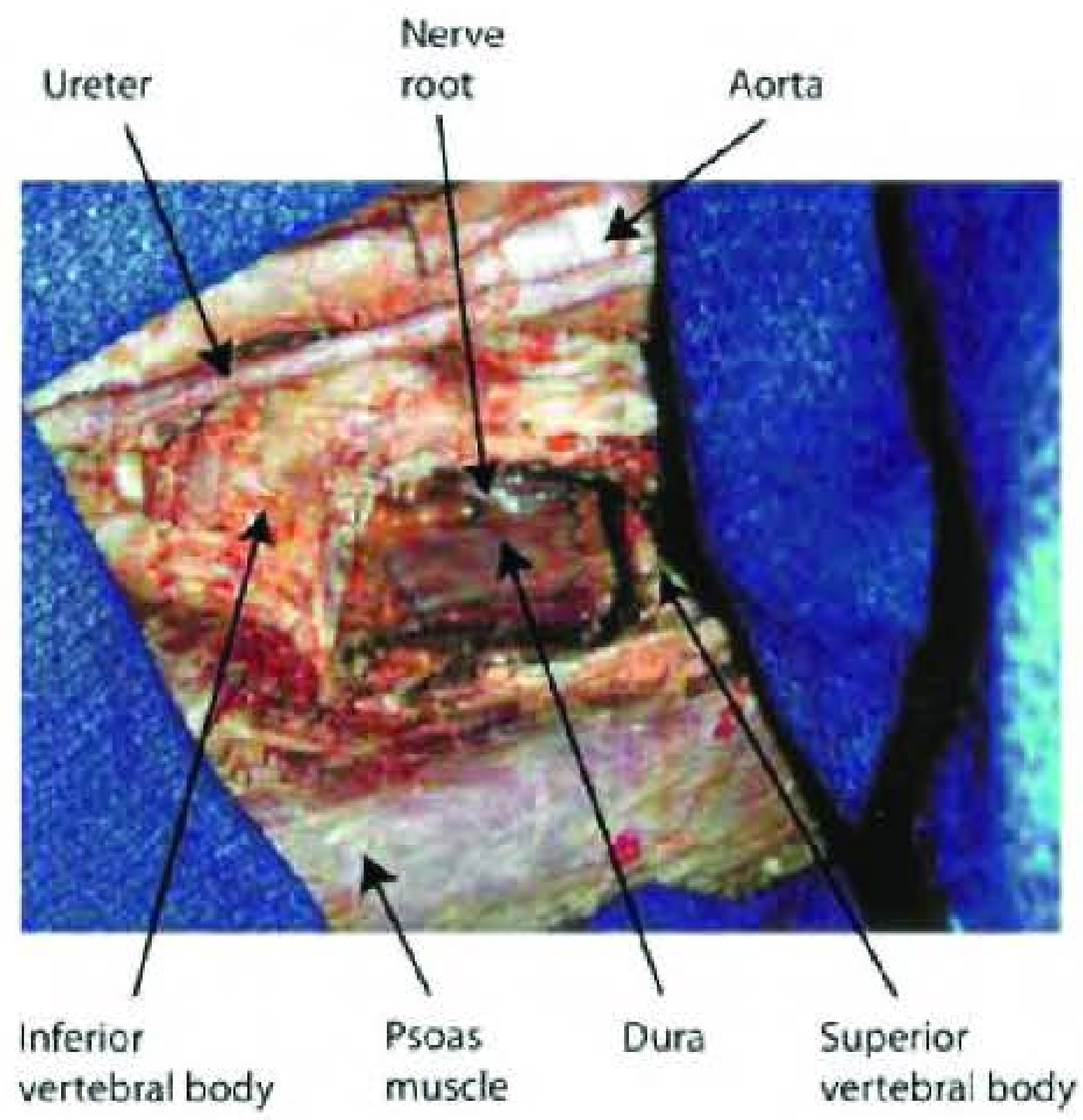

FIGURE 30–7 The posterior longitudinal ligament has been resected, allowing visualization of the underlying dura and exiting the contralateral nerve root.

PITFALLS, PEARLS, CONSIDERATIONS

- Avoid injuries to the ureter by identifying it early and protecting it
- Ligate all segmental vessels
- Avoid entering the abdominal cavity
- Avoid putting holes in the diaphragm
- Confirm level radiographically
- Postoperative chest and abdominal radiographs are taken to look for free air or pneumothorax

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PART III

PERIPHERAL NERVE APPROACHES

CARPAL TUNNEL RELEASE

Ernest Senz, Matt Ammerman, Mark Grant, Damirez Fossett

INDICATIONS FOR APPROACH

- Compression syndromes of the median nerve at the wrist

ANATOMY

The median nerve, the must important nerve supplying the hand, is composed of a medial branch of the lateral cord of the brachial plexus and an external branch of the medial cord of the plexus. It is composed of roots from C6 to T1. The median nerve innervates the flexors of the thumb and first two fingers as well as the muscles of opposition of the thumb. It also provides sensory innervation to the thumb, index, and third fingers.

The median nerve travels in close association with the brachial artery along the medial aspect of the upper arm. It then courses laterally beneath the lacertus fibrosus in the antecubital fossa and dives deep between the two heads of the pronator teres muscle. Branches of the nerve supply the pronator teres muscle as well as the flexor carpi radialis and palmaris longus muscles. The nerve continues in the forearm, running deep to the flexor digitorum superficial is, which it also innervates, and passes beneath the flexor retinaculum in the carpal tunnel at the wrist. In the forearm, the median nerve gives rise to a large branch, the anterior interosseous nerve. This branch innervates the flexor digitorum profundus muscle of the index finger and the flexor pollicis longus muscle. At the carpal tunnel, the median nerve gives rise to a superficial palmar sensory branch, which innervates the proximal aspect of the palm. In the tunnel or just distal to it, the nerve also gives rise to the recurrent thenar branch. This motor branch innervates the opponens pollicis, the abductor pollicis brevis, and the flexor pollicis brevis muscle. In the palm, the median nerve divides into its distal terminal branches to provide innervation to the lumbricals and sensation to the first three digits.

POSITIONING AND SKIN INCISION

The patient is placed supine on the operating room table. A right-handed surgeon should sit above the arm, facing the patient's feet, to operate on the left hand and in the axilla, facing the patient's head, to operate on the right hand.

Many variations exist for the skin incision. Two standard incisions include a transverse incision at the wrist crease for use of a retinaculatome to transect the carpal ligament and a curvilinear vertical incision involving the palm of the hand and the wrist crease (Fig. 31–1A, B). Dual-slit incisions can be used for endoscopic approaches.

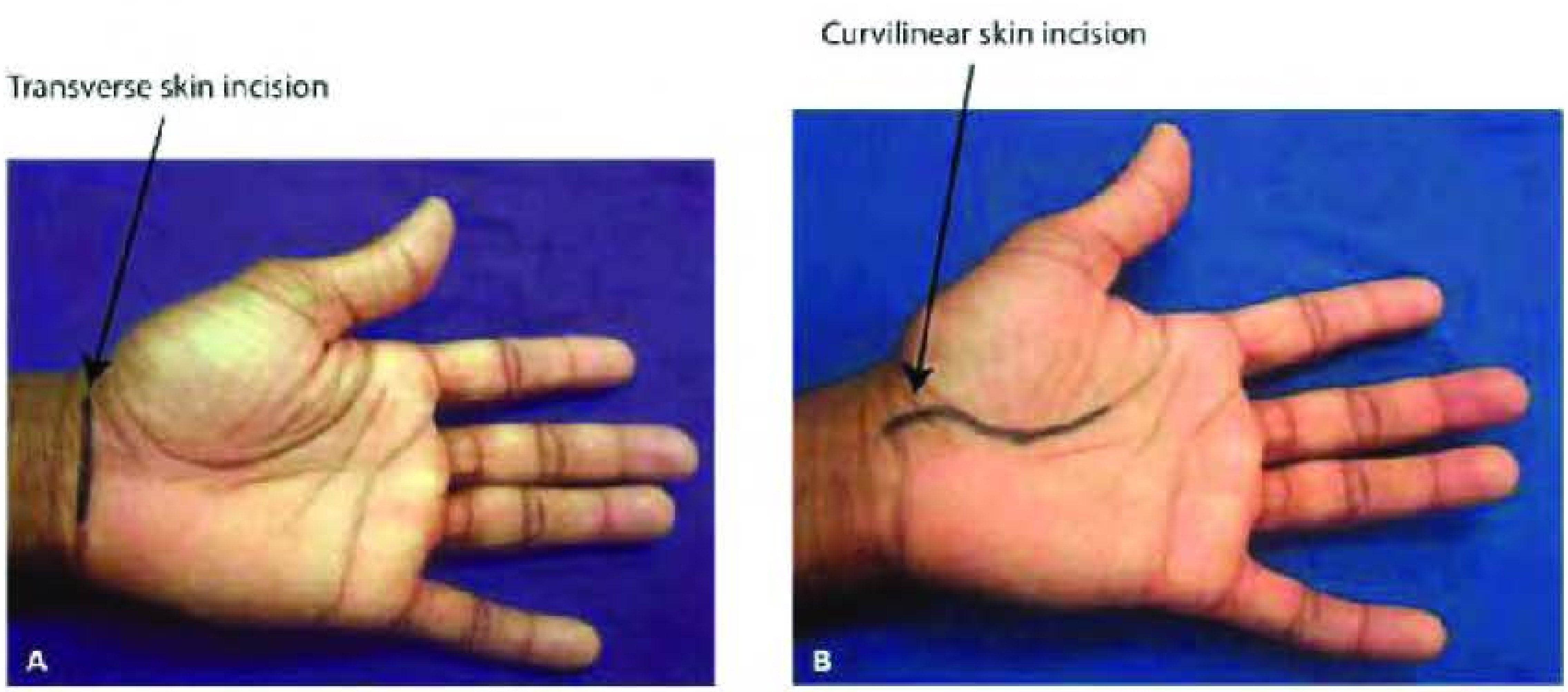

FIGURE 31–1 **A**: Transverse wrist incision. **B**: Curvilinear palmar incision.

The curvilinear incision begins just to the ulnar side of the interthenar crease. This usually corresponds to an imaginary line running between the middle and ring fingers. The incision curves slightly at the wrist crease to improve exposure and may extend distally as high as a line even with the crotch of the thumb.

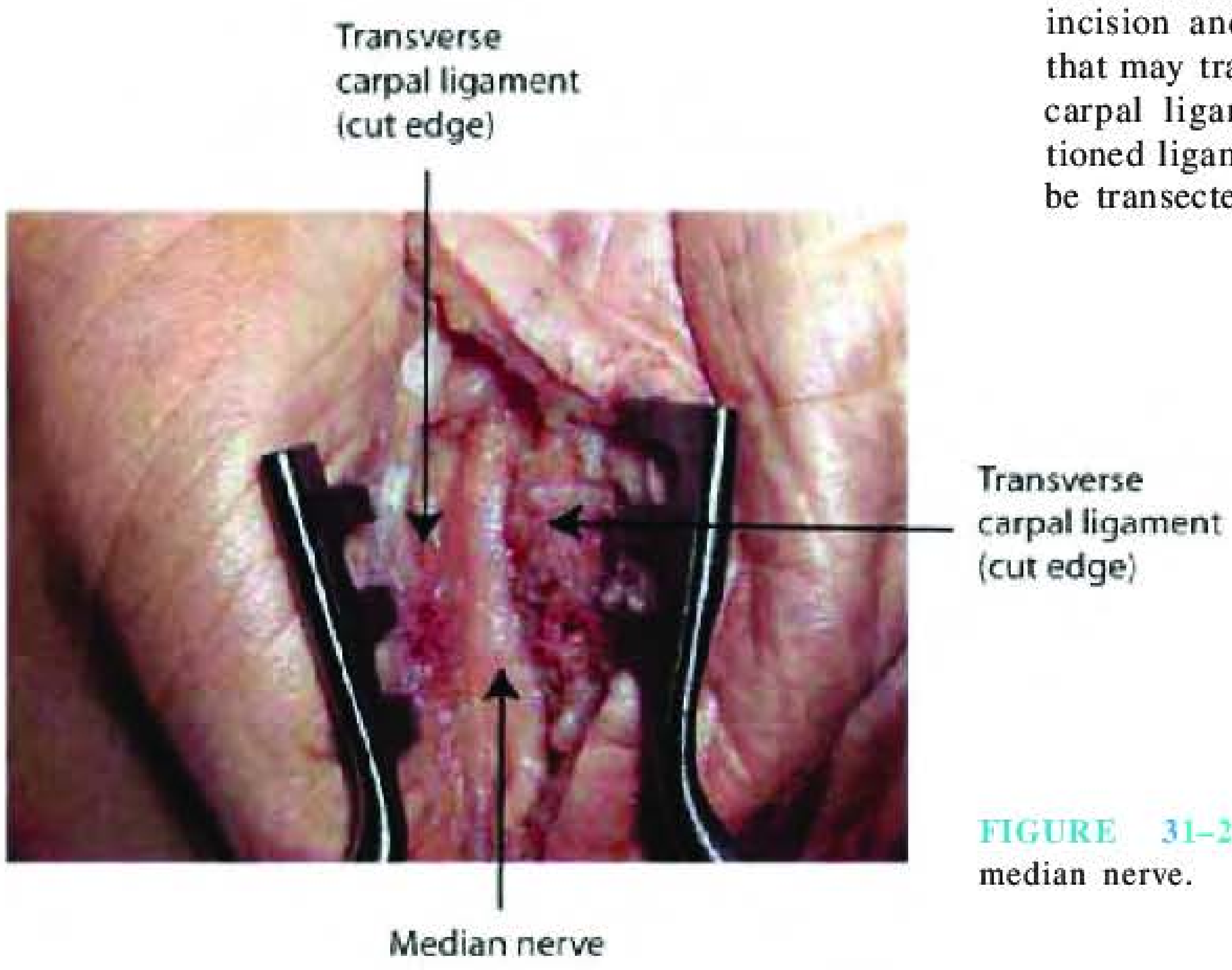

FIGURE 31–2 Section of the ligament reveals the underlying median nerve.

SURGICAL TECHNIQUE

The subcutaneous fat is spread, and the fibers of the palmaris longus tendon arc split. The transverse carpal ligament is identified and split with either a no. 15 blade or tenotomy scissors following the course of the nerve to ensure complete decompression (Fig. 31–2). Care should be taken to avoid the palmar cutaneous nerve during the skin incision and any motor branches from the median nerve that may traverse the carpal ligament. When the transverse carpal ligament is cut, fat may extrude through the sectioned ligament. The full extent of the carpal ligament must be transected distal into the midpalm.

PITFALLS, PEARLS, CONSIDERATIONS

- Avoid the palmar cutaneous nerve during skin incision
- Identify and avoid sectioning aberrant motor brandies of the median nerve when transecting the ligament
- Do not cross the wrist crease with the incision; hypertrophic scarring may recreate carpal tunnel syndrome
- Avoid direct trauma to the median nerve
- Hematoma formation at the wound site is a source for postoperative pain
- Cut the whole ligament
- Be sure the diagnosis is correct

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Chapter 32

RADIAL NERVE DECOMPRESSION

Ernest Senz, Matt Ammerman, Damirez Fossett

INDICATIONS FOR APPROACH

- Radial nerve entrapment syndromes

ANATOMY

The radial nerve, composed of components of the C5 through T1 nerve roots, is the major extensor nerve of the upper extremity. It innervates the extensor muscles of the forearm, hand, and digits. The radial nerve is a direct continuation of the posterior cord of the brachial plexus. Before leaving the axilla, it gives rise to the posterior brachial cutaneous nerves and to the motor brandies to the long and medial heads of the triceps brachii muscle. It then spirals around the humerus in association with the profunda artery and courses distally in the radial groove beneath the triceps. Along this segment, it innervates the triceps muscle and gives off several other cutaneous branches. It pierces the lateral intermuscular septum proximal to the elbow and courses beneath, while innervating the medial edge of the brachioradialis muscle.

After crossing the elbow joint, the nerve sends branches to the extensor carpi radialis longus and brevis muscles before dividing into the superficial radial branch and a deep interosseous branch. The superficial radial nerve continues beneath the brachioradialis muscle becomes superficial to cross the wrist in the anatomic snuffbox and provides sensory innervation to the dorsum of the hand. The deep interosseous branch dives deep through the supinator muscle while innervating it, passes around the radius, and then divides into motor branches that supply the extensor digitorum: the extensor digiti quinti proprius, the extensor carpi ulnaris, the abductor pollicis longus, the extensor poilicis longus, the extensor pollicis brevis, and the extensor indicis proprius muscles.

POSITIONING AND SKIN INCISION

The patient is positioned supine with the arm outstretched, A curvilinear incision is made, beginning 8 cm above the flexor crease of the elbow at the anterolateral aspect of the upper arm (Fig. 32–1). It extends across the flexor crease approximately 10 cm down the mid upper forearm.

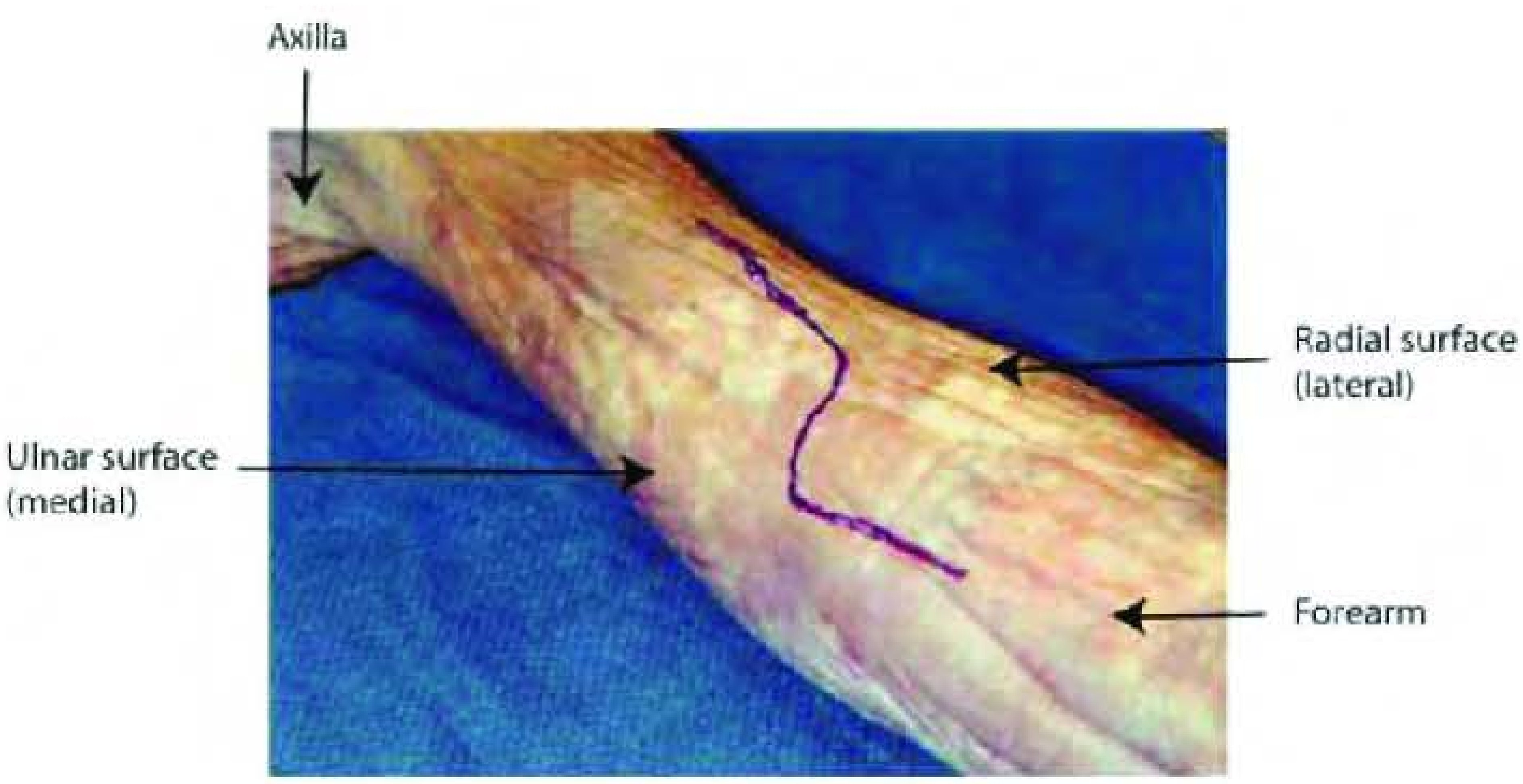

FIGURE 32–1 The curvilinear incision begins anterolateral in the distal upper arm and extends 10 cm down the middle upper forearm.

SURGICAL TECHNIQUE

The radial nerve is isolated in the distal upper arm by developing a plane between the lateral surface of the biceps and brachialis muscles and the proximal brachioradialis muscle (Fig. 32–2). It then is followed into the forearm, where it branches into a superficial sensory branch and the posterior interosseous nerve (Fig. 32–3). The nerve passes beneath the fibrous arcade of Frohse, which is the usual site of entrapment. The arcade is sectioned to free the nerve.

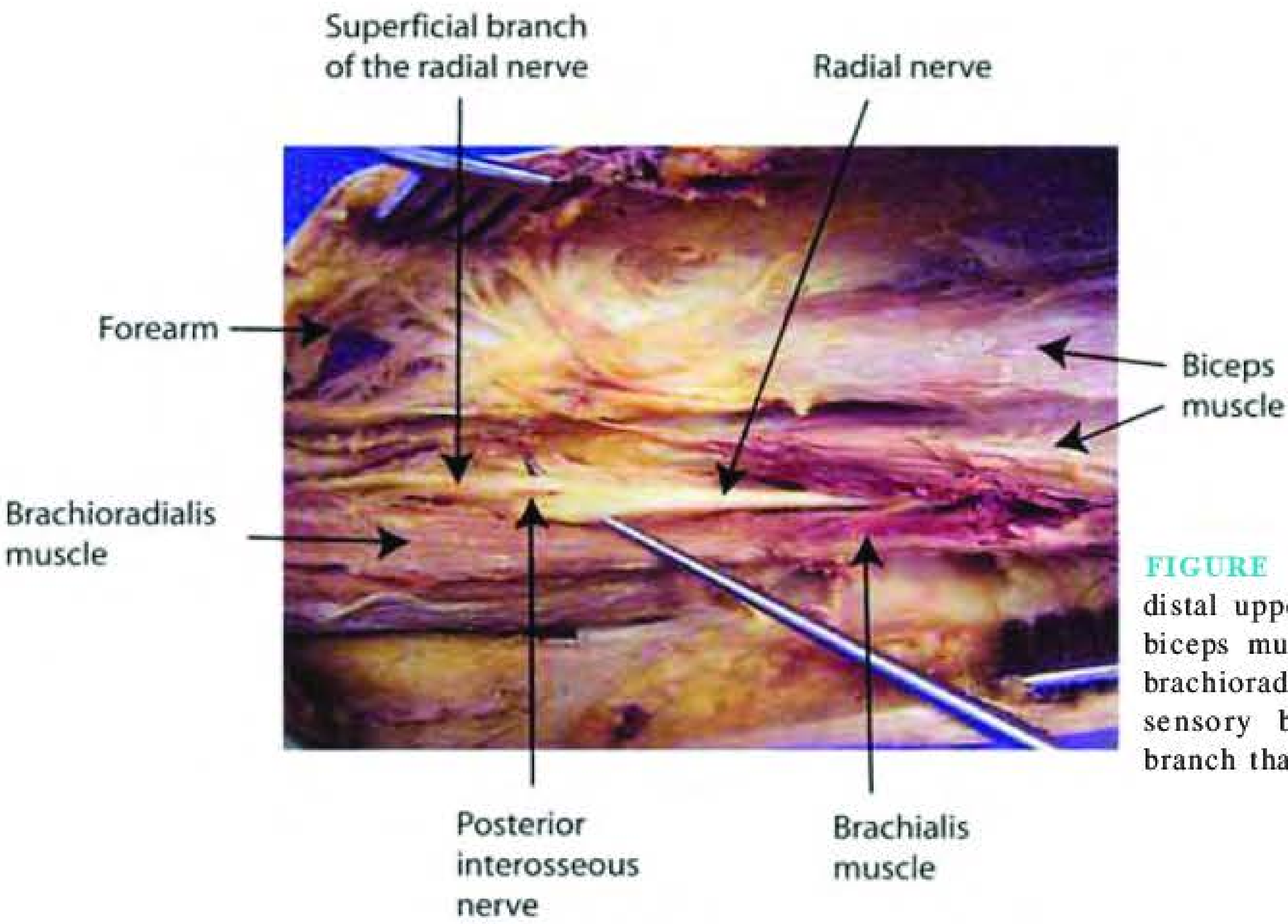

FIGURE 32–2 The radial nerve is exposed in the distal upper arm between the lateral surface of the biceps muscle and medial surface of the proximal brachioradialis muscle. it branches into a superficial sensory branch, and the posterior interosseus branch that dives beneath the arcade of Frohse.

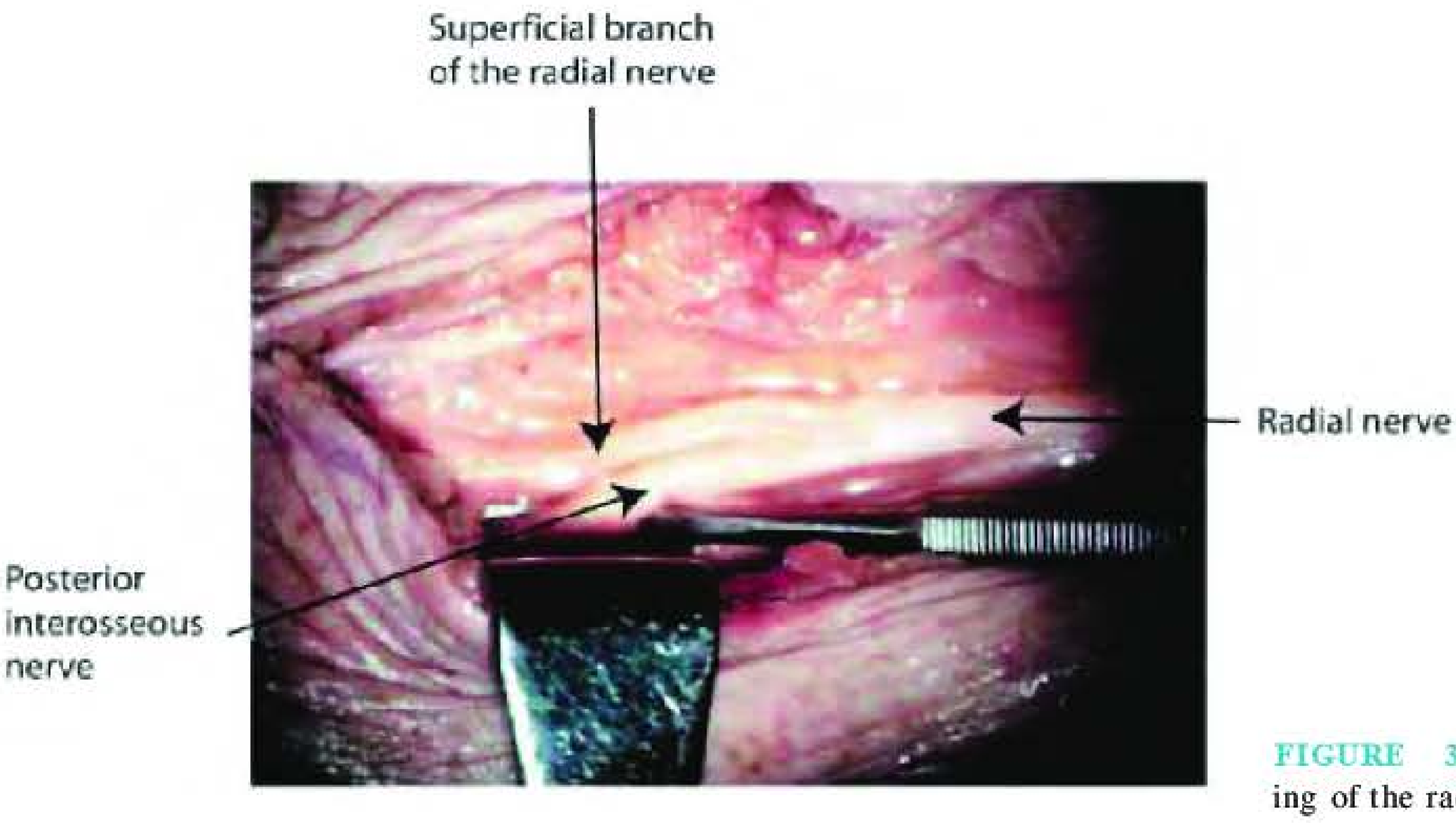

FIGURE 32–3 High-power view of the branching of the radial nerve.

PITFALLS, PEARLS, CONSIDERATIONS

- Recurrent radial artery and veins may be injured
- Lipomas, gangliomas, and other lesions may cause compression

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Chapter 33

Ulnar Nerve Decompression and Transposition

Ernest Senz, Matt Ammerman, Damirez Fossett

Indications for Approach

- Ulnar nerve compression syndromes

Anatomy

The ulnar nerve is composed of components of the C8 and T1 nerve roots and arises from the medial portion of the medial cord of the brachial plexus. It provides the major motor innervation of the interosseous muscles of the hand and the flexor muscles of the wrist, the fourth and fifth digits. The nerve courses on the medial side of the upper arm lying dorsal to the median nerve, the brachial artery, and the intermuscular septum. At the elbow, it passes through the ulnar notch under the medial epicondyle and then dives between and innervates the two heads of the flexor carpi ulnaris muscle. In the forearm, it runs between the flexor carpi ulnaris. and the flexor digitorum profundus muscles just medial to the ulnar artery. It becomes superficial lying just deep to the tendon of the flexor carpi ulnar is muscle at the wrist and passes into the palm superficial to the flexor retinaculum but deep to the palmar carpal ligament and the palmaris brevis muscle in Guyon's canal. Proximal to the wrist, the ulnar nerve gives off the superficial palmar branch to provide sensation for the medial aspect of the palm. In the palm, the nerve divides into a superficial branch, which primarily provides sensory innervation to the medial aspect of the palm and the dorsum of the hand, and a deep branch, which innervates the palmar and dorsal interossei, the third and fourth lumbrieals, the adductor pollicis, and the abductor, flexor, and opponens digiti minimi muscles.

Positioning and Skin Incision

The patient is placed supine with the arm fully extended, abducted, and rotated and the hand supinated such that the ulnar surface of the arm is maximally visible. The hand may be taped to the operating table to help maintain the appropriate position.

Because the ulnar nerve may be trapped in two places, the location of the incision depends on the region of presumed entrapment. When entrapment is at the region of the elbow, a lazy omega-shaped incision is made beginning 6 cm proximal to the medial epicondyle in the median bicipital groove and extending to the border of the flexor carpi ulnaris muscle 5 cm distal to the epicondyle. The curvilinear portion of the incision should be carried anterior to the medial epicondyle to keep it away from the dorsal surface of the elbow (Fig. 33–1). When entrapment is at the wrist, a curvilinear incision is made at the wrist crease over the ulnar artery and carried into the palm of the hand.

FIGURE 33–1 Typically, a lazy omega incision is used to expose the ulnar nerve.

SURGICAL TECHNIQUE

ENTRAPMENT AT THE ELBOW

Entrapment at the elbow can be treated with simple decompression alone or with decompression with transposition. After the skin incision is fashioned and the deep fascial layer localized, the nerve can be identified by palpation. Incising the fascial layer allows the nerve to be followed as it travels through the cubital tunnel at the medial epicondyle (Fig. 33–2). The aponeurosis of the flexor carpi ulnaris is sectioned and the whole nerve exposed and lifted out of the cubital tunnel (Fig. 33–3). The aponeurosis then can be closed and the nerve left lying above it in the subcutaneous tissue.

If transposition is desired, the incision needs to be lengthened so that the nerve can be liberated from surrounding muscle and connective tissue (Fig. 33–4). The nerve can be placed subcutaneously, intramuscularly, or submuscularly (Fig. 33–5). The submuscular procedure

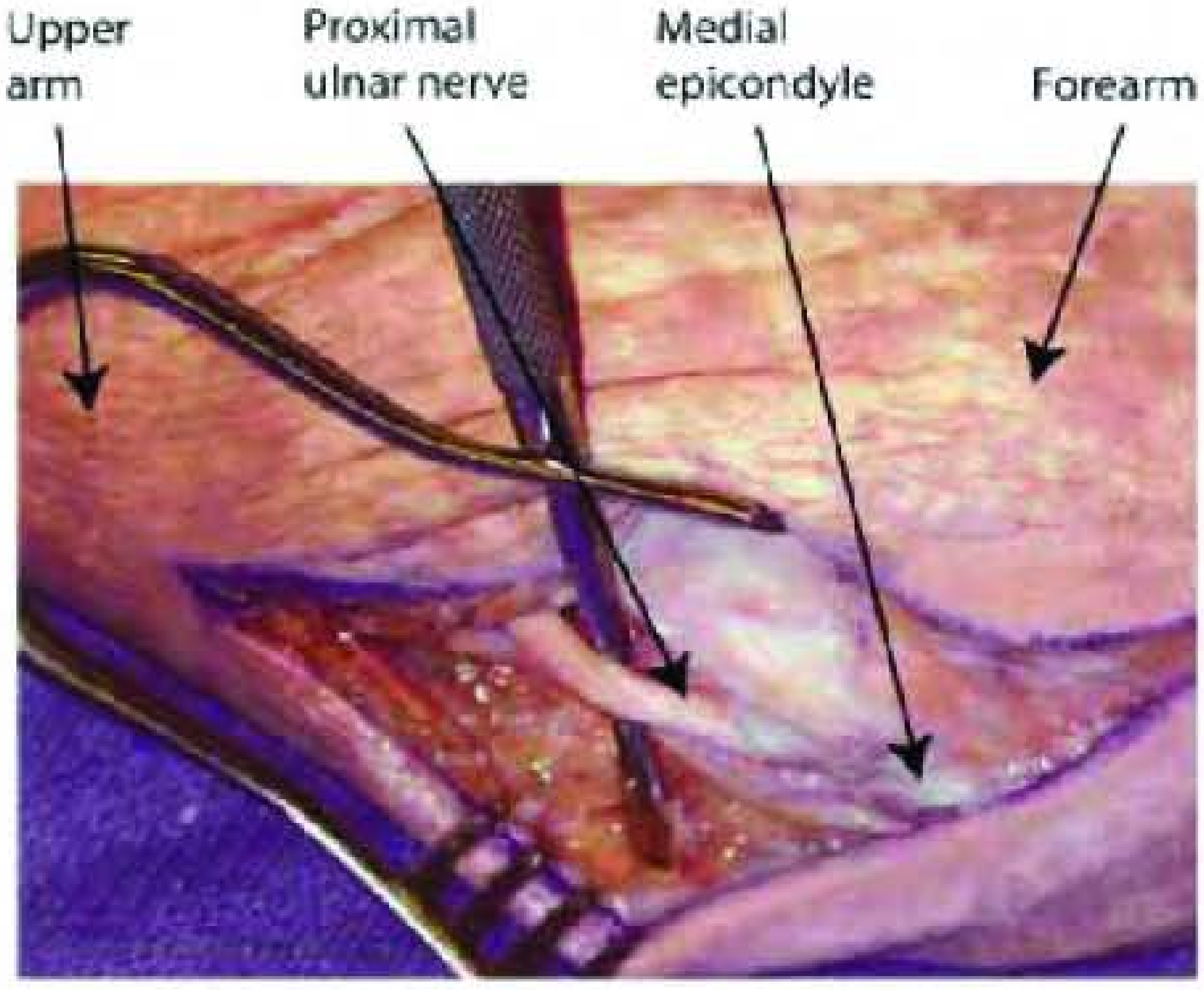

FIGURE 33–2 The ulnar nerve is identified just proximal to entering the ulnar groove.

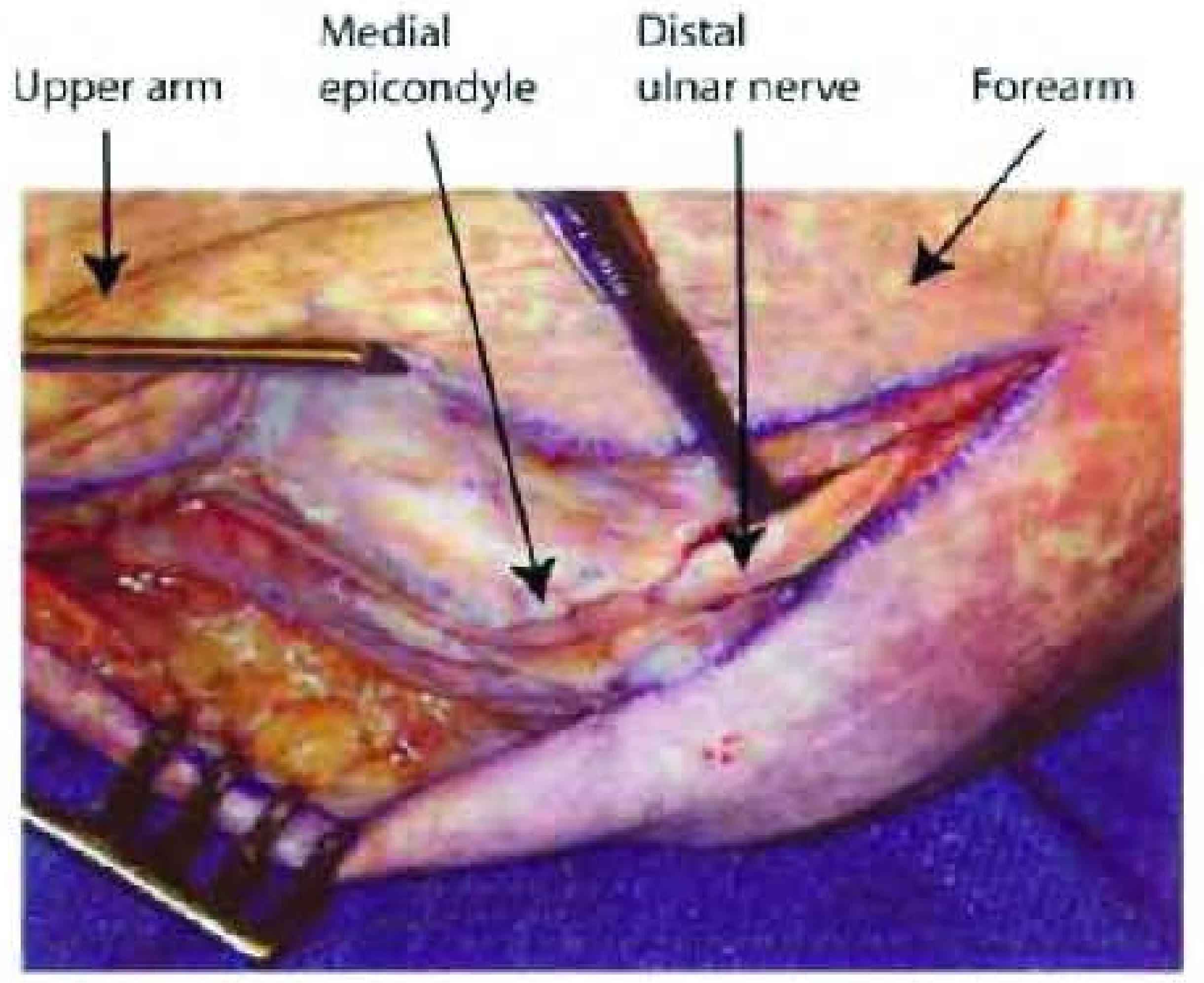

FIGURE 33–3 The medial epicondyle is visualized. The ulnar nerve is seen lying within the ulnar groove distally. The nerve is seen diving between the two heads of the flexor carpi ulnaris muscle.

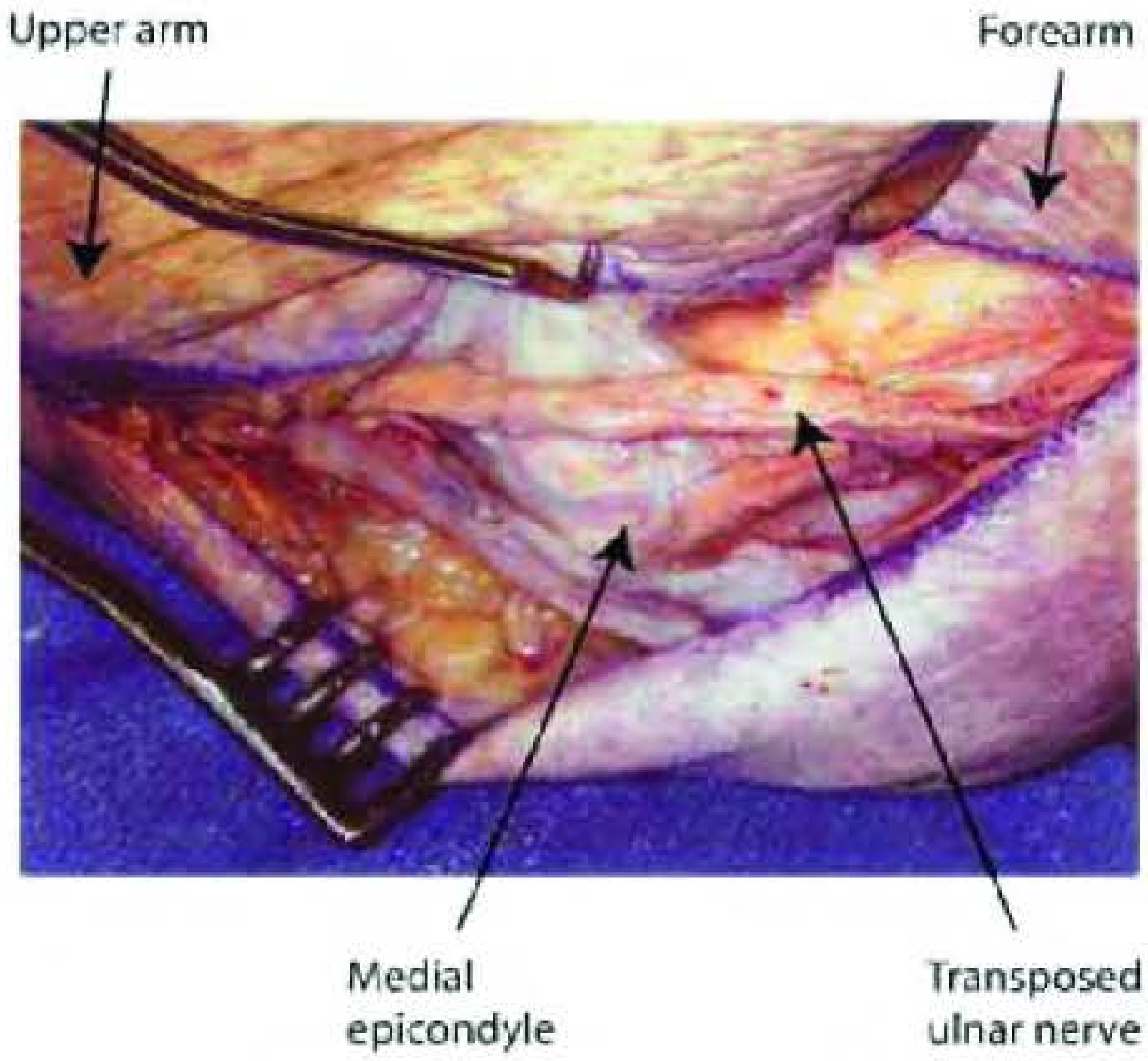

FIGURE 33–4 The nerve has been transposed out of the ulnar groove.

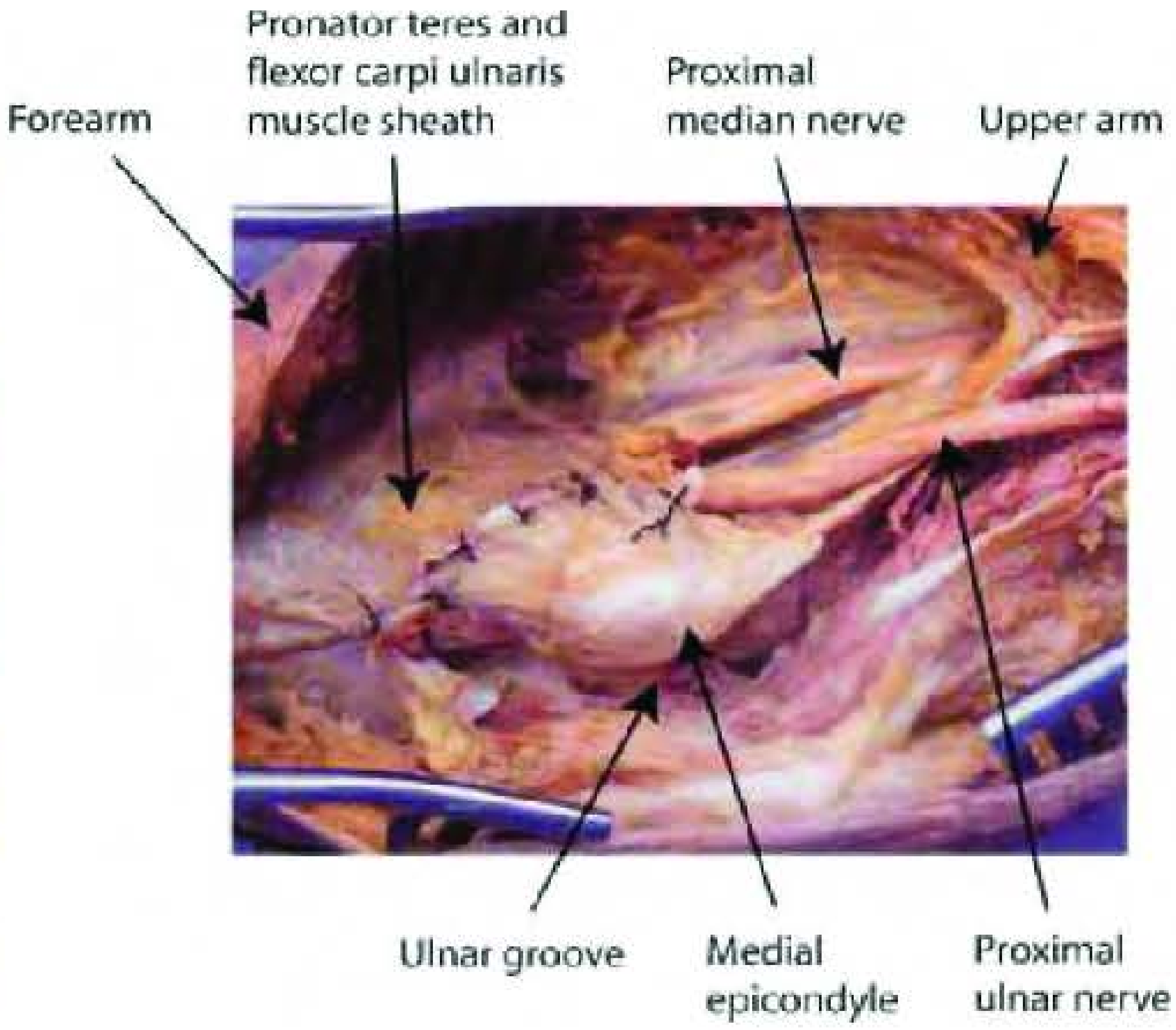

FIGURE 33–5 The nerve has been buried in a submuscular fashion next to the median nerve.

is described here. Proximally, one should identify the coracobrachialis muscle and distally, the two heads of the flexor carpi ulnaris muscle, and the pronator teres muscle. The pronator–flexor muscle mass is transected with a Z-shaped incision, and the medial intermuscular septum is sectioned. The ulnar nerve then is transposed to lie adjacent to the median nerve. The pronator–flexor muscle mass is repaired to hold the nerve in its transposed position.

ENTRAPMENT AT THE WRIST

The nerve is entrapped within Guyon's canal between the pisiform and hamate bones and the palmar fascia and flexor retinaculum of the palm. The tunnel is located more superficially than the transverse carpal ligament. Once the artery and nerve are identified, they can be followed into the tunnel, and any constricting bands can be sectioned (Figs. 33–6 and 33–7). Occasionally, a ganglion is found to be the compressive pathology at this level.

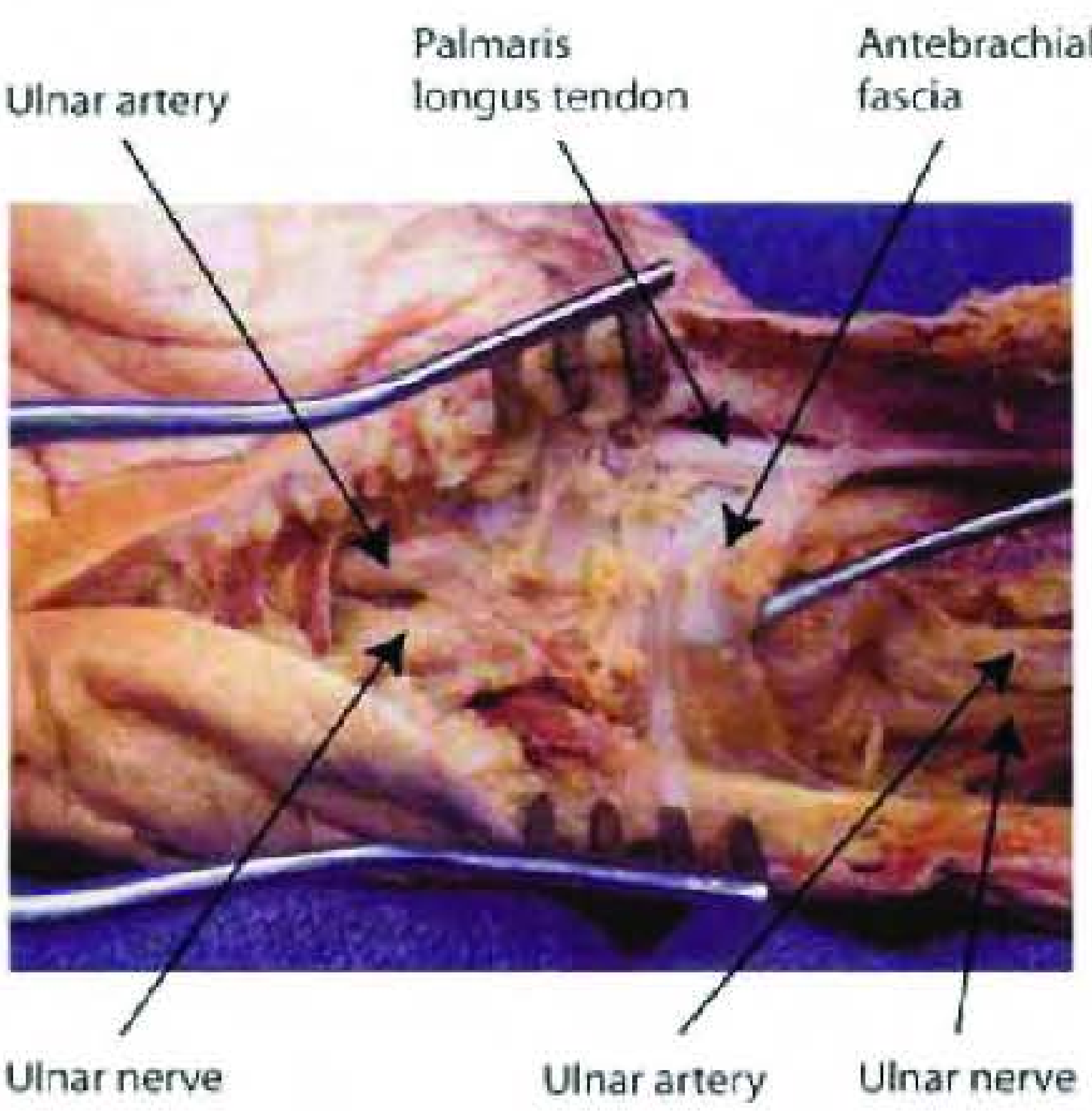

FIGURE 33–6 Distally, the ulnar nerve is seen passing beneath the fascial sheath at the wrist. The ulnar artery is seen medially.

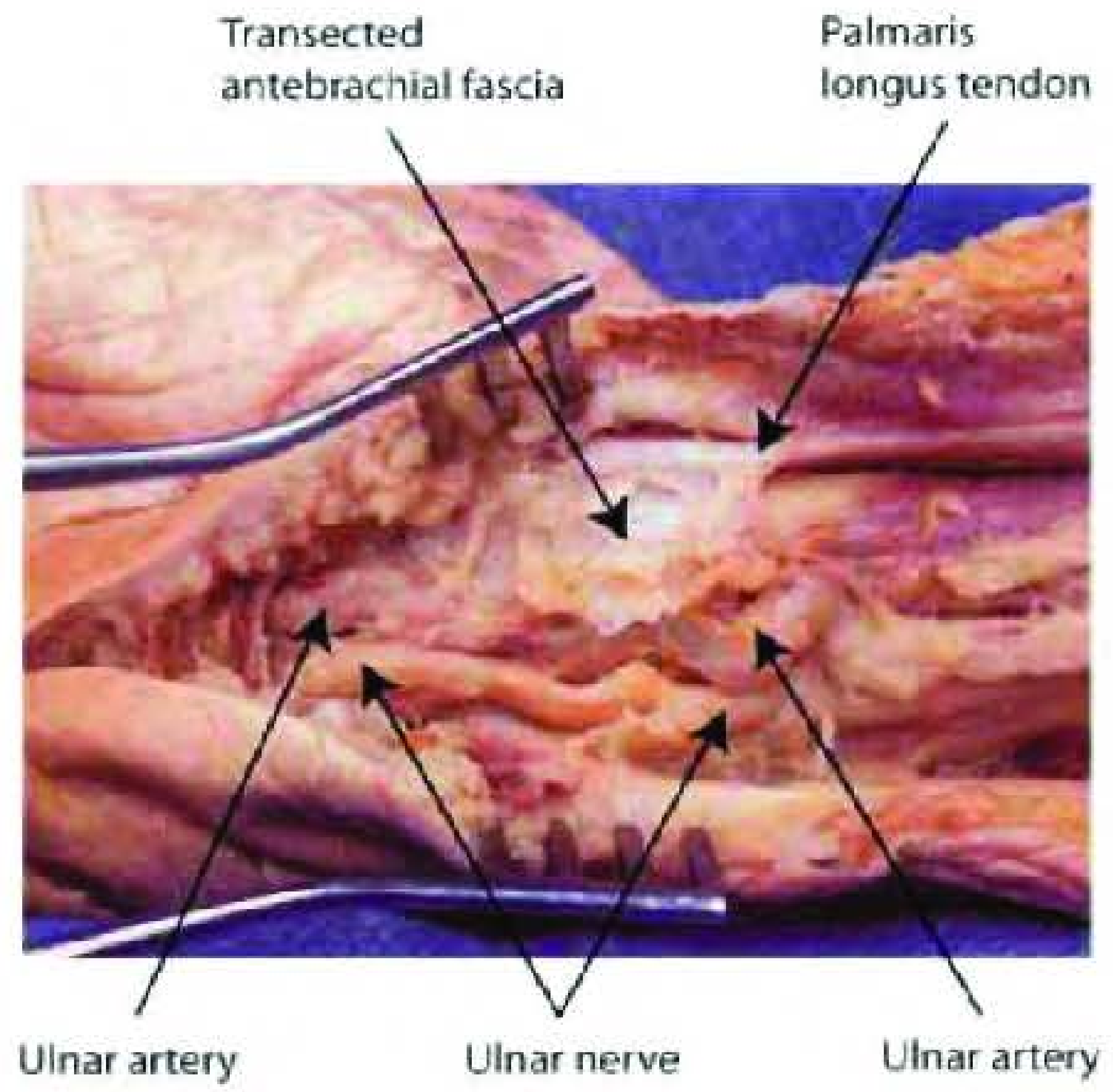

FIGURE 33–7 The fascia has been sectioned to liberate the ulnar nerve and artery at the wrist.

PITFALLS, PEARLS, CONSIDERATIONS

- Take care not to devascularize the nerve during transposition
- Make sure the nerve is, not kinked
- Subcutaneous placement may leave the nerve exposed to trauma
- Scar and fibrosis may occur with subcutaneous or intramuscular placement
- Watch for ulnar artery in the wrist

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Anterior Exposure of the Brachial Plexus

Ernest Senz, Emel Avci, Damirez Fossett

Indications for Approach

- Brachial plexus exploration
- Neurotization of the plexus elements
- Tumor resection
- Brachial plexus blunt or penetrating trauma

Anatomy

The brachial plexus is composed of components of me C5 through T1 nerve roots. These nerves are responsible for upper-extremity movement and sensation. The plexus is divided into roots, trunks, divisions, cords, and ends in individual nerves (Fig. 34–1).

The cervical roots exit the spinal canal through their respective neural foramen and travel between the anterior and middle scalene muscles (Fig. 34–2). The long thoracic nerve (C5 and C7), which supplies the serratus anterior muscle, and the dorsal scapular nerve (C5), which supplies the rhomboid muscles, arise from the plexus at the root level.

Three trunks are formed from the roots of the brachial plexus. The upper trunk is formed from the C5 and C6 roots, the middle trunk from the C7 root, and the lower trunk from the C8 and T1 roots. The supraclavicular nerve, which supplies the subclavius muscle, and the suprascapular nerve, which passes through the suprascapular notch to supply the supraspinatus and infraspinatus muscles, arises from the supraclavicular portion of the upper trunk.

Deep to the clavicle, each trunk splits into anterior and posterior divisions. No individual nerves arise at the level of

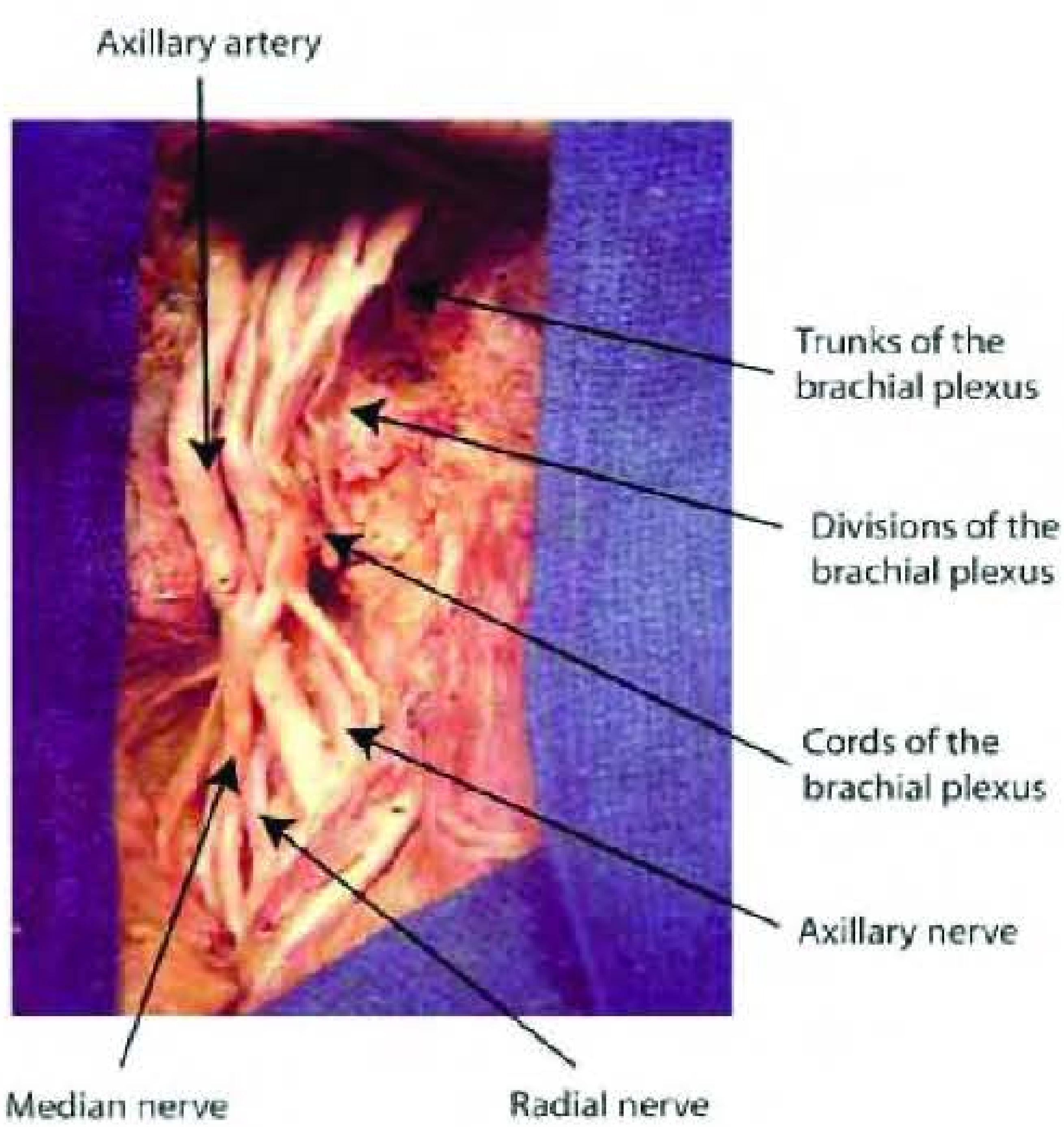

FIGURE 34–1 Panoramic view of the anatomy of the left brachial plexus. The clavicle has been resected.

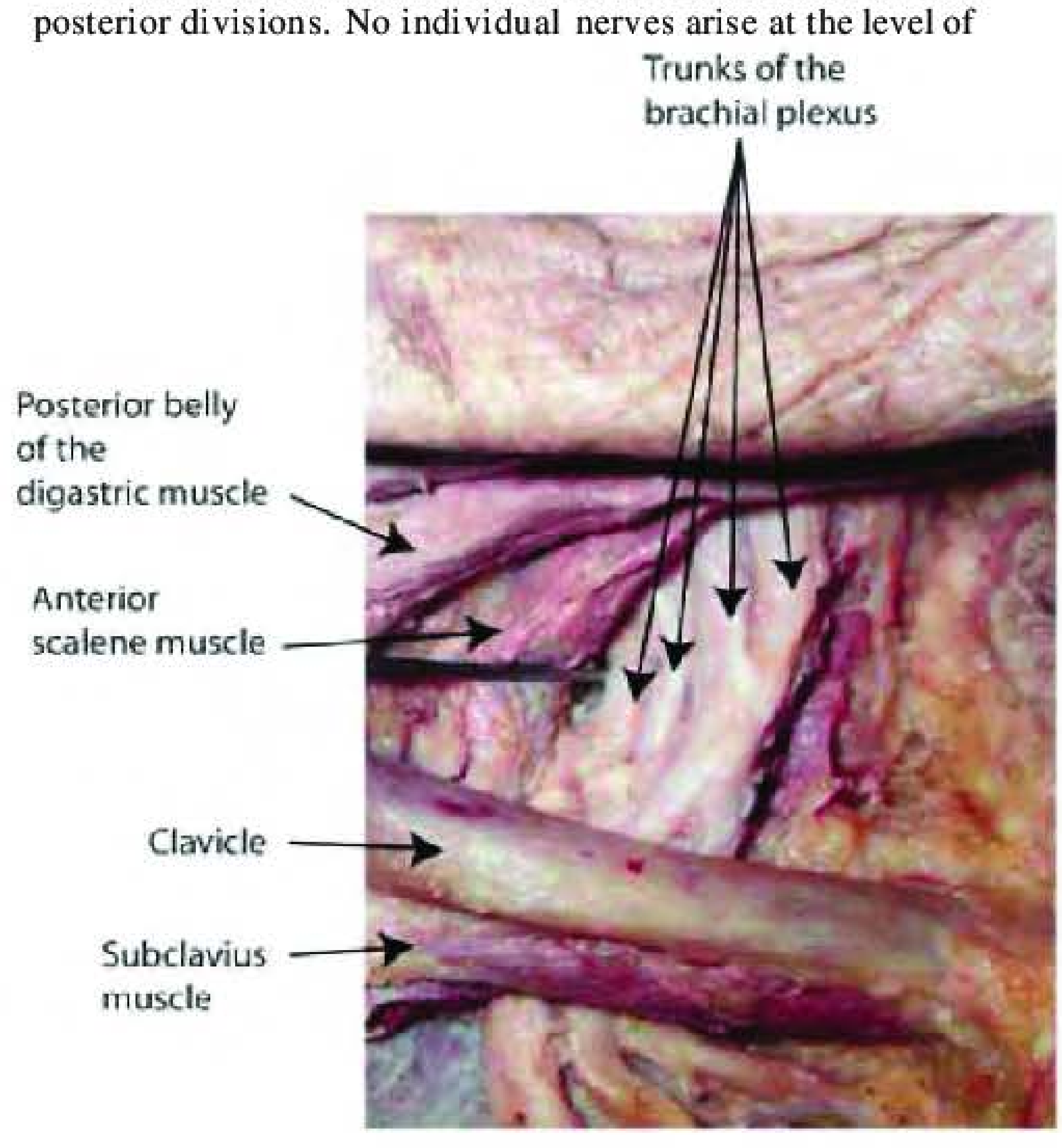

FIGURE 34–2 The cervical nerve roots exit through their neural foramen and unite to form the trunks of the brachial plexus.

the divisions. Lying just lateral to the axillary artery, the plexus passes deep to the pectoralis minor muscle and superficial to the subscapulars and teres major muscles. The divisions unite infraclavicularly to form cords named for their anatomic relationship to the axillary artery (Fig. 34–3).

The anterior divisions of the upper and middle trunks unite to form the lateral cord. The anterior division of the lower trunk continues as the medial cord, and the three posterior divisions unite to form the posterior cord. Aside from the portions of the medial and lateral cords that unite to form the median nerve, all branches of the plexus at the cord level are terminal nerves.

The lateral cord gives rise to the lateral pectoral nerve, which supplies the pectoralis major muscles, and the musculocutaneous nerve, which travels distally through the coracobrachialis muscle to supply it as well as the brachialis and biceps muscle, A branch from the lateral cord is joined by a branch from the medial cord to form the median nerve. The medial cord, in addition to its contribution to the median nerve, also gives rise to the ulnar nerve; the medial pectoral nerve, which supplies the pectoralis major and minor muscles; and the medial brachial and antebrachial cutaneous nerves, which provide sensory innervation to the forearm and arm. The posterior cord gives rise to the upper and lower subscapular nerves, which penetrate and innervate the subscapularis and teres major muscles; the thoracodorsal nerve, which innervates the latissimus dorsi muscle; the axillary nerve, which passes laterally and posteriorly through the quadrilateral space and gives off branches to the shoulder joint and the teres minor, as well as major branches to the deltoid muscle and skin of the shoulder. The posterior cord then continues as the radial nerve.

POSITIONING AND SKIN INCISION

The patient is positioned supine on the operating table with the head rotated slightly toward the contra lateral side. A lazy-S–shaped incision is made that begins about 7 cm above the clavicle, follows the posterior border of the sternocleidomastoid muscle, and then turns laterally to head toward the junction of the lateral and medial third of the clavicle. For further exposure, the incision may be carried distally and laterally along the deltopectoral groove toward the axilla (Fig. 34–4).

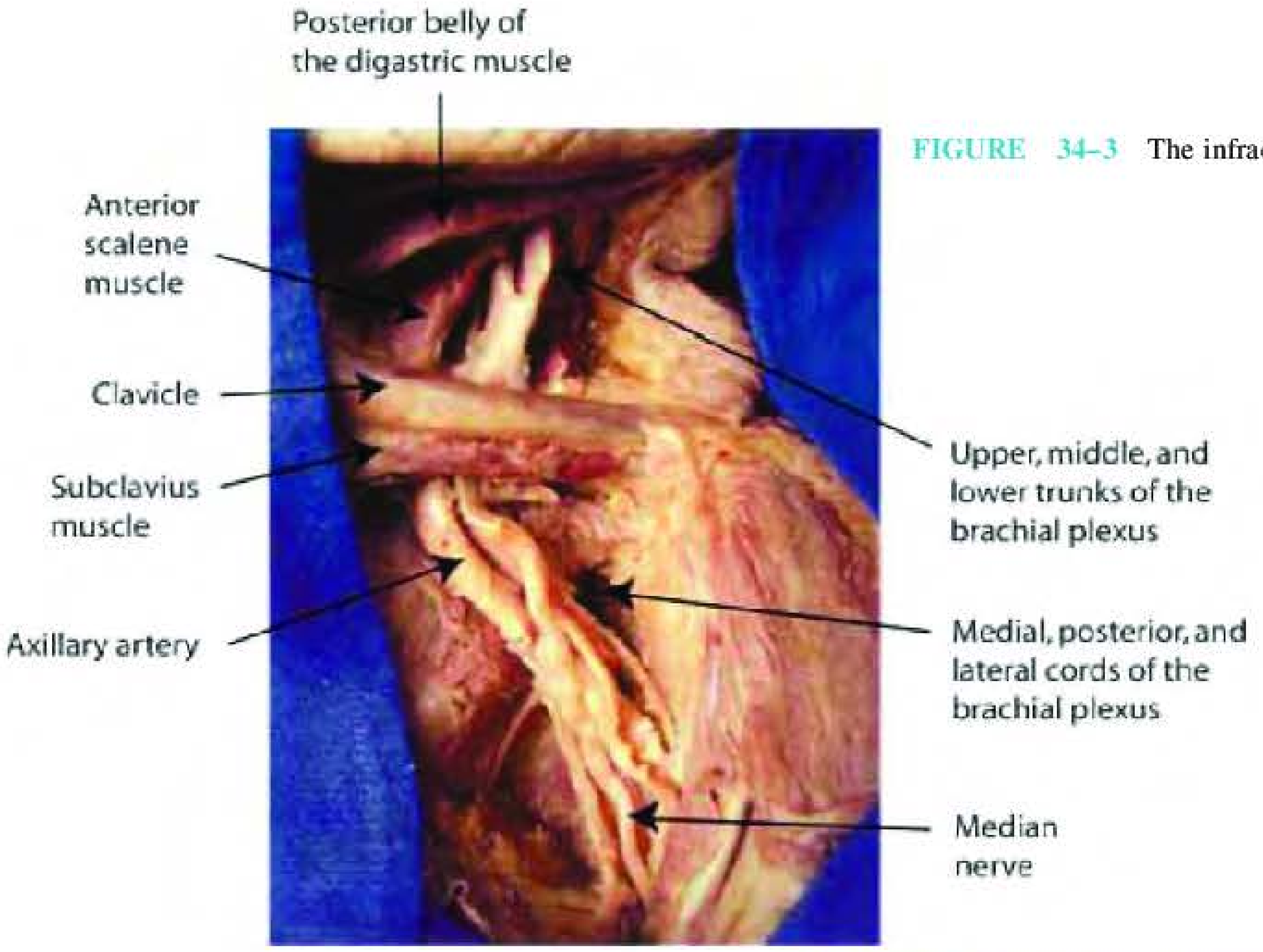

FIGURE 34–3 The infraclavicular brachial plexus is demonstrated.

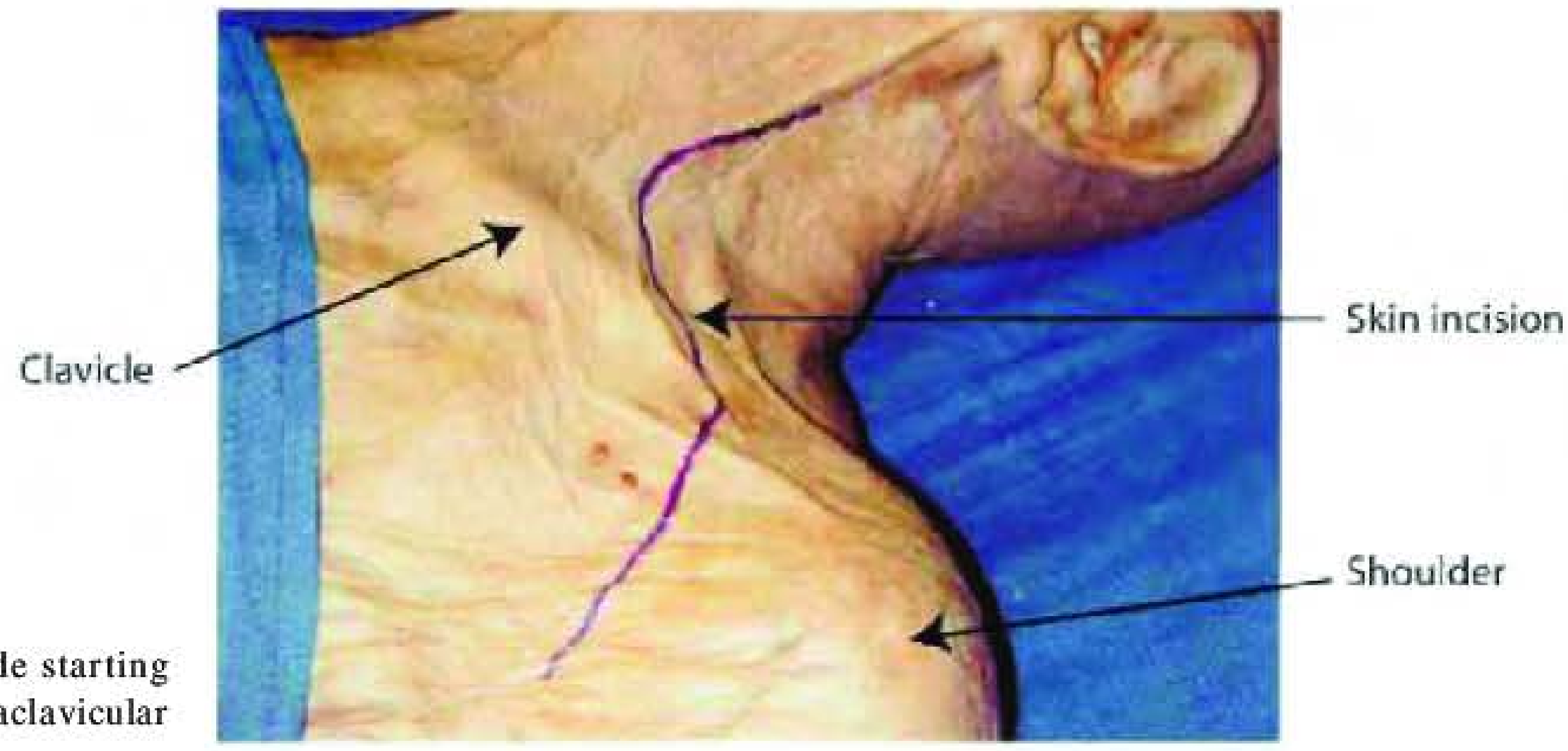

FIGURE 34–4 A curvilinear incision is made starting in the cervical region and extending to the infraclavicular region.

SURGICAL TECHNIQUE

The platysma muscle is divided in the direction of its fibers. Directly deep to the platysma are fibers of the cervical plesus running toward the clavicle. The external jugular vein should be identified and ligated. The omohyoid muscle is identified and dissected, and the deep cervical fascia is identified and opened to expose the anterior scalene muscle (Fig. 34–5). The brachial plexus will be identified between the anterior and middle scalene muscles, coursing in a direction toward the intervertebral foramina. Further exposure of the plexus may involve sectioning of the omohyoid, anterior, or middle scalene muscles (Fig. 34–6).

The periosteum of the clavicle is detached anteriorly and posteriorly, and the midportion of the clavicle is resected. Infraclavicular opening of the deltopectoral groove exposes the lower segments of the brachial plexus (Figs. 34–7 and 34–8). The tendon of the pectoralis minor

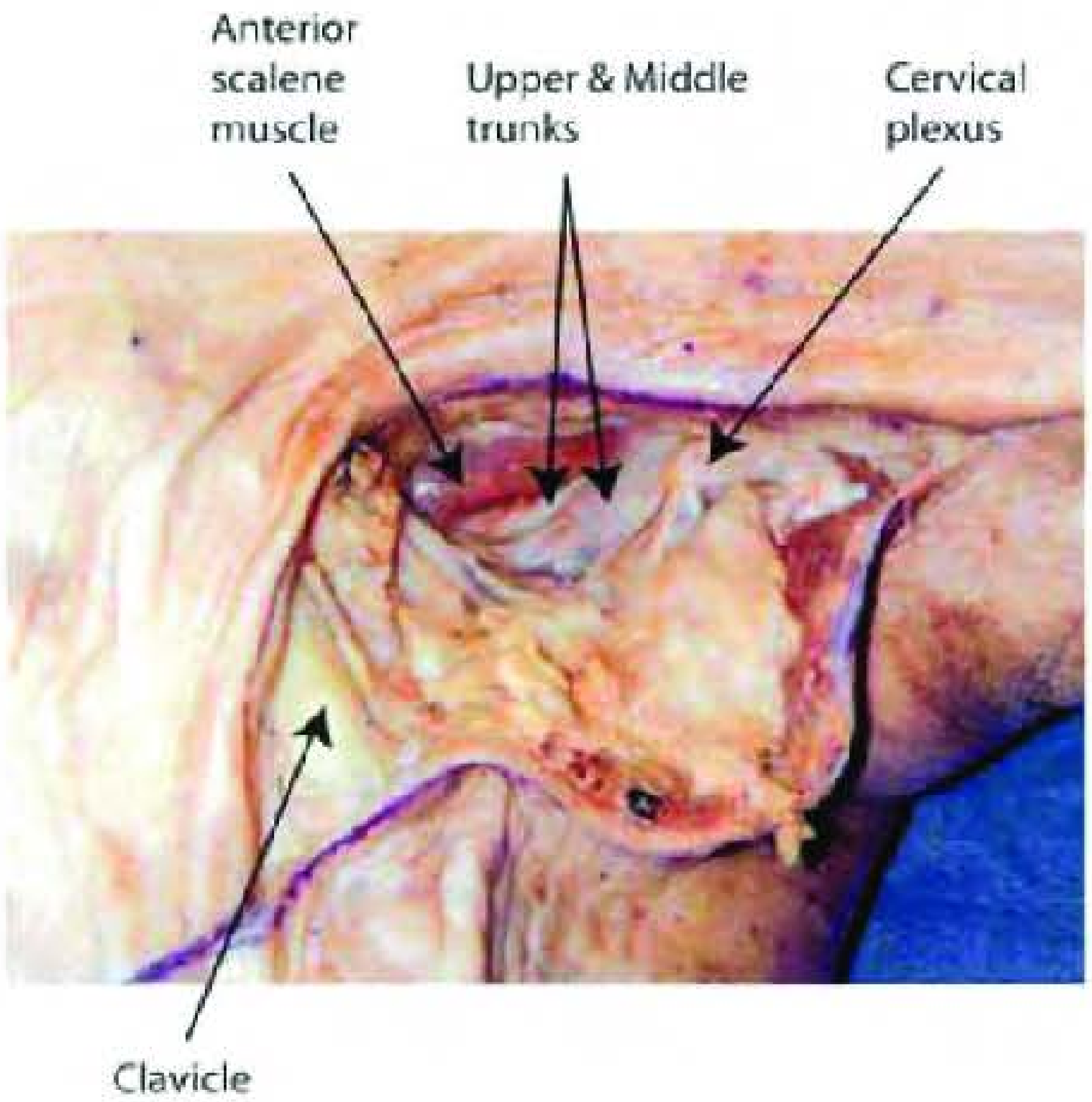

FIGURE 34–5 The clavicle and anterior scalene muscle are good landmarks. Roots of the cervical plexus as well as the upper and middle trunks of the brachial plexus are visualized.

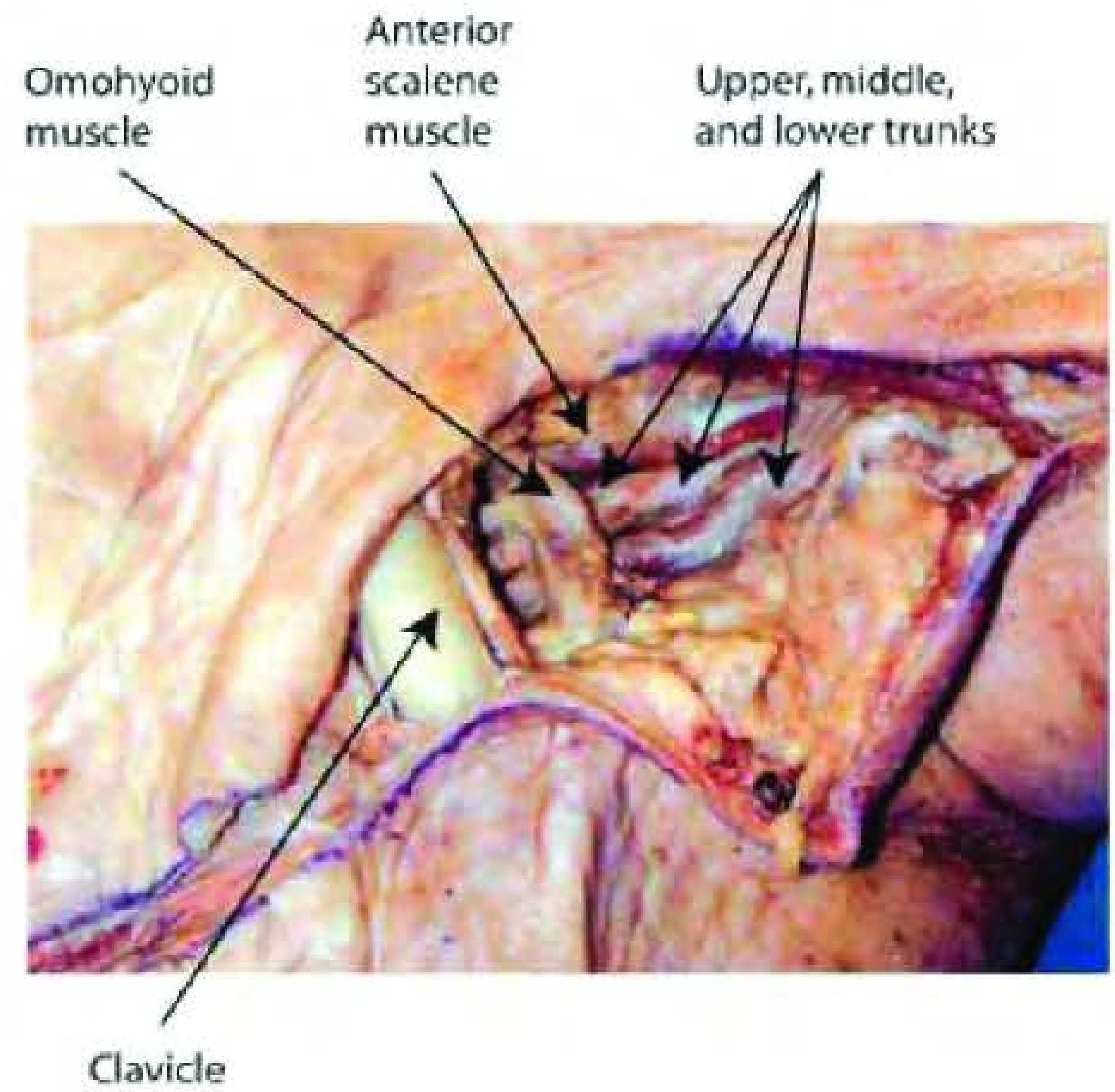

FIGURE 34–6 The omohyoid muscle is seen coursing above the brachial plexus. The upper, middle, and inferior trunks are visible under the anterior scalene muscle.

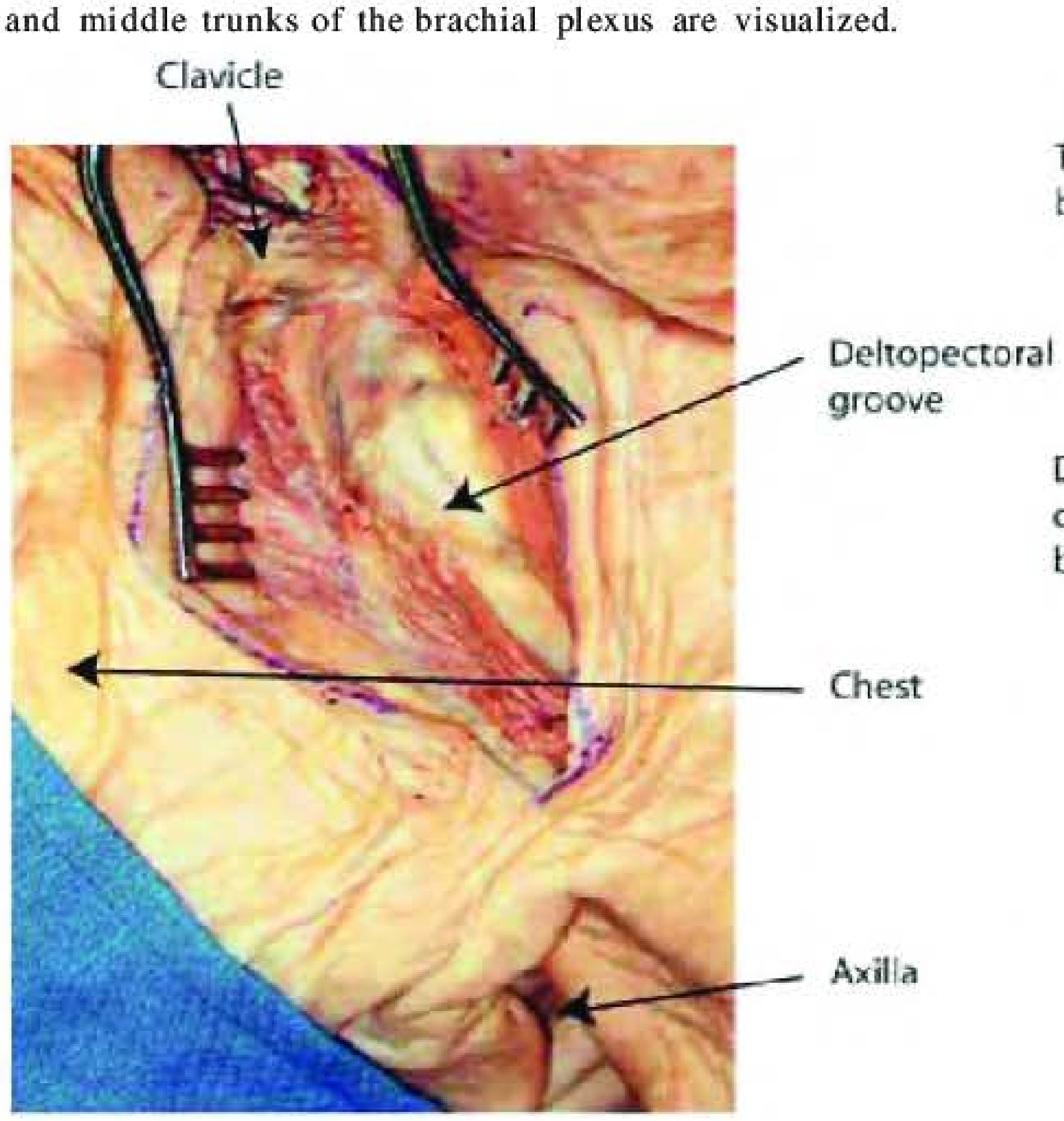

FIGURE 34–7 The incision has been extended to include the infraclavicular region. The deltopectoral groove is exposed.

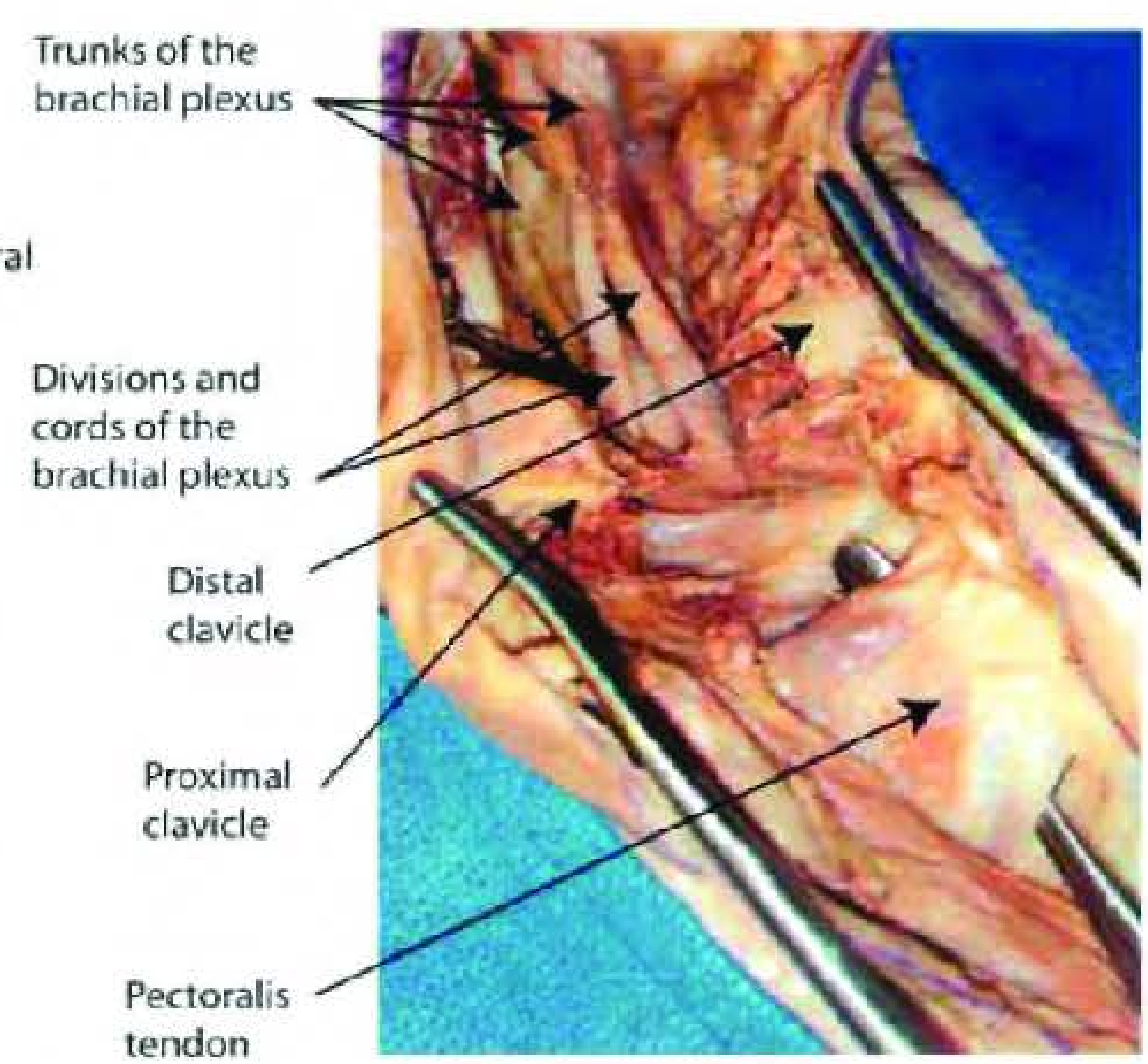

FIGURE 34–8 The clavicle has been resected and the deltoid-pectoral groove opened to expose the tendon of the pectoralis minor as well as the divisions and cords of the brachial plexus.

muscle may need to be sectioned to complete visualization of the lower plexus branches (Figs. 34–9 and 34–10). The tendon may he reanastomosed with reabsorbable sutures.

The use of intraoperative electromyography (EMG) has been found to be essential in cases of trauma or nerve tumor. The EMG allows delineation of the normal nerve fibers to facilitate the dissection and repair of the nerve.

The wound should be closed by reapproximating the ends of the deep muscles that have been transected. The clavicular bone segment is replaced and internally fixed. The subcutaneous tissue and skin are closed in two layers.

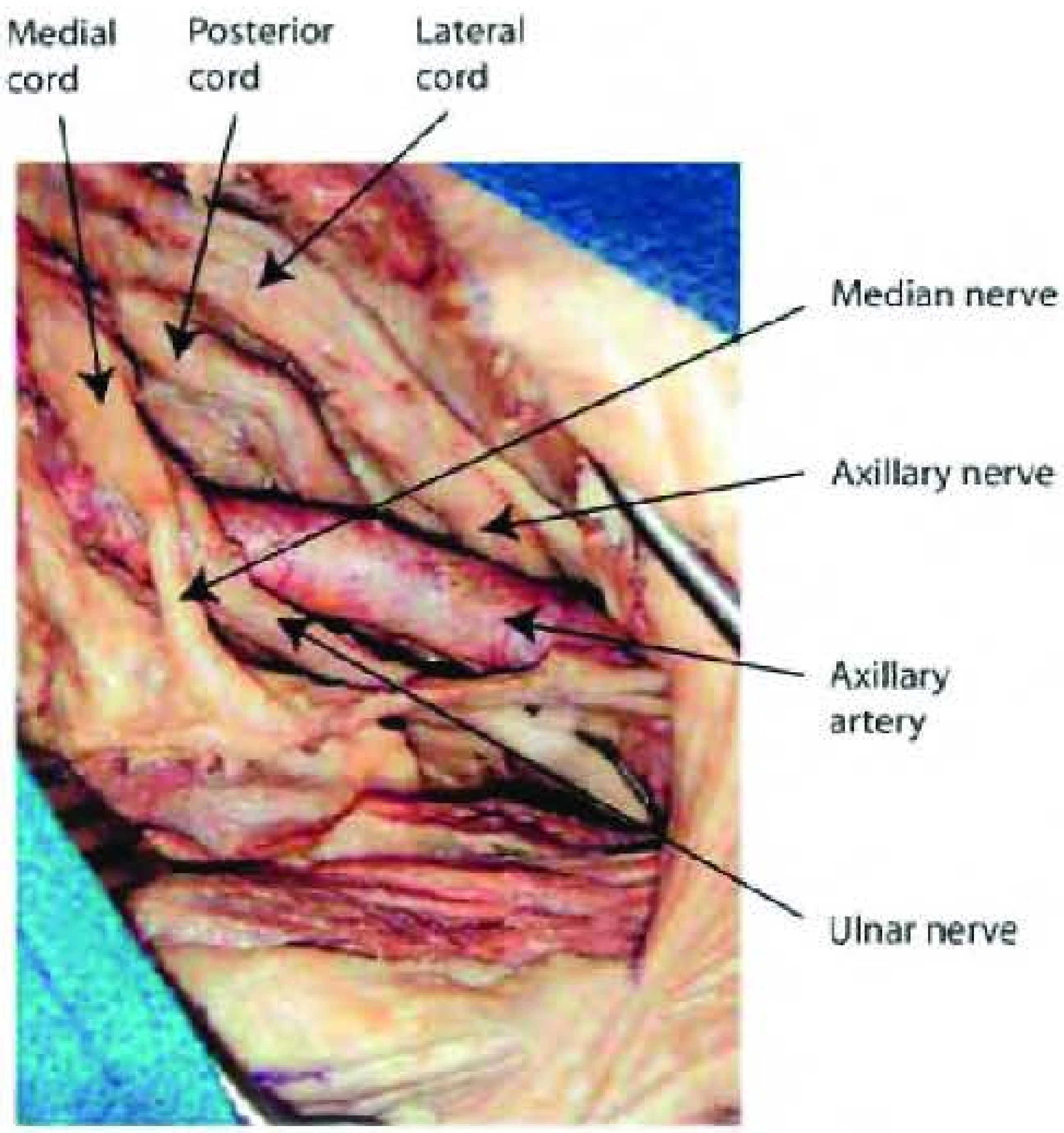

FIGURE 34–9 The relationship of the brachial plexus to the axillary artery is defined. The median, ulnar, radial, and axillary nerves can be identified.

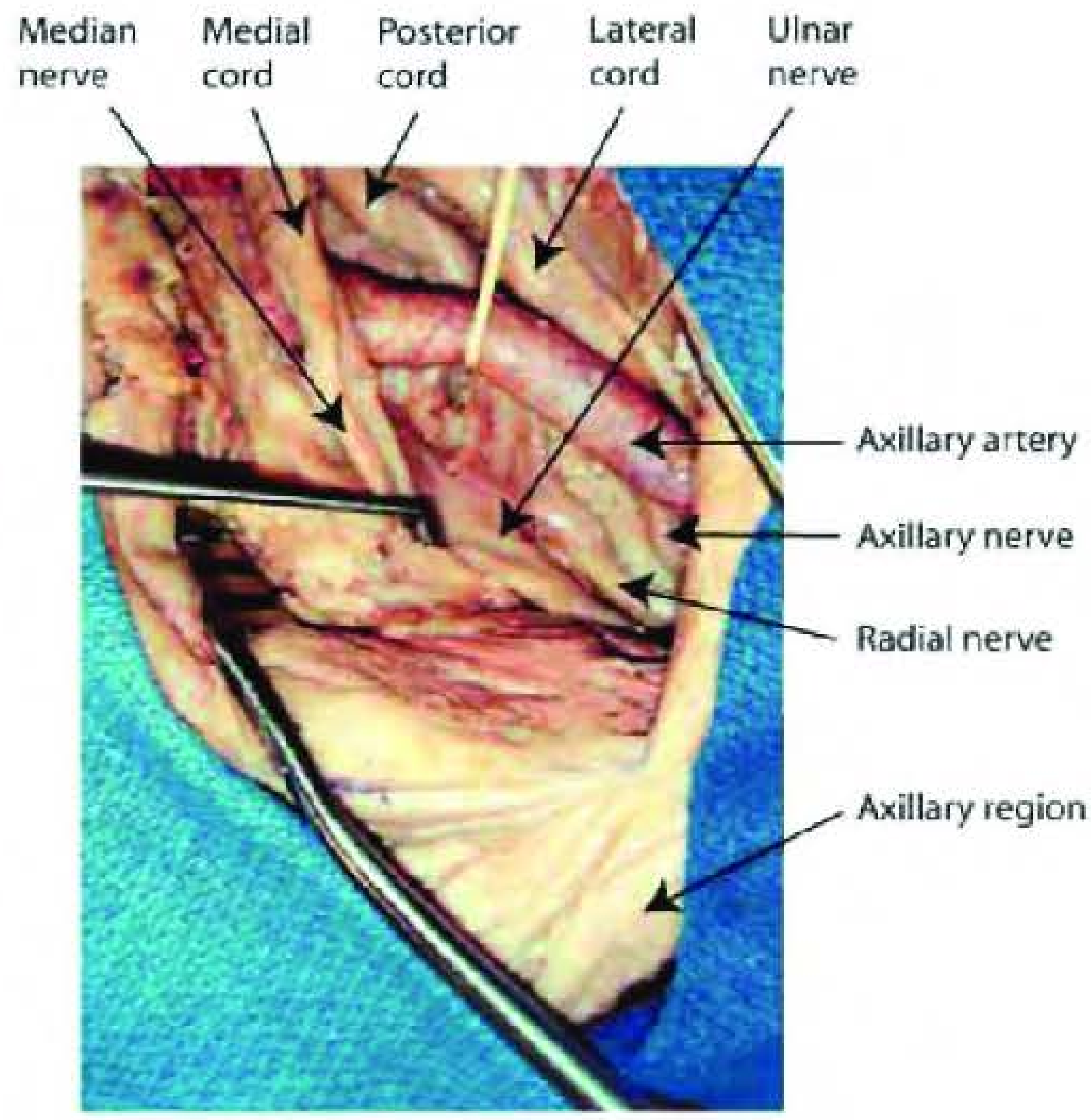

FIGURE 34–10 The axillary artery has been refracted medially to expose the merging of cords of the brachial plexus.

PITFALLS, PEARLS, CONSIDERATIONS

- Axillary artery injury
- Nerve branch stretch injuries
- Partial or complete nerve transection
- Cervical nerve root plexus injuries

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Chapter 35

THORACIC OUTLET SYNDROME

Emel Avci, Damirez Fossett

INDICATIONS FOR APPROACH

- Compression of lower brachial plexus trunk
- Arterial or venous compression

POSITIONING AND SKIN INCISION

The patient is placed in the supine position. The skin incision is placed 1 cm above the clavicle, beginning at the lateral margin of the sternocleidomastoid muscle and ending at the jmiction of the middle and lateral thirds of the clavicle.

SURGICAL TECHNIQUE

The platysma is transected, and the clavicular head of the sternocleidomastoid muscle is detached from the clavicle, leaving a small cuff with which to reattach the muscle on closure. Under the muscle, the supraclavicular fat pad is identified (Fig. 35–1). Dissection will allow the omohyoid to be visualized and transected. The transverse cervical artery and vein must be identified, ligated, and sectioned if necessary for exposure. Mobilization of the fat pad allows the underlying anterior scalene muscle to come into view. The phrenic nerve will be seen running in a lateral-to-medial fashion across this muscle (Fig. 35–2). It must be mobilized and protected from injury. If this nerve is followed superiorly, its attachment to me upper trunk of the brachial plexus can be visualized.

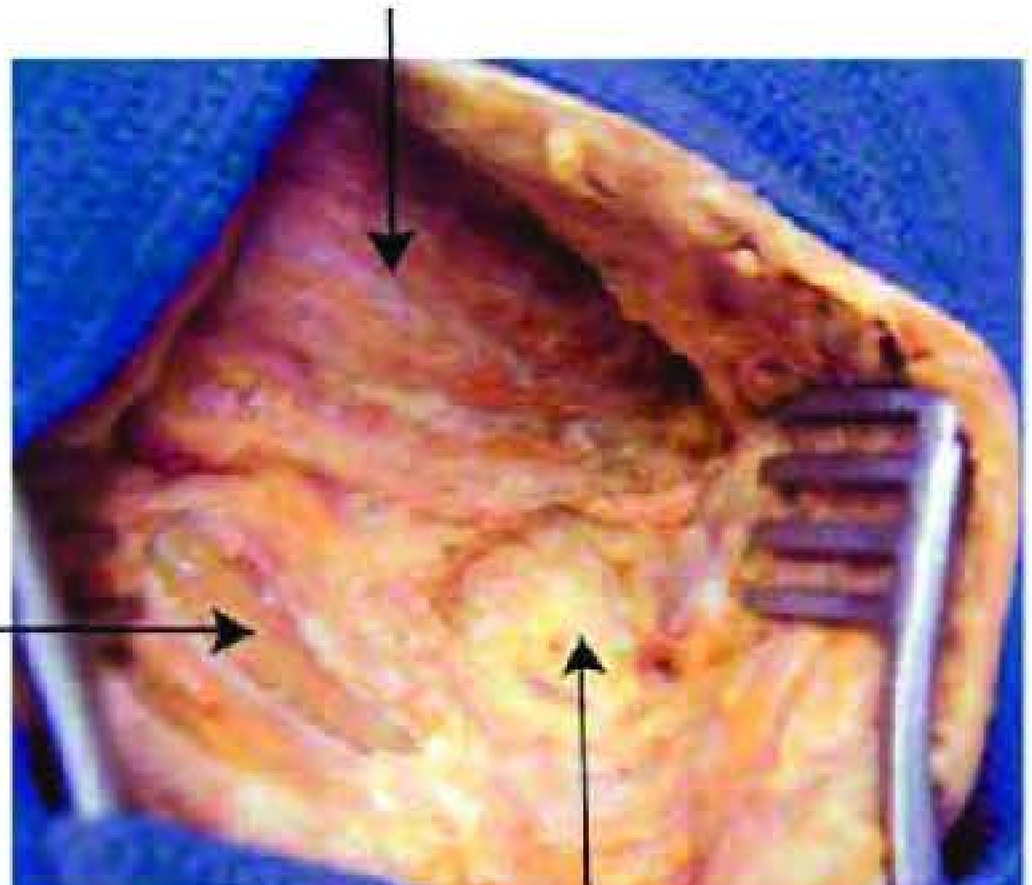

FIGURE 35–1 The sternocleidomastoid muscle is shown with its underlying fat pad.

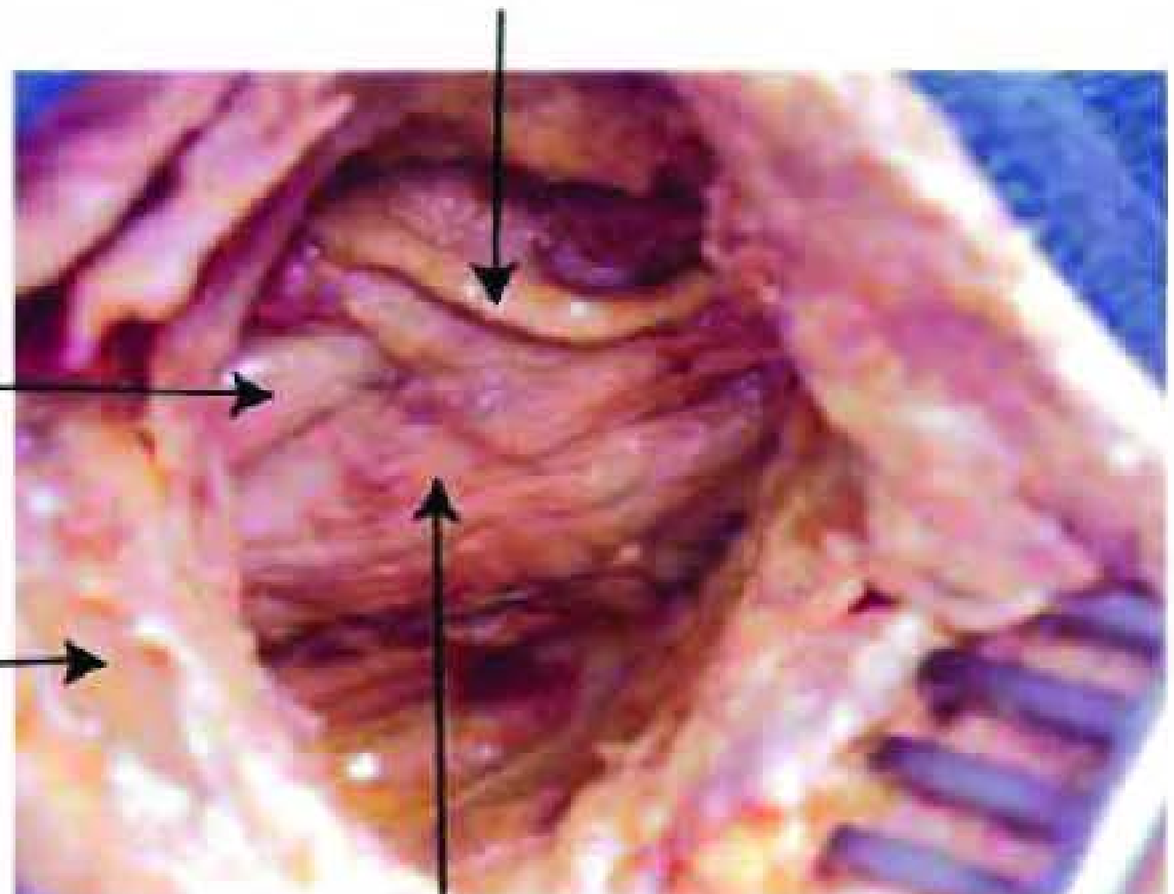

FIGURE 35–2 The sternocleidomastoid is reflected to show the anterior scalene muscle and the phrenic nerve. The upper trunk of the brachial plexus can be seen.

The anterior scalene muscle must be partially transected or partially resected at this stage to gain entrance into the region of interest. The muscle is attached to the first rib. During sectioning, care must be taken to avoid injury to the subclavian artery and vein as well as the phrenic nerve. Mobilization of muscle requires sectioning its attachments to the trans verse processes. Once detached, the muscle can be fully resected. With the muscle resected, the *C5* and C6 nerve root contributions to the upper trunk can be seen and the middle and lower trunks visualized and identified (Fig. 35–3). Sibson's fascia over the dome of the lung must be released to visualize C8 and T1 (Fig. 35–4). The T1 root may be buried deep behind the pleura. Care must be taken to avoid pleural tears. All fibrous bands in the region of the lower trunk must be sectioned for adequate decompression. Cervical ribs usually indent the plexus from behind, and if one is identified, it must be removed. More commonly, fascial bands arising from the cervical rib and heading to the first rib constitute the compressive pathology. These must all be sectioned.

The scalene muscle does not need to be reconstructed on closure The sternocleidomastoid is reattached to the clavicle and the wound closed in its anatomic layers.

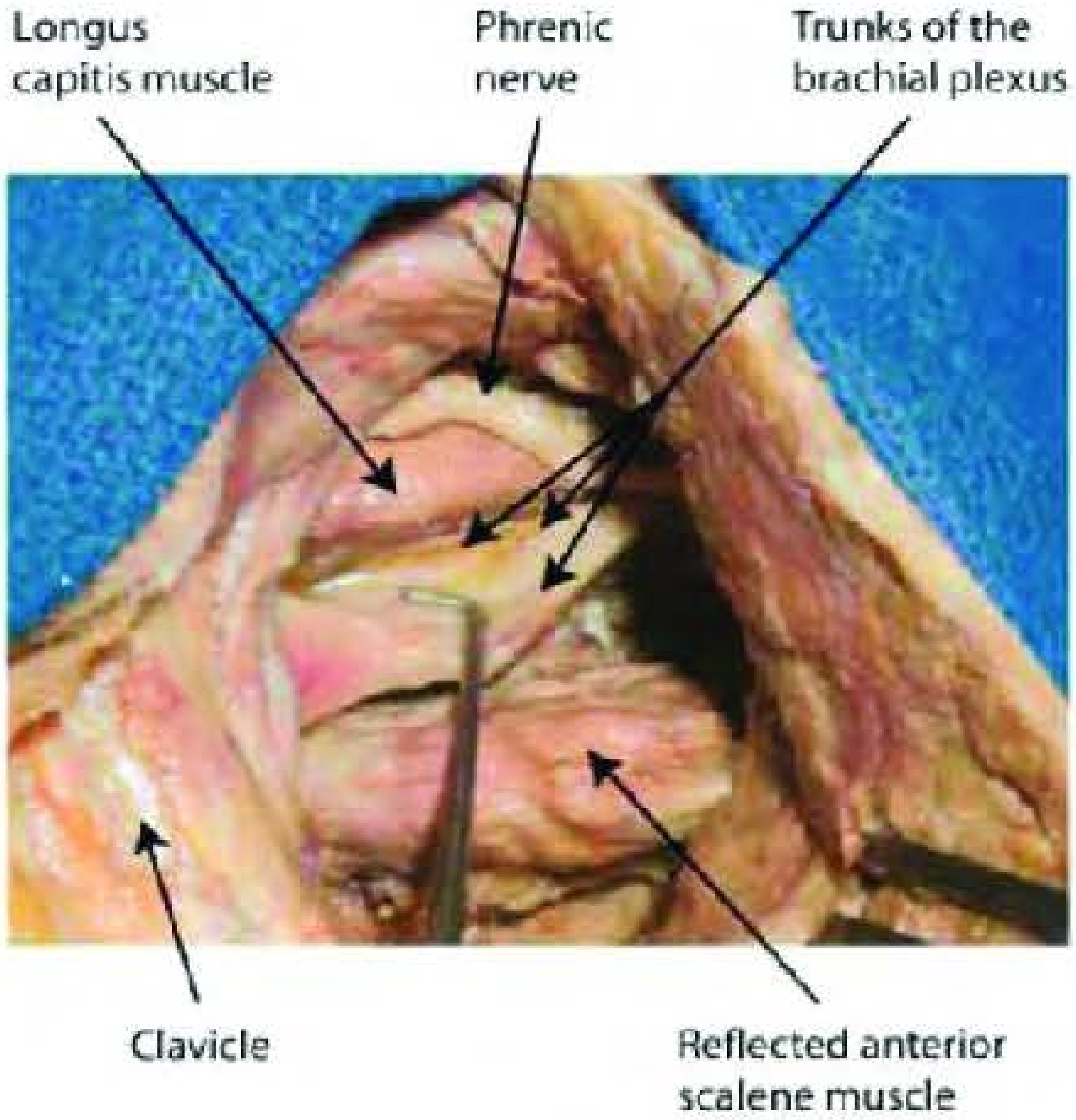

FIGURE 35–3 The anterior scalene has been transected to show the upper, middle, and lower trunks of the brachial plexus.

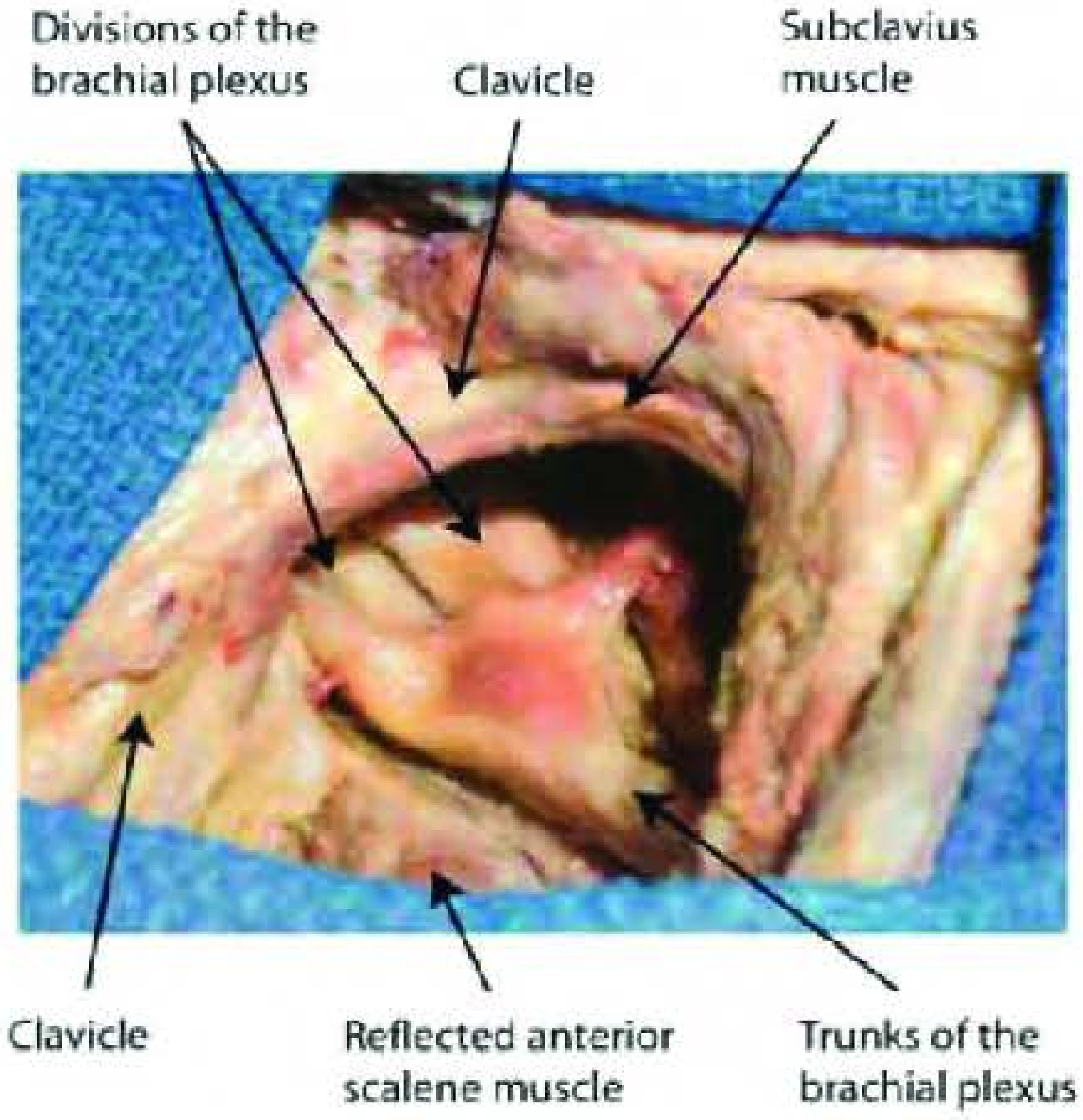

FIGURE 35–4 The distal portions of the brachial plexus are seen passing into the infraclavicular region. Fascia and fibrous bands over these segments have been resected for enhanced visualization.

PITFALLS, PEARLS, CONSIDERATIONS

- Full workup should be done before a diagnosis is made
- Avoid injury to the phrenic nerve
- Avoid injury to the subclavian vessels
- Pneumothorax
- Chylothorax

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SUPRASCAPULAR NERVE ENTRAPMENT

Emel Avci, Damirez Fossett

INDICATIONS FOR APPROACH

- Entrapment of the suprascapular nerve

ANATOMY

The suprascapular nerve is a mixed peripheral nerve that arises as a large branch from the superior trunk (C5 and C6 roots) of the brachial plexus. The sensory component of the nerve has no cutaneous distribution but supplies the posterior capsule of the shoulder joint. The motor component supplies the supraspinatus and infraspinatus muscles. The nerve crosses the posterior triangle of the neck deep and parallel to the inferior belly of the omohyoid muscle. It then runs under the trapezius muscle, through the suprascapular notch below the suprascapular ligament, and into the supraspinous fossa. The suprascapular artery and vein pass above the suprascapular ligament and join the nerve in the supraspinous fossa. After supplying the supraspinatus muscle, the nerve curves arcund the lateral border of the scapular spine into the infraspinatus fossa, where it enters the deep surface of the infraspinatus muscle.

POSITIONING AND SKIN INCISION

The patient is placed in the lateral position with the ipsilateral arm supported on an armrest or pillow. A 7- to 8-cm skin incision is made 2 cm above and parallel to the superior border of the scapular spine (Fig. 36–1).

SURGICAL TECHNIQUE

The dissection is carried through the fibers of the trapezius muscle parallel to the superior border of the scapula (Fig. 36–2). Care should be taken to identify and avoid injury to the spinal accessory nerve. Running the forefin-

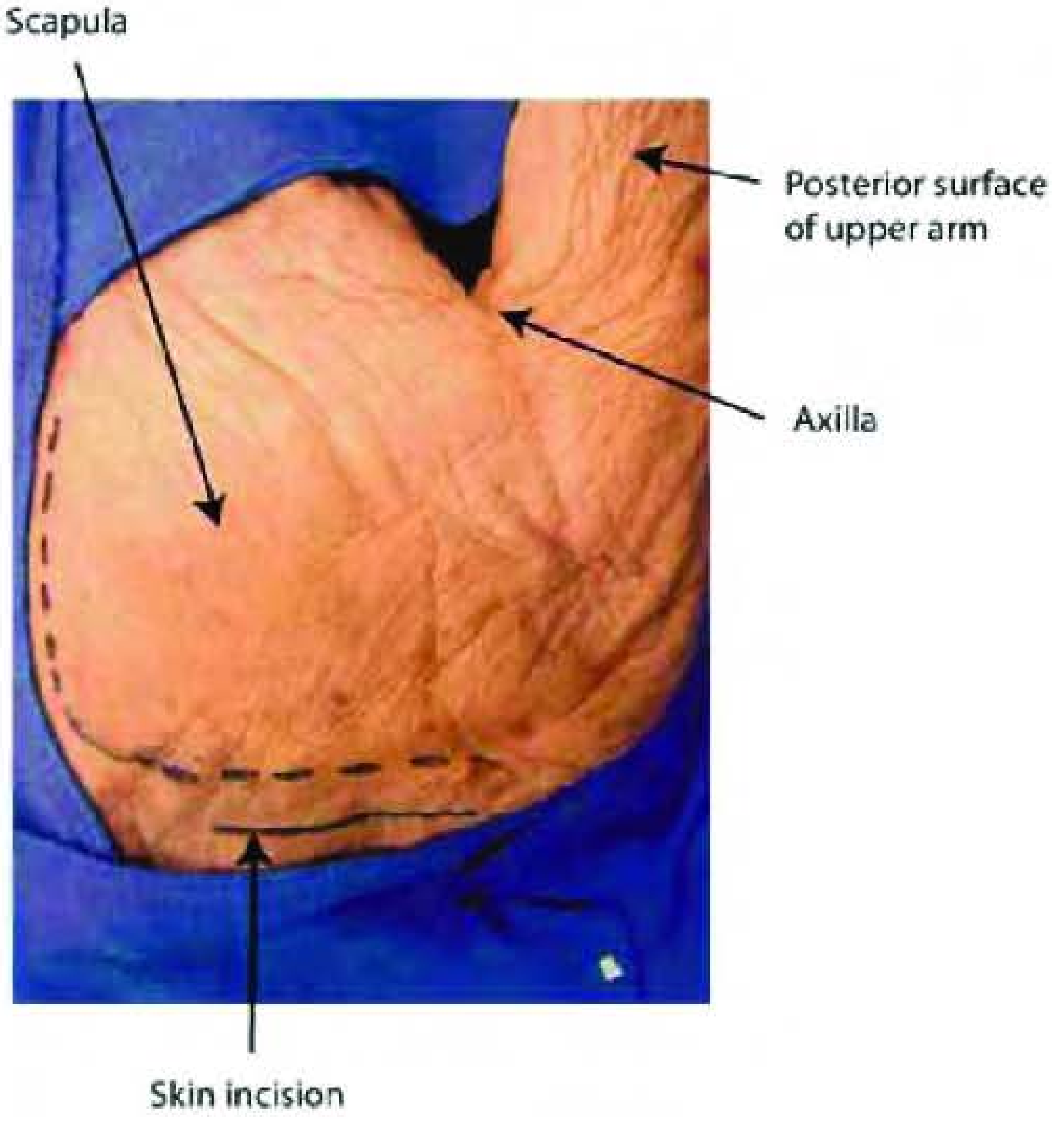

FIGURE 36–1 A small incision is made above the scapular spine.

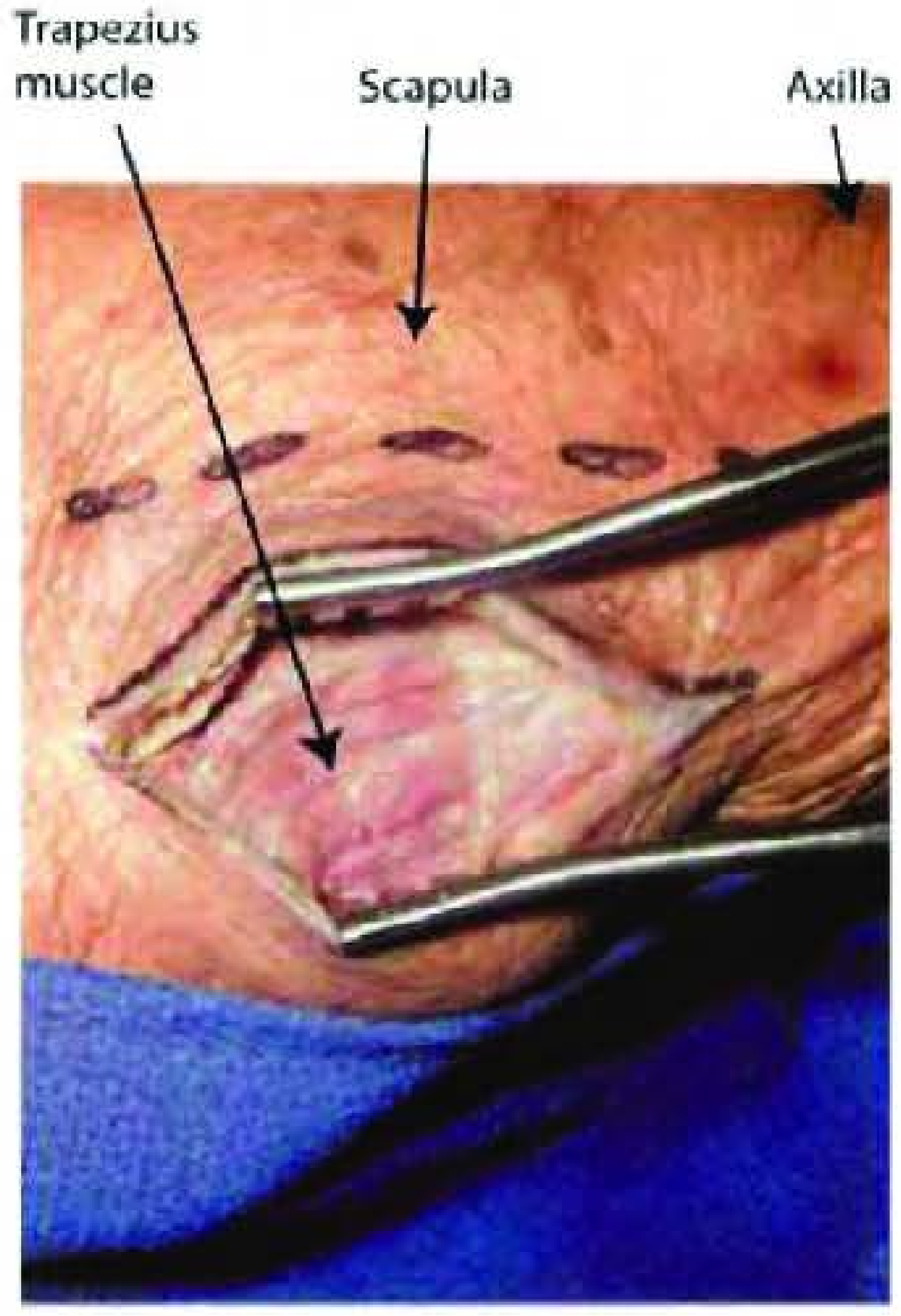

FIGURE 36–2 The trapezius muscle is identified beneath the subcutaneous tissue.

ger along the superior border of the scapula, a depression can be identified that corresponds to the scapular notch. Similarly, the omohyoid muscle can be followed to its attachment on the superior border of the scapula. Just lateral to this attachment should be the suprascapular notch. A self-retaining retractor is placed; under direct vision, the suprascapular artery and vein, ligament, and nerve can be dissected. The artery and vein run above the ligament, the nerve below it (Fig. 36–3), A right-angled dissector is placed beneath the ligament, and it is sectioned to decompress the underlying nerve (Fig. 36–4). The vessels should be protected. It is not necessary to see the nerve to decompress it.

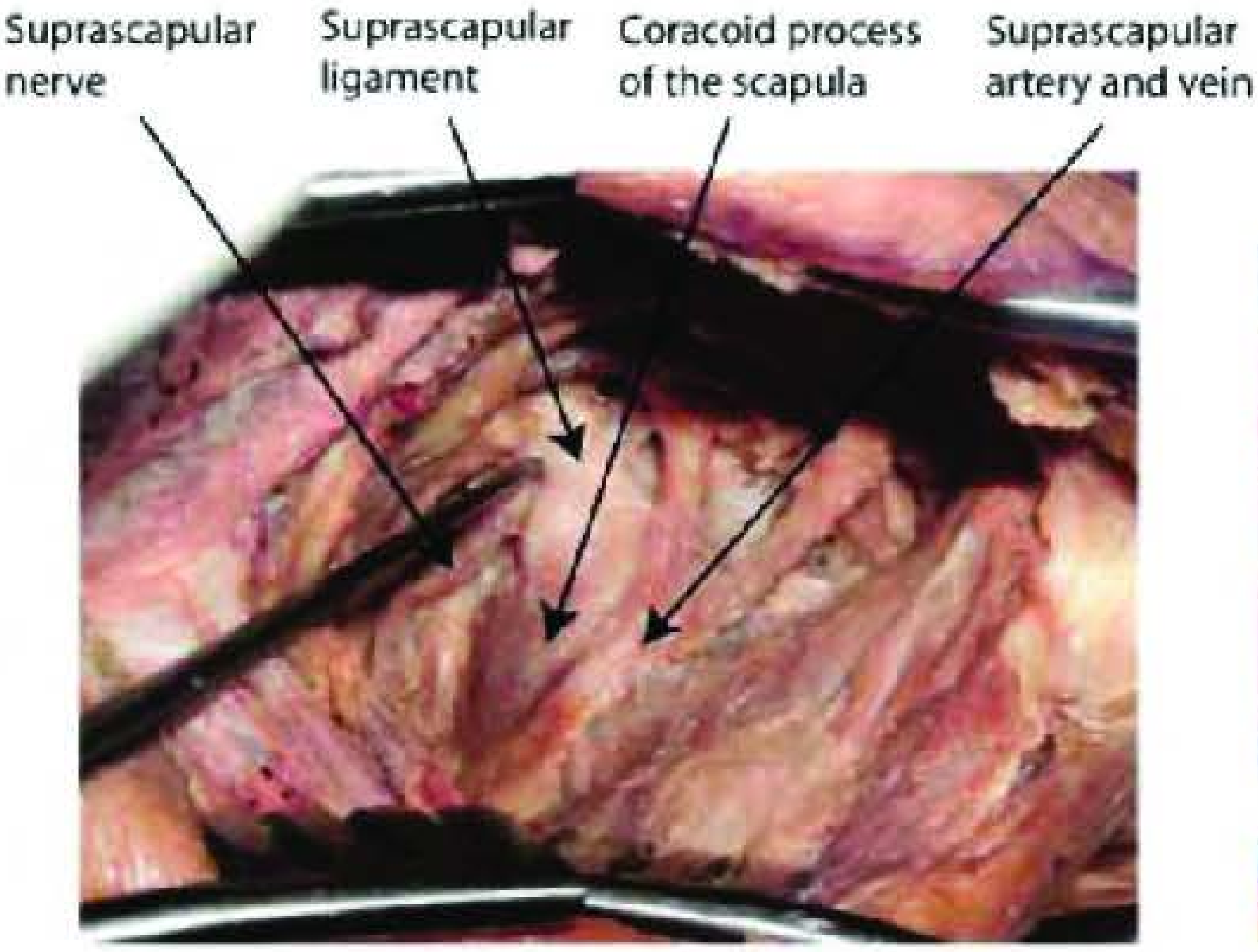

FIGURE 36–3 The suprascapular ligament is identified within the suprascapular notch.

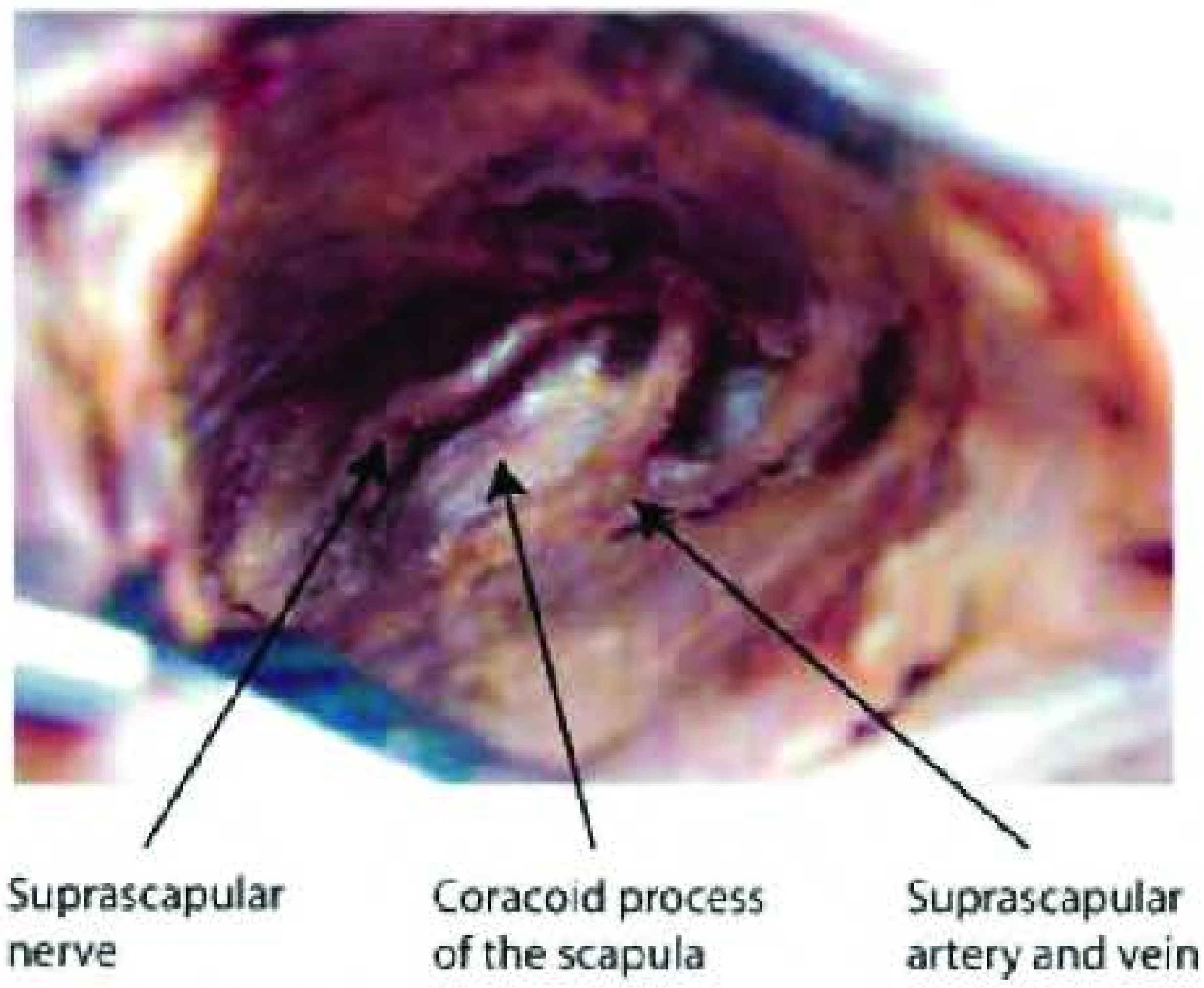

FIGURE 36–4 The suprascapular ligament has been sectioned to reveal the underlying suprascapular nerve.

PITFALLS, PEARLS, CONSIDERATIONS

- Avoid injuring the artery
- Check for ganglion cysts under the supraspinatus muscle, which can also compress the nerve

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Chapter 37

Surgical Decompression of the Lateral Femoral Cutaneous Nerve

Ernel Avci, Damirez Fossett

Indications for Approach

- Meralgia paresthetica

Anatomy

The lateral femoral cutaneous nerve is a pure sensory nerve arising from the second and third lumbar nerves of the lumbar plexus. It emerges from beneath the lateral border of the psoas major muscle, runs obliquely forward and inferiorly across the iliacus muscle, and then passes from the iliac fossa into the thigh beneath the inguinal ligament just medial to the anterior superior iliac spine. The nerve pierces the inguinal ligament between the two roots of attachment of the ligament to the iliac bone and enters the thigh near the anterior border of the sartorius muscle. The sartorius muscle has an aponeurotic expansion from its tendinous attachment to the anterior superior iliac spine that attaches to the inferior border of the inguinal ligament. The lateral femoral cutaneous nerve pierces this aponeurotic expansion and descends inferiorly to pierce the fascia lata and enter the subcutaneous tissue.

Positioning and Skin Incision

The patient is placed in the supine position, and the anterior superior iliac spine is identified. A 5- to 6-cm skin incision beginning 2 cm below the attachment of the lateral inguinal ligament to the anterior iliac spine is created parallel to the inguinal crease (Fig. 37–1).

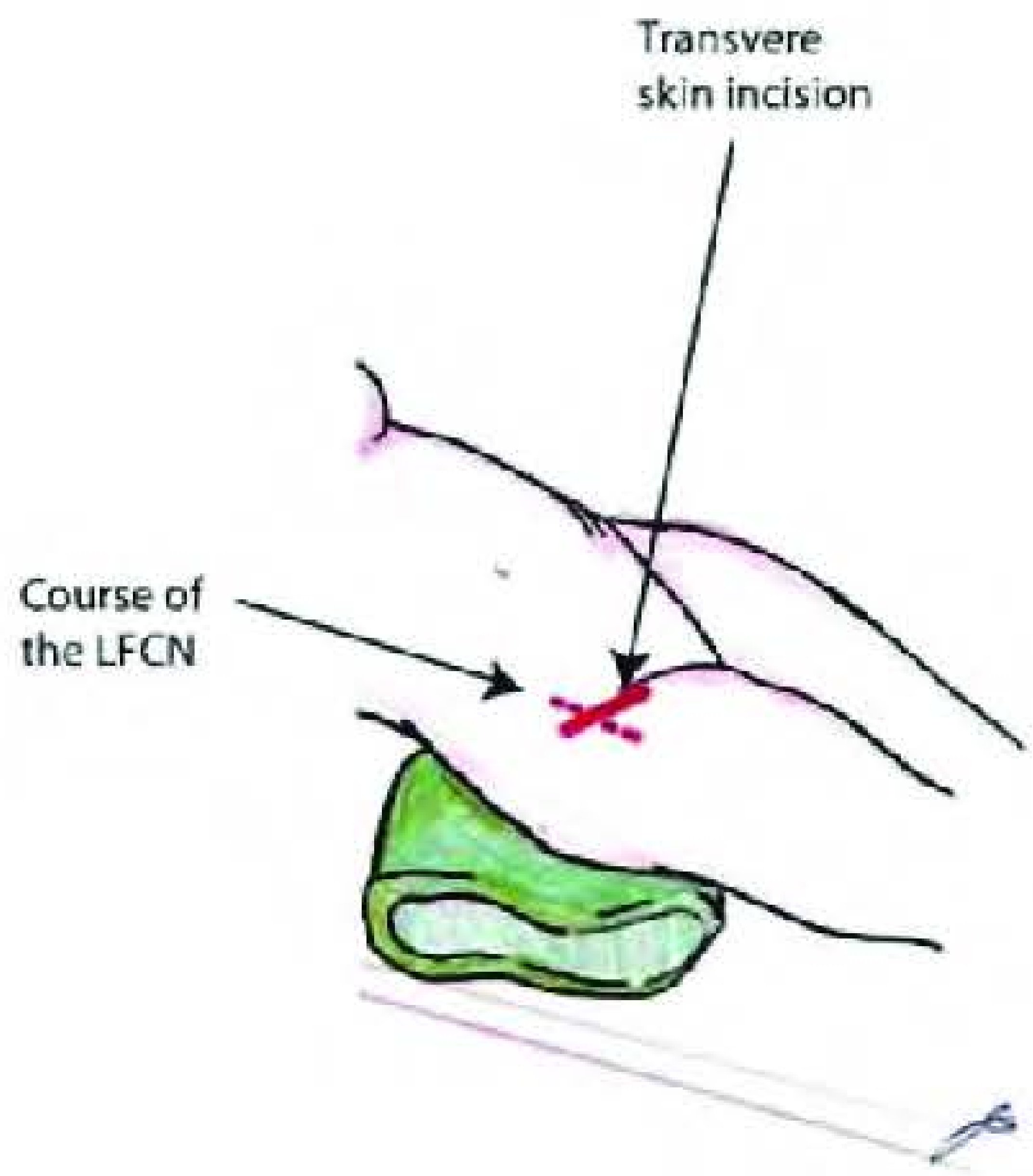

FIGURE 37–1 Illustration of the linear skin incision made transversely beginning 2 cm below the inguinal ligament attachment to the anterior superior iliac spine. The hashed line represents the general course of the lateral femoral cutaneous nerve (LFCN).

SURGICAL TECHNIQUE

The course of the nerve is variable so that an exploration is usually necessary. The subcutaneous fat is dissected until the fascia of the anterior border of the proximal sartorius muscle is identified. A branch of the nerve can usually be found coursing over the muscle, and this branch can be traced back to the main trunk. The main trunk then can be followed to its passageway through the inguinal ligament; typically about 1 cm medial to the anterior superior iliac spine (Fig. 37–2). The nerve is decompressed by sectioning the deeper part of the ligamentous tunnel through which it travels.

Neurectomy of the nerve instead of neurolysis can be performed through the same approach. If a neurectomy is performed, traction is placed on the nerve so that the cut end will retract back through the inguinal tunnel after sectioning.

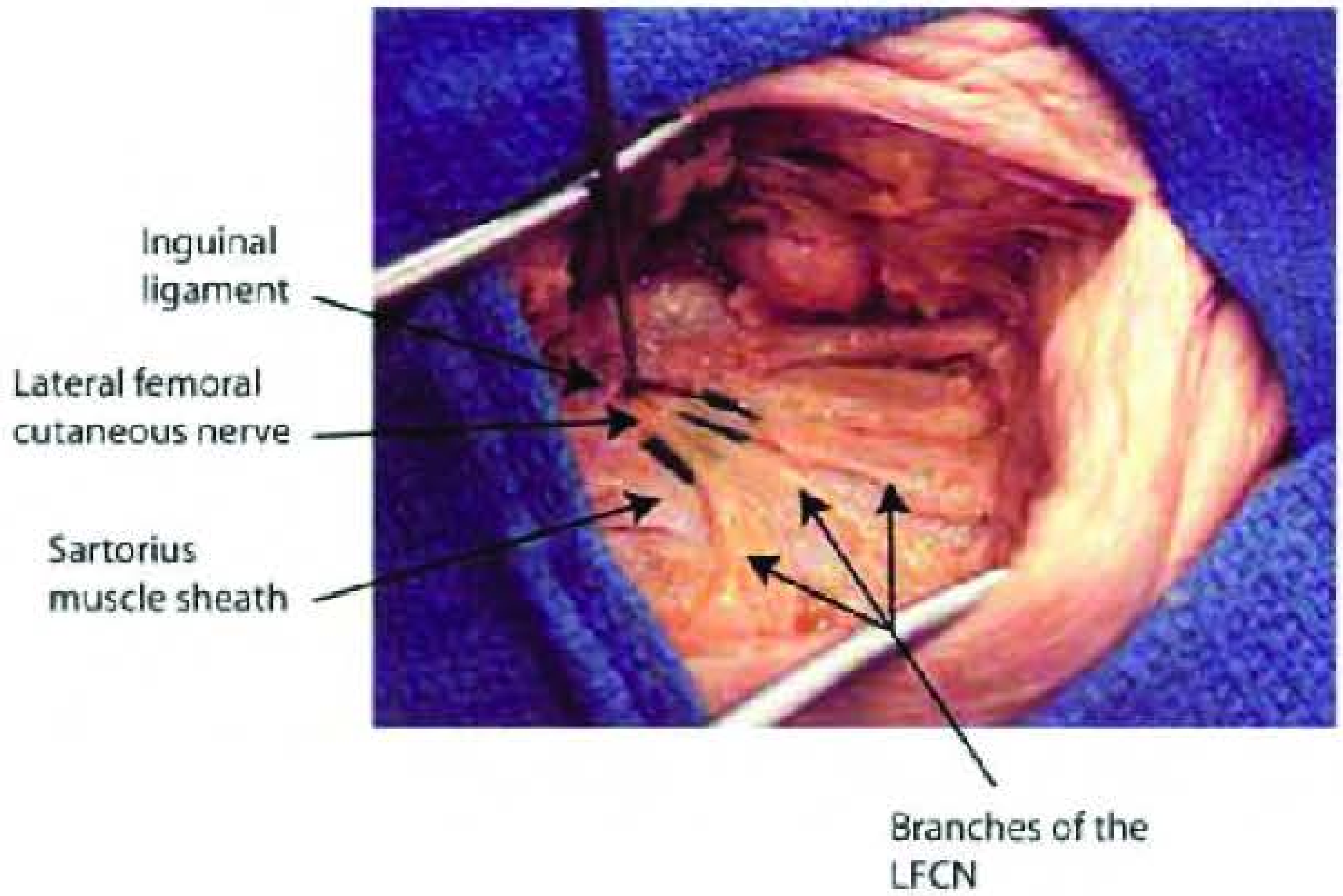

FIGURE 37–2 High-power view of the main trunk of the lateral femoral cutaneous nerve (LFCN) passing through the inguinal ligament before branching. A contrasting background has been placed behind the nerve to enhance visualization.

PITFALLS, PEARLS, CONSIDERATIONS

- Do not make small incisions
- The nerve is deeper than you think
- If a neurectomy is planned, be sure the lateral femoral cutaneous nerve is the nerve being cut

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Sciatic Nerve Exploration

Ernest Senz, Matt Ammerman, Mark Grant, Damirez Fossett

Indications for Approach

- Pelvic or femoral fractures and dislocations
- Sharp and blunt injuries
- Neurotization

Anatomy

The sciatic nerve is composed of roots from the lumbosacral plexus. Its terminal nerves are the tibial nerve, composed of roots from L4 to S3, and the peroneal nerve, composed of roots from L4 through S2. The sciatic nerve courses over the sacrum and leaves the pelvis through the sciatic notch inferior to the piriformis muscle. It is accompanied by the inferior gluteal artery and nerve and by the posterior femoral cutaneous nerve. The nerve travels beneath the gluteus maximus muscle and over the deeper obturator intemus, gemelli, and quadratus femoris muscles.

In the upper posterior thigh, the nerve is lateral to the biceps femoris and medial to the iliotibial tract. It turns, courses deep to the biceps femoris, and then runs between the biceps femoris and semitendinosus muscles. In the lower thigh, the sciatic nerve splits into its two divisions: the posterior tibial nerve and the peroneal nerve. The sciatic also gives off small muscular branches to the long head of the biceps femoris, the semitendinosus, the semimembranosus, and fibers of the adductor magnus in the upper thigh.

Positioning and Skin Incision

The patient is placed in the prone position with the hips slightly flexed and the lower extremities extended. A reverse question mark incision is made beginning 2 to 3 cm lateral and inferior to the posterior superior iliac spine. The incision curves laterally over the greater trochanter, returns to the midline, and extends along the posterior midline of the thigh (Fig. 38–1).

Surgical Technique

Fibers of the gluteus maximus are identified after dissection through the subcutaneous tissue (Fig. 38–2). This muscle is reflected medially in its entirety. Care should be taken during dissection and reflection of the muscle to not injure the inferior gluteal artery and nerve as they course deep to

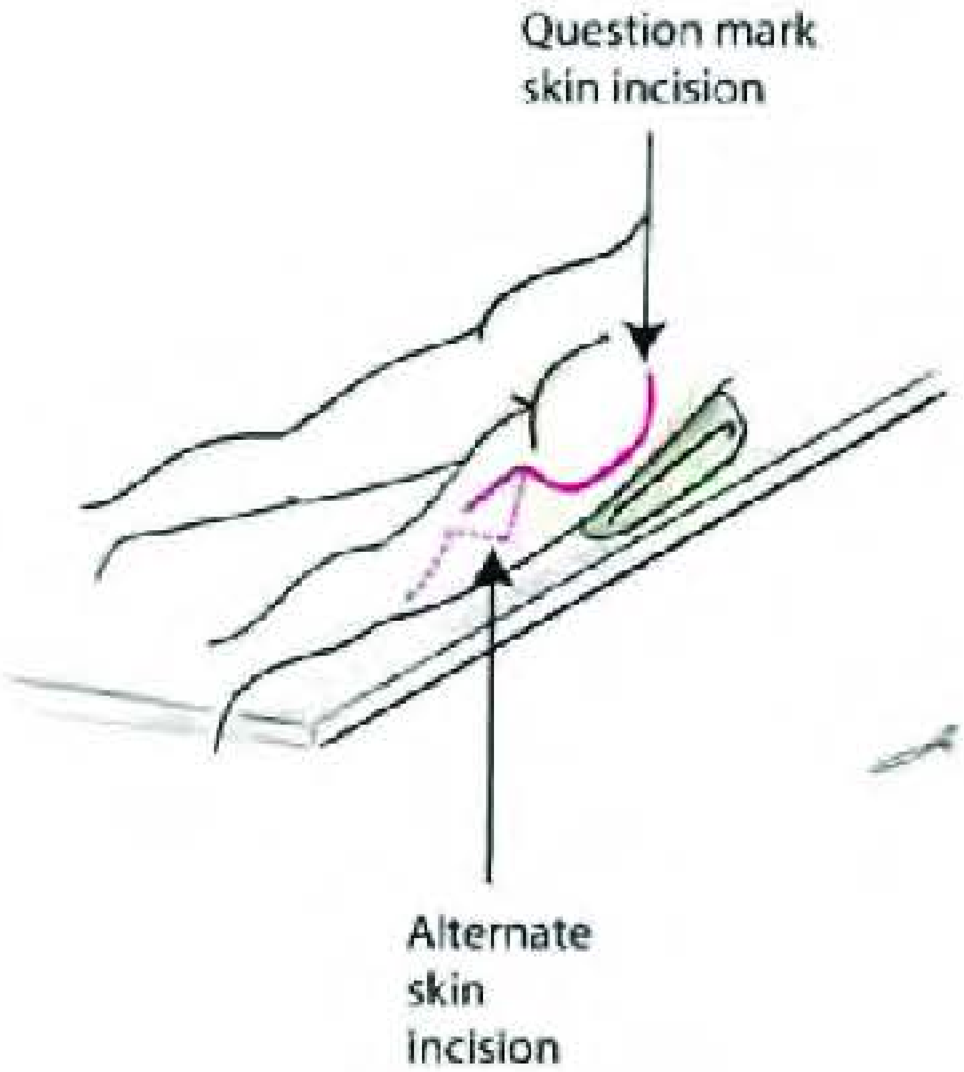

FIGURE 38–1 A curvilinear incision over the gluteus maximus is performed.

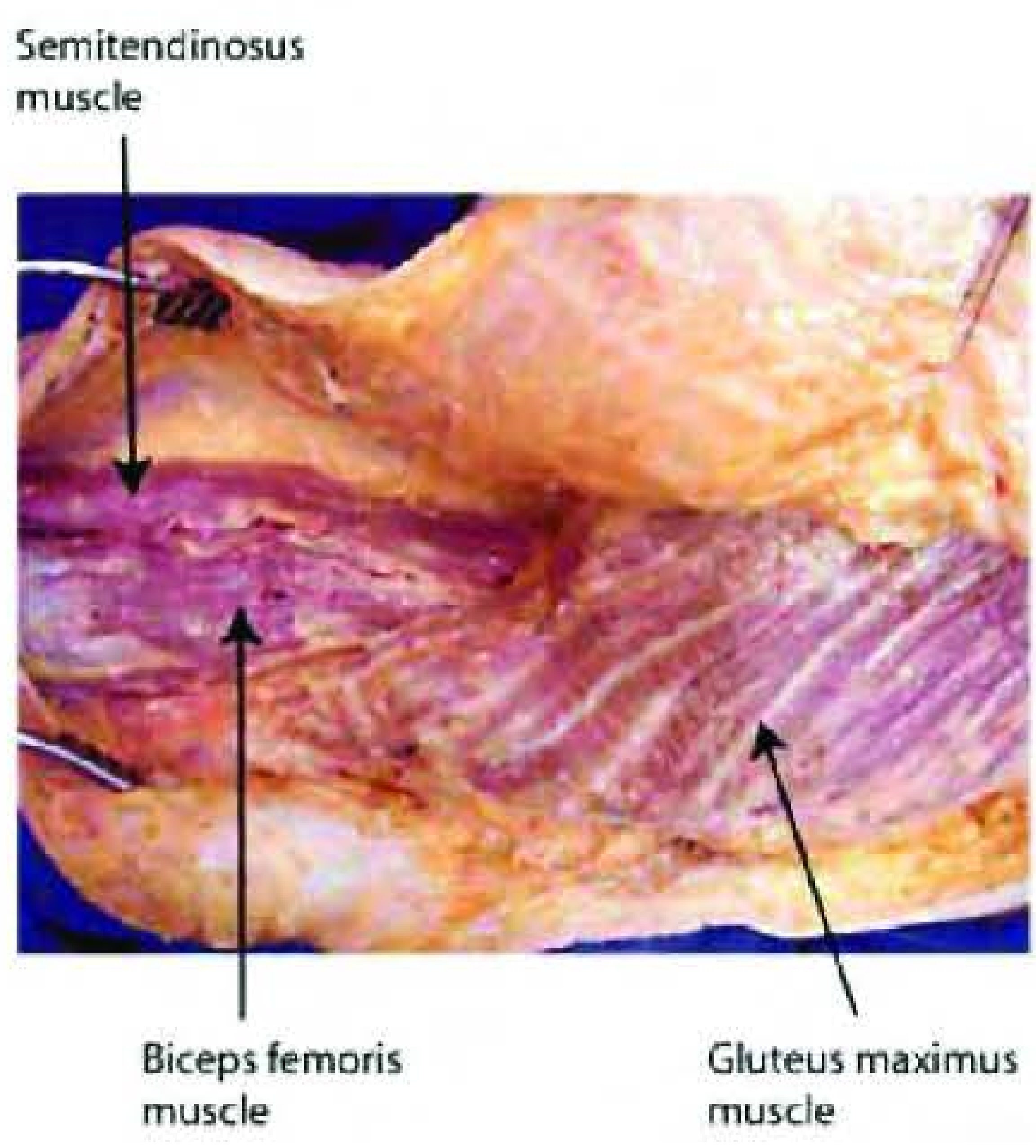

FIGURE 38–2 The gluteus maximus, biceps femoris, and semitendinosus muscles are visualized after elevating the skin flap.

and penetrate the muscle (Fig. 38–3). The sciatic nerve is seen to course above the gemelli, the obturator internus, and the quadratus femoris muscles. Superiorly, the nerve is seen to run beneath or course through the two heads of the pyriformis muscle Crossing toward the greater trochanter (Fig. 38–4). The nerve can be followed distally into the upper thigh by tracing it as it runs deep to the biceps femoris muscle. Note that the posterior femoral cutaneous nerve lies superficial to the biceps femoris muscle and can be injured by retraction. The sciatic nerve can be followed more distally between the posterior muscles of the thigh until it divides into its terminal branches, the common peroneal and tibial nerves (Fig. 38–5).

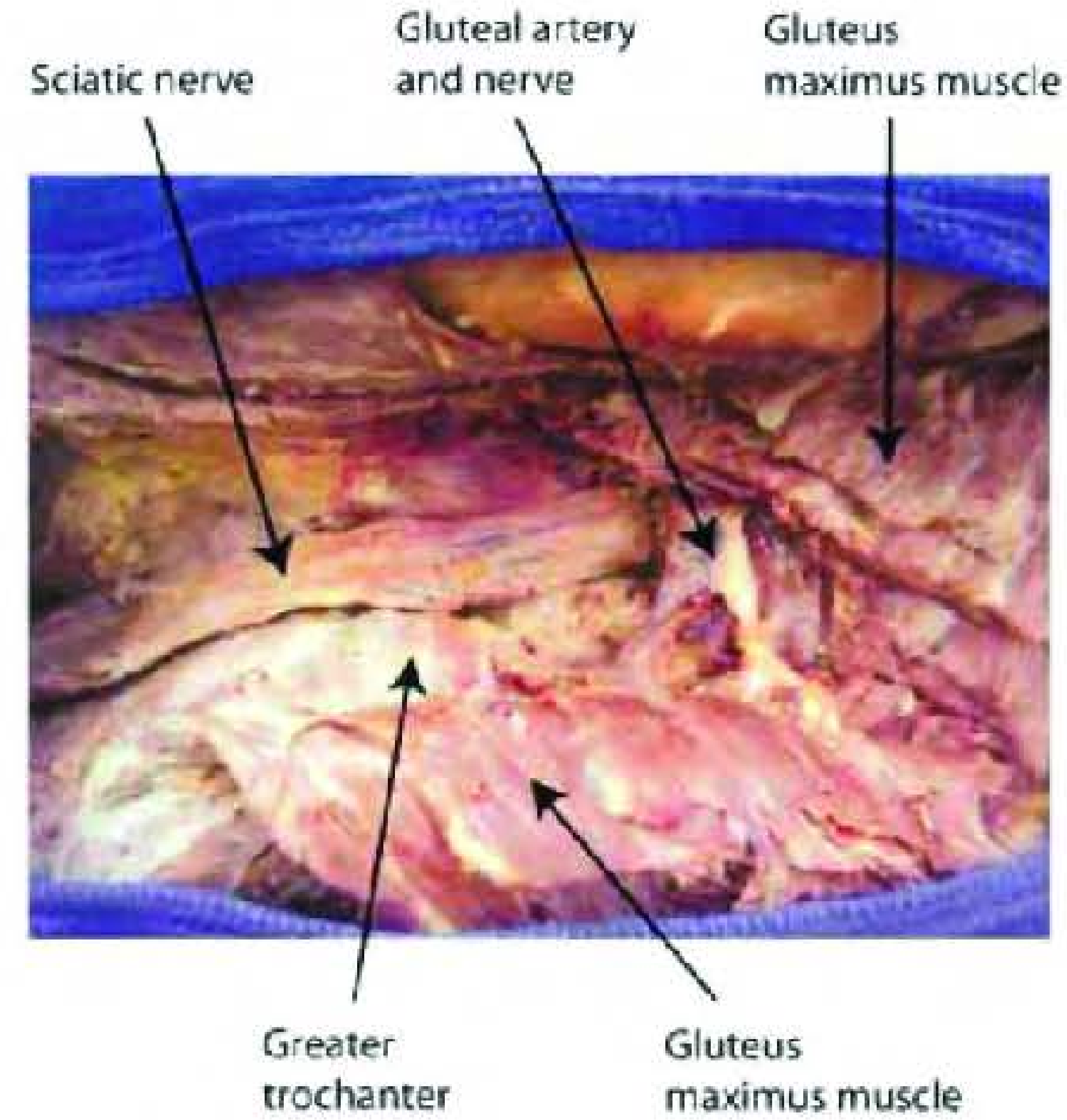

FIGURE 38–3 The gluteal artery and nerve are seen penetrating the reflected gluteus muscle.

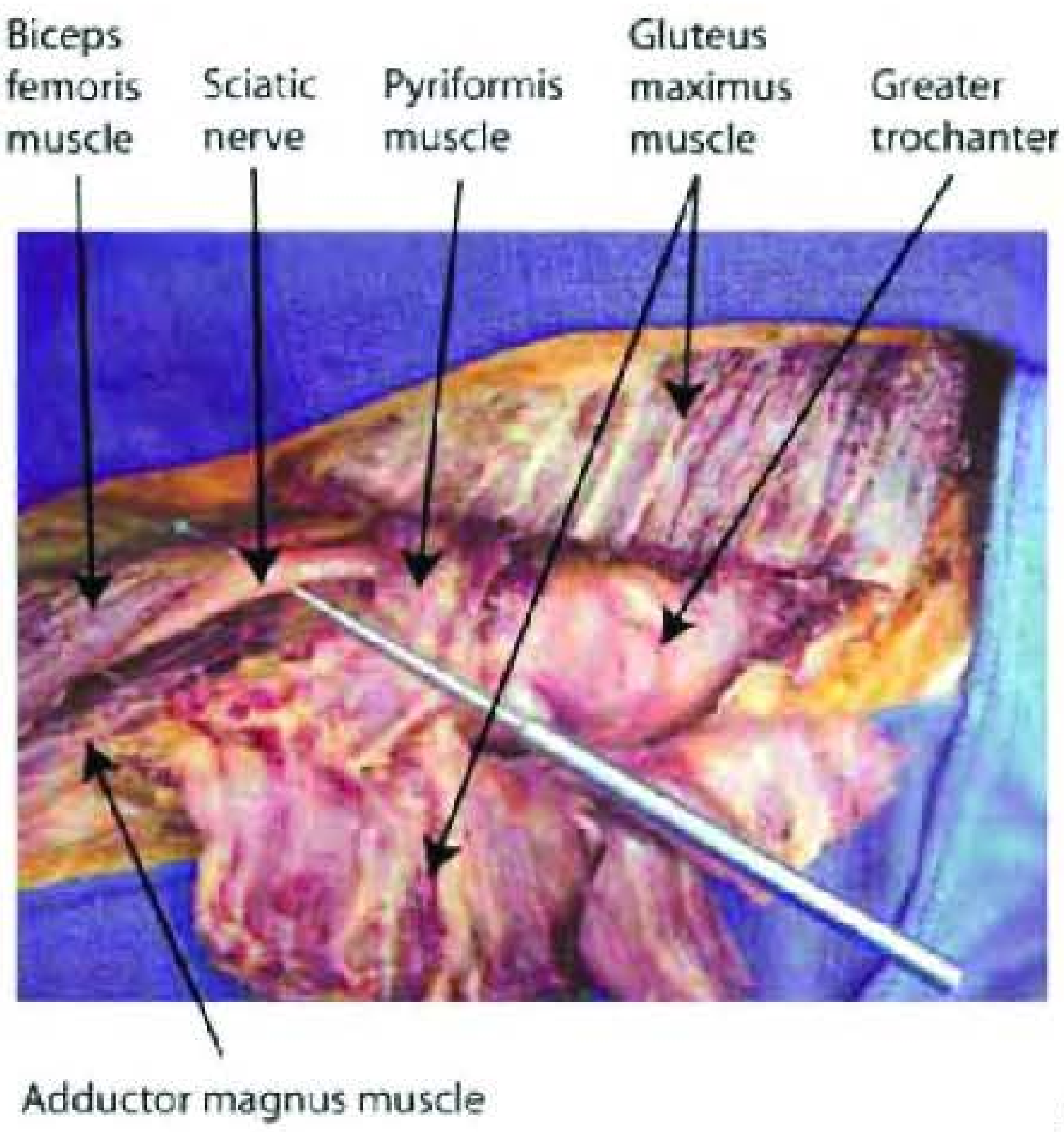

FIGURE 38–4 The sciatic nerve emerges through the sciatic notch. It is bounded by the heads of the biceps femoris distally and the piriformis muscle proximally.

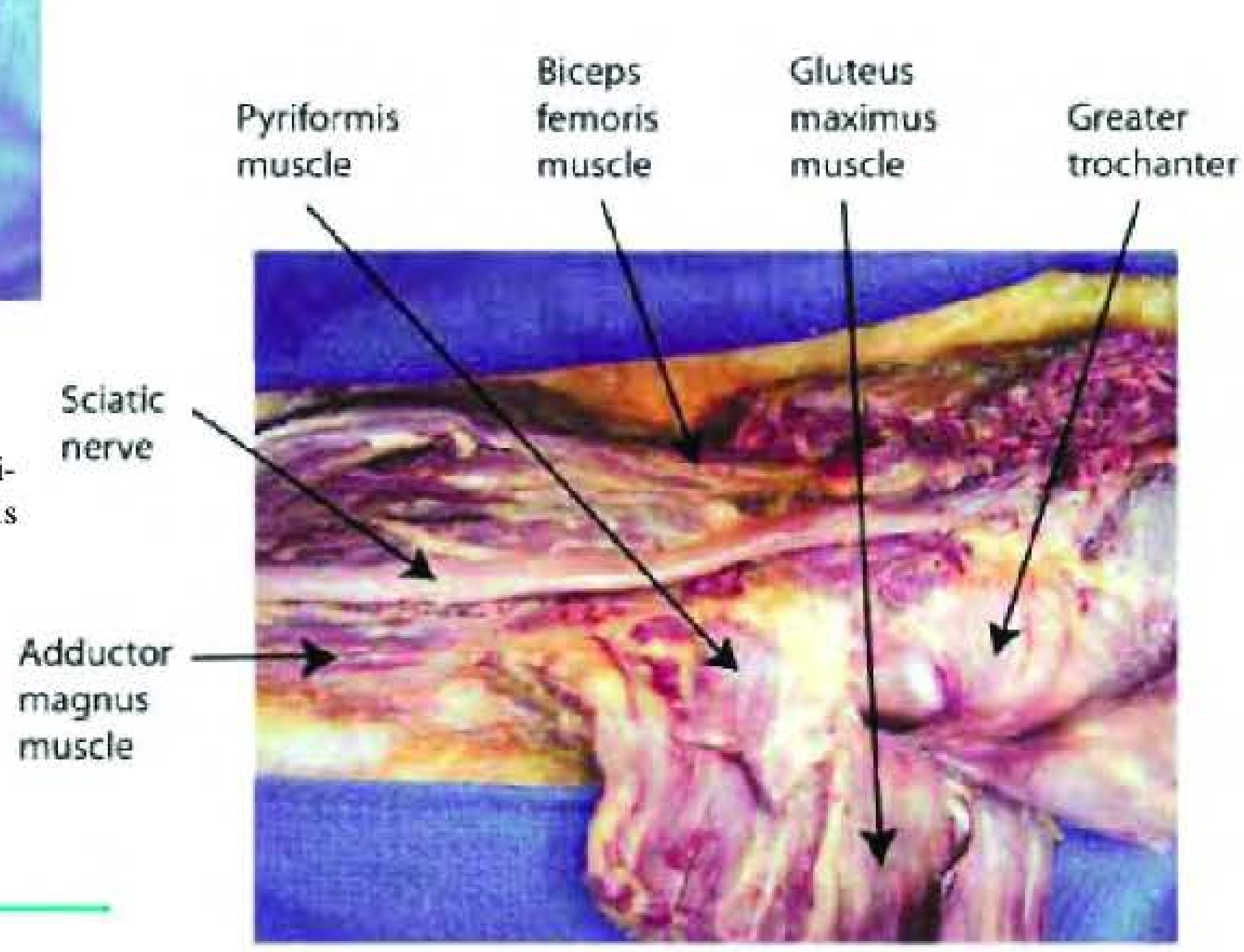

FIGURE 38–5 The sciatic nerve is followed distally between the muscles of the posterior thigh, where it gives off muscular branches. It will ultimately divide into its terminal branches: the tibial nerve and the peroneal nerve.

PITFALLS, PEARLS, CONSIDERATIONS

- Injury to the inferior gluteal nerve and artery
- Injury to the posterior femoral cutaneous nerve

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SURAL NERVE BIOPSY

Damirez Fossett

INDICATIONS FOR APPROACH

- Biopsy for peripheral neuropathy workup
- Sural nerve neuropathy
- Sural nerve grafts

ANATOMY

The common peroneal nerve is a terminal branch of the sciatic nerve arising from the L4 through S2 nerve roots. It travels along the medial margin of the biceps femoris, wraps around the fibula head, and dives deep to the peroneus longus muscle, where it divides into three branches that subserve sensory and motor innervation to the lower leg and foot.

In the popliteal fossa, the peroneal nerve gives rise to a lateral cutaneous branch and also joins with a medial branch of the tibial nerve to form the sural nerve. This sensory nerve innervates the skin over the dorsal and lateral aspect of the leg as well as the lateral aspect of the foot.

POSITIONING AND SKIN INCISION

The patient is placed in the lateral position with the surgical leg up. The down leg is slightly flexed, and the surgical leg is extended to allow visualization of the lateral malleolus. A pillow should be placed between the two legs.

The skin incision is made halfway between the lateral malleolus and the Achilles tendon (Fig. 39–1). It should extend about 5 to 6 cm long and does not need to go below the level of the lateral malleolus. Occasionally, the incision may need to extend more proximally up the lateral calf to identify the nerve.

SURGICAL TECHNIQUE

The subcutaneous tissue is dissected, and the saphenous vein is identified. Just deep and lateral to the vein, one will find the sural nerve (Fig. 39–2). The nerve should be dissected free and a segment elevated with a dissector and transected to provide at least a 1-cm section for pathology.

FIGURE 39–1 The incision is made midway between the lateral malleolus and the Achilles tendon.

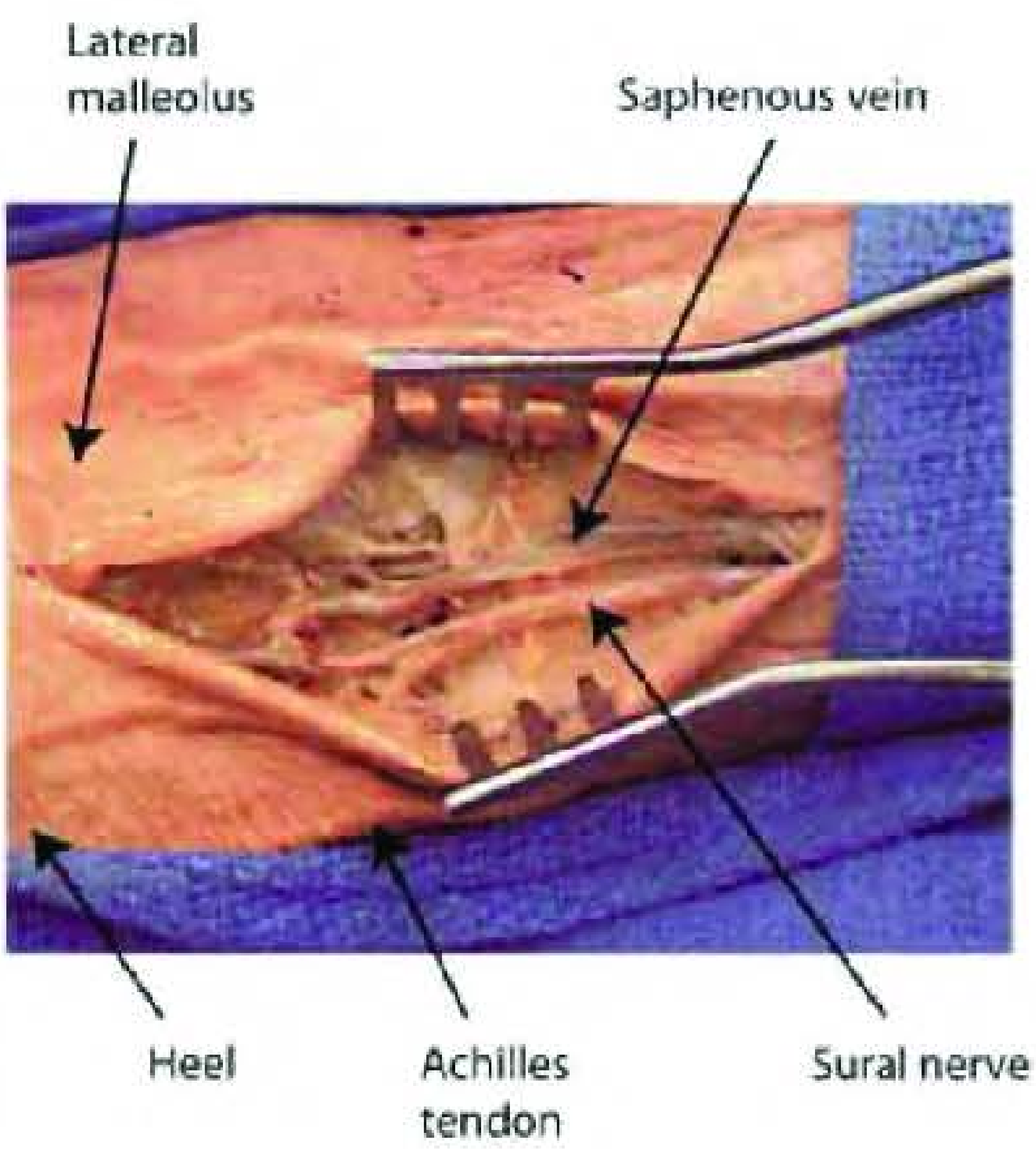

FIGURE 39–2 The sural nerve is identified deep and lateral to the vein.

PITFALLS, PEARLS, CONSIDERATIONS

- Inability to find the nerve may require more proximal dissection
- Nerve is lateral and deep to the vein
- Wound infections
- A pathologic nerve may be very small
- If unable to locate the nerve, look more superficially, not deep

SUGGESTED READINGS

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PART IV

NEURO-ENDOSCOPY

MINIMALLY INVASIVE SUPRAORBITAL CRANIOTOMY

Carlos Acevedo, Damirez Fossett

INDICATIONS FOR APPROACH

- Anterior circulation vascular lesions
- Anterior cranial base tumors
- Sellar and parasellar region tumors
- Anterior and lateral incisural space Lesions
- Lesions on the ventral surface of the pons and midbrain

POSITIONING AND SKIN INCISION

The patient is placed supine with the head held in May field three-point fixation. Depending on the location of the lesion and the anatomic window selected, the head may be variably rotated contralaterally. ft is rotated 10 to 20 degrees for ipsilateral middle cerebral artery and hippocampal gyrus pathology. It is rotated 20 to 40 degrees for sellar and suprasellar region pathology and 40 to 60 degrees for anterior cranial base lesions. Ten to fifteen degrees of dorsiflexion is standard, but up to 30 degrees may be necessary for Lesions that extend high. A slight tilt to the contralateral shoulder also may be helpful.

The skin incision is made over the eyebrow, beginning at the supraorbital foramen or notch and ending at the lateral edge of the eyebrow in front of the zygomatic process (Fig. 40–1). The scalpel should be introduced obliquely to avoid damaging the hair follicles. Safety stitches can be placed at the ends of the incisions to help avoid tears from retraction. Following the incision, subdermal dissection exposes the fascia of the frontal and temporal muscles. The supraorbital nerve should be identified and protected. The temporal fascia then is cut at the superior temporal line for approximately 2 cm, and subperiosteal dissection and retraction of the muscle are performed to expose the temporal region. The frontal fascia can now be incised in a semicircular fashion, elevated, and retracted with its base toward the orbital rim.

SURGICAL TECHNIQUE

Whereas there is no standard supraorbital keyhole craniotomy, there are several variations that can be considered (Fig. 40–2). If the orbital rim is not taken, the craniotomy has three variants: frontomedial, frontosupraorbital, and frontolaterobasal. A burr hole is placed laterally in the temporal

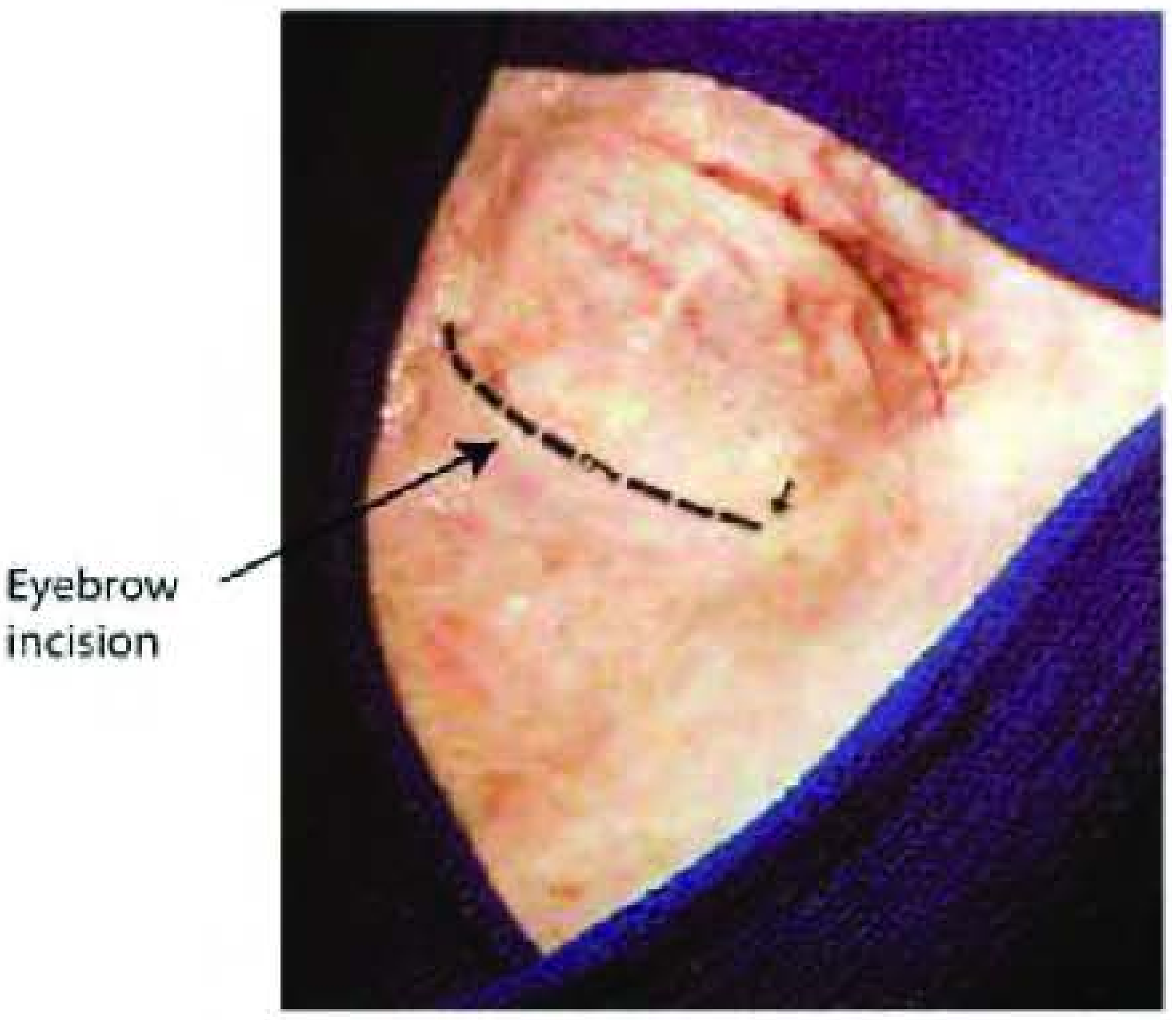

FIGURE 40–1 Eyebrow incision for the supraorbital keyhole approach.

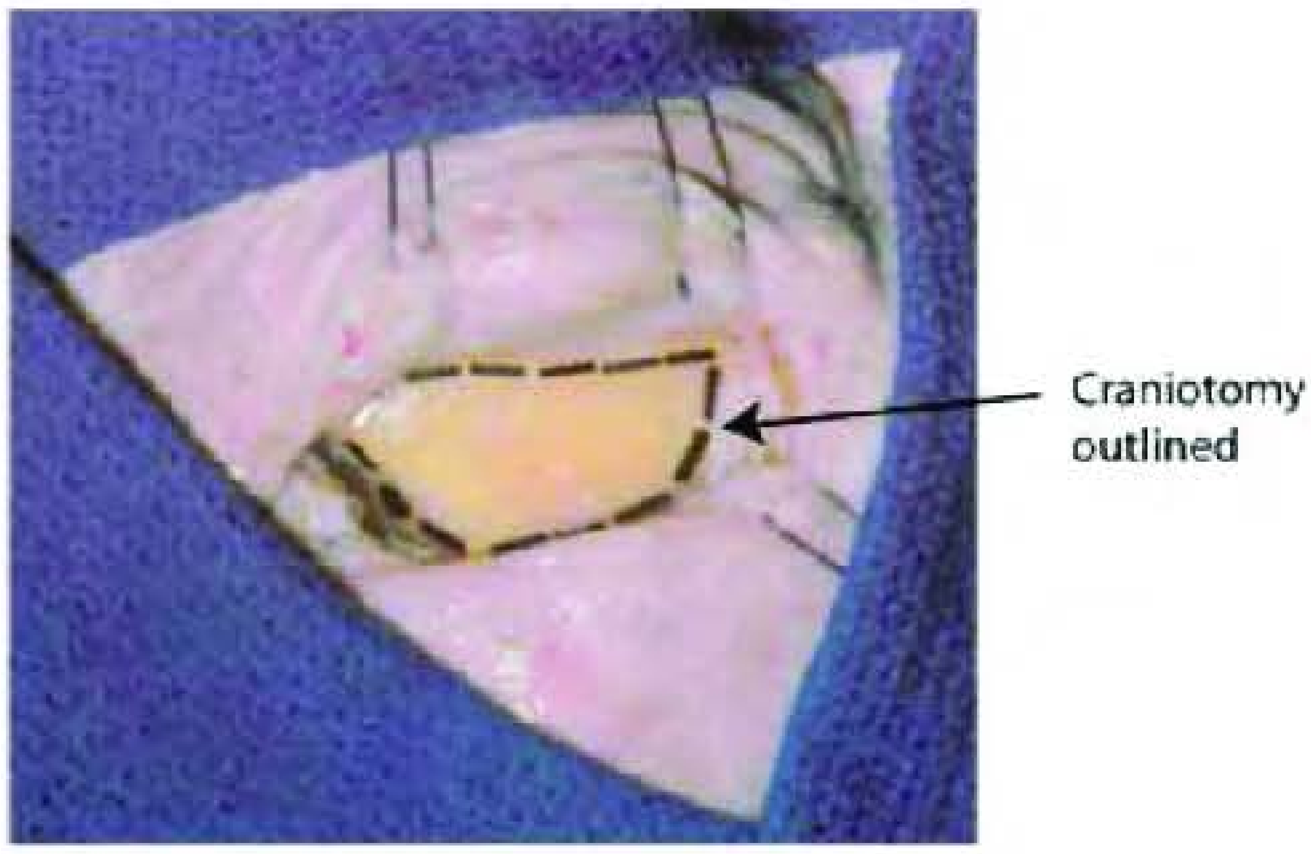

FIGURE 40–2 Craniotomy is outlined for the supraorbital keyhole approach.

fossa, just below the superior temporal line and about 5 mL above the McCarty's keyhole. This should prevent violation of the periorbita. After epidural dissection, a craniotomy 3.5 cm wide and 2 cm high is performed with a high-speed drill above the orbital rim and lateral to the supraorbital nerve (Fig. 40–3). Care should be taken to avoid the frontal sinus. Once the bone flap is elevated, the internal cortical layer of the frontal fossa, the sphenoid wing, and the bony irregularities of the anterior fossa floor should be drilled away. The dura is incised in a semicircular fashion and retracted toward the orbit (Fig. 40–4). For lesions extending cephalad, the craniotomy can be extended to include the orbital rim and roof. These also can be incorporated into the craniotomy (one or two flaps) (Figs. 40–5 and 40–6).

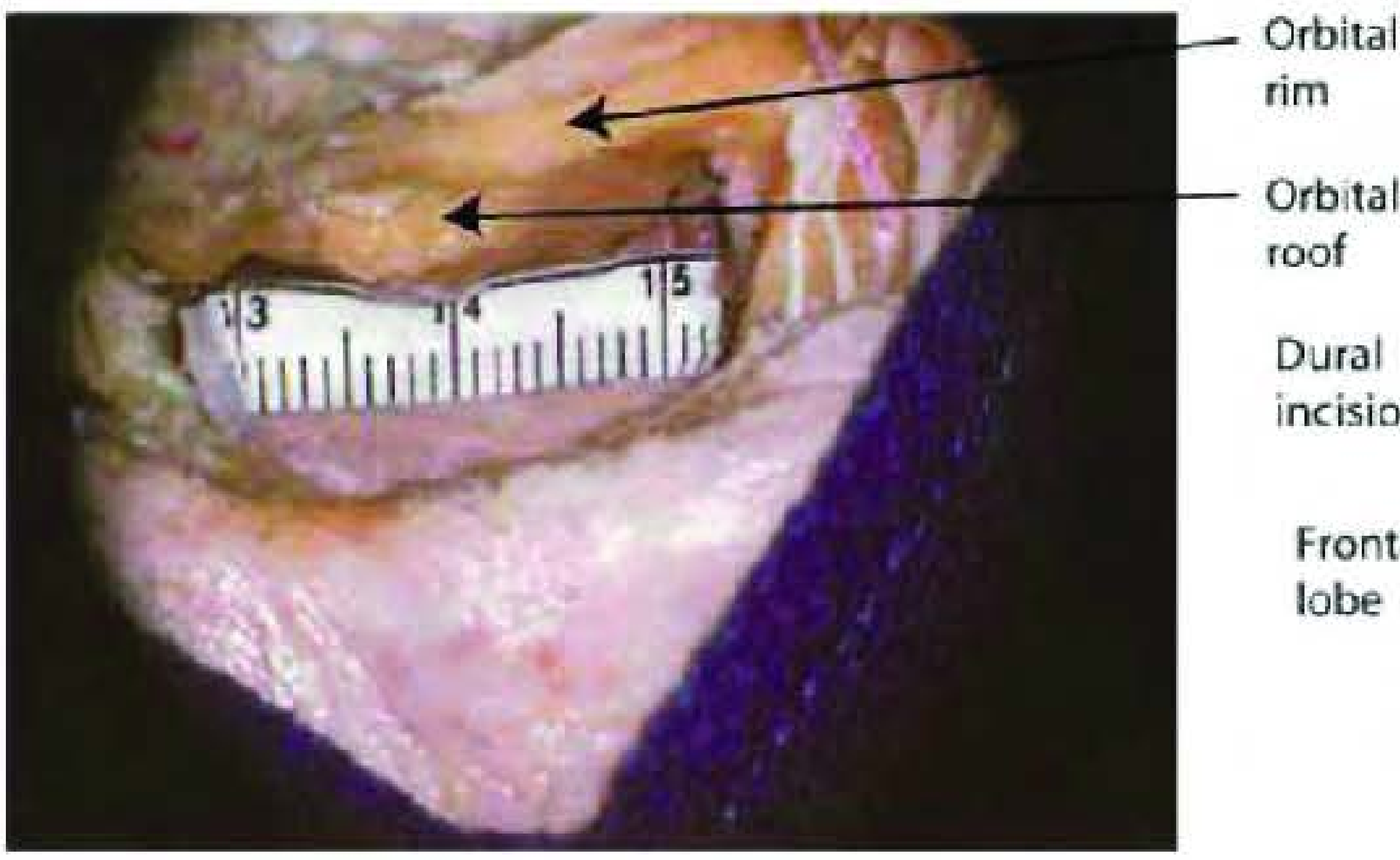

FIGURE 40–3 This craniotomy spans 2.5 cm at its base.

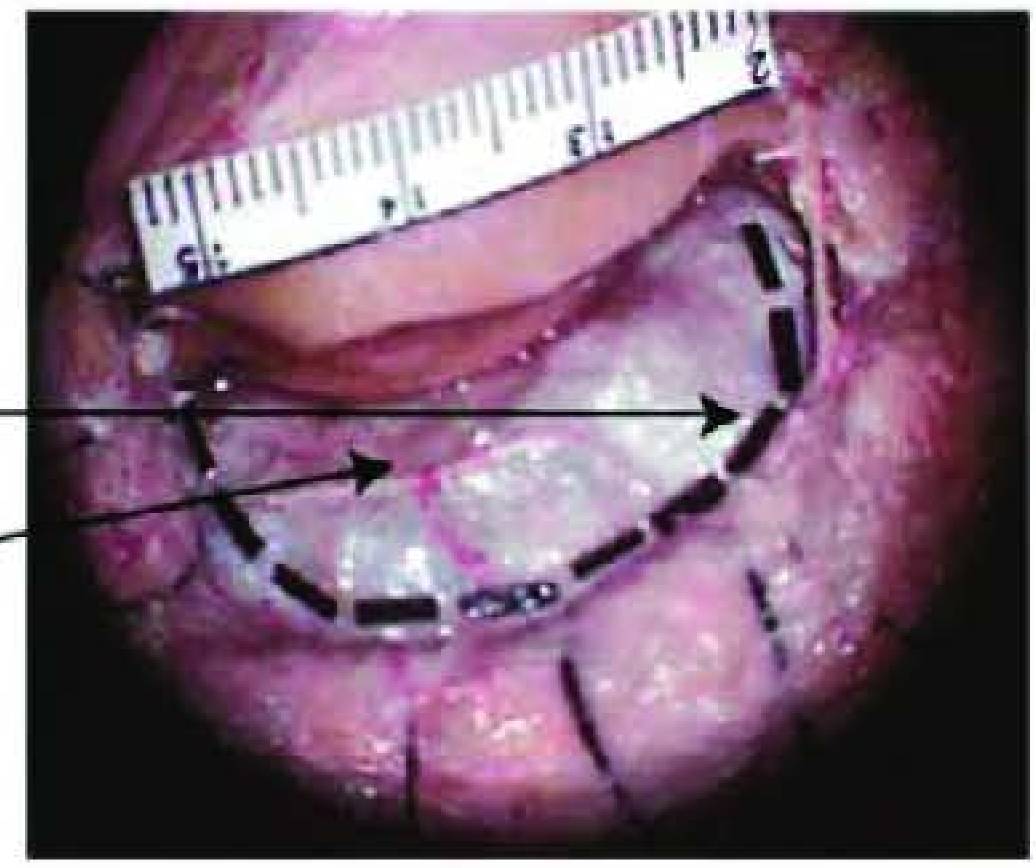

FIGURE 40–4 The dural incision is outlined.

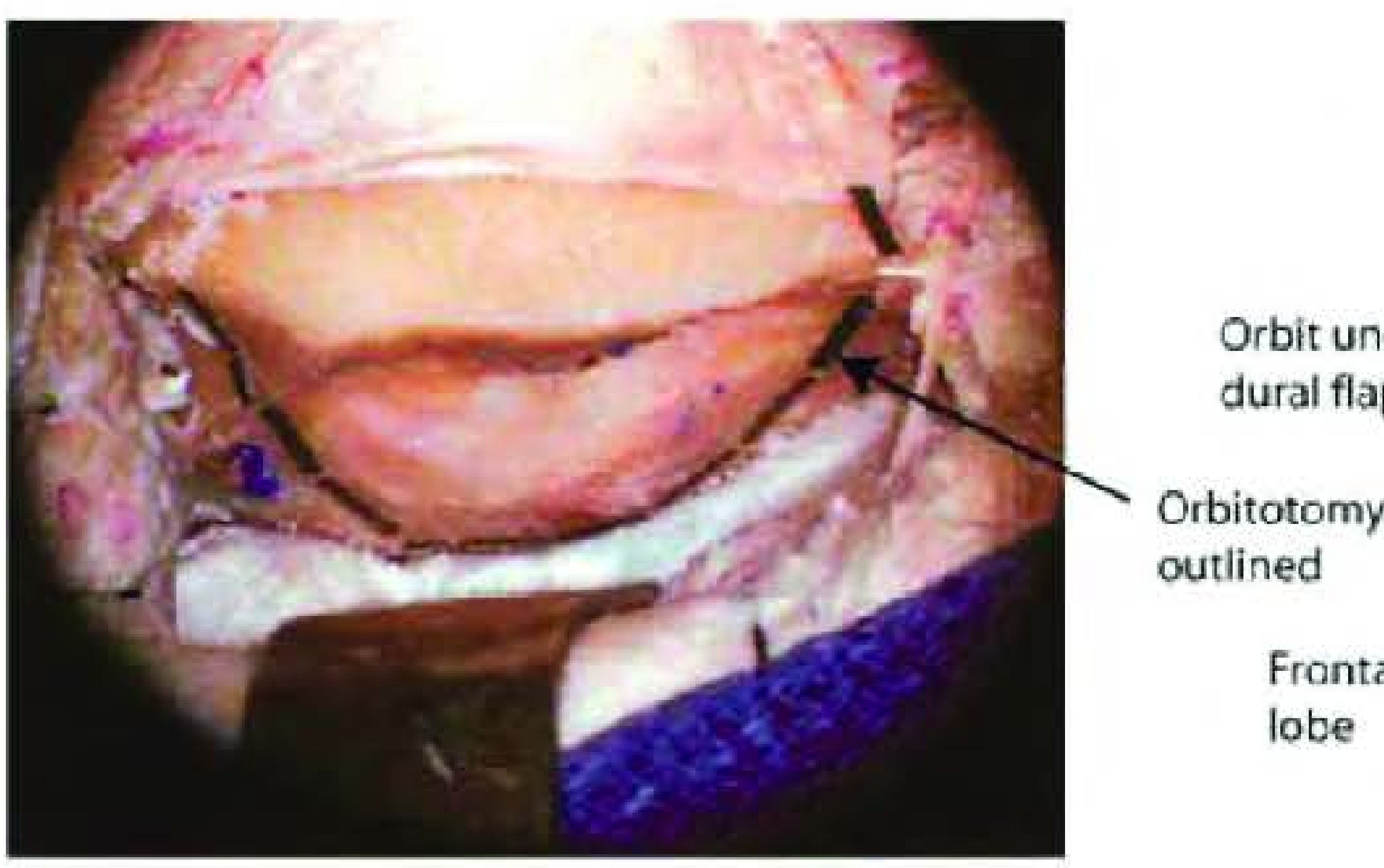

FIGURE 40–5 The orbitotomy cuts are outlined.

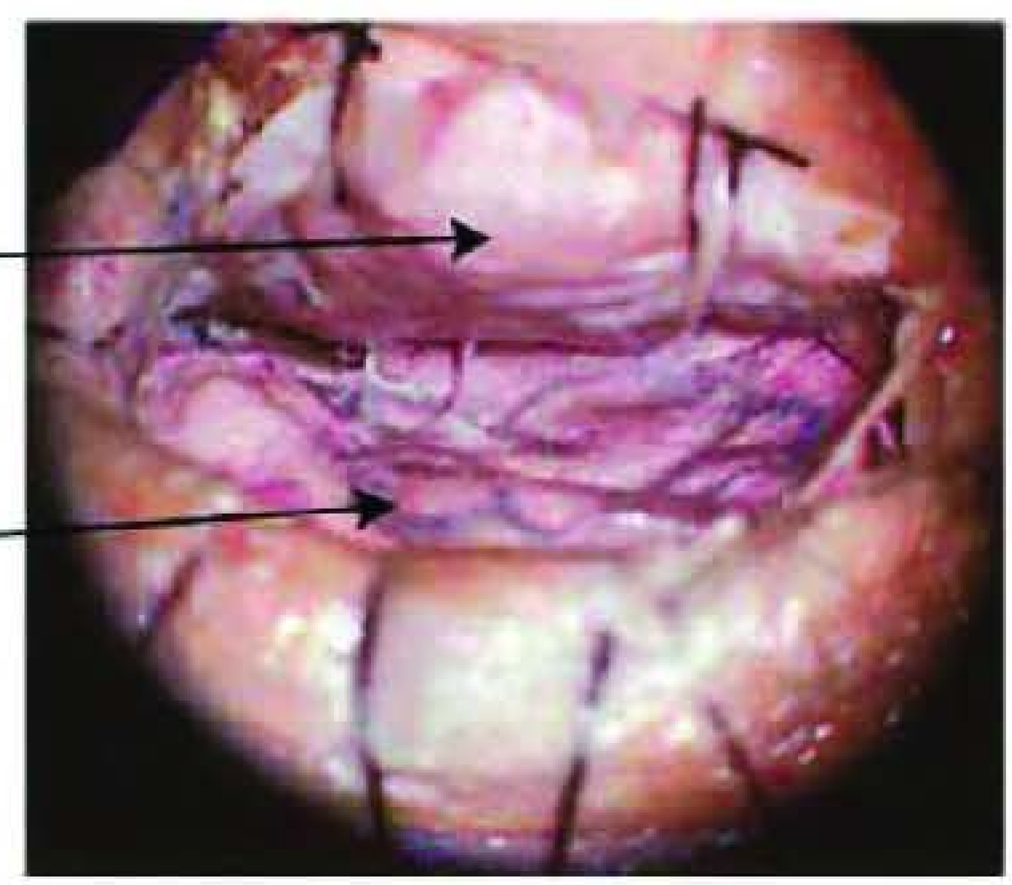

FIGURE 40–6 The orbitotomy has been performed and the dura opened.

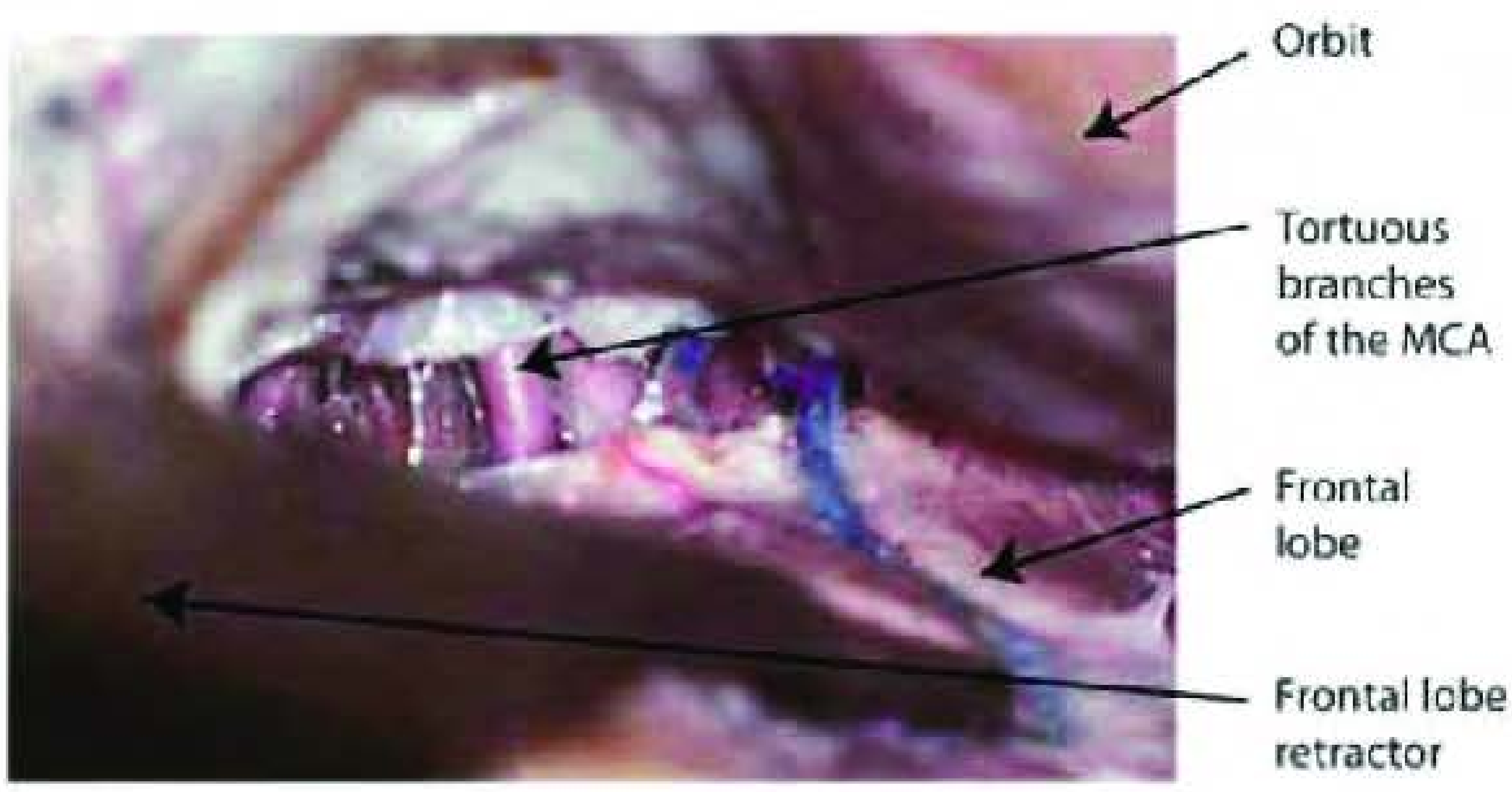

FIGURE 40–7 Opening of the sylvian fissure to see tortuous branches of the middle cerebral artery (MCA).

Using the operating microscope, the arachnoid dissection begins laterally at the sylvian fissure, first freeing the frontal lobe and then draining the cerebrospinal fluid from the sylvian and carotid cisterns and exposing the middle cerebral and internal carotid arteries (Figs. 40–7–40–12). The

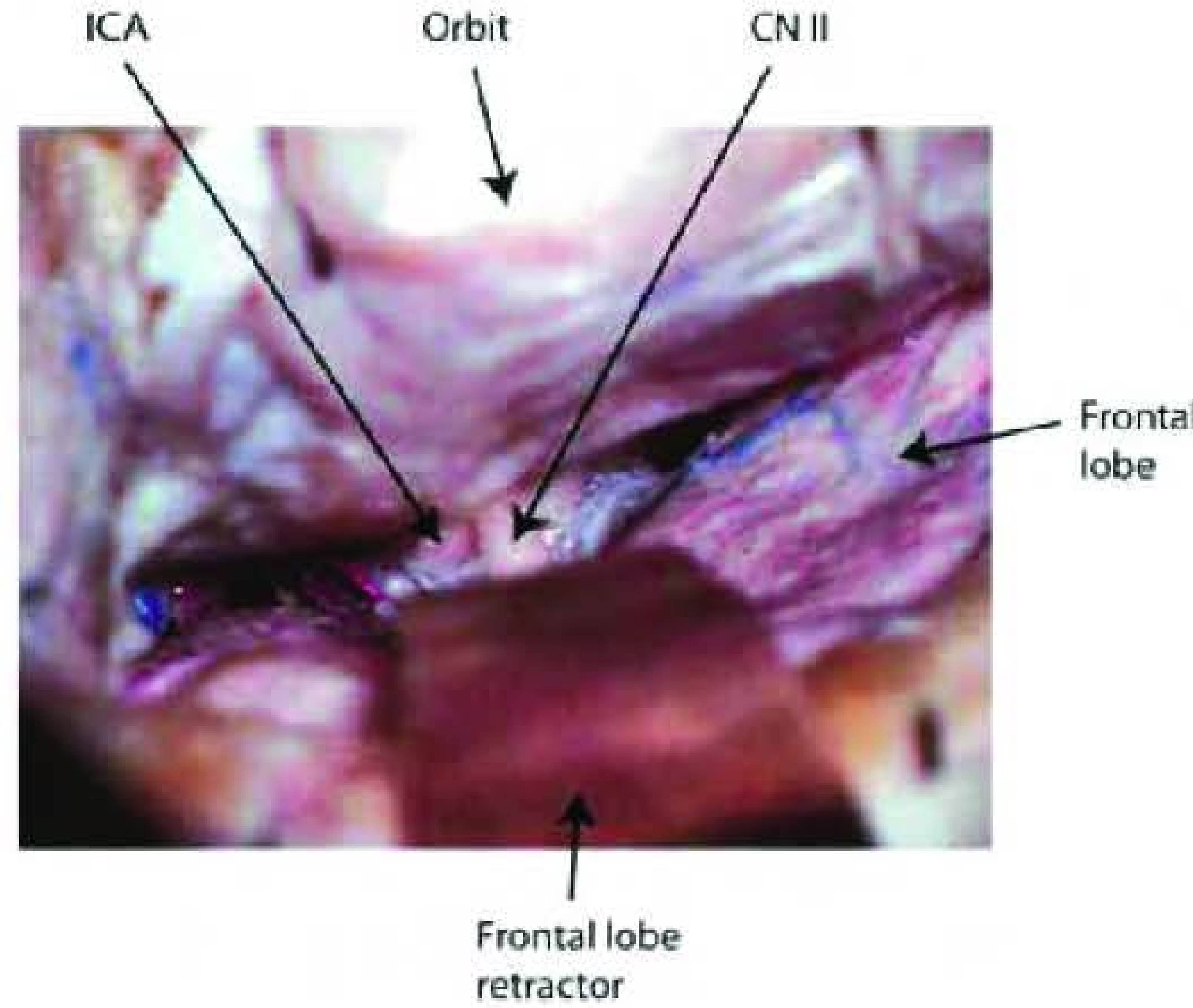

FIGURE 40–8 Arachnoid bands enveloping the optic-carotid complex, ICA, internal carotid artery; CN, cranial nerve.

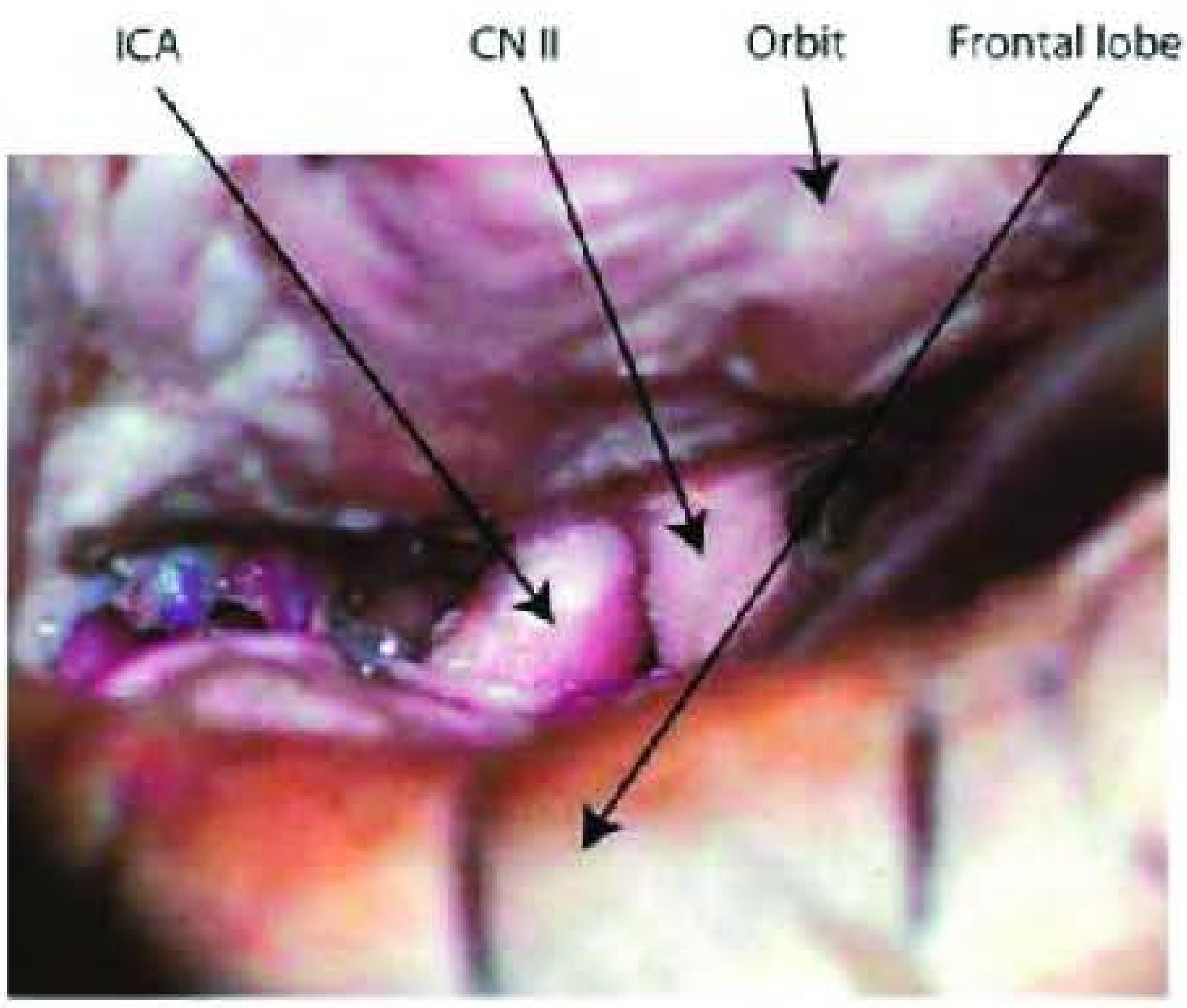

FIGURE 40–9 The optic–carotid cistern has been opened. ICA, internal carotid artery; CN, cranial nerve.

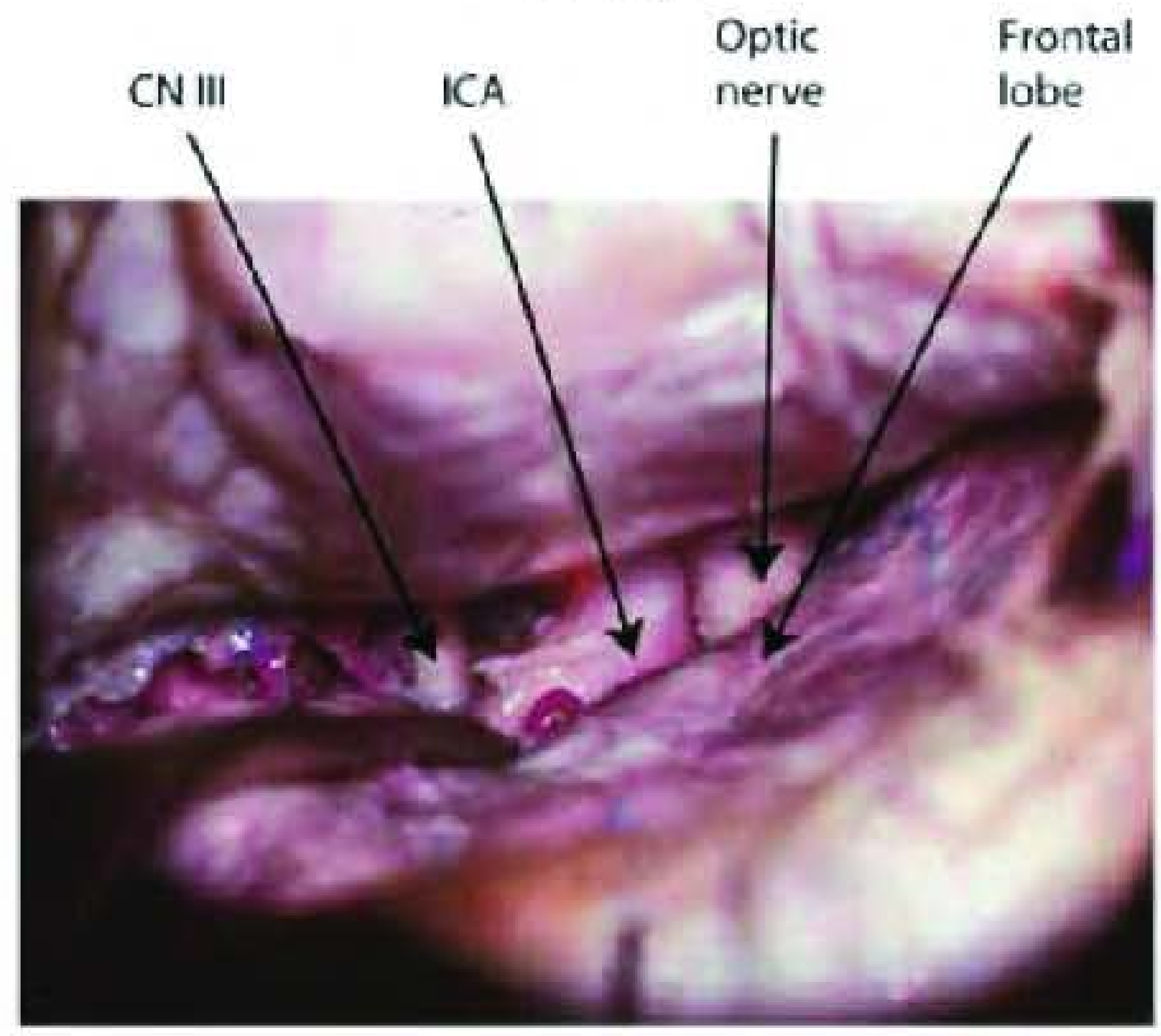

FIGURE 40–10 The optic nerve, carotid artery, and third cranial nerve (CN III) come into view. ICA, internal carotid artery.

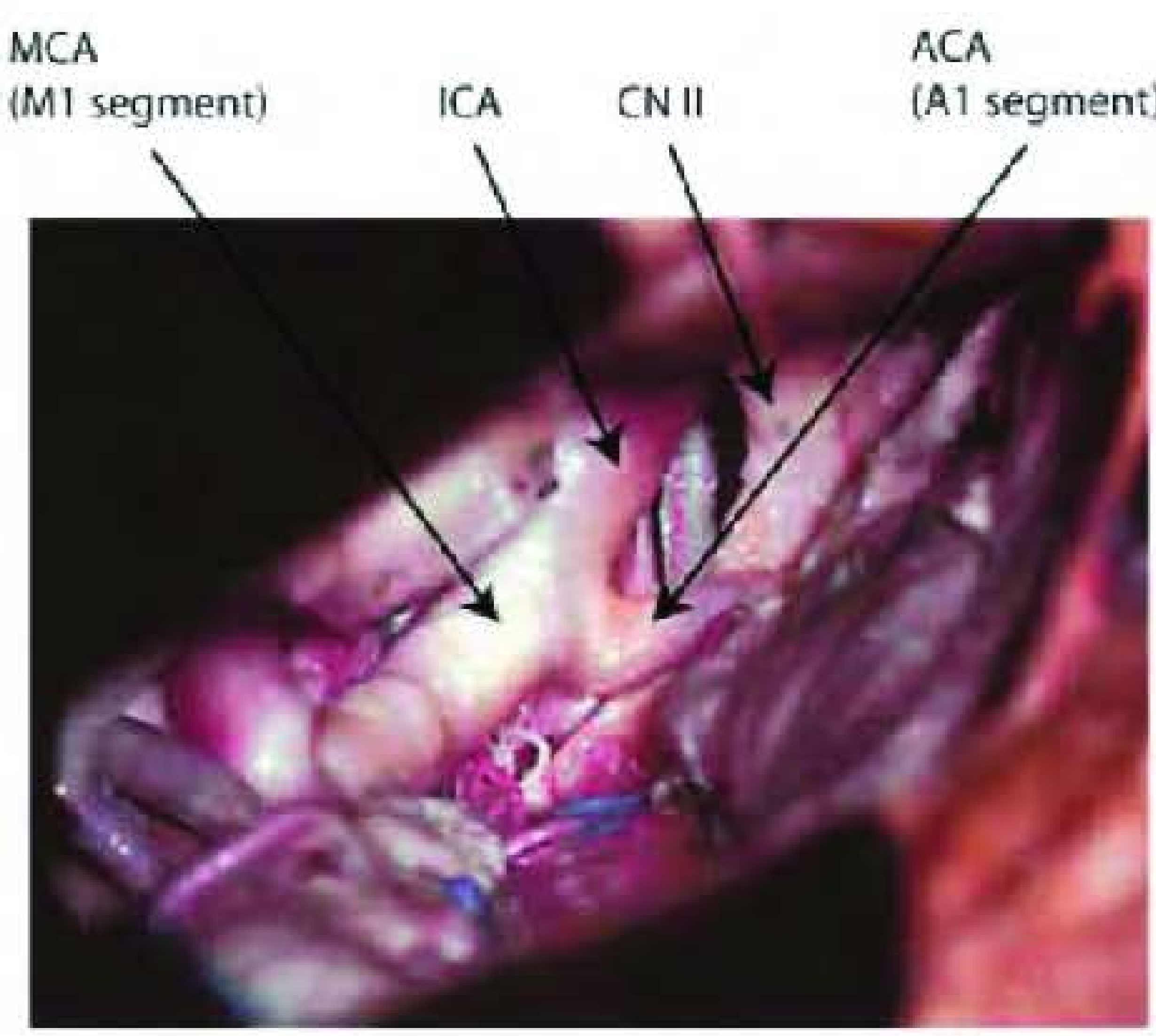

FIGURE 40–11 The carotid bifurcation is well visualized. Perforators from the carotid and an Al perforator can be seen. CN, cranial nerve; MCA, middle cerebral artery; ICA, internal carotid artery; ACA, anterior cerebral artery.

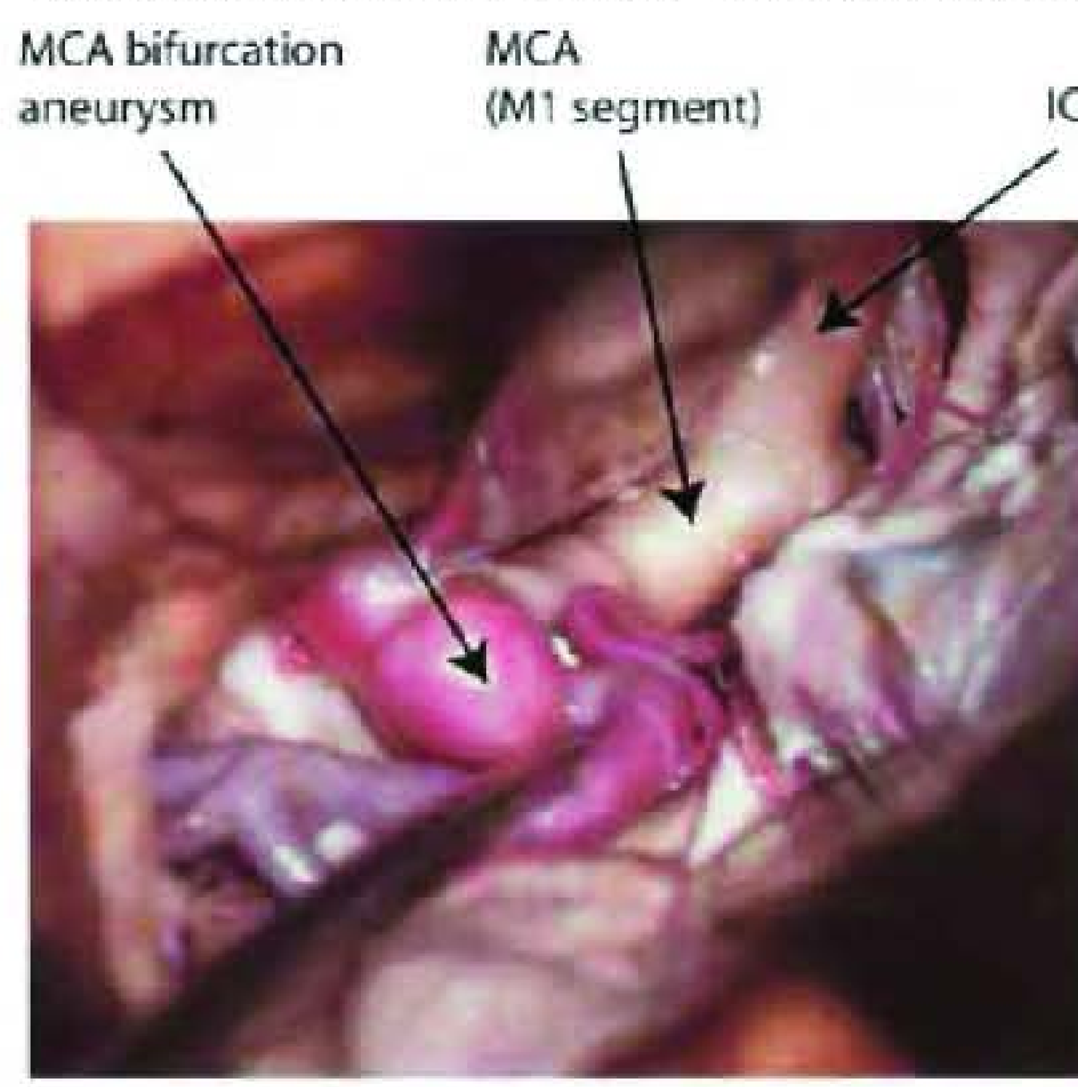

FIGURE 40–12 A middle cerebral artery (MCA) bifurcation aneurysm is discovered. ICA, internal carotid artery.

dissection then continues posterior and medial to identify and open the chiasmatic cistern and expose the optic nerve, anterior cerebral and anterior communicating complex, olfactory nerve located lateral to the gyrus rectus, and the lamina terminalis (Figs. 40–13–40–17). To avoid tears of the

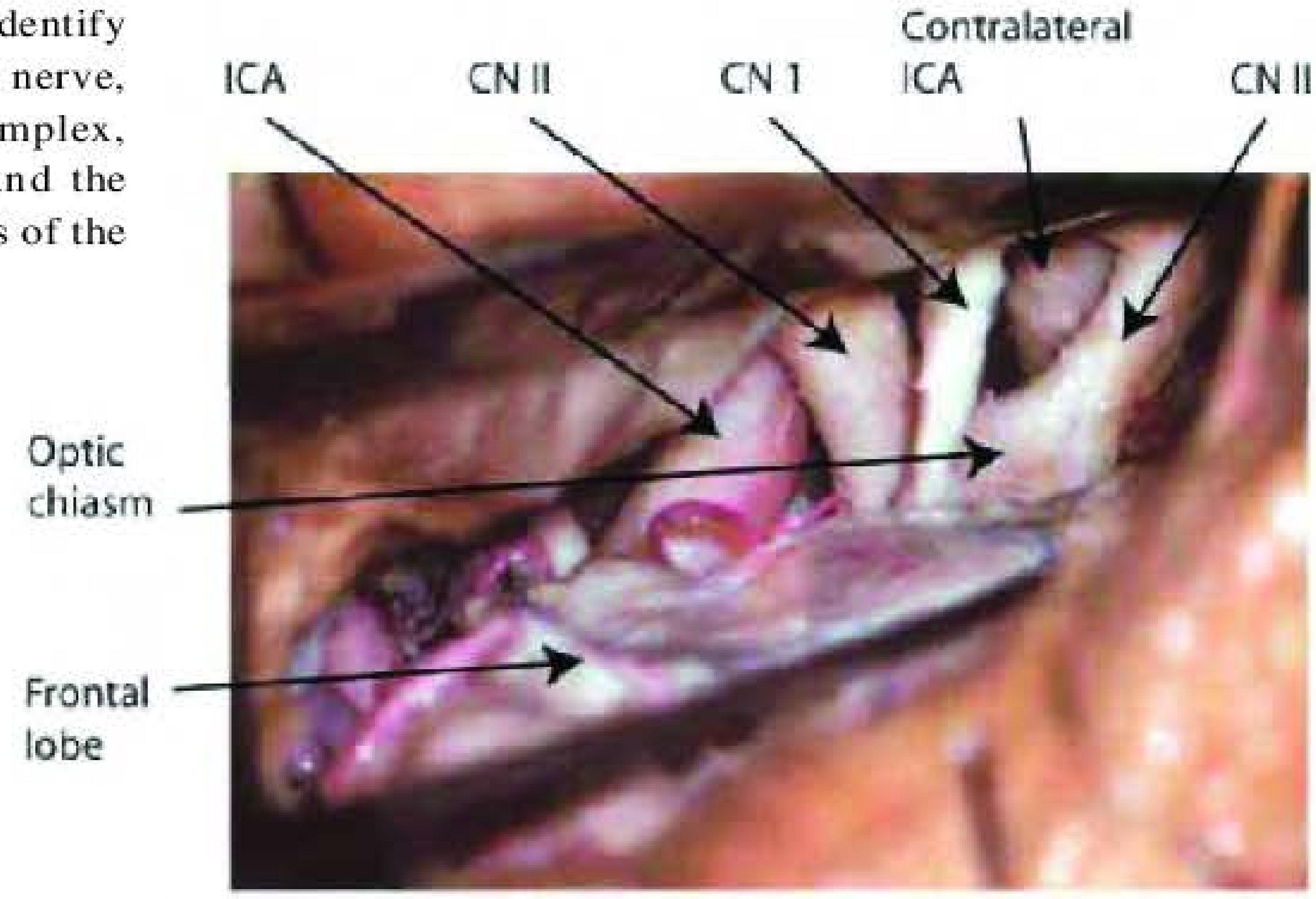

FIGURE 40–13 The olfactory nerve is visualized above the optic chiasm. The contralateral internal carotid artery (ICA) is seen between the optic nerves. The ipsilateral ICA is well visualized. CN, cranial nerve.

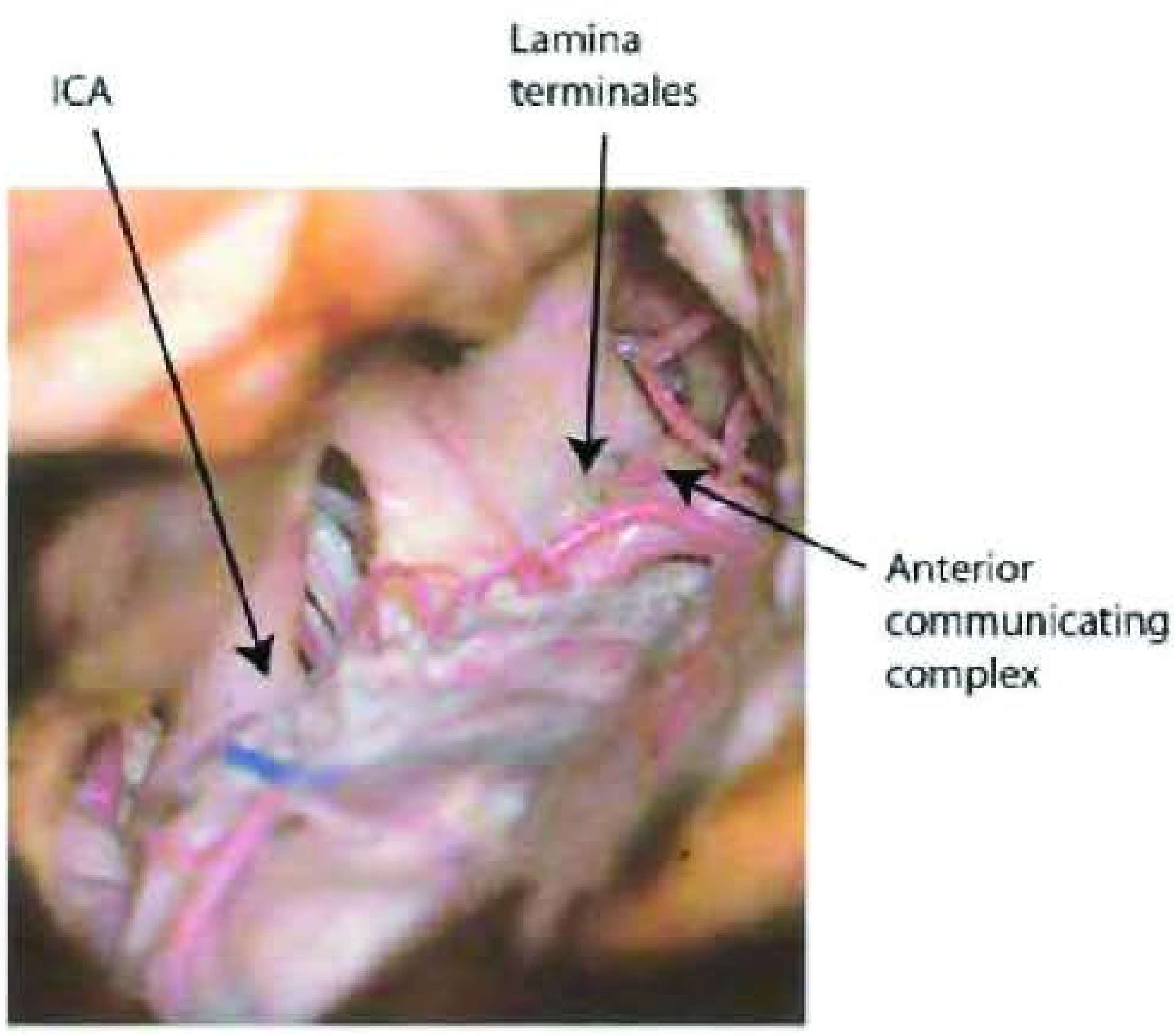

FIGURE 40–14 With slight retraction, the lamina terminals and the anterior communicating complex come into view. ICA, internal carotid artery.

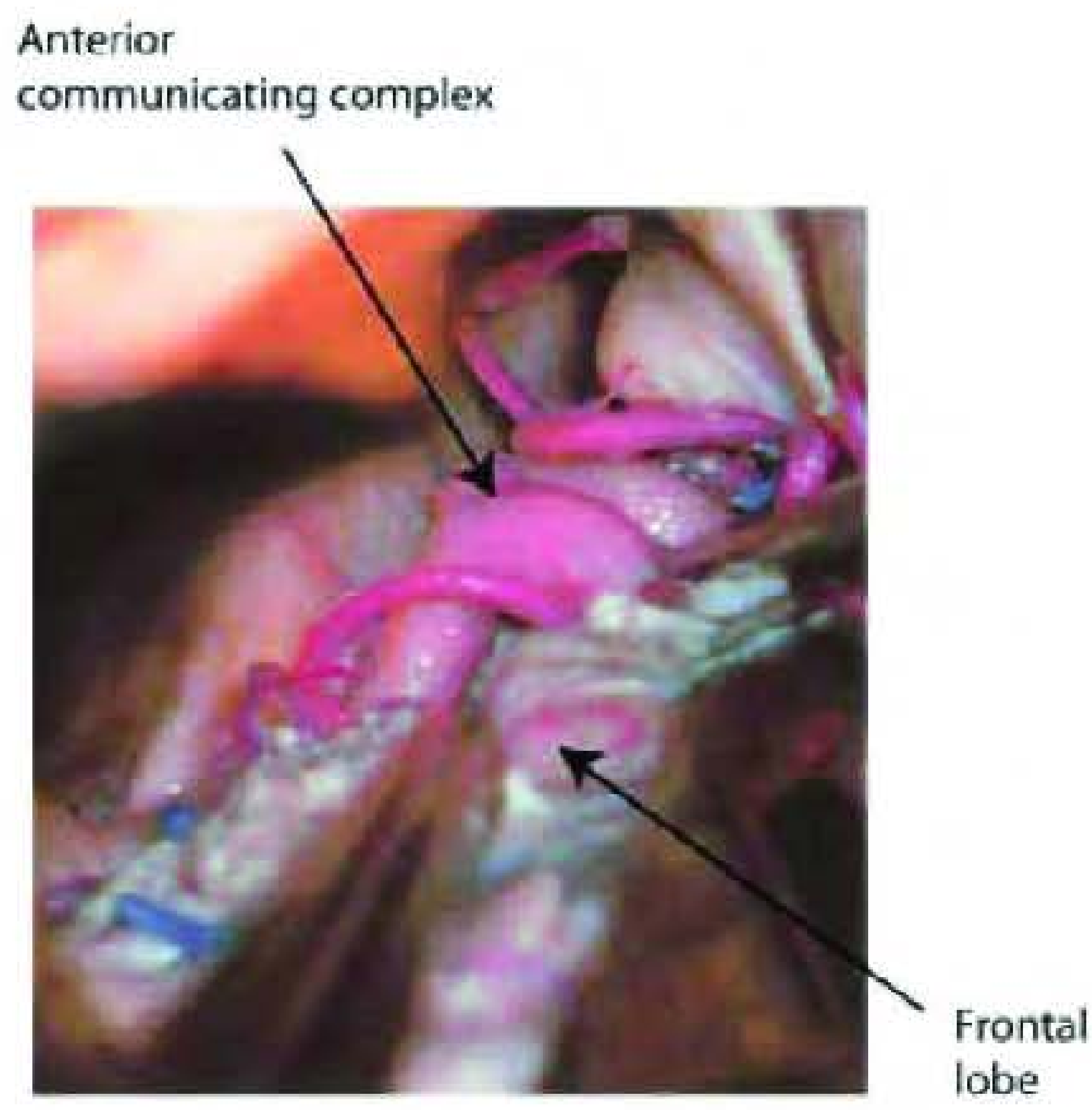

FIGURE 40–15 The anterior communicating complex is well seen.

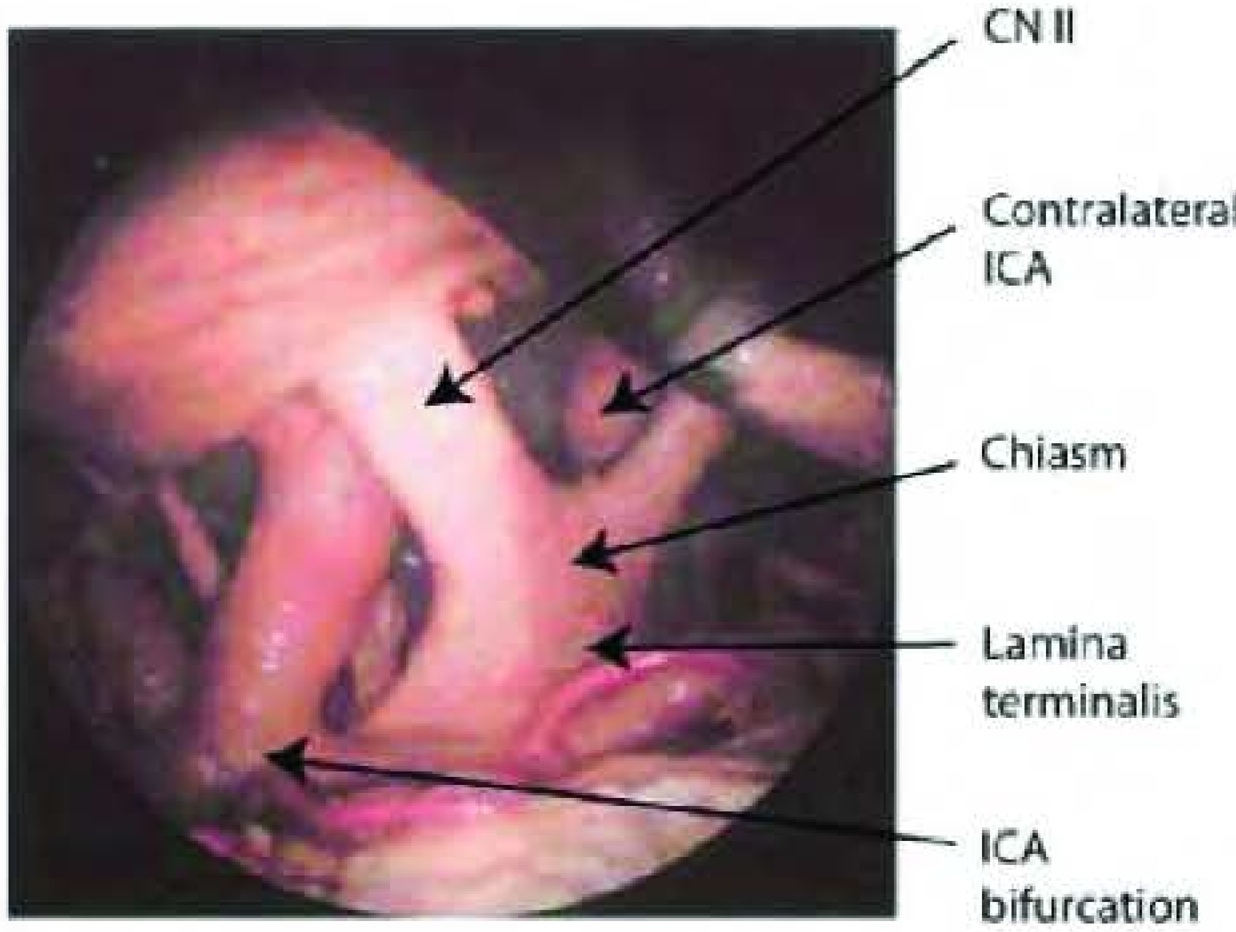

FIGURE 40–16 A panoramic endoscopic view with the 30-degree endoscope. ICA, internal carotid artery; CN, cranial nerve.

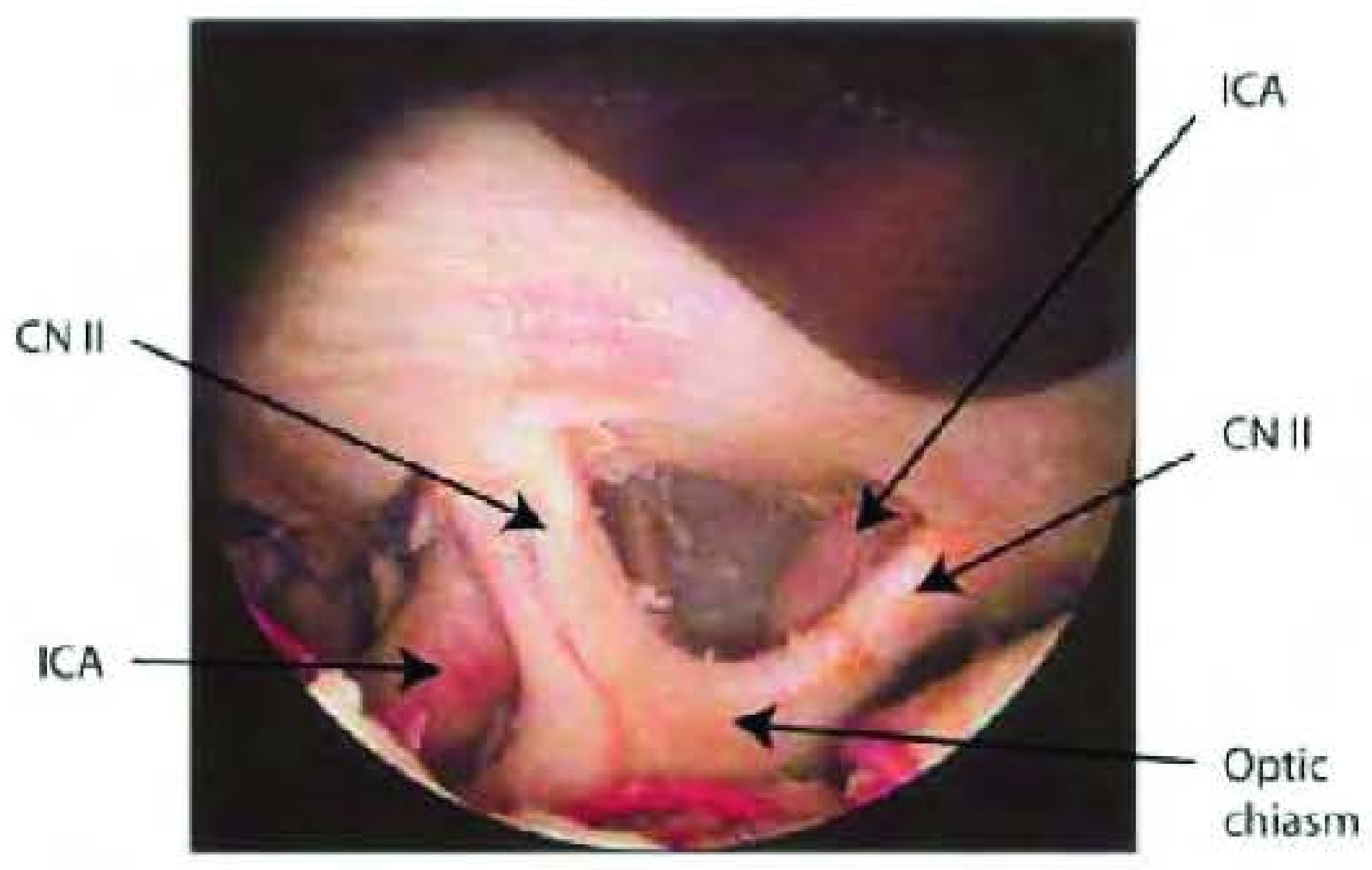

FIGURE 40–17 The optic chiasm and both internal carotid arteries (ICAs) are visualized with the 30-degree endoscope. CN, cranial nerve.

olfactory nerve due to the frontal lobe falling away, its arachnoid layer should be opened widely so that the nerve is freed from thy frontal lobe and rests on the floor of the anterior cranial fossa. To reach the anterior and lateral incisural spaces, it is necessary to work through anatomic windows such as the optical–carotid triangle, between the optic nerves, behind or in front of the pituitary stalk, or between the oculomotor nerve and the carotid artery (Figs. 40–11, 40–12, 40–16, and 40–18–40–21). The interpeduncular cistern is reached by opening the membrane of Lilliquist and contains

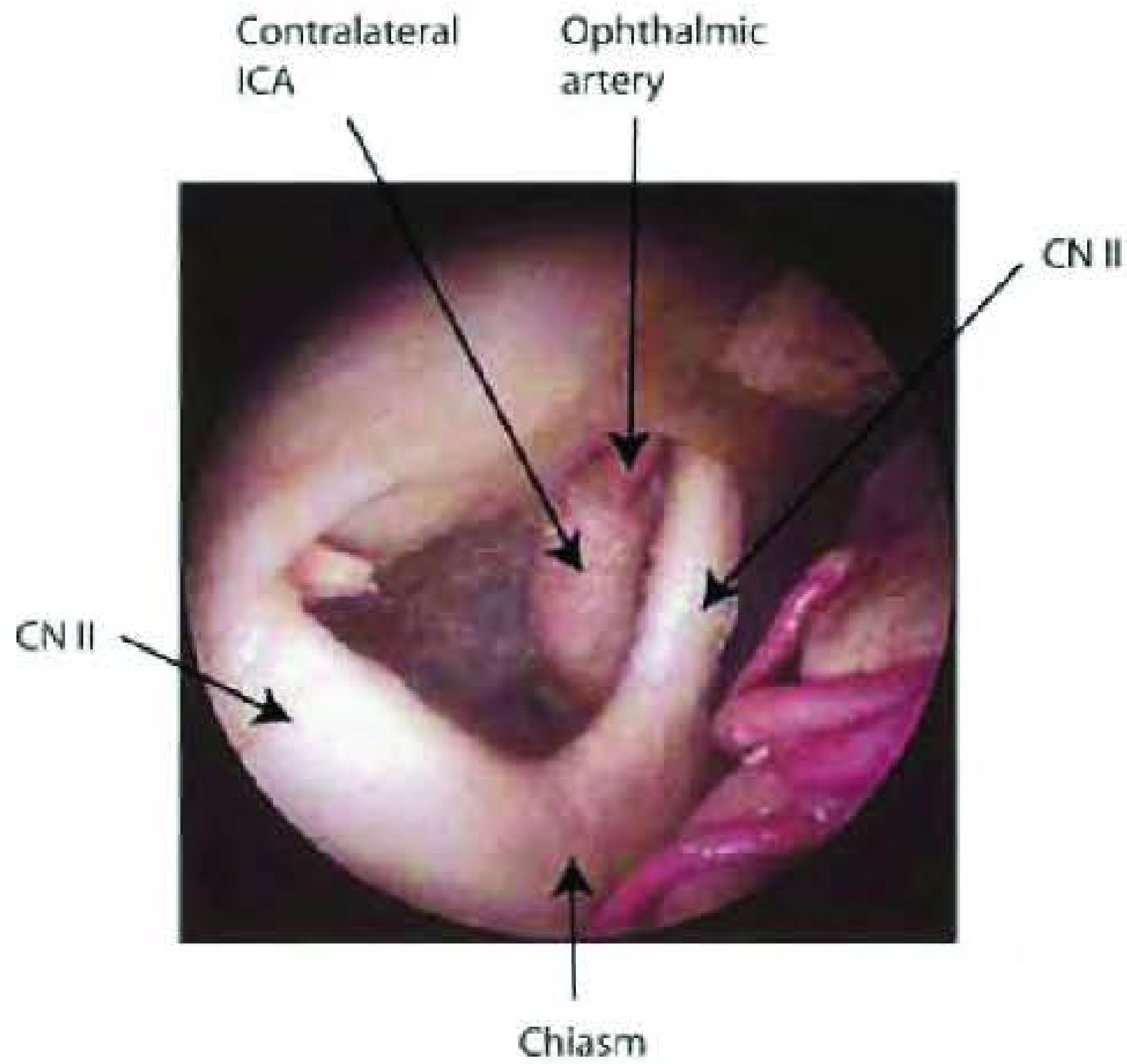

FIGURE 40–18 The contralateral ophthalmic artery can be seen. The falciform ligament is seen forming the root of the optic canal. ICA, internal carotid artery; CN, cranial nerve.

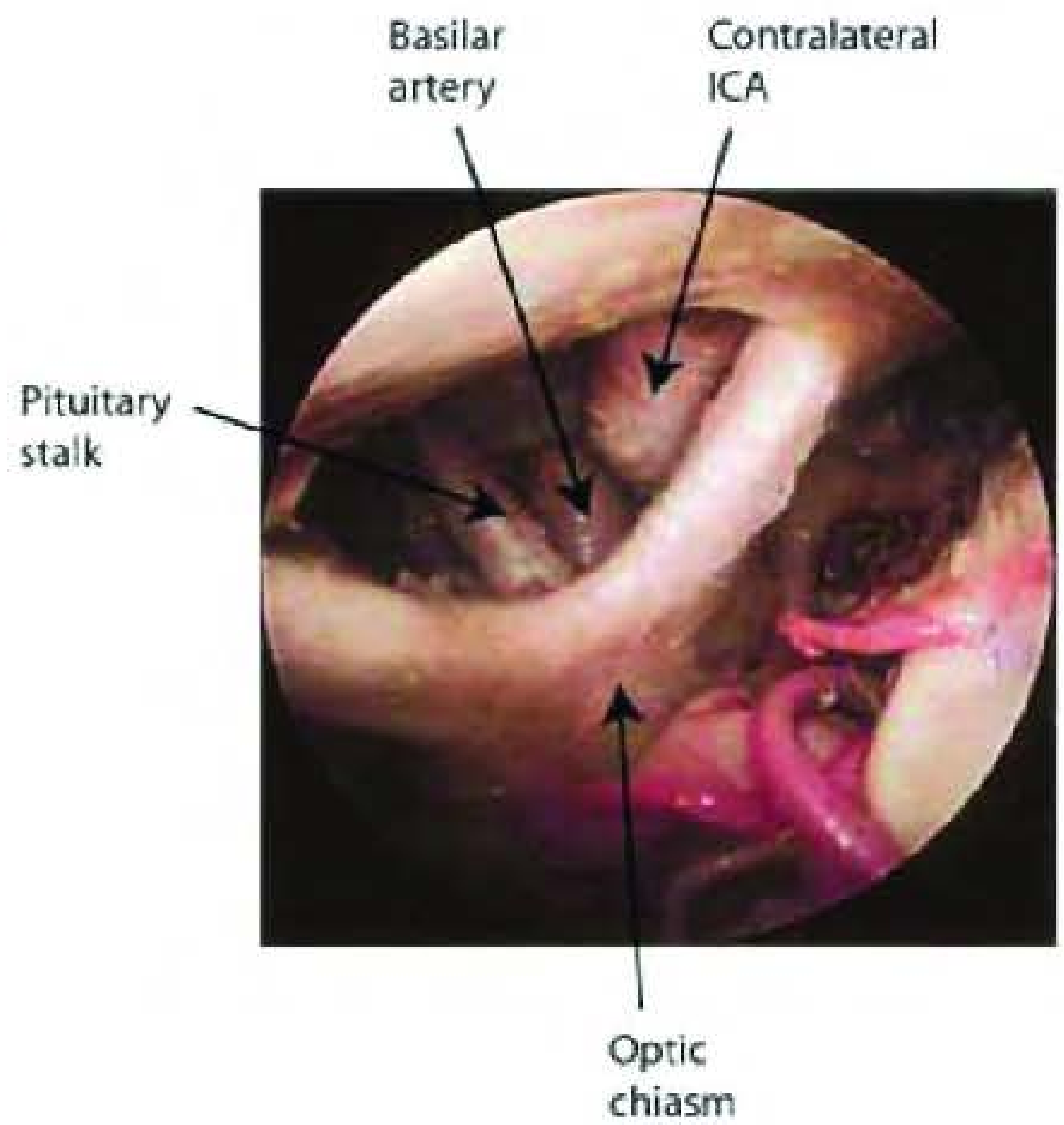

FIGURE 40–19 The pituitary stalk, basilar artery, and anterolateral internal carotid artery (ICA) arc visualized through the prechiasmatic window with a 70-degree endoscope.

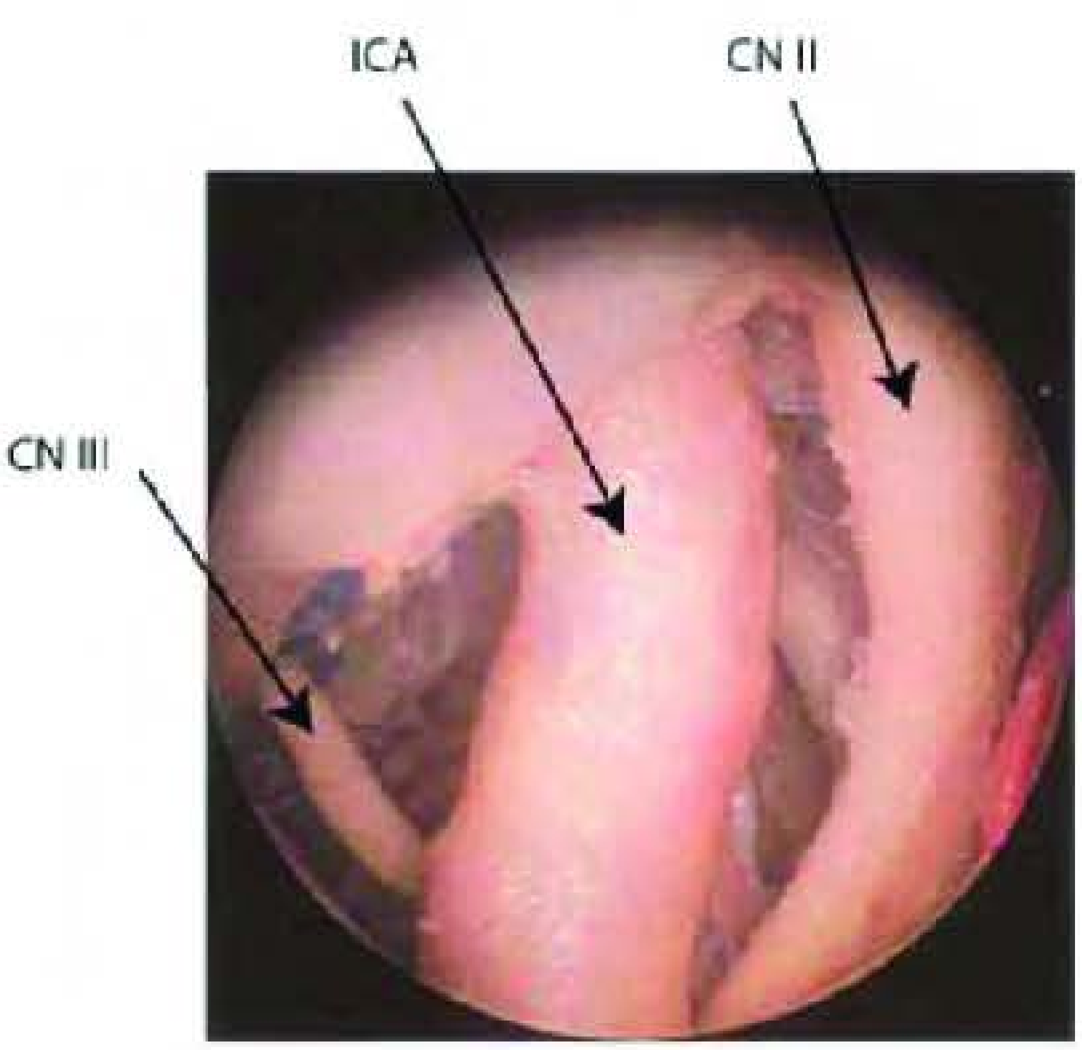

FIGURE 40–20 The carotid–oculomotor corridor and the optic–carotid corridor are shown with a zero-degree endoscope. CN, cranial nerve; ICA, internal carotid artery.

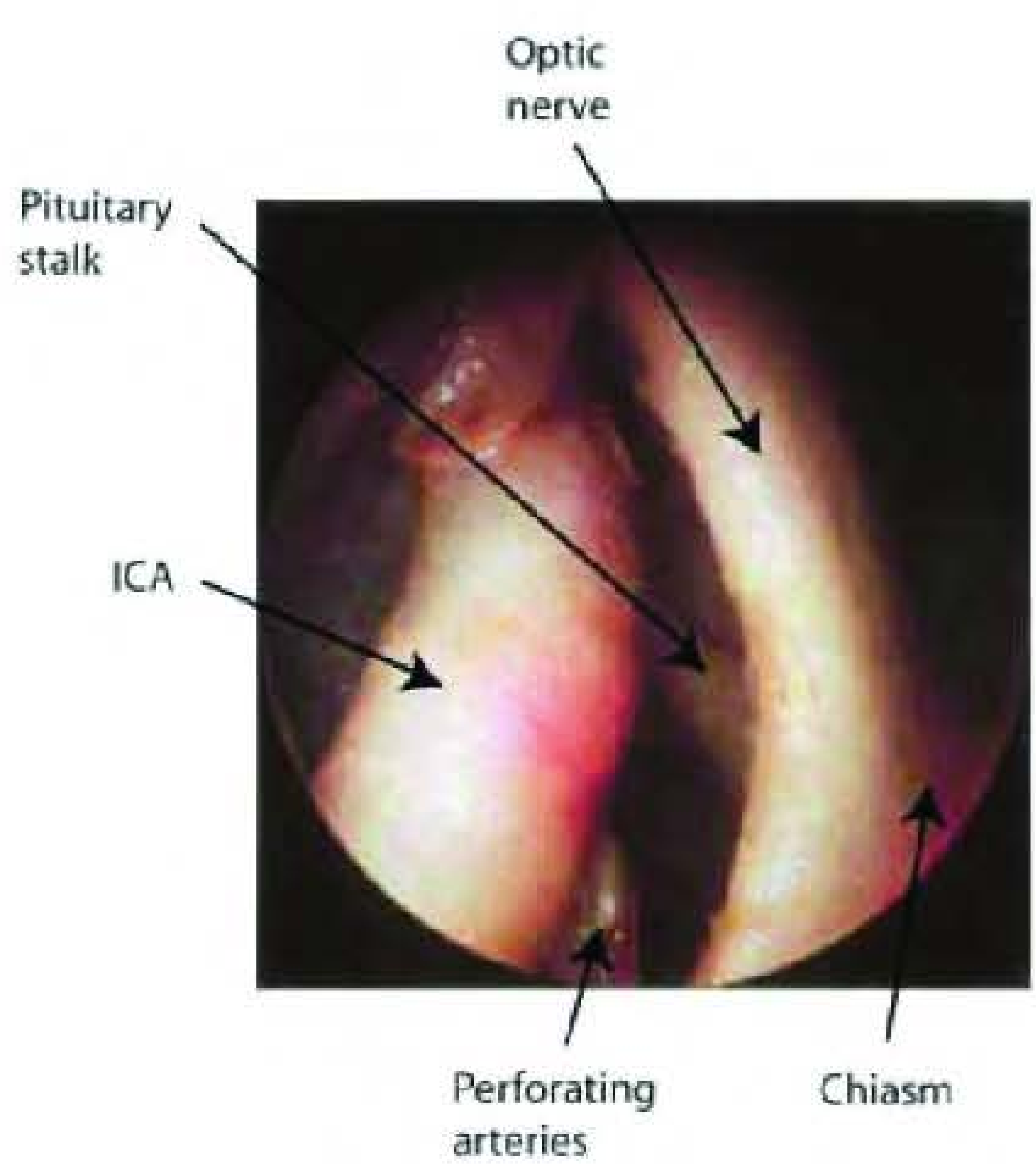

FIGURE 40–21 Through the optic-carotid cistern, the pituitary stalk and perforators from the C4 segment of the internal carotid artery (ICA) can be visualized with a 30-degnee endoscope.

the superior third of the basilar artery and both the posterior cerebral and superior cerebellar arteries (Figs. 40–22 and 40–23). The cerebral peduncles and the ventral surface of the pons make up the posterior wall of the cistern. The dissection may be extended toward the contralateral side (Fig. 40–24).

The dura is closed in a watertight fashion. No dural tackup stitches are necessary. The bone flap is repositioned and fixed by using silk sutures or microplates and screws. The frontal and temporal fascias are closed in the usual fashion. Subdermal and intradermal running sutures are used to close the skin.

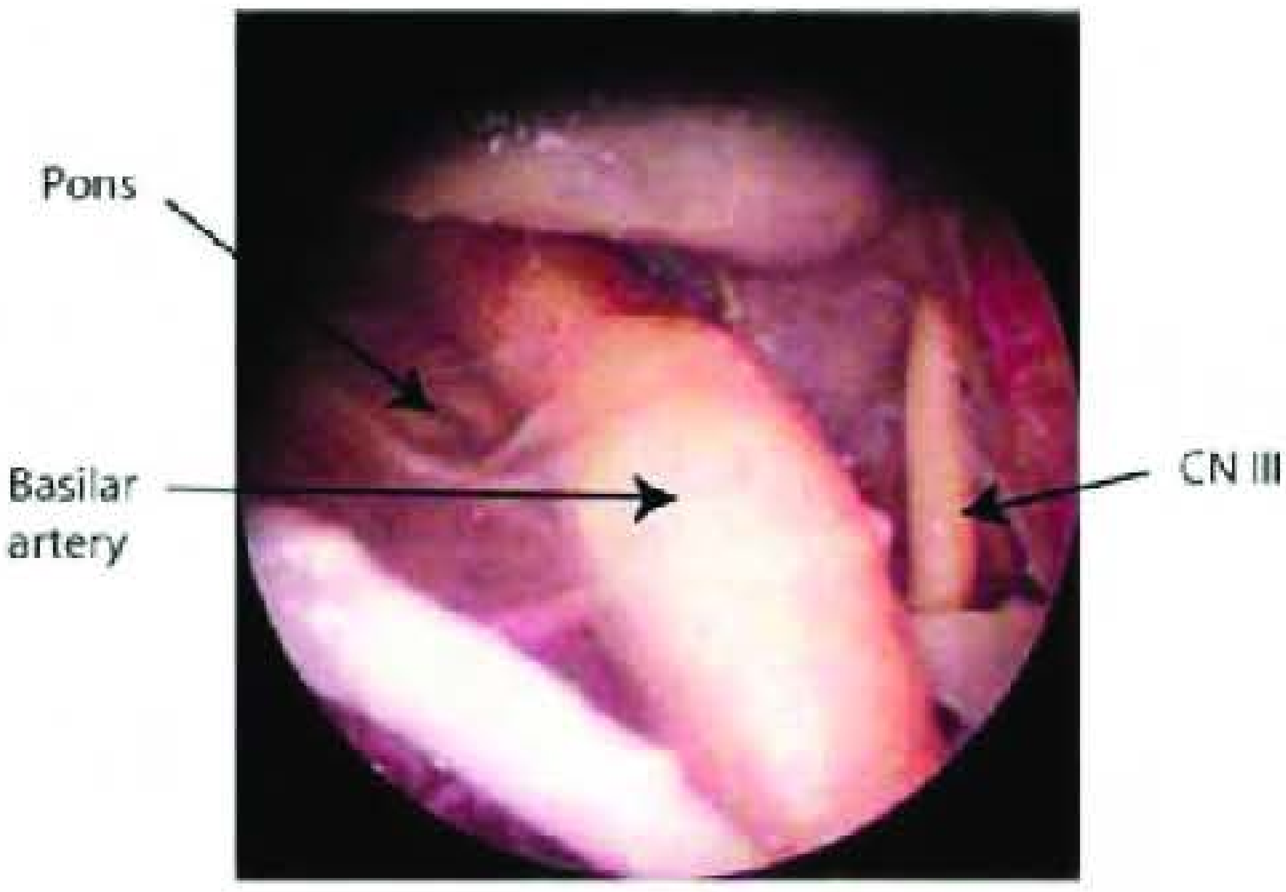

FIGURE 40–22 Note the basilar bifurcation relationship to the dorsum sella. Both third nerves can be seen, CN, cranial nerve.

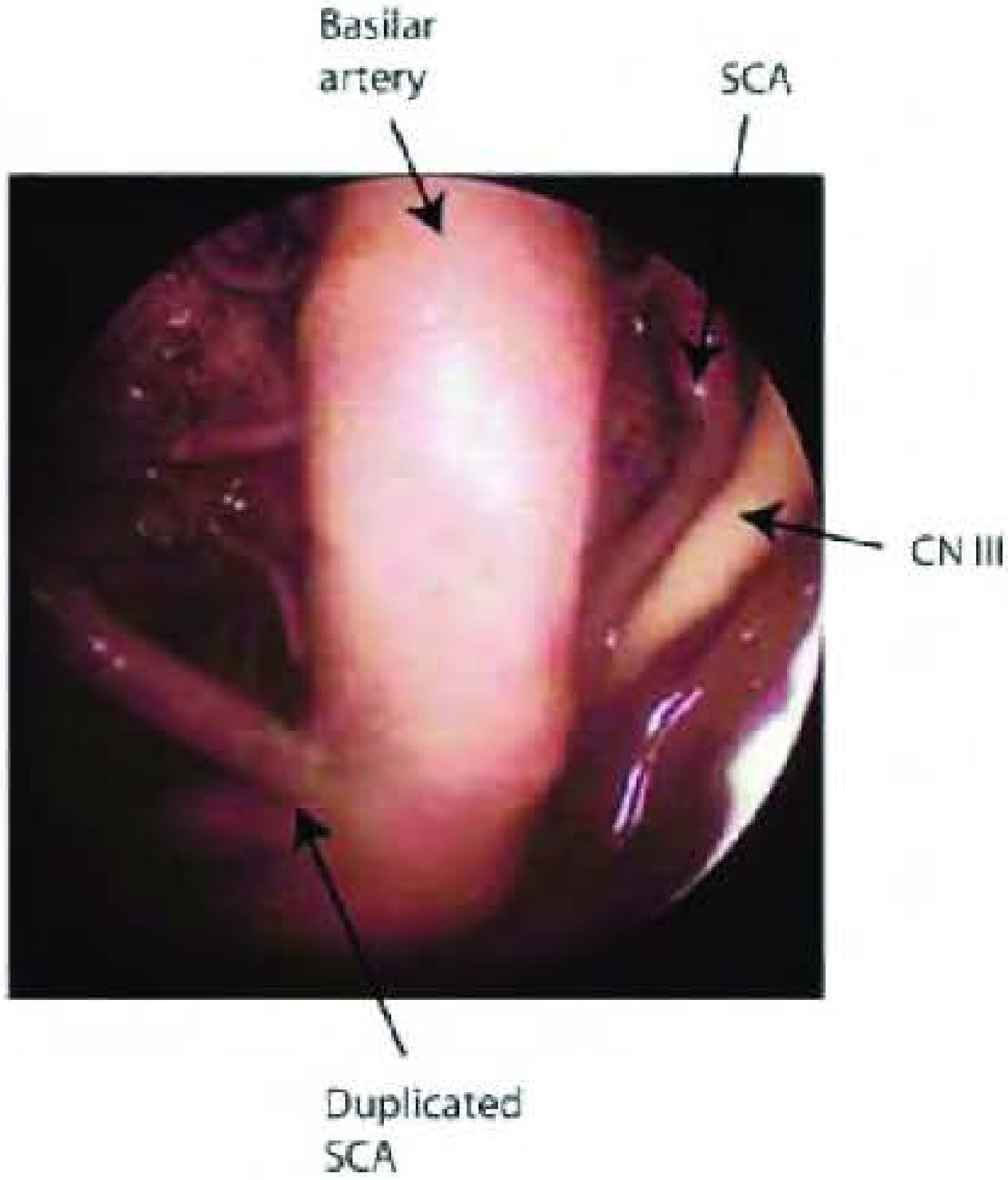

FIGURE 40–23 With the 30-degree endoscope, a bifurcated left superior cerebellar artery (SCA) can be seen. The right third nerve is visualized coursing above the contralateral SCA. CN, cranial nerve.

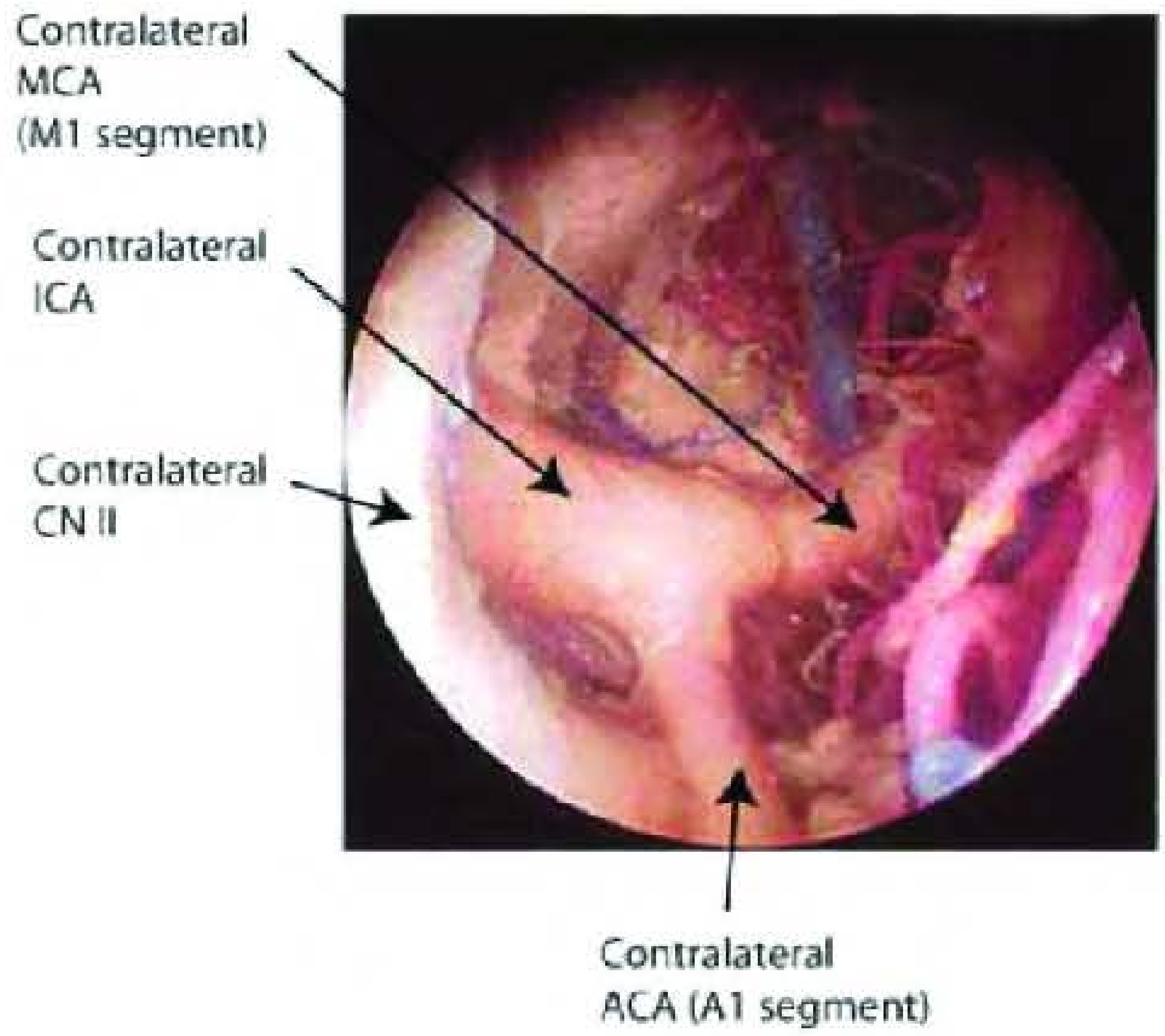

FIGURE 40–24 The contralateral carotid bifurcation. MCA, middle cerebral artery; ICA, internal carotid artery; ACA, anterior cerebral artery; CN, cranial nerve.

Pitfalls, Pearls, Considerations

- Assistance with the endoscope is extremely useful though there is always the risk of stretching structures behind the tip of the lens
- Vascular control of lesions on the ophthalmic or clinoidal segments of the carotid artery is difficult to achieve
- Alternative methods for proximal control, such as neck dissection or endovascular techniques, should be considered
- Frontal sinus entry should be avoided. If encountered, it should be reconstructed in the usual manner

Suggested Readings

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Chapter 41

MINIMALLY INVASIVE SUBTEMPORAL CRANIOTOMY

Carlos Acevedo, Damirez Fossett

INDICATIONS FOR APPROACH

- Lesions in the spheroid sinus
- Lesions in the petrous apex
- Posterior fossa lesions

POSITIONING AND SKIN INCISION

The patient is positioned in the supine position with a shoulder roll beneath the ipsilateral shoulder. The head is rotated toward the contralateral shoulder. The degree of rotation is dictated by the location of the pathology. The skin incision is located anterior to the tragus of the ear (Fig. 41–1). A small "v" may be made in the otherwise linear incision to make it more cosmetic.

SURGICAL TECHNIQUE

A 2.5-cm-diameter craniotomy flap is turned, and with blunt dissection, the dura is lifted from the floor of the middle cranial fossa (Fig. 41–2). The middle meningeal artery is identified and followed to its entrance into the foramen

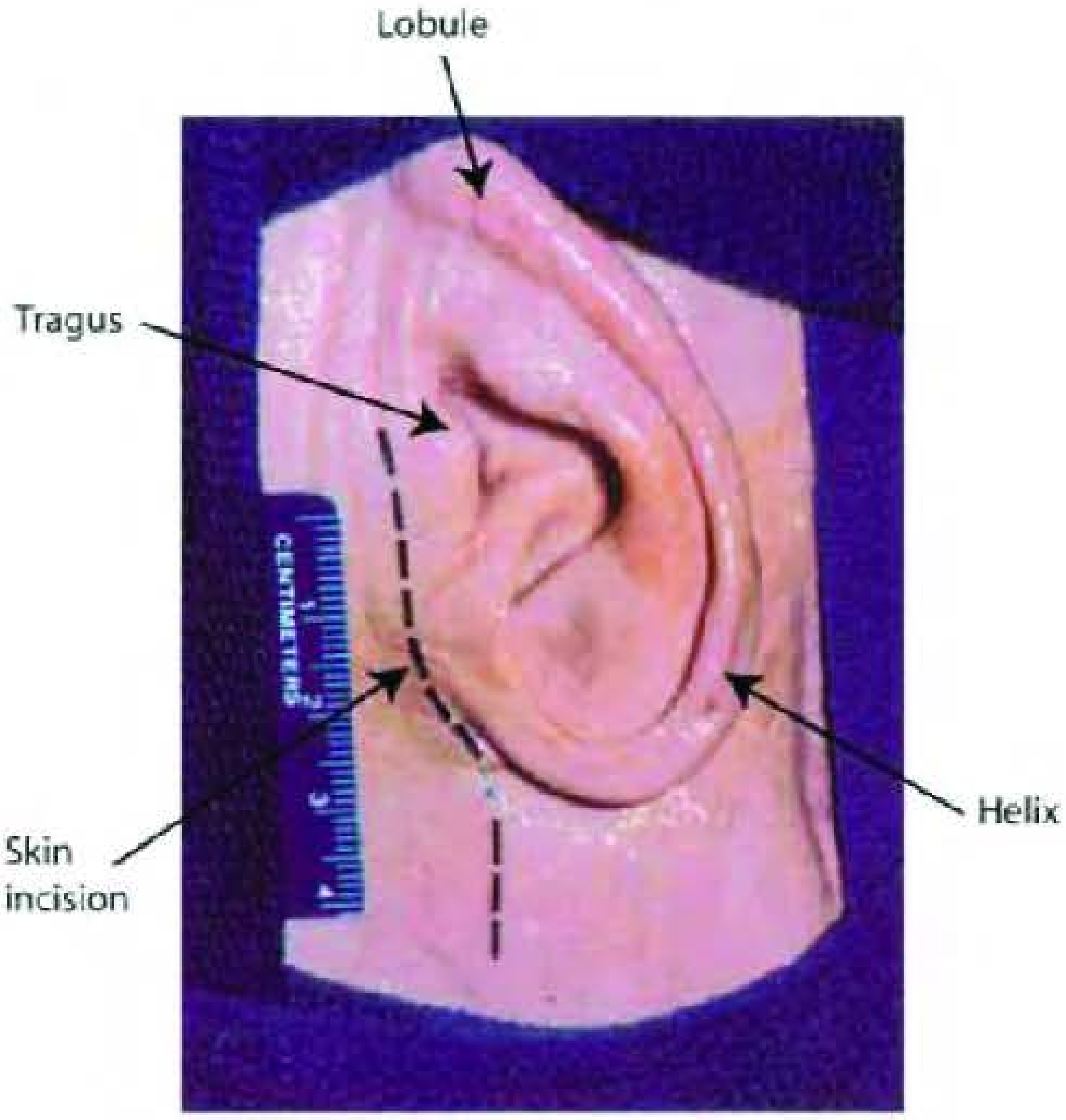

FIGURE 41–1 Skin incision anterior to the tragus of the ear.

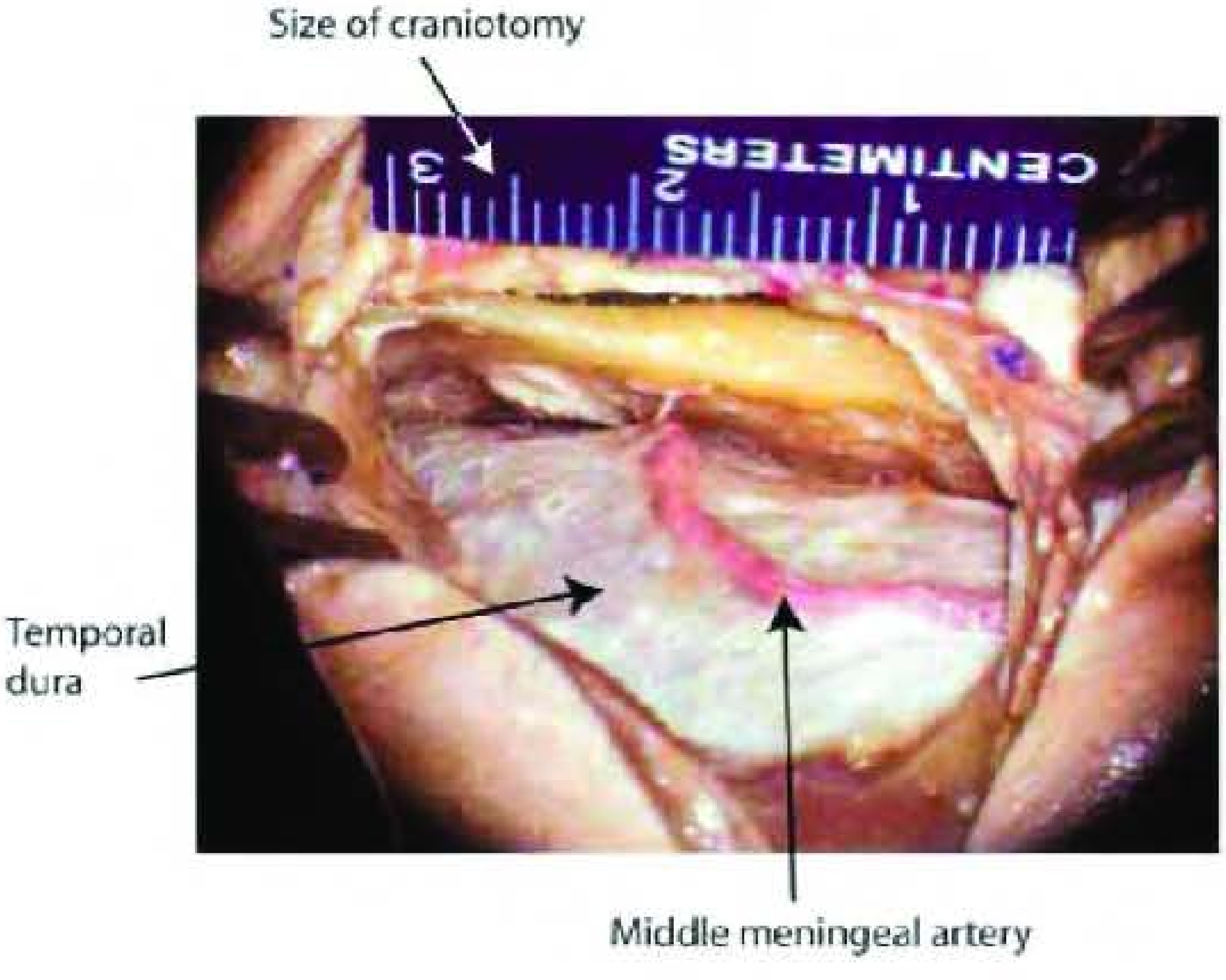

FIGURE 41–2 A right-sided keyhole craniotomy is performed. The middle meningeal artery is visualized.

spinosum (Fig. 41–3). The artery is coagulated and sectioned, which allows further elevation of the dura to identify the other foramina in the floor of the middle fossa (Fig. 41–4). V_3 is seen exiting via the foramen ovale, and V_2 is identified exiting via the foramen rotundum. The dura is split into its two leaves at the region of the fifth nerve branches and gasserian ganglion, thus allowing for an extradural approach to the gasserian ganglion as well as the cavernous sinus (Fig. 41–5). Drilling the bone of the middle fossa between V_3 and V_2 defines an extradural entrance into the sphenoid sinus (Fig. 41–6). Drilling between V_1 and V_2 also allows a more superior entrance into the sphenoid sinus. Introduction of the endoscope through either the anterolateral or lateral triangles of the cavernous sinus allows exploration of the sphenoid sinus and removal of pathology involving the cavernous and sphenoid sinuses.

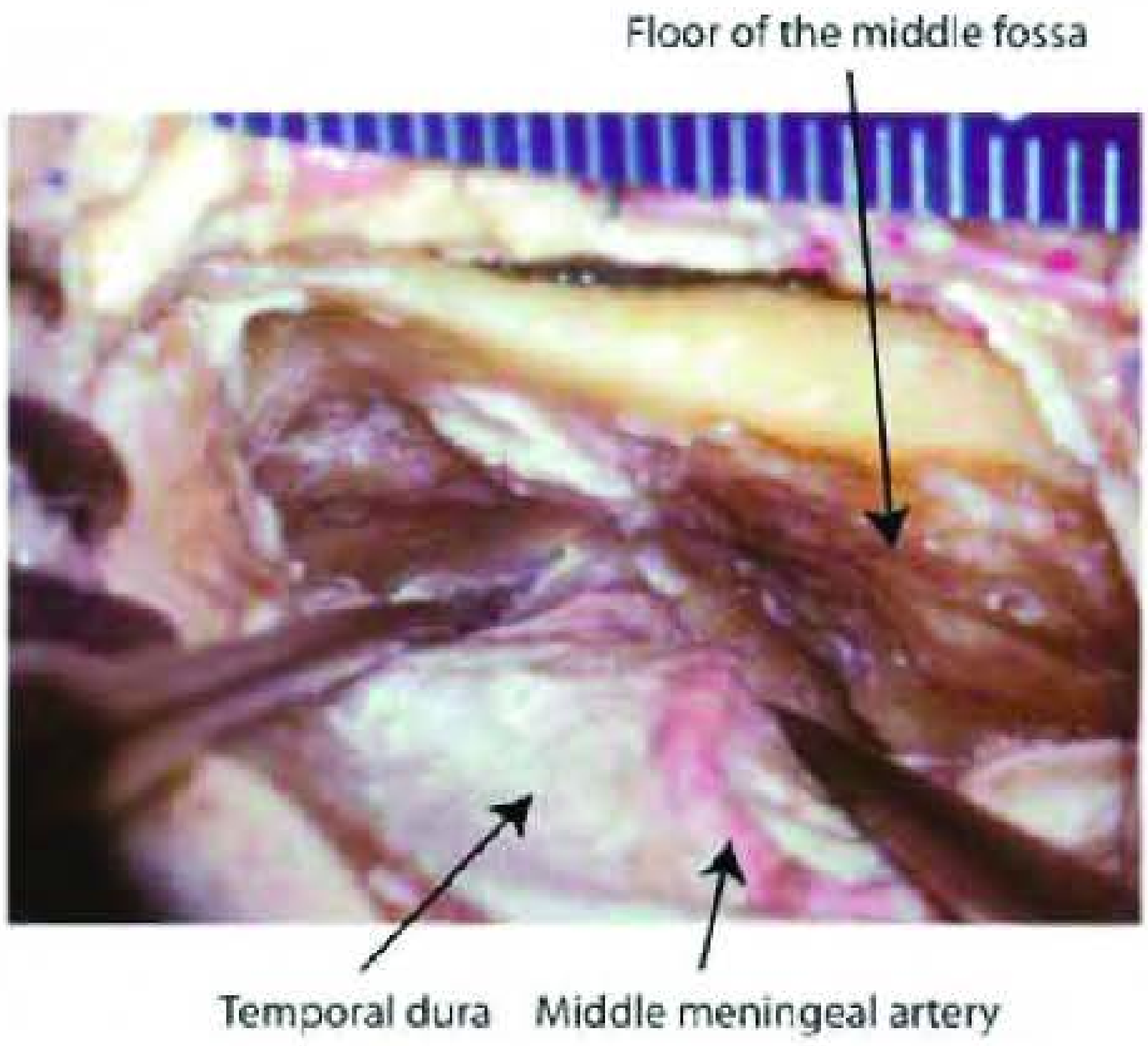

FIGURE 41–3 The middle meningeal artery is followed to the foramen spinosum and floor of the middle fossa. The zygomatic arch is preserved.

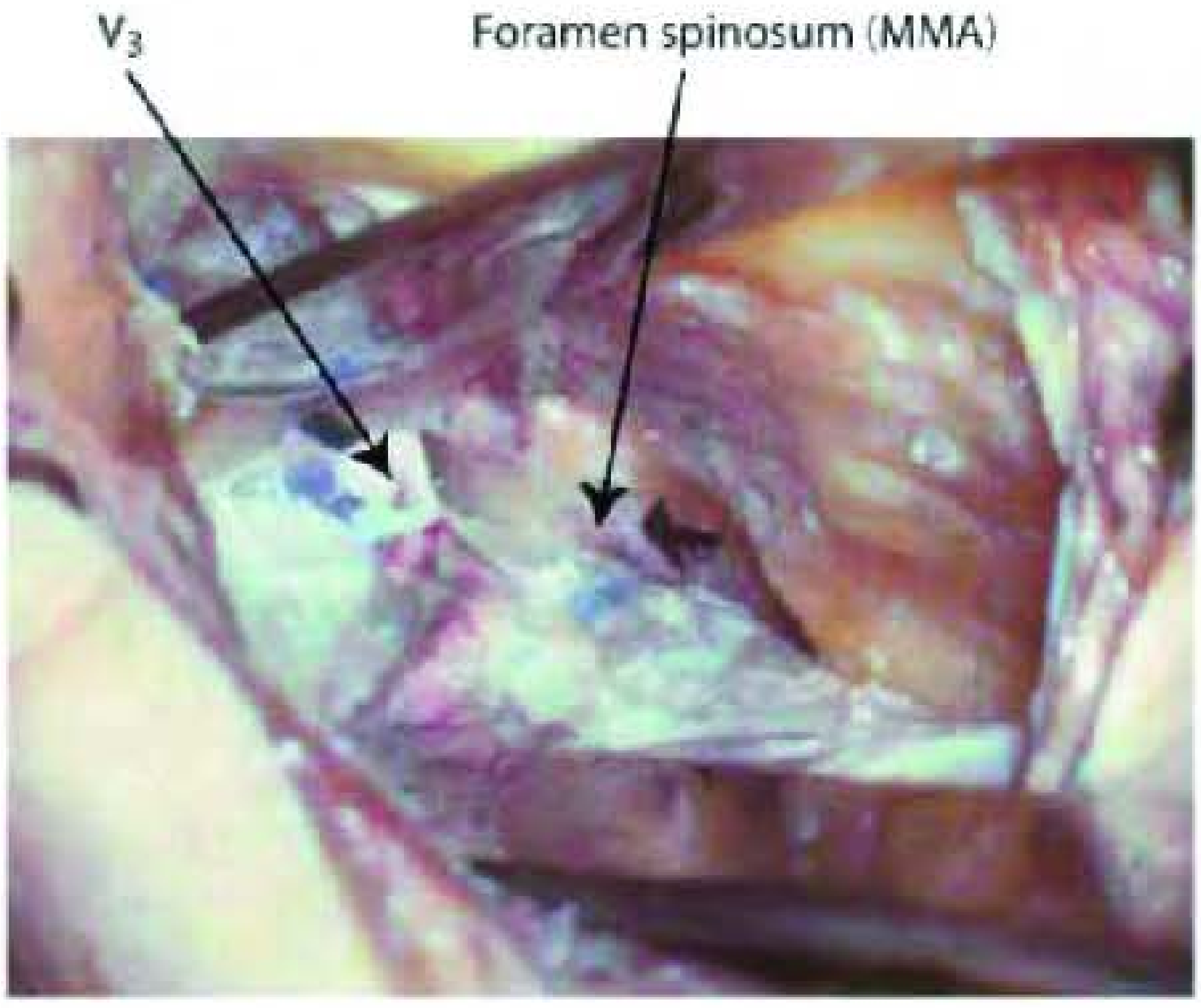

FIGURE 41–4 The foramen of the middle cranial fossa are visualized.

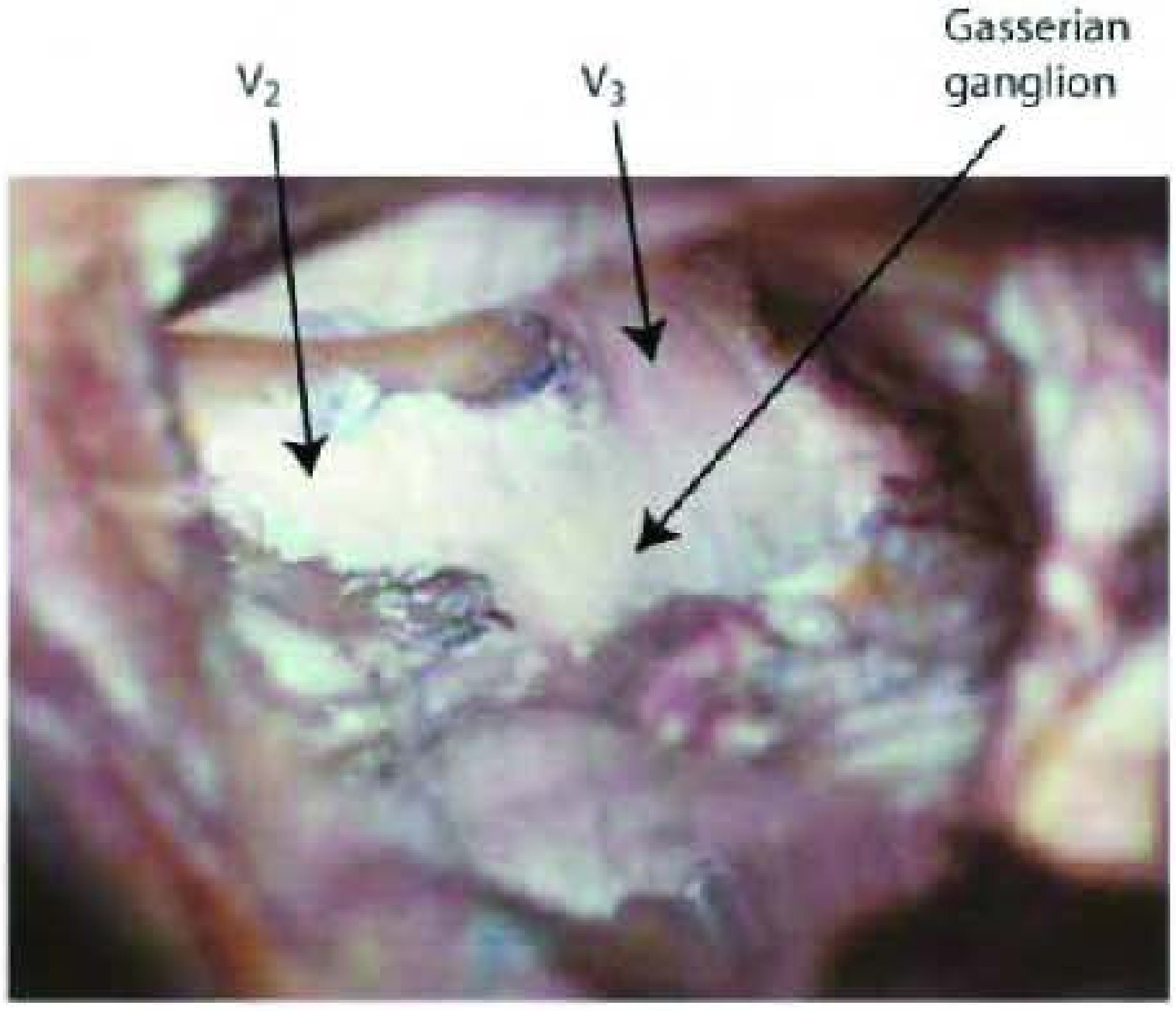

FIGURE 41–5 After splitting the lateral wall of the cavernous sinus, cranial nerve (CN) V_2, and V_3, and the gasserian ganglion are well seen extradurally.

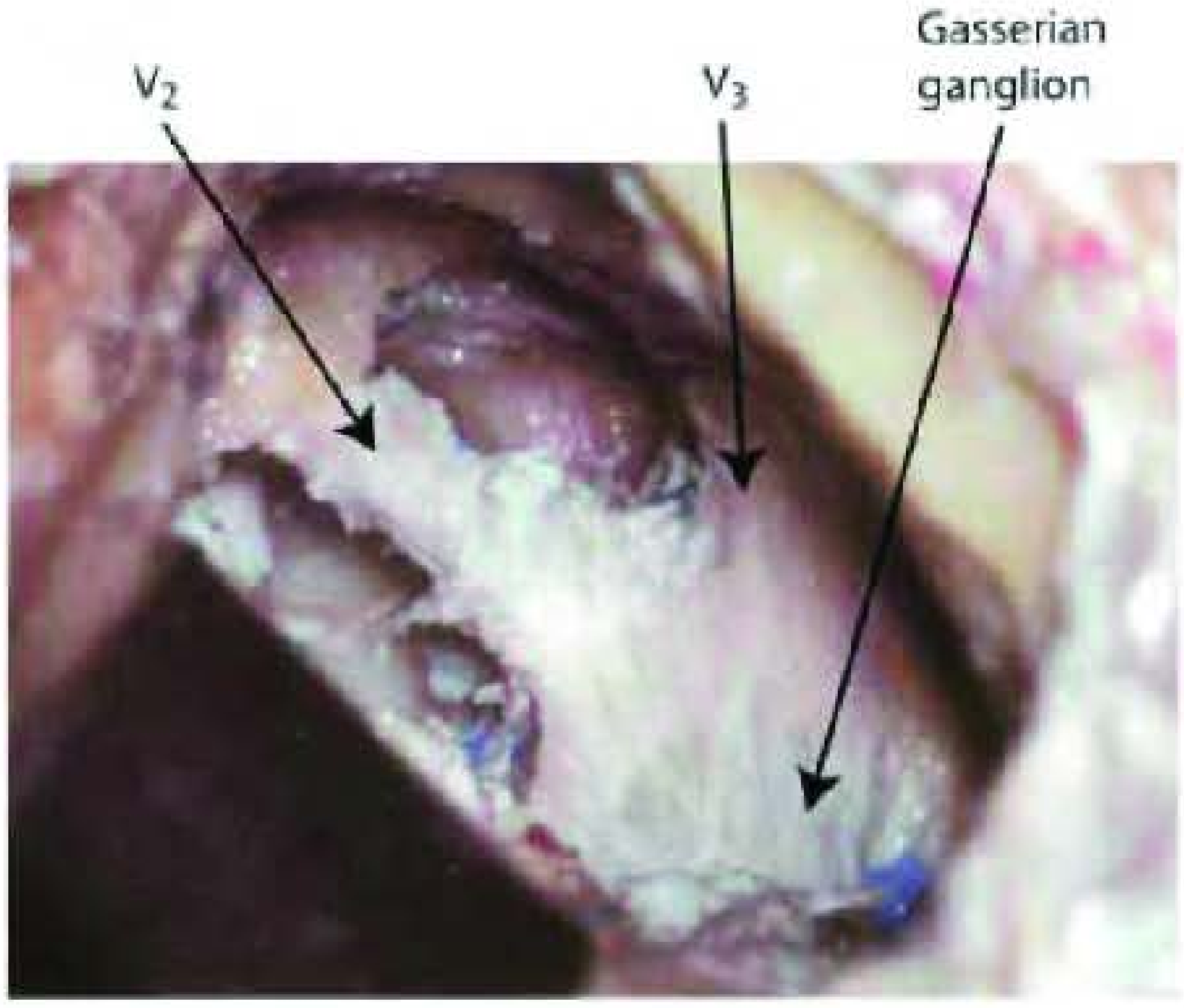

FIGURE 41–6 The anterolateral and lateral triangles of the cavernous sinus have been opened. The sphenoid sinus is reached extradurally.

Dissection a Jong the floor of the middle fossa allows identification of the petrous carotid artery (Fig. 41–7). Kawese's triangle can be drilled, providing a route of access to the posterior fossa. If the dura is opened and the ventriculoscope is inserted, the basilar artery, anterior inferior cerebellar artery, and sixth nerve can be visualised (Fig. 41–8). Angling the scope allows the identification of the porus trigeminus, which, if opened, reveals the fifth nerve (Fig. 41–9). The superior petrosal sinus and the superior cerebellar artery also can be visualised. The tentorium can be incised and the fourth cranial nerve identified (Fig. 41–10). With the tentorial incision, access is provided to the superolateral pons. The superior cerebellar artery and cranial nerves IV through VIII can be identified

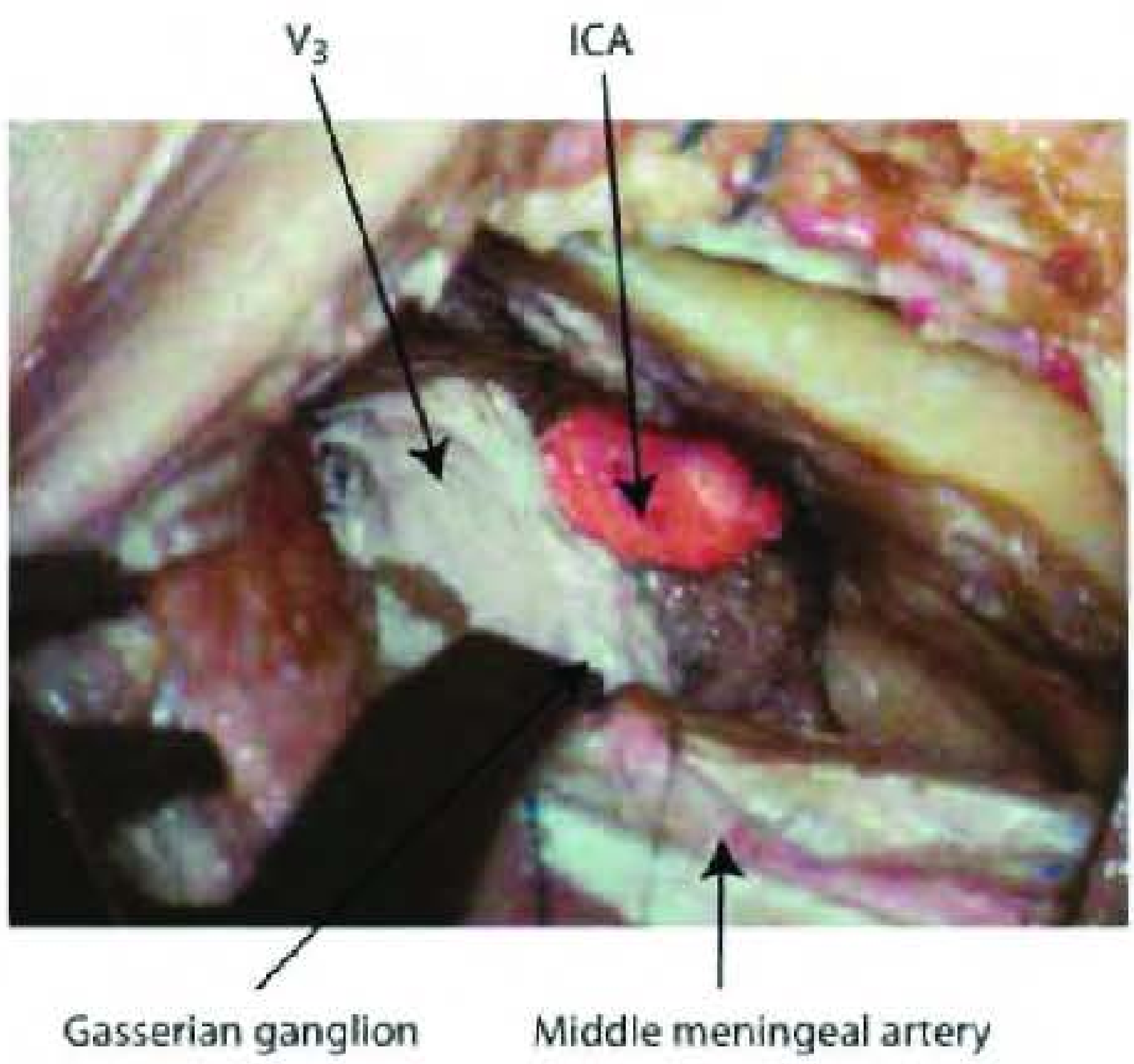

FIGURE 41–7 The horizontal portion of the petrous carotid is exposed. ICA, internal carotid artery.

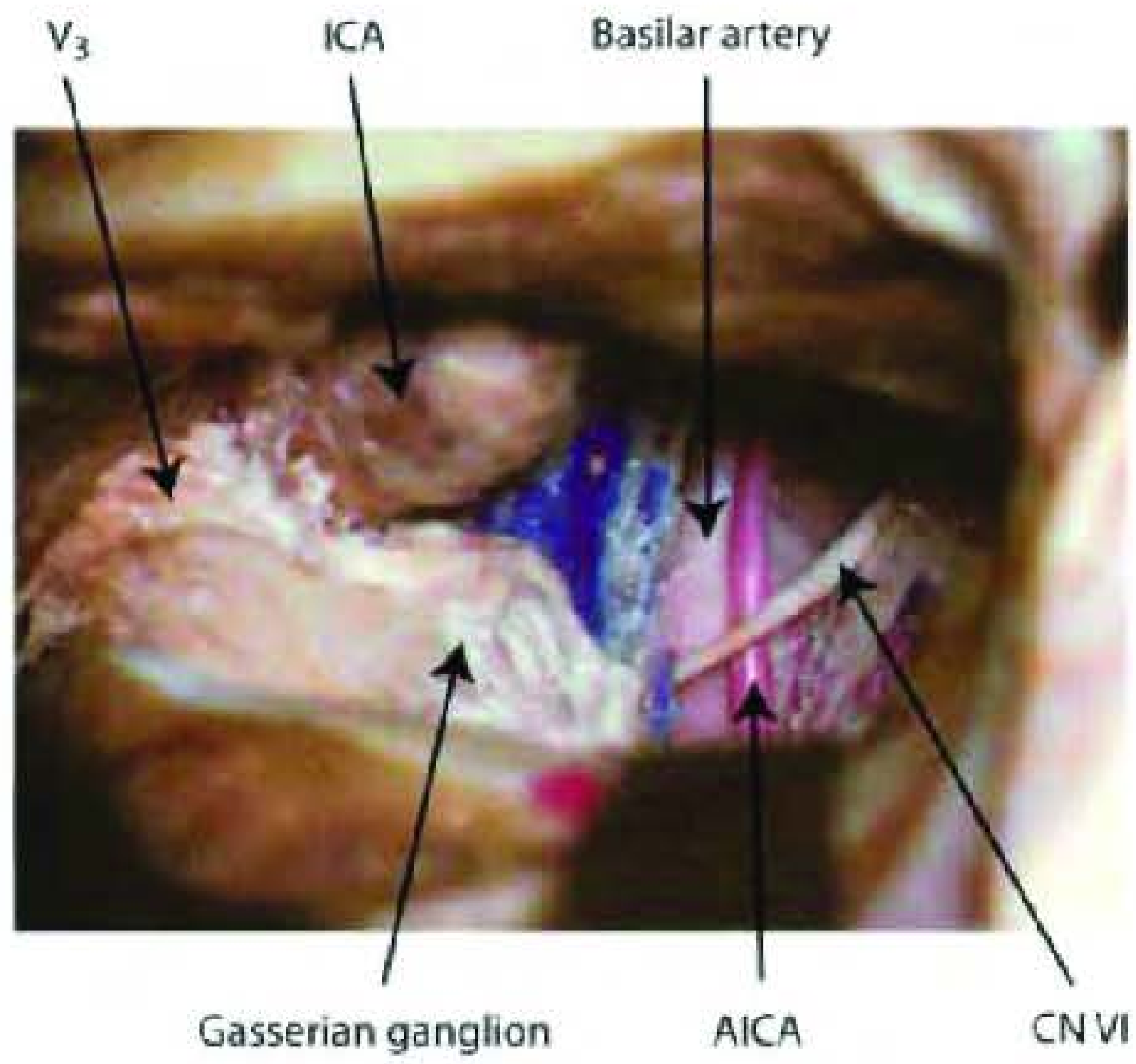

FIGURE 41–8 The posterior fossa dura is opened allowing visualization of the basilar artery, anterior inferior cerebellar artery (AICA), and the sixth cranial nerve (CN). The petrous internal carotid and the gasserian ganglion are also shown. ICA, internal carotid artery.

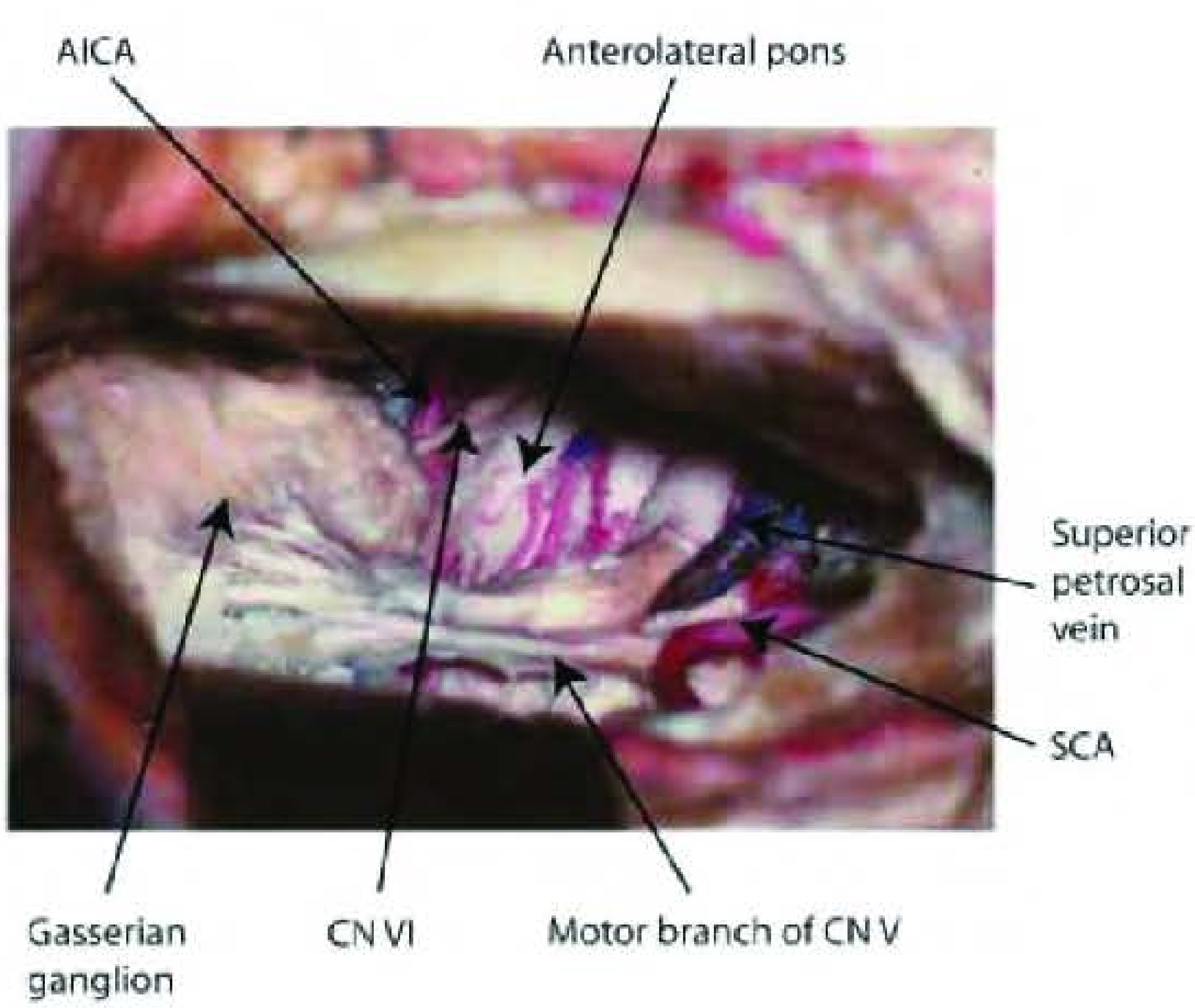

FIGURE 41–9 The porus trigeminus is opened and the course of the fifth nerve is exposed. The superior petrosal vein and the superior cerebellar artery (SCA) are seen in the region of the fifth nerve. AICA, anterior inferior cerebellar artery; CN, cranial nerve.

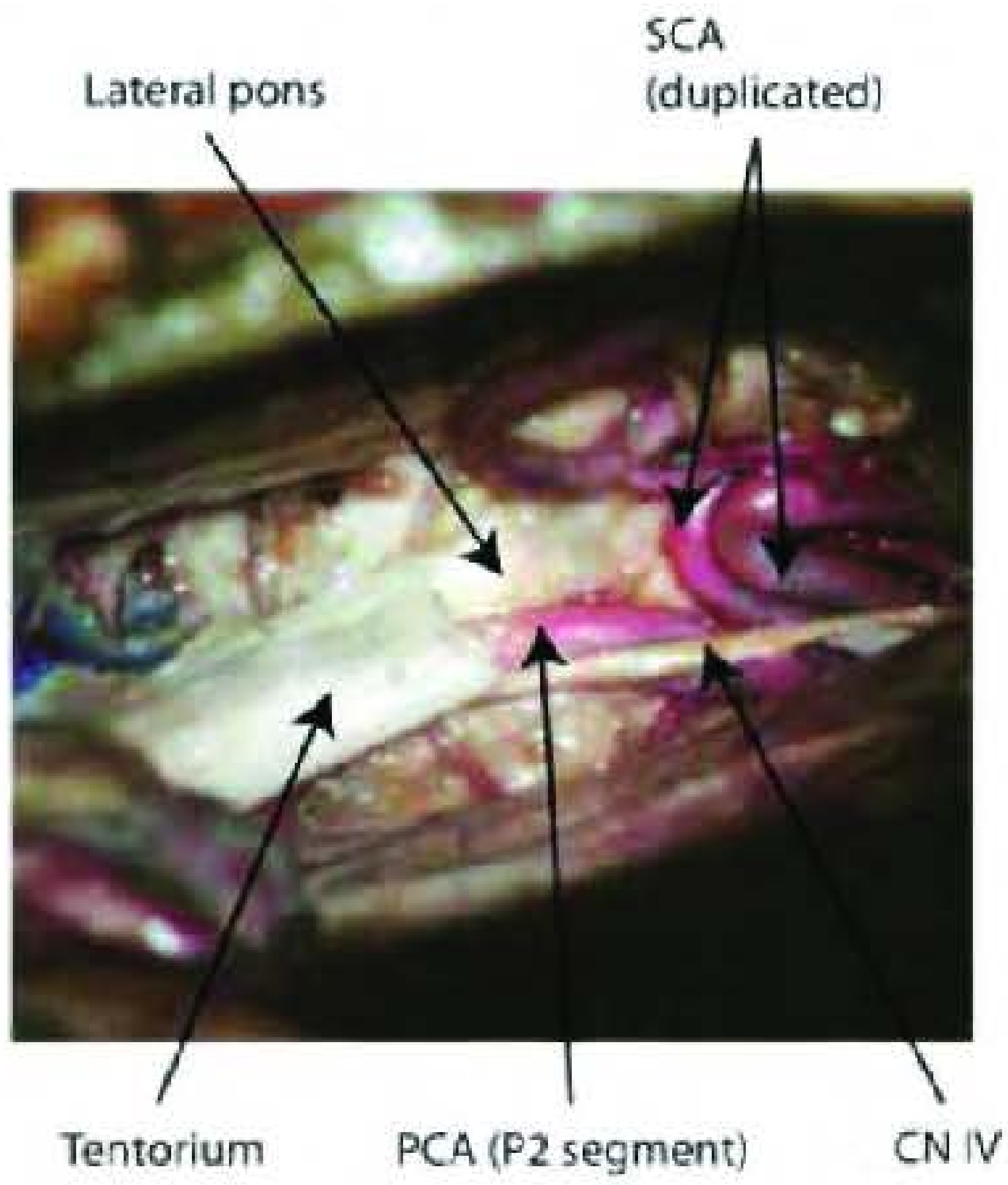

FIGURE 41–10 The tentorium is partially incised, and the fourth nerve (CN IV) is visualized. The duplicated superior cerebellar artery (SCA), posterior cerebral artery (PCA), and superolateral pons are visible.

(Figs. 41–11–41–13). After the internal auditory meatus (IAM) is drilled, the internal auditory artery can be identified coursing alung with the VII–VIII complex (Fig. 41–14). Dorello's canal can be identified with the seventh nerve exiting through it (Fig. 41–15). When the ventriculoscope is oriented more inferiorly, the vertebrobasilar junction, the posterior inferior cerebellar artery, and the lower cranial nerves can be seen (Figs. 41–16–41–18).

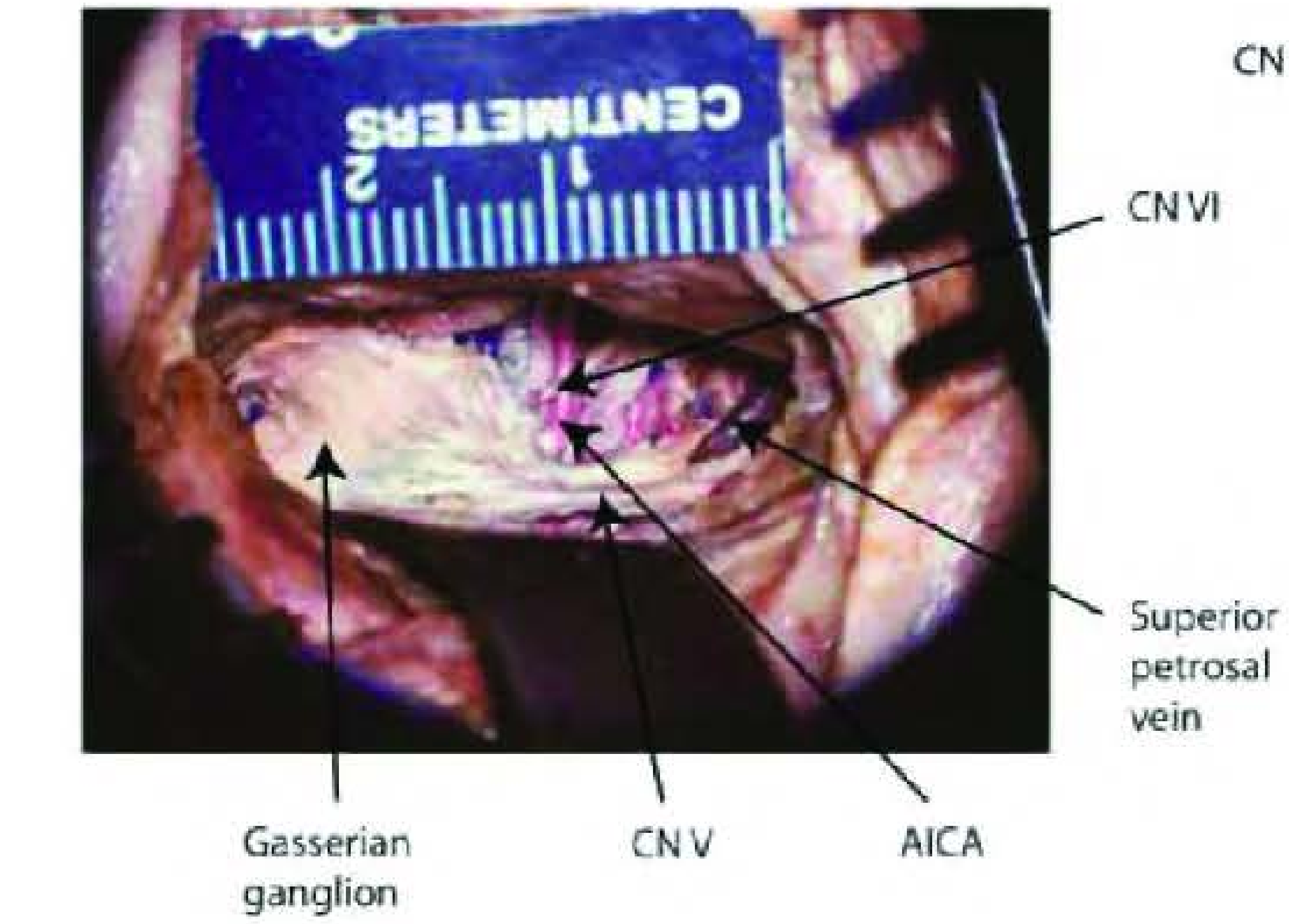

FIGURE 41–11 Panoramic view of the approach through a 2.5-cm keyhole. AICA, anterior inferior cerebellar artery.

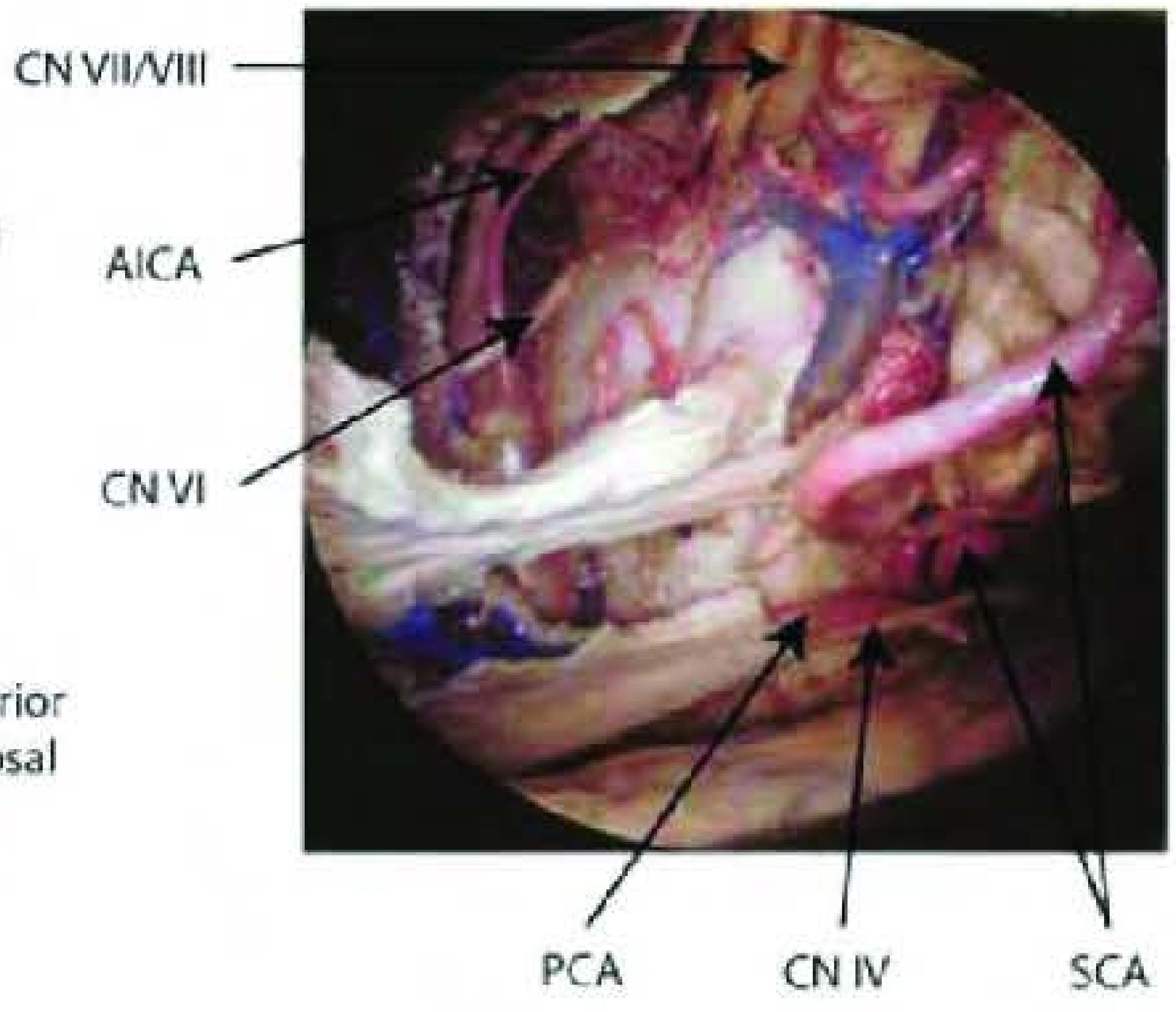

FIGURE 41–12 Panoramic view with a 30-degree endoscope of cranial nerves (CNs) IV, V, VI, VII, and VIII. The tentorium has been partially incised. The basilar artery, anterior inferior cerebellar artery (AICA), posterior cerebral artery (PCA), and petrosal vein are all seen. SCA, Superior cerebellar artery.

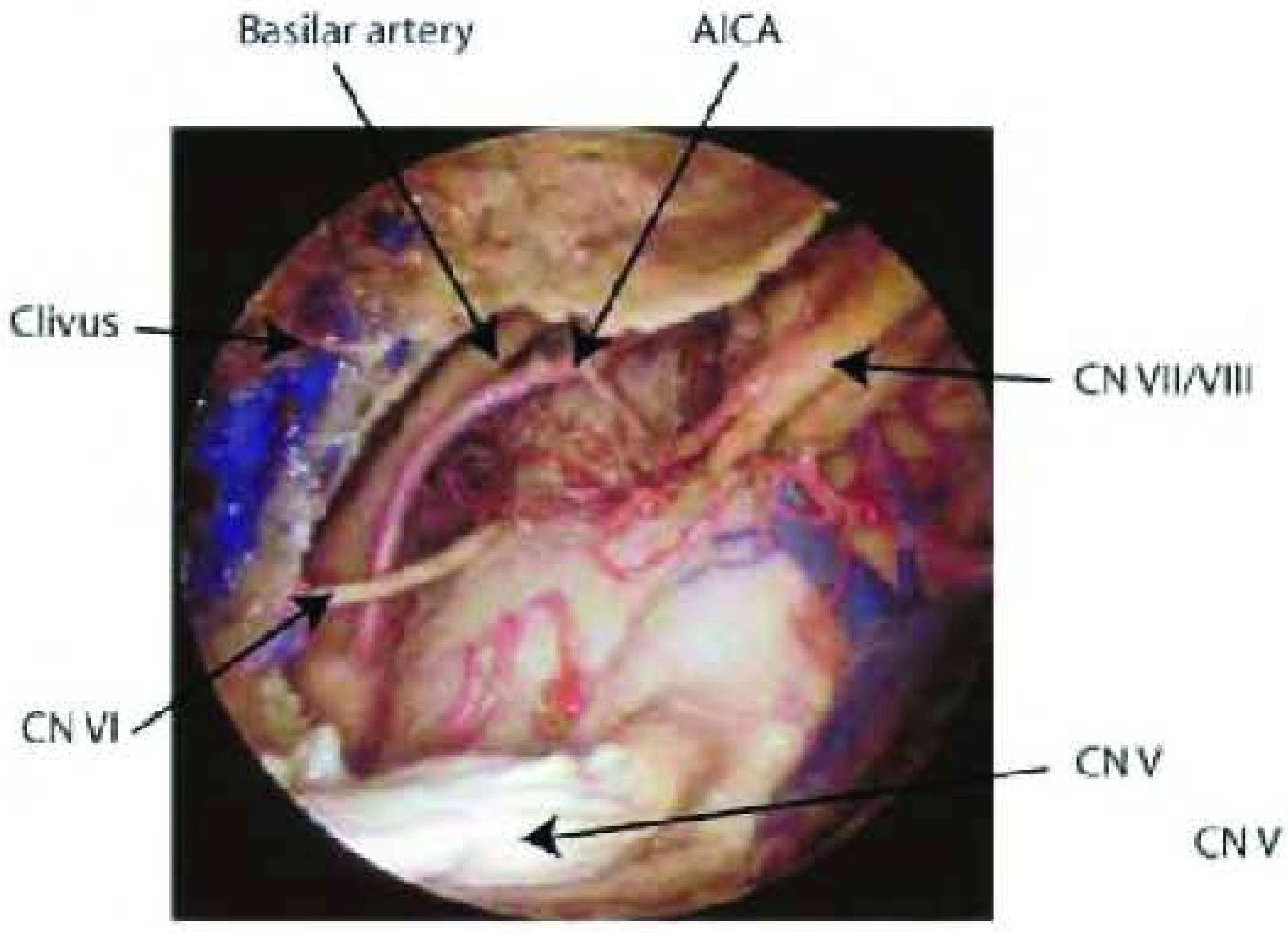

FIGURE 41–13 High-power view of cranial nerve (CN) V, VI, VII, and VIII. The anterolateral pons is also visualized. AICA, anterior inferior cerebellar artery.

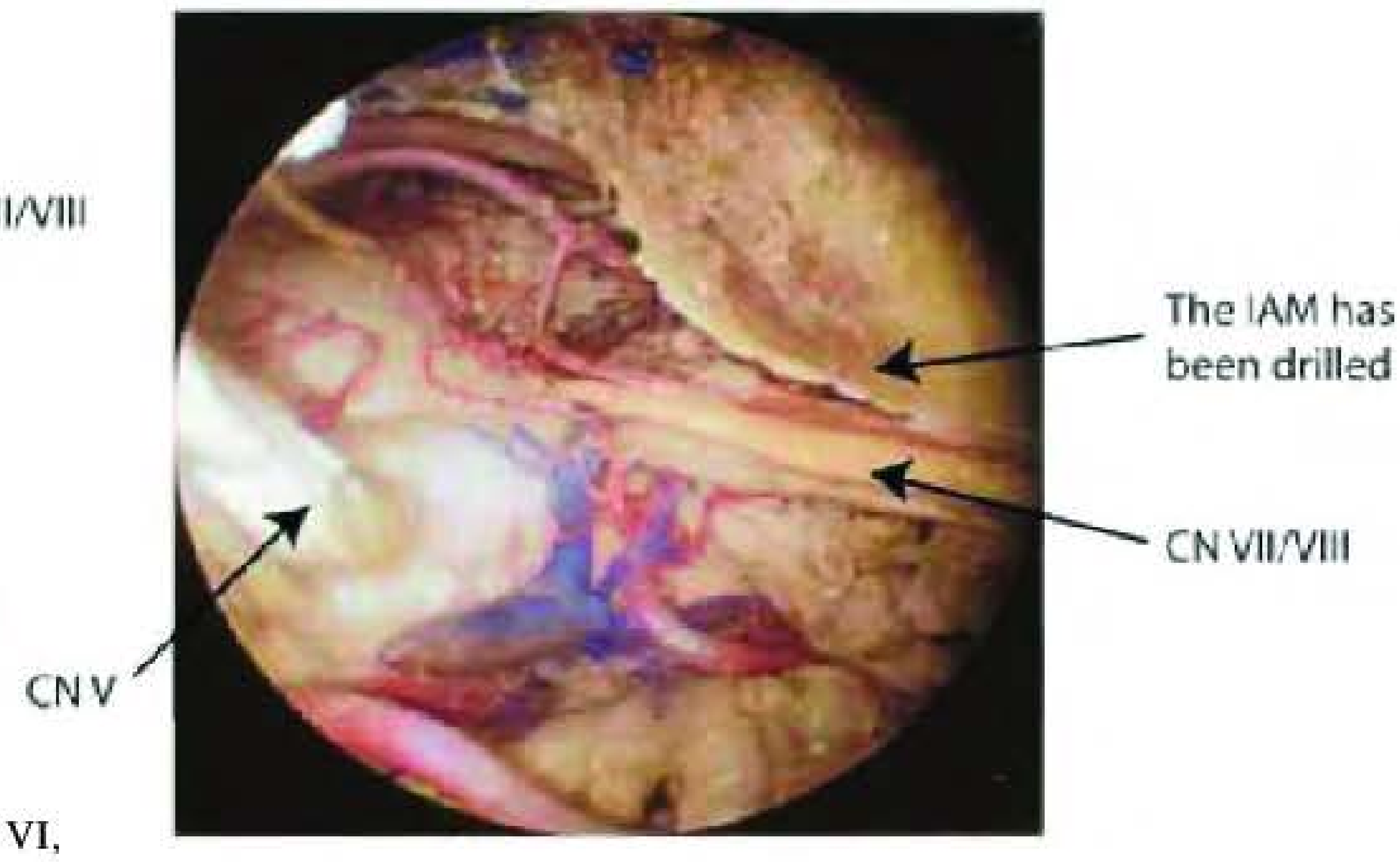

FIGURE 41–14 High-power view of the VII–VIII complex. The internal auditory meatus has been drilled. The internal auditory artery is seen following the nerve. CN, cranial nerve; IAM internal auditory meatus.

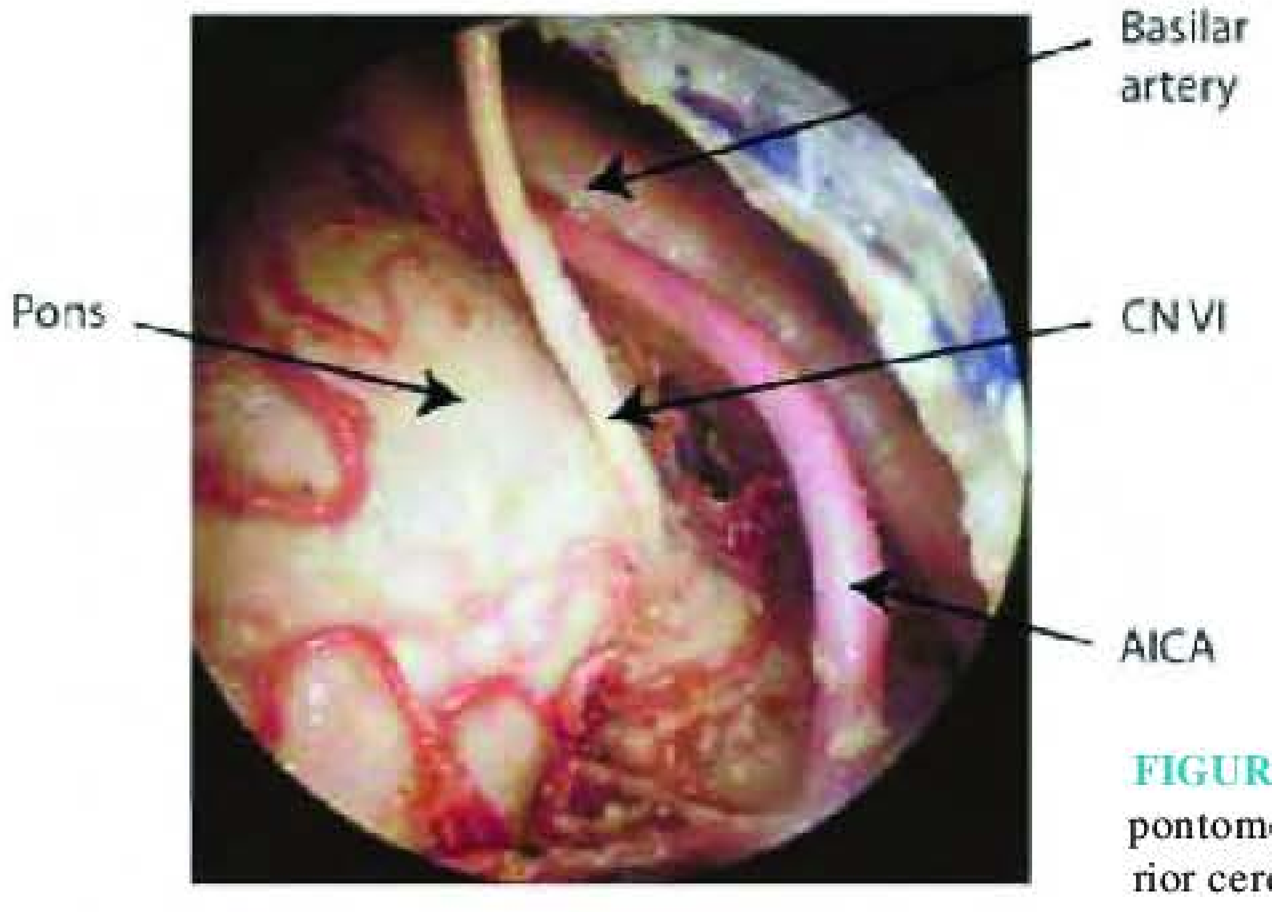

FIGURE 41–15 High-power view of cranial nerve (CN) VI coursing from the pontomedullary sulcus to Dorello's canal. The basilar arrery and the anterior inferior cerebellar artery (AICA) also are seen.

The dura should be closed in a watertight fashion both in the posterior fossa as well as in the temporal region. The small craniotomy flap is replaced and a multi-layered closure performed of the subcutaneous tissues. The skin is closed in the usual fashion.

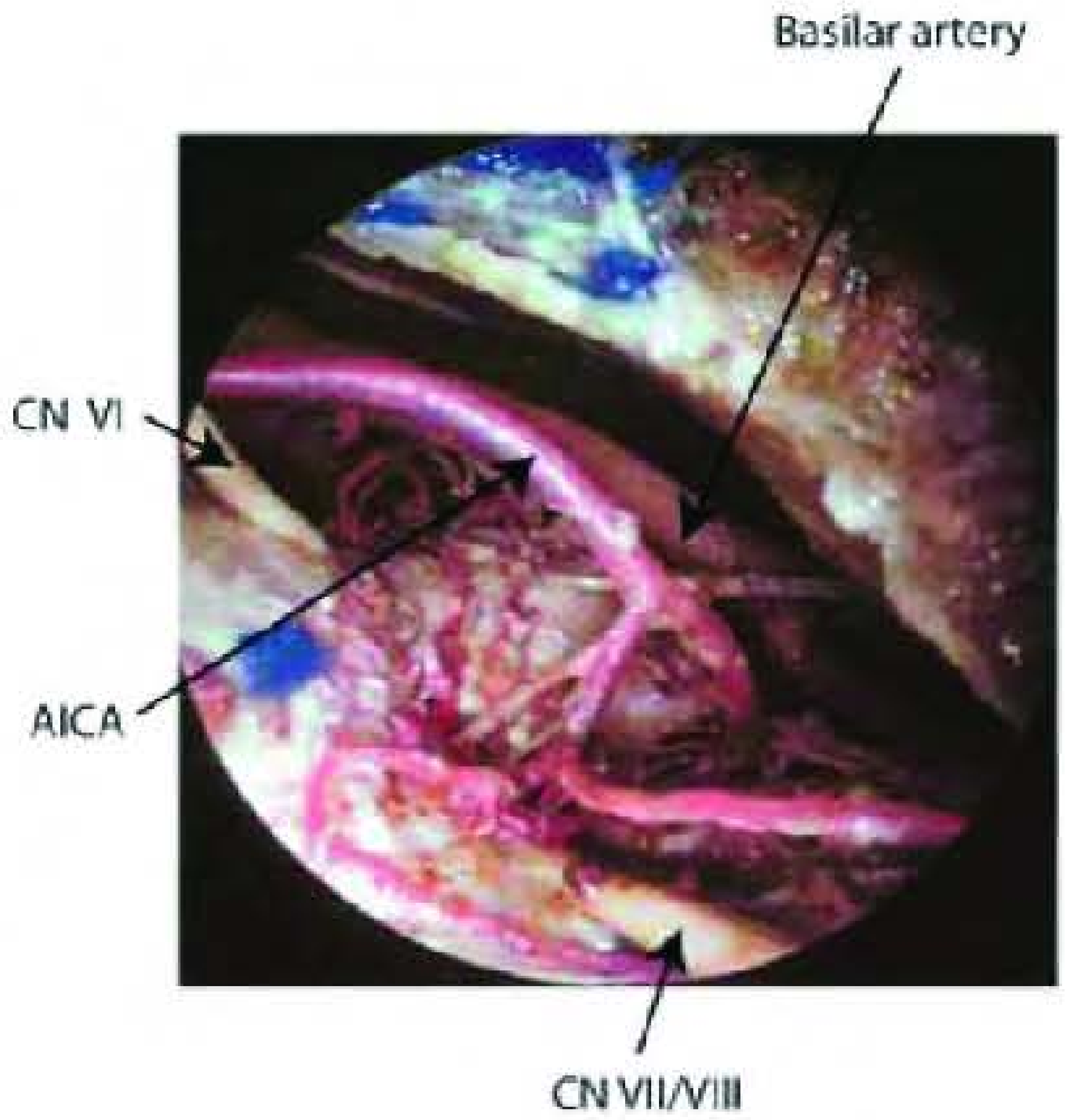

FIGURE 41–16 Following the basilar artery interiorly, anterior inferior cerebellar artery (AICA) and the lower cranial nerves can be visualized.

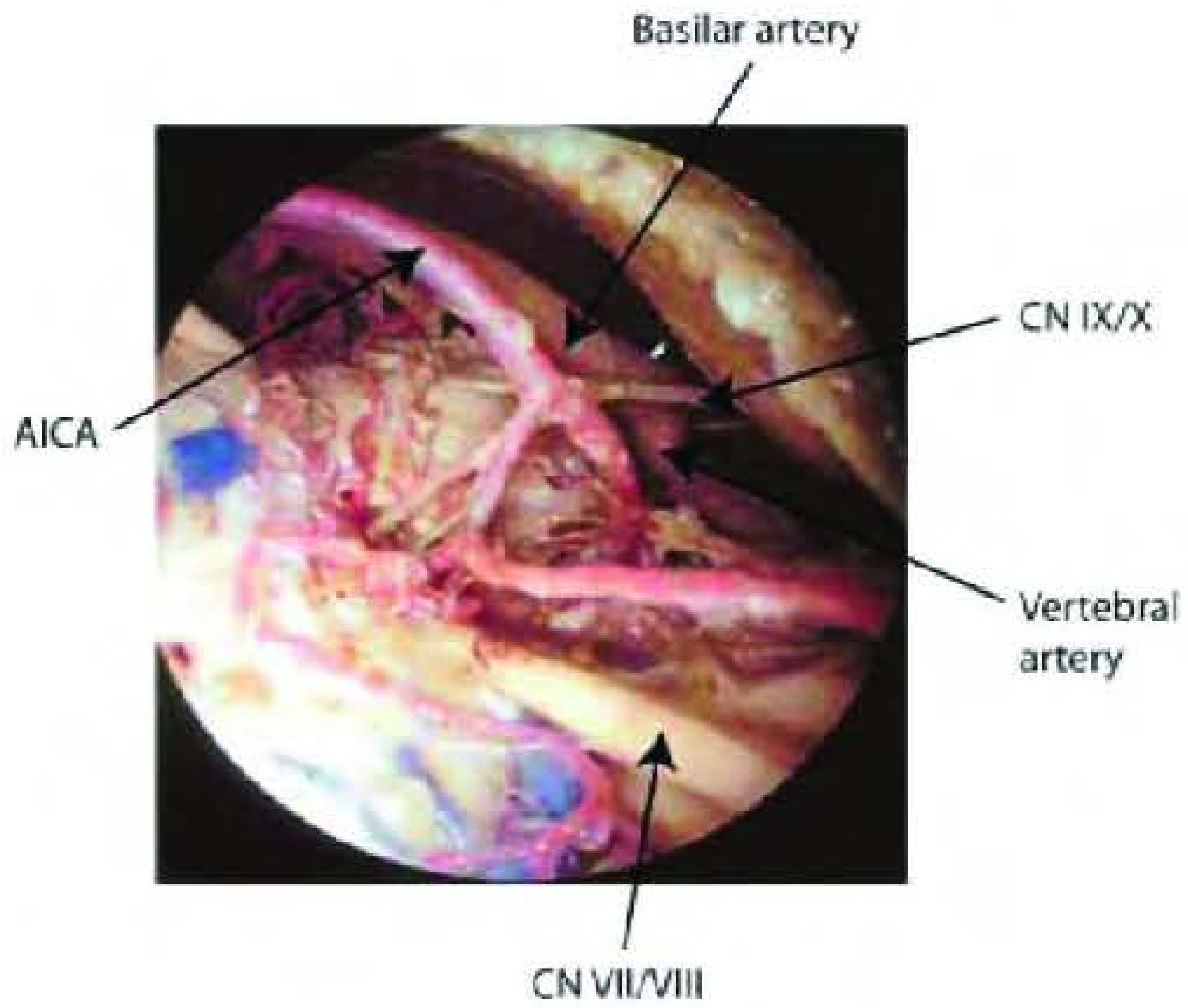

FIGURE 41–17 The anterior inferior cerebellar artery and the vertebral artery are visualized. Cranial nerves (CNs) VI, VII/VIII, and IX/X are visualized. AICA, anterior inferior cerebellar artery.

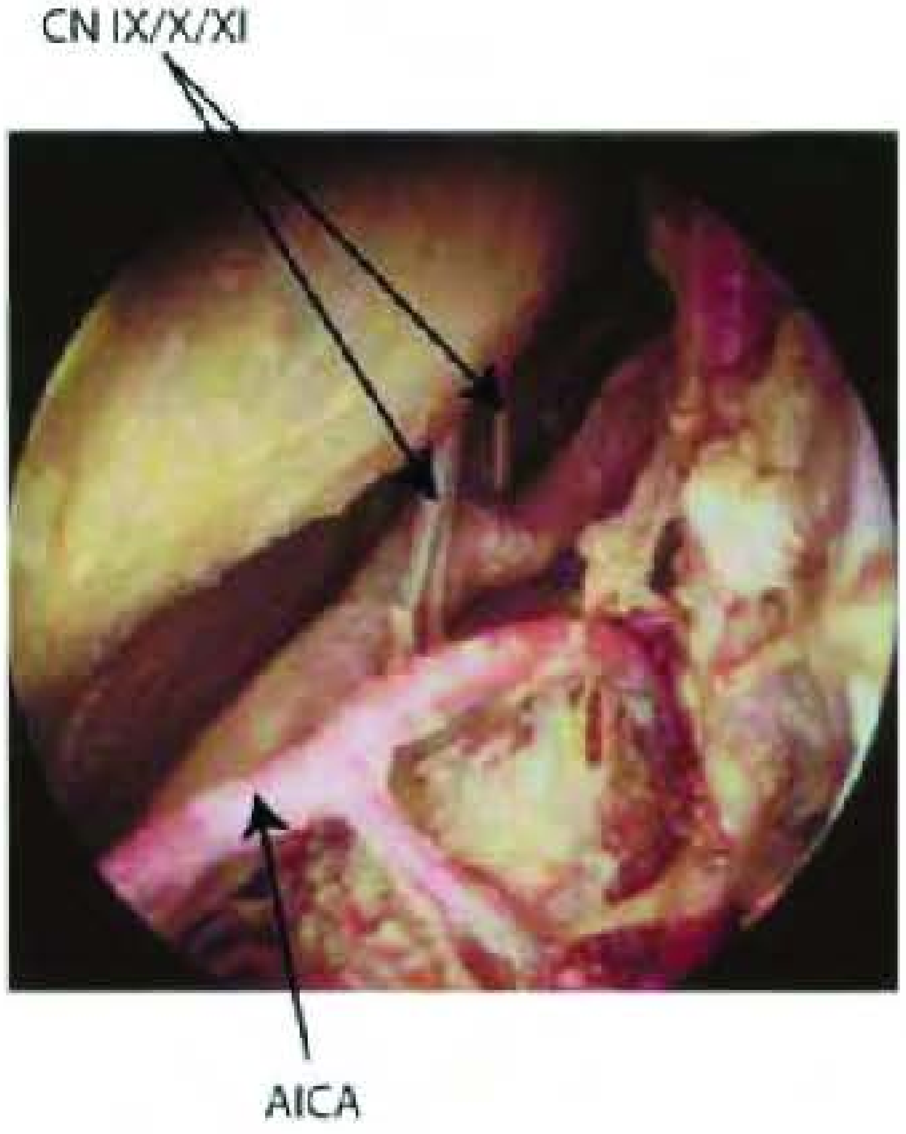

FIGURE 41–18 The vertebrobasilar junction can be seen surrounded by rootlets of the lower cranial nerves. AICA, anterior inferior cerebellar artery; CN, cranial nerve.

PITFALLS, PEARLS, CONSIDERATIONS

- Vascular injury
- Facial nerve injury
- Temporal lobe retraction injury

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ENDOSCOPIC INTRAVENTRICULAR ANATOMY

Carlos Acevedo, Damirez Fossett

INDICATIONS FOR APPROACH

- Intraventricular tumors
- Intraventricular arteriovenous malformations
- Evacuation of hematomas
- Third ventriculostomy

POSITIONING AND SKIN INCISION

The patient is placed in three-point fixation in the supine position with the head parallel to the walls of the operating theater. The head is flexed slightly to allow a line of sight into the ventricular system.

The most common site of entry to the ventricular system is through Kocher's point (Fig. 42–1), which is located about 2 cm anterior to the coronal suture and 2 cm off the midline. It is the point commonly used for ventriculostomy placement. After a small incision is made, a bur hole is placed. The dura is bipolar coagulated and opened with a no. 15 blade.

SURGICAL TECHNIQUE

The ventriculoscope is passed through the frontal cortex to the ventricular system. The target is a point where a plane through the external auditory meatus intersects a plane through the medial canthus of the ipsilateral eye. Once in the ventricular system, orientation must be established. If vessels are seen to the left of the choroid plexus, the left lateral ventricle has been entered, and if vessels are seen to the right of the choroid plexus, the right lateral ventricle has been entered.

The frontal horn of the lateral ventricle lies anterior to the foramen of Monroe. The body lies behind the foramen of Monroe and above the thalamus. The atrium is located posterior to the thalamus and inferior to the parietal lobe. The occipital horn extends posteriorly into the occipital lobe, and the temporal horn extends forward from the antrum into the temporal lobes.

The walls of the lateral ventricles are composed predominantly of the thalamus and the caudate. The lateral ventricles wrap around the thalamus, the superior surface of which makes up the floor of the body of the ventricle. The atrium and occipital horn are located posterior to the thalamus, and the temporal horn is inferior to the thalamus. The head of the caudate nucleus, a C-shaped structure that wraps around the thalamus, forms the lateral wall of the frontal horn and the body of the ventricle. The fornix, another C-shaped structure that wraps around the thalamus, forms the lower part of the medial wall of the body of the lateral ventricle. In the atrium, it forms the medial part of the anterior wall; in the temporal hum, the fimbria compose the medial part of the floor (Figs. 42–2–42–5). The corpus callosum forms a large part of the roof of the lateral ventricle as well as the anterior wall of the frontal horn. The septum pellucidum separates the two lateral ventricles.

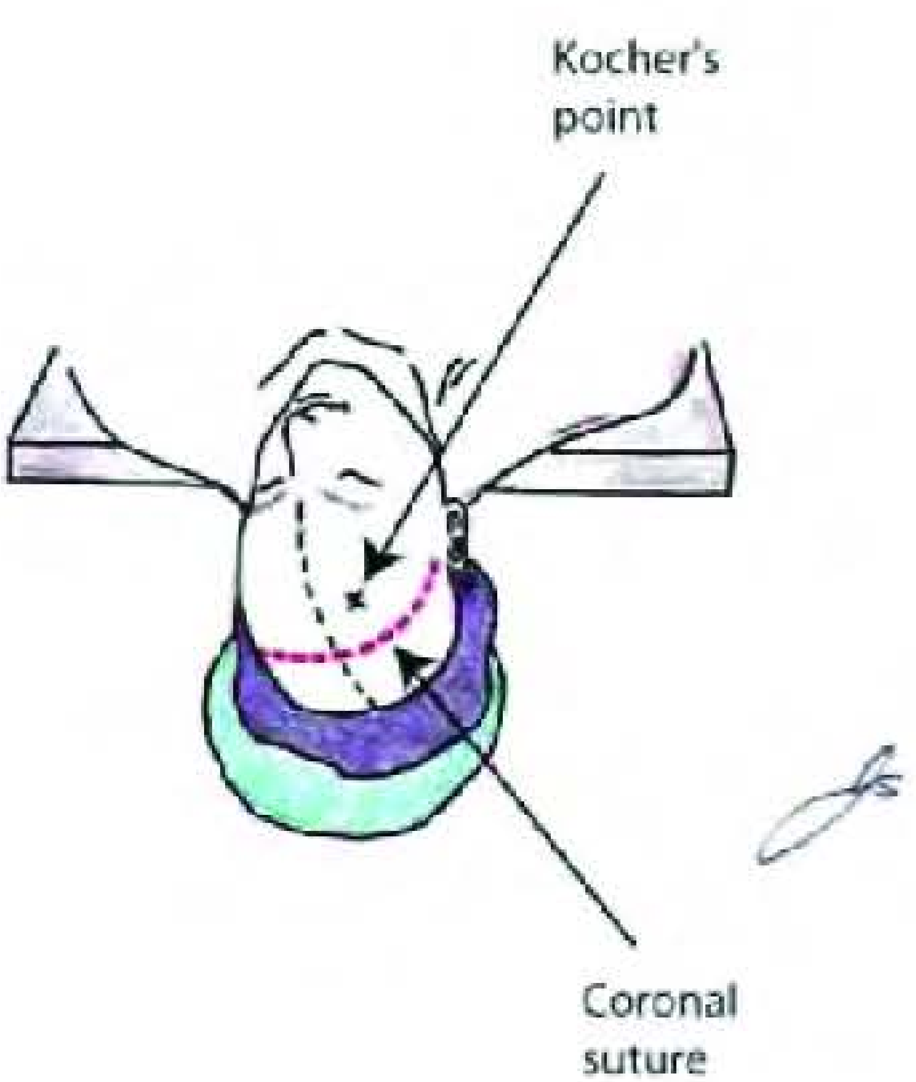


FIGURE 42–1 Illustration of Kocher's entry point.

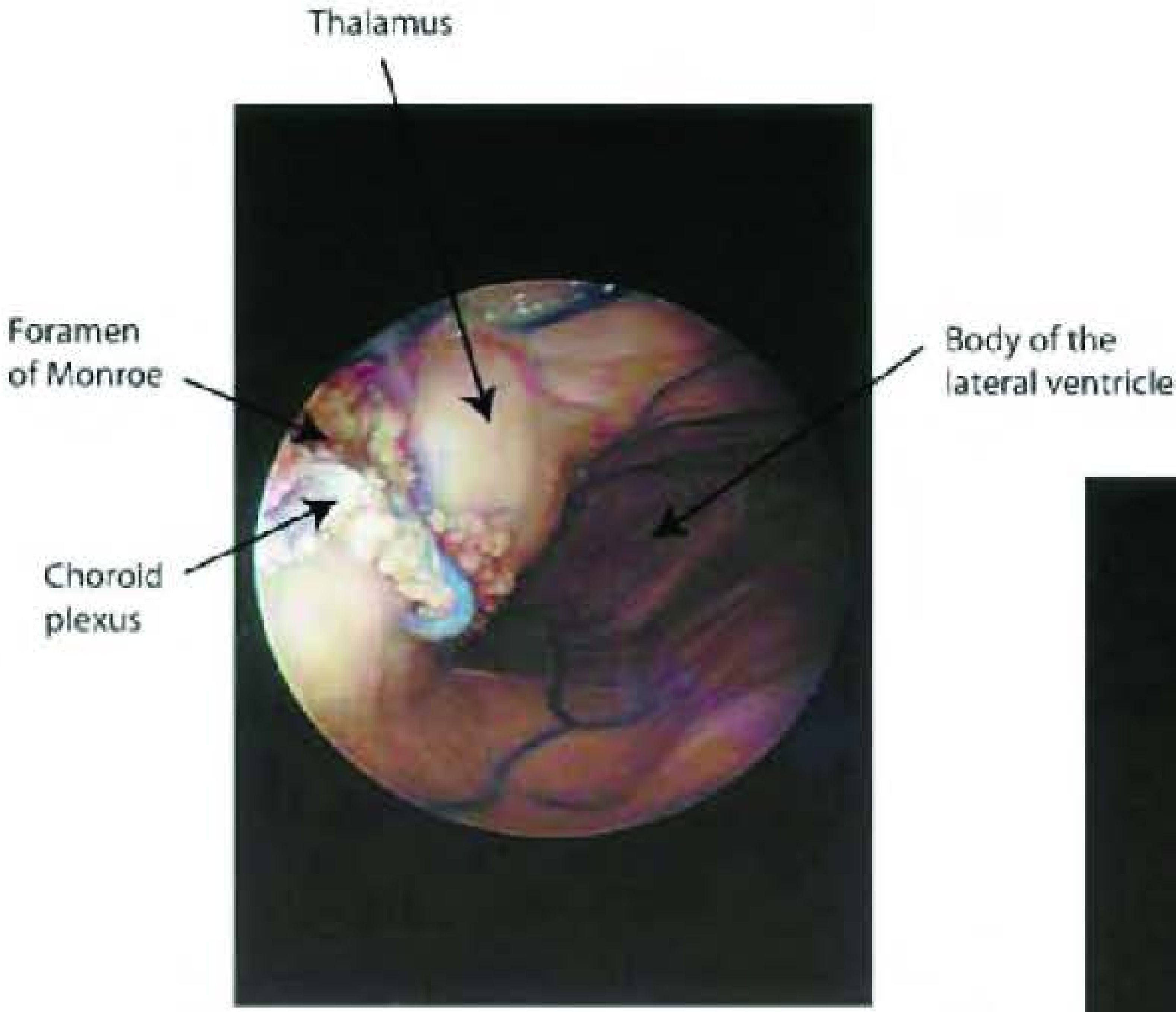


FIGURE 42–2 From the parieto-occipital point of the left atrium, the thalamic contour can he appreciated as welt as the choroid plexus.

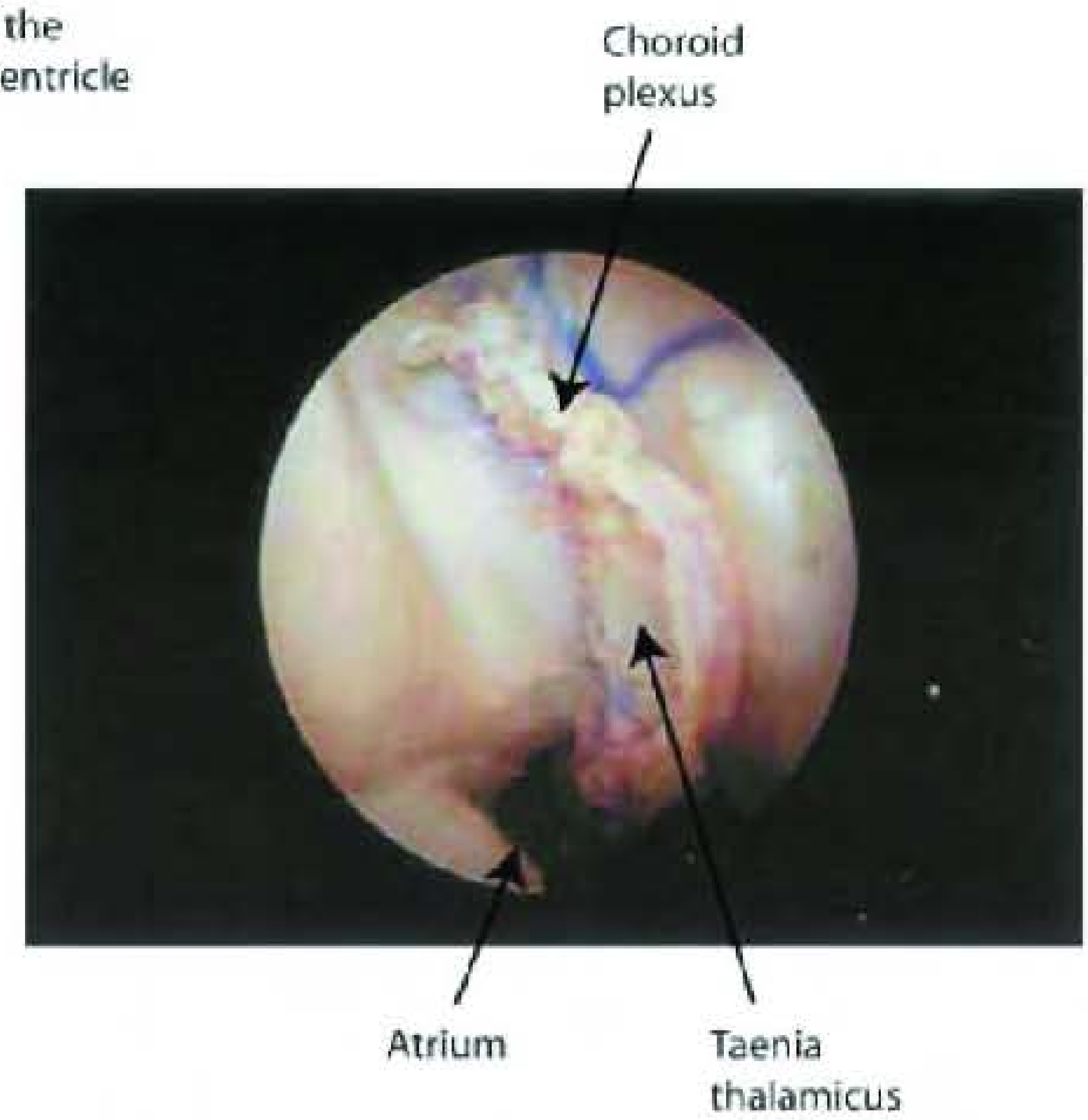


FIGURE 42–3 The choroid plexus is attached to the fimbria, curving around the thalamus and heading toward the temporal horn of the lateral ventricle.

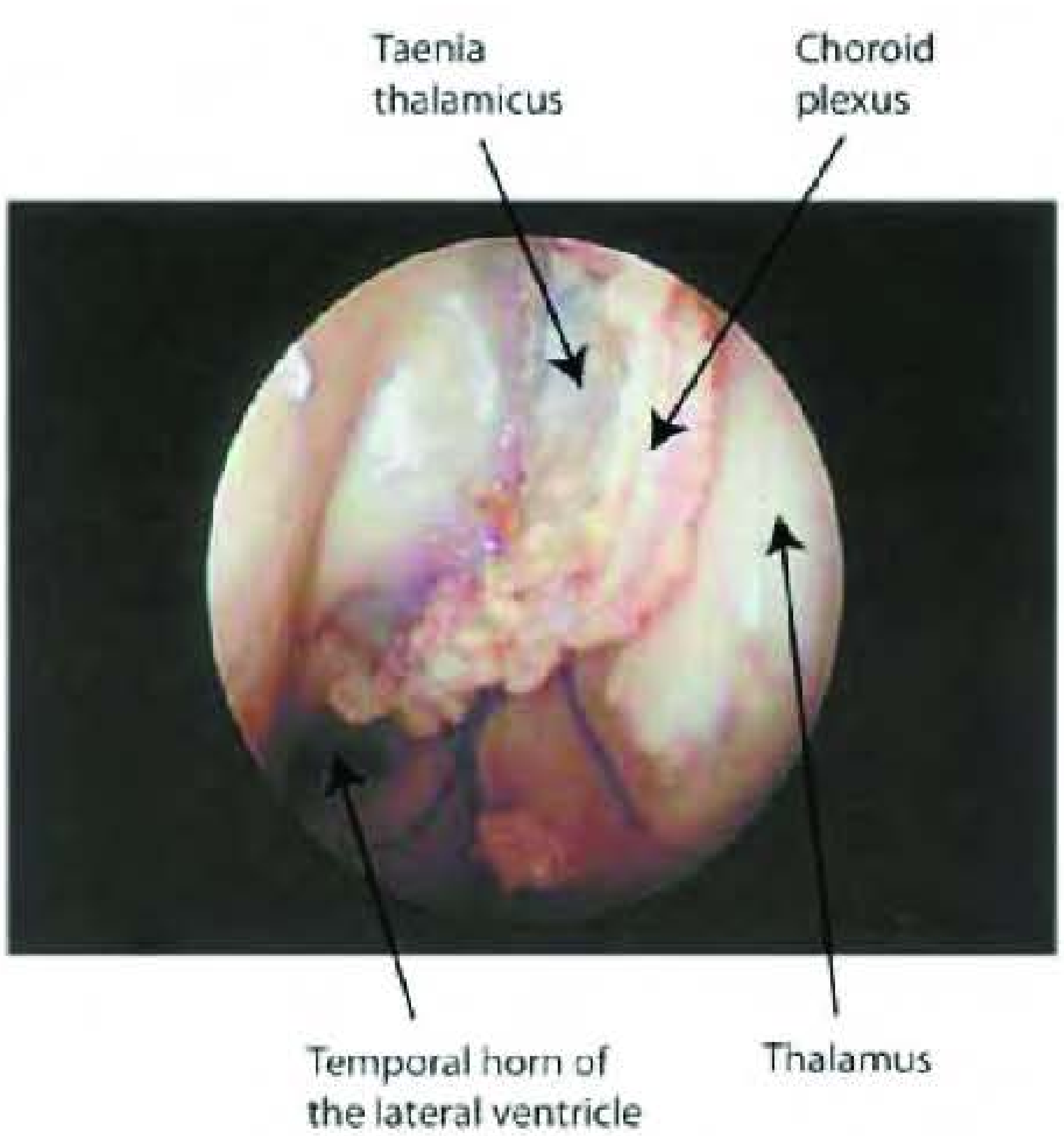


FIGURE 42–4 Panoramic view of the temporal horn of the lateral ventricle with the choroid plexus attached to the fimbria.

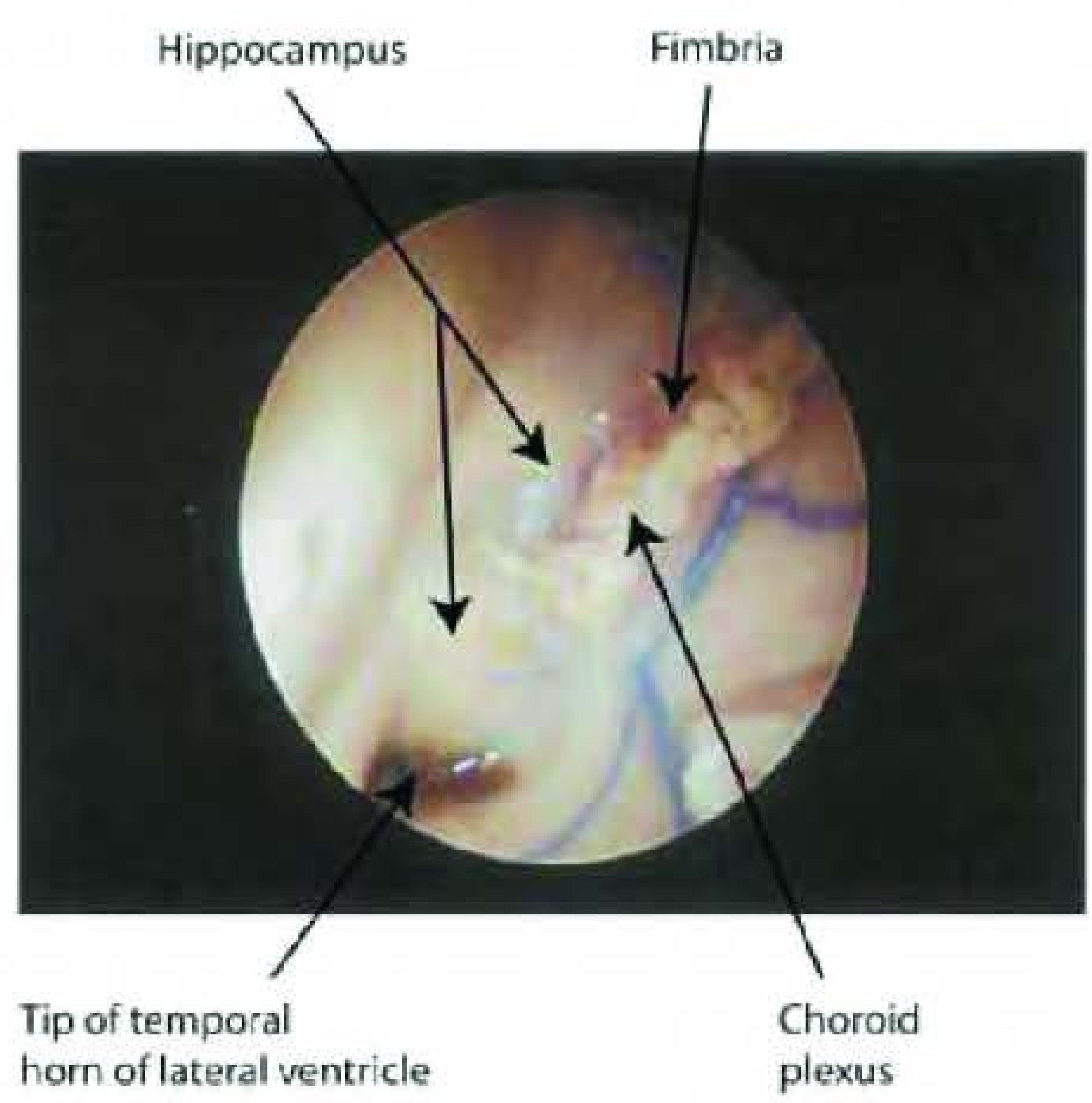


FIGURE 42–5 Tip of the temporal horn of the la tural ventricle.

With the ventriculoscope in place, the choroid plexus can be seen heading toward the foramen of Monroe (Figs. 42–6 and 42–7). It is attached to the choroidal fissure, a cleft between the fornix, medially, and the thalamus laterally in the body, atrium, and temporal horns. The choroid plexus extends through the foramen of Monroe into the roof of the third ventricle. The anterior caudal vein joins the thalamostriate vein and enters the foramen of Monroe posteriorly to join the internal cerebral vein located in the velum interpositum along the roof of the third ventricle. The thalamostriate vein runs in a sulcus that separates the caudate nucleus and the thalamus. The angle formed by the thalamostriate vein joining the internal cerebral vein is called the venous angle and is the angiographic localizer that approximates the foramen of Monroe on a lateral angiogram.

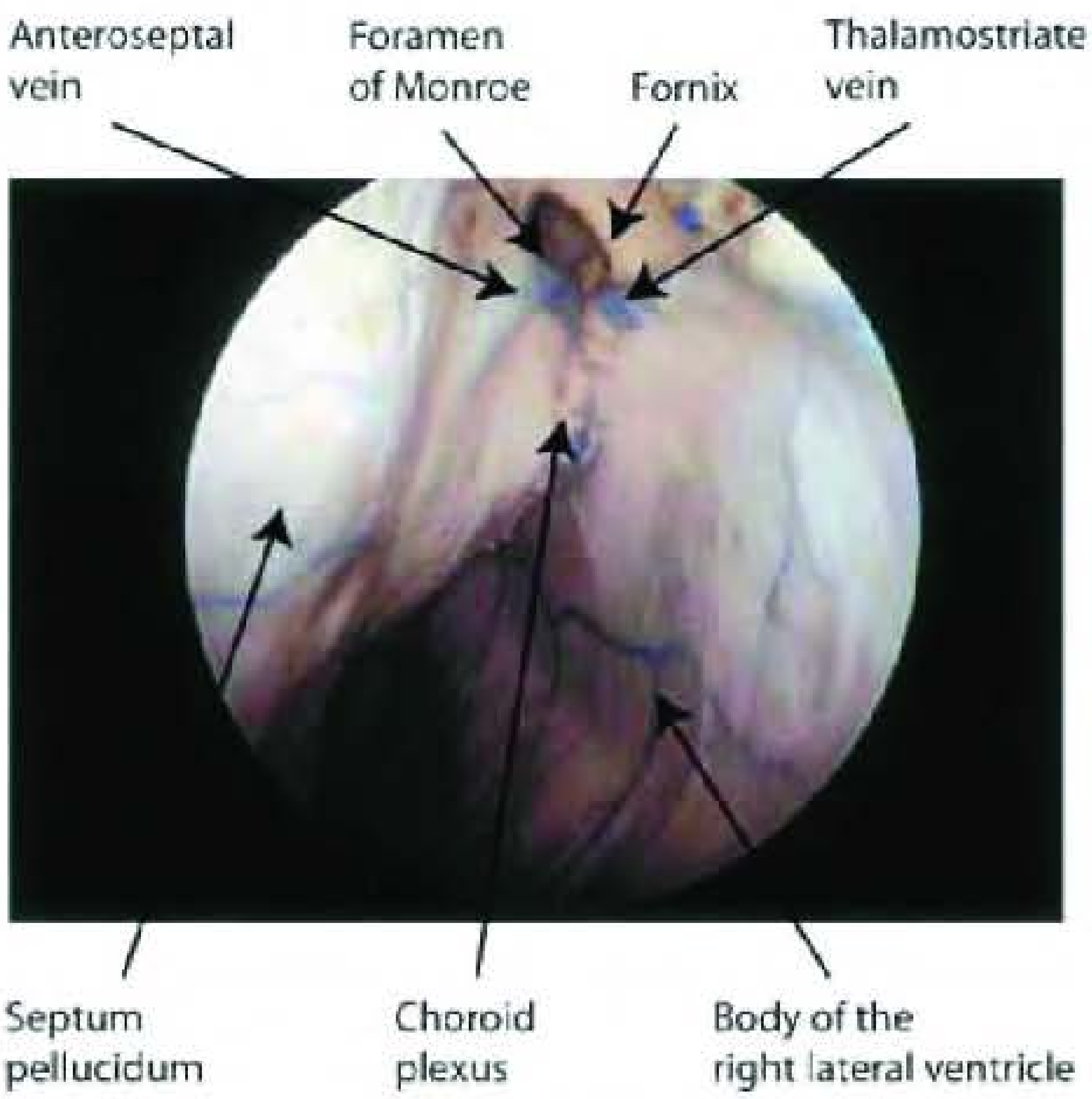


FIGURE 42–6 Panoramic view of the right lateral ventricle with the 70-degree endoscope inserted at Kocher's point. The foramen of Monroe, thalamostriate vein, anterior septal vein, and choroid plexus are seen.

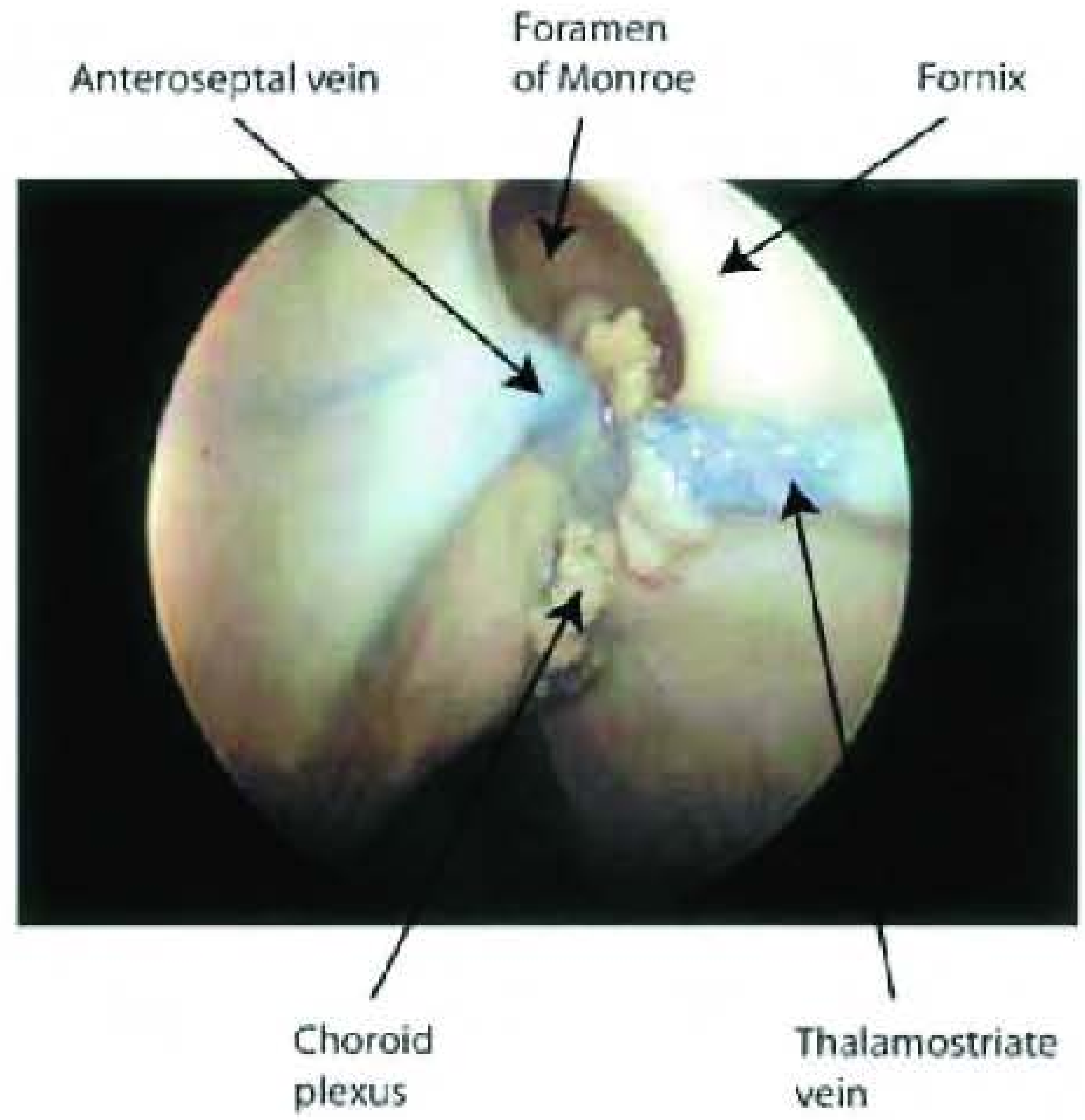


FIGURE 42–7 High-power view of the foramen of Monroe and its venous landmarks, the anteroseptal vein, and the thalamostriate vein. The choroid plexus is seen traversing the foramen.

If the ventriculoscope is passed through the foramen of Monroe, it enters the third ventricle (Figs. 42–8–42–11). The third ventricle is positioned in the geographic center of the head. It is below the body of the lateral ventricles, above the sella turcica, and between the cerebral hemispheres, thalami, and walls of the hypothalamus. It communicates with the lateral ventricles through the foramen of Monroe and with the fourth ventricle through the sylvian aqueduct. The roof of the ventricle is formed by an upper layer, the fornix, and a tower layer, the tela choroidea, separated by a vascular layer called the velum interpositum. The internal cerebral veins, into which the thalamostriate veins flow, lie in the velum interpositum. The choroid plexus of the third ventricle arises from the tela choroidea, which is contiguous with the choroid plexus of the lateral ventricles via the choroidal fissure. Within the third ventricle, the anterior and posterior commissures can be visualized.

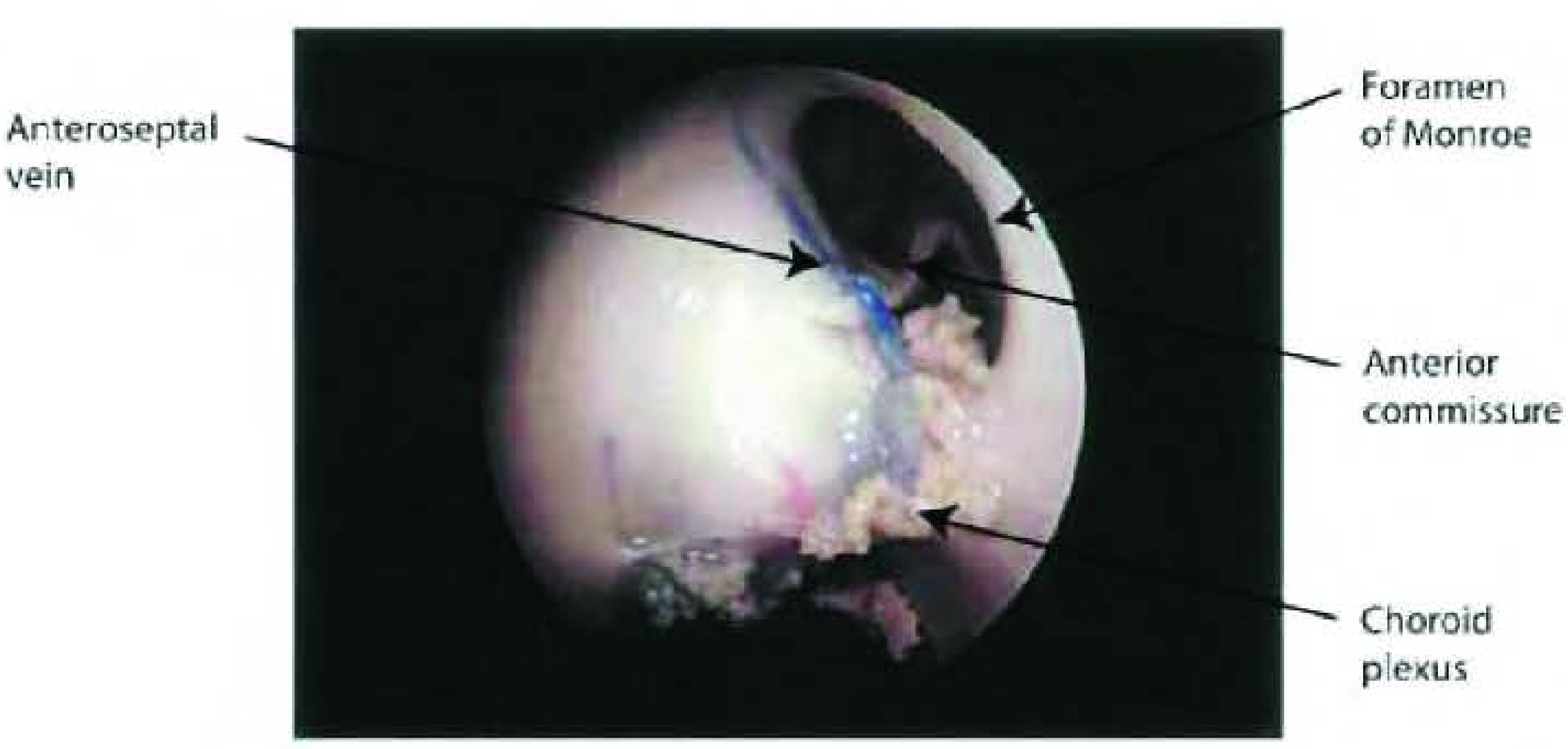


FIGURE 42–8 The anterior commissure is visualized through the foramen of Monroe.

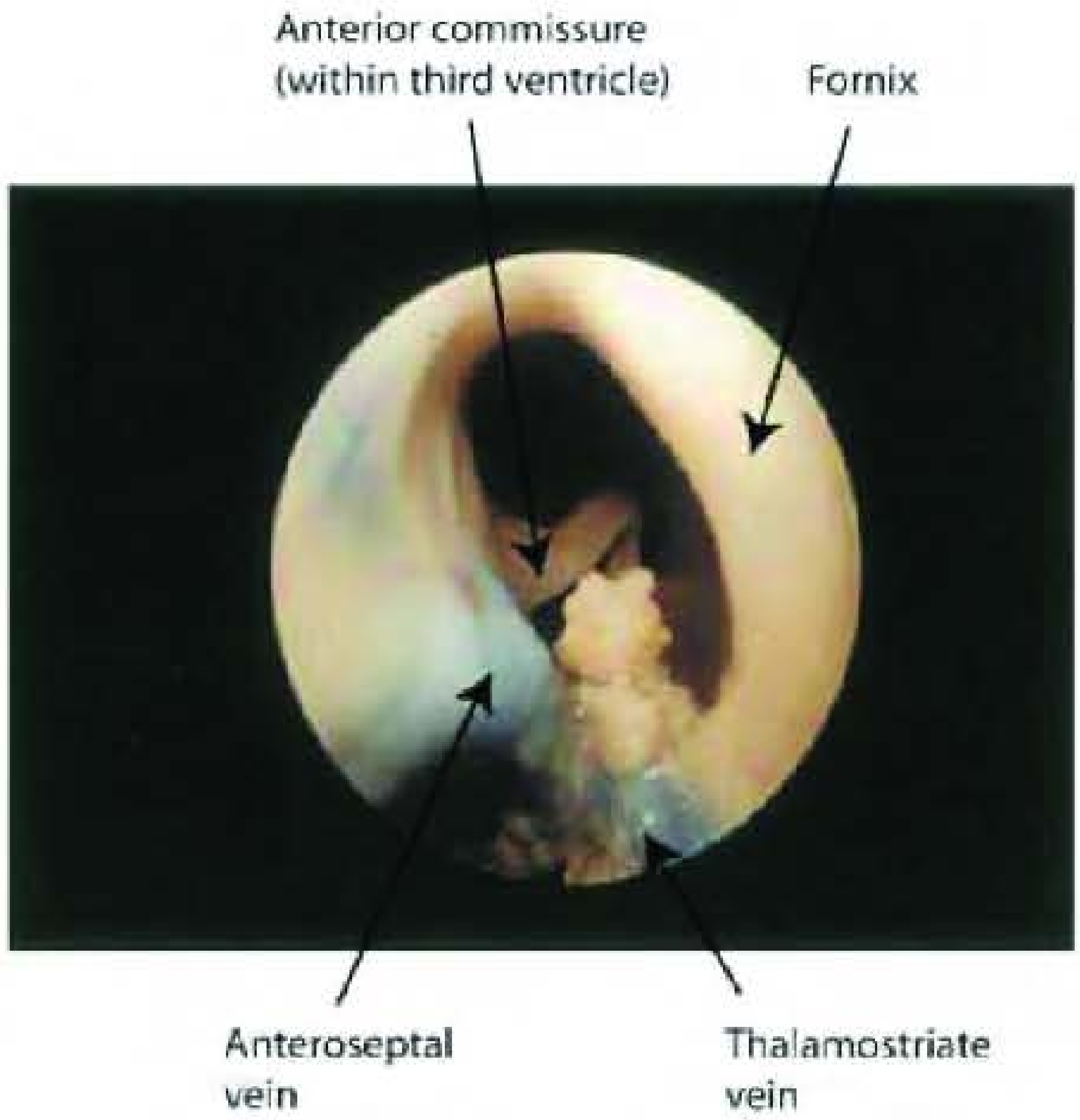


FIGURE 42–9 Transforaminal view of the anterior commissure as well as the venous confluens and choroid plexus traversing the foramen.

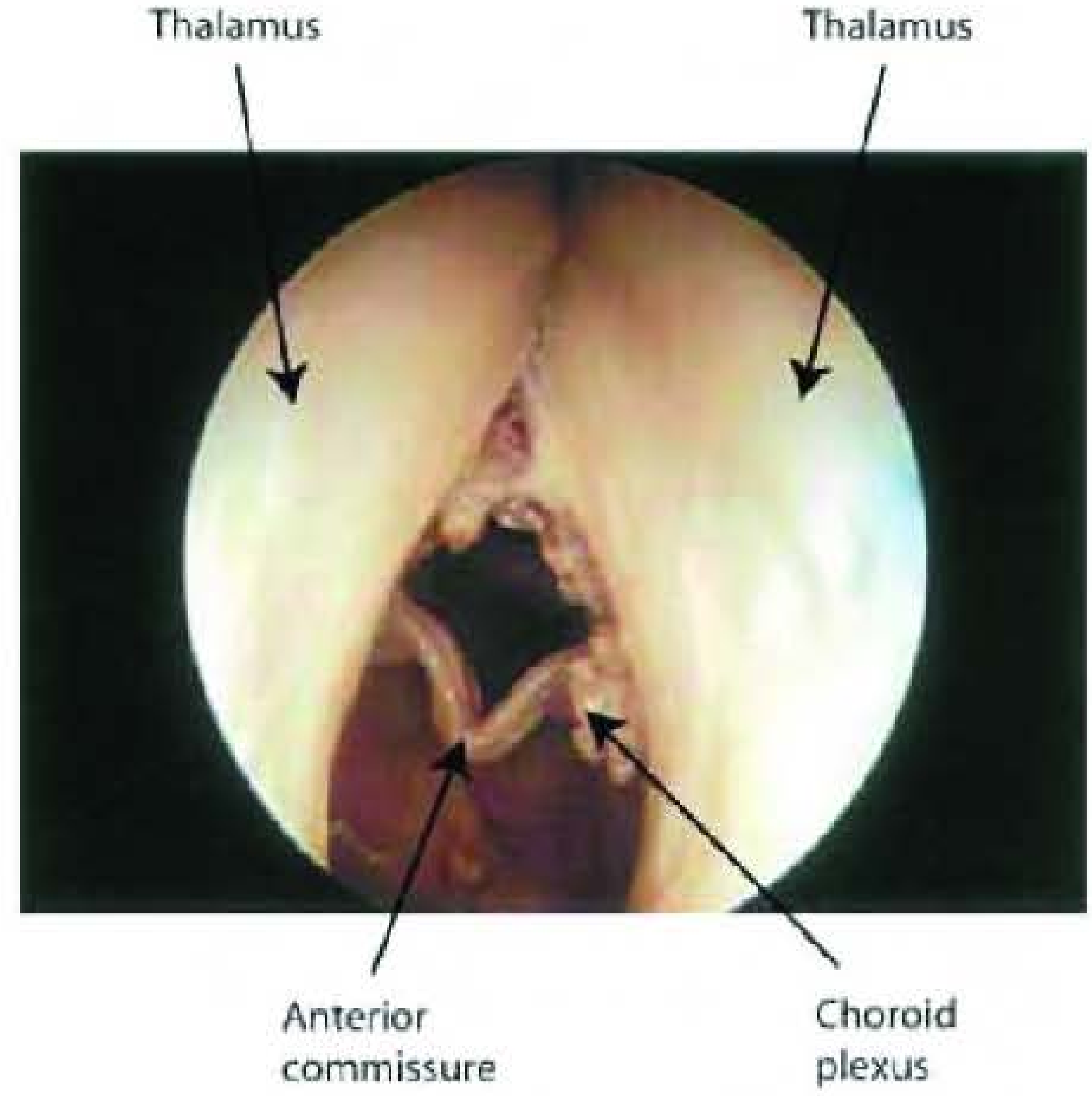
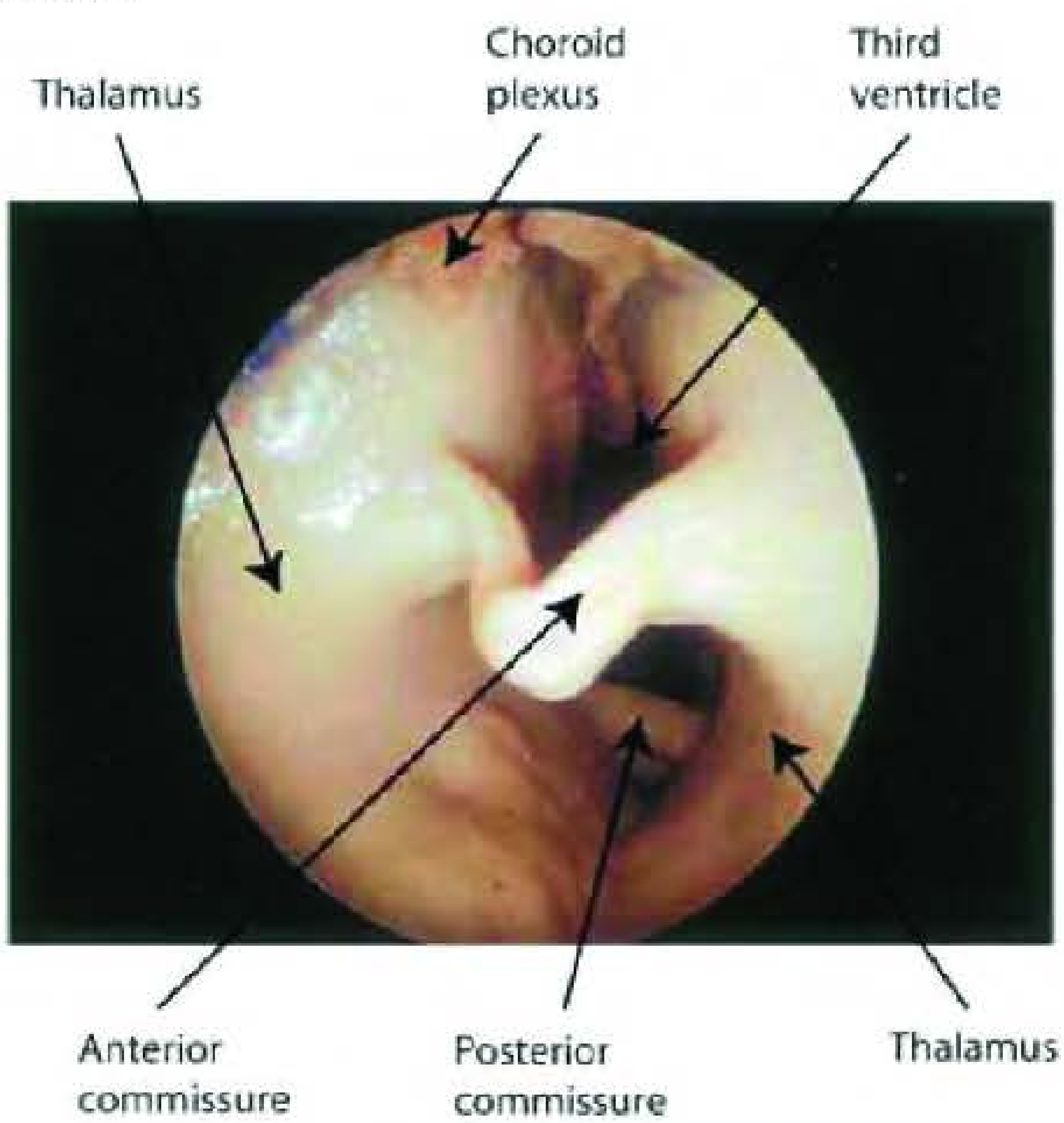


FIGURE 42–10 Body of the third ventricle. The lateral walls and anterior commissure are seen.



The floor of the third ventricle extends from the optic chiasm anteriorly to the orifice of the aqueduct (Fig. 42–12). The anterior portion of the floor is formed by the diencephalonic structures, and the posterior portion is composed of mesencephalic structures. These structures include the optic chiasm, the infundibulum of the hypothalamus, the tuber cinereum, the mamillary bodies, the posterior perforated substance, and part of the tectum. When viewed from inside, the optic chiasm forms the anterior floor of the third ventricle, the infundibular recess lies behind, the mamillary bodies project upward in a paired fashion on the inner surface of the floor posterior to the infundibular recess, and the aqueduct lies still more posteriorly. Opening the tuber cinereum allows communication with the prepontine and quadrigeminal basal cisterns, a fact that is used in the placement of a

FIGURE 42–11 The anterior and posterior commissures are visualized. The choroid plexus is hanging from the roof.

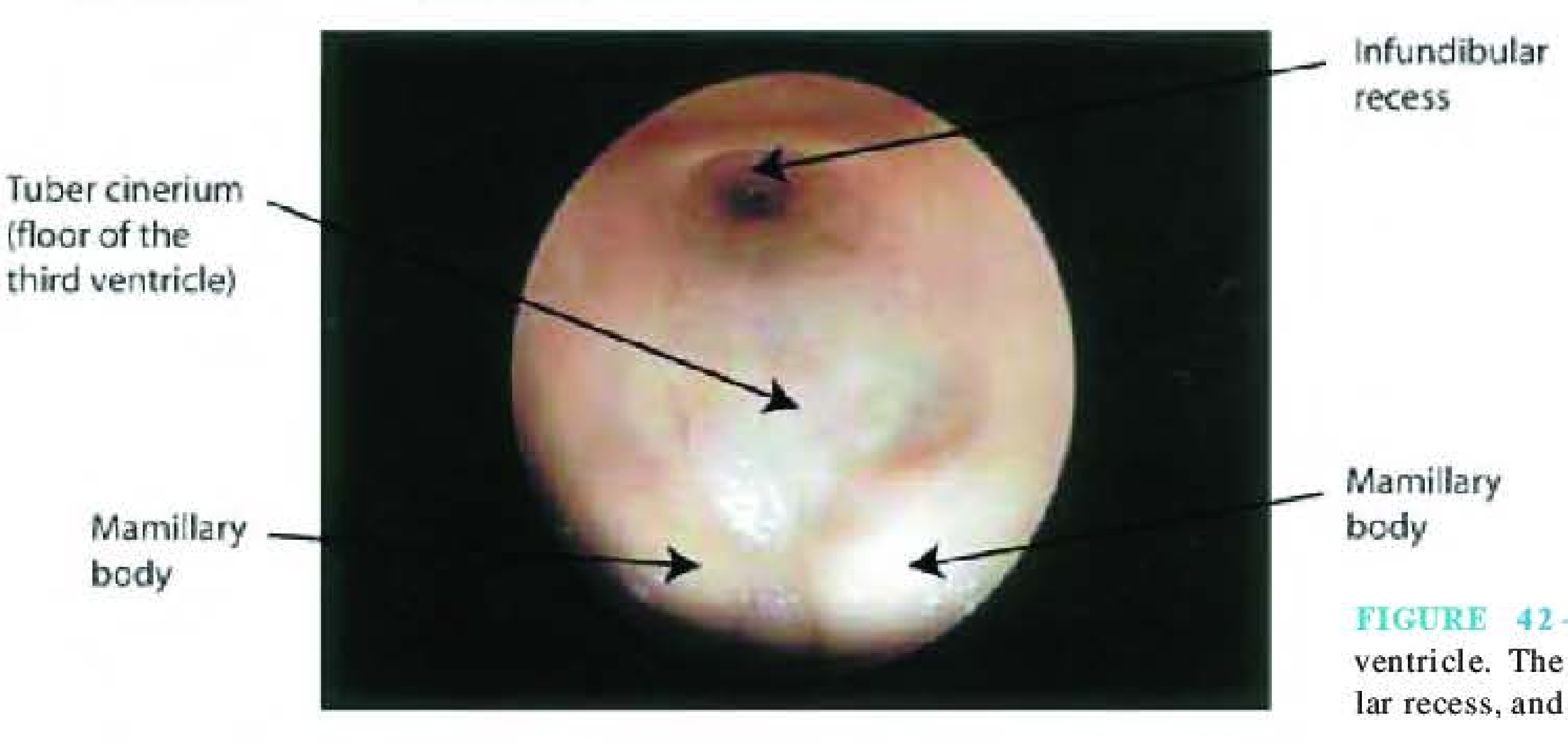


FIGURE 42–12 Floor of the anterior third ventricle. The mamillary bodies, infundibular recess, and tuber cinereum are seen.

third ventriculostomy. Opening the tuber cinereum also allows visualization of prepontine neurovascular anatomy (Figs. 42–13–42–17).

The anterior wall of the third ventricle from superior to inferior is composed of the columns of the fornix, the foramen of Monroe, the anterior commissure, the lamina terminalis, the optic recess, and the optic chiasm. The anterior commissure is a compact bundle of myelinated fibers connecting the midline in front of the columns of the fornix. The lamina terminalis forms the interval between the anterior commissure and the optic chiasm. The optic recess is the name given to the small cleft between the superior surface of the optic chiasm and the lamina terminalis. The posterior wall of the third ventricle extends from the suprapineal recess to the sylvian aqueduct below. It consists of the suprapineal recess, the habenular commissure, the pineal body, the pineal recess, the posterior commissure, and the sylvian aqueduct. The lateral walls are formed by the hypothalami inferiorly and the thalamus superiorly. The massa intermedia projects into the upper half of the third ventricle and often connects the opposing surfaces of the thalamus.

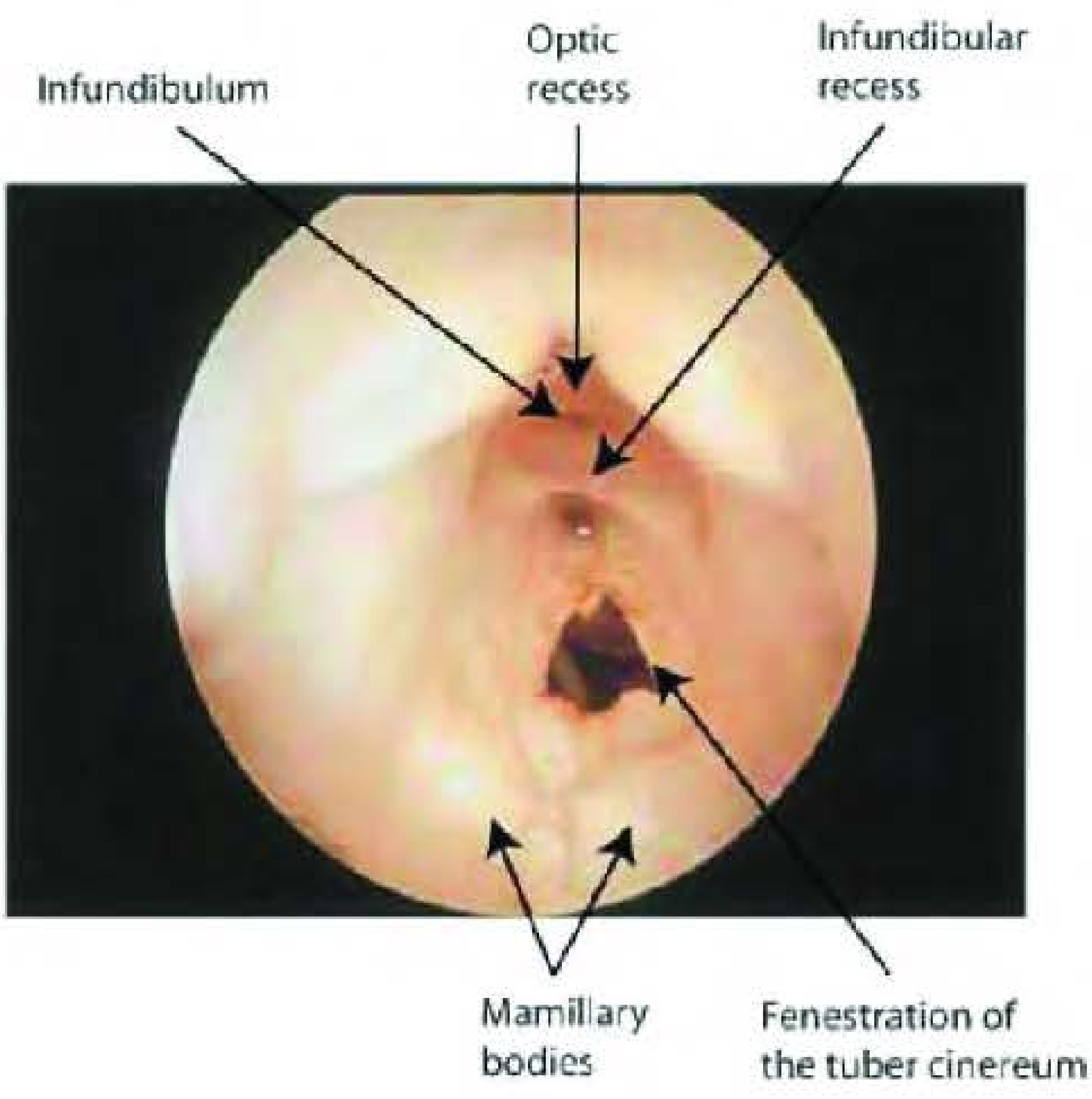


FIGURE 42–13 Panoramic view of the floor of the third ventricle with the tuber cinereum fenestrated.

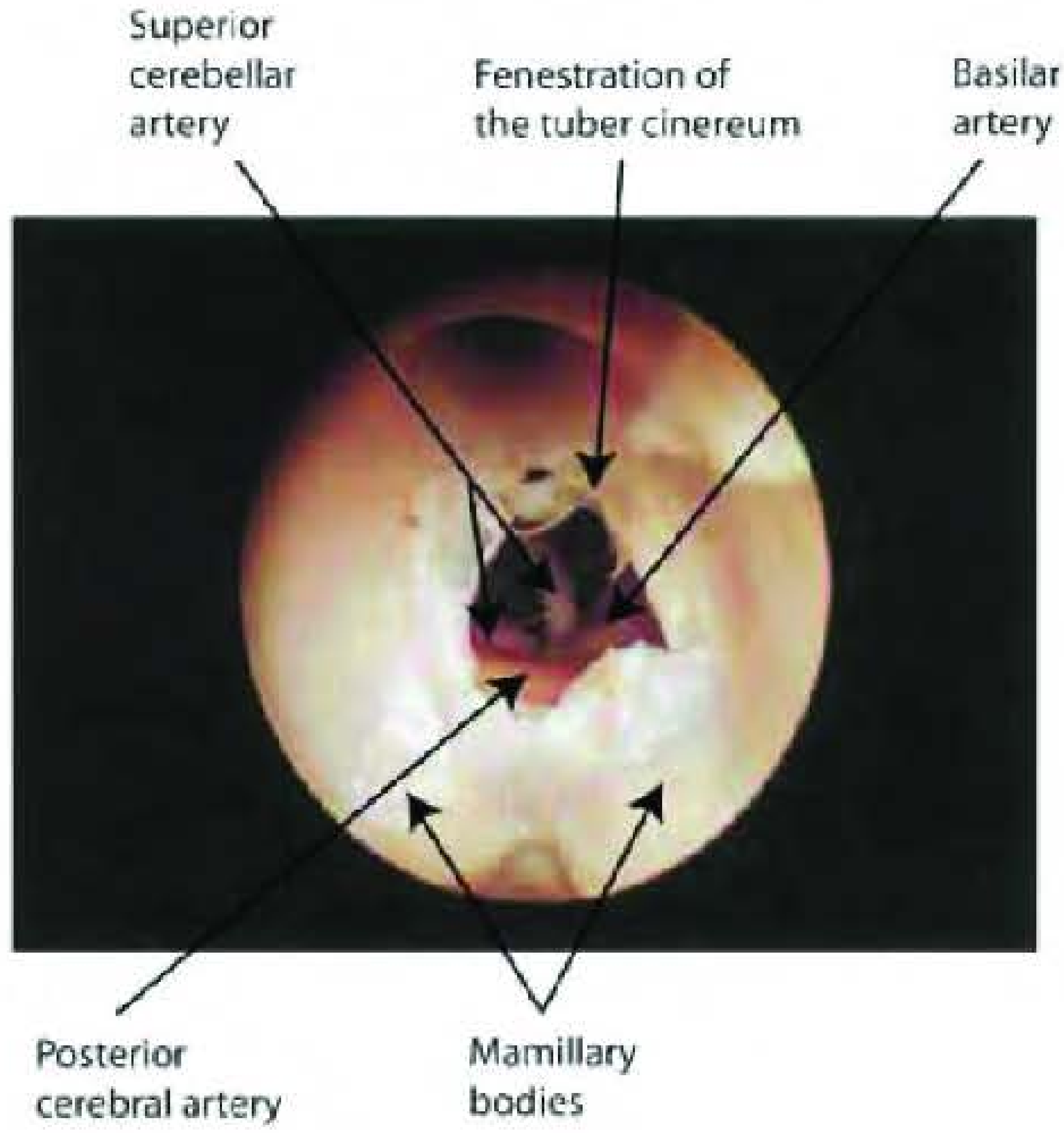


FIGURE 42–14 The basilar artery and its branches can be seen through the fenestrated tuber cinereum.

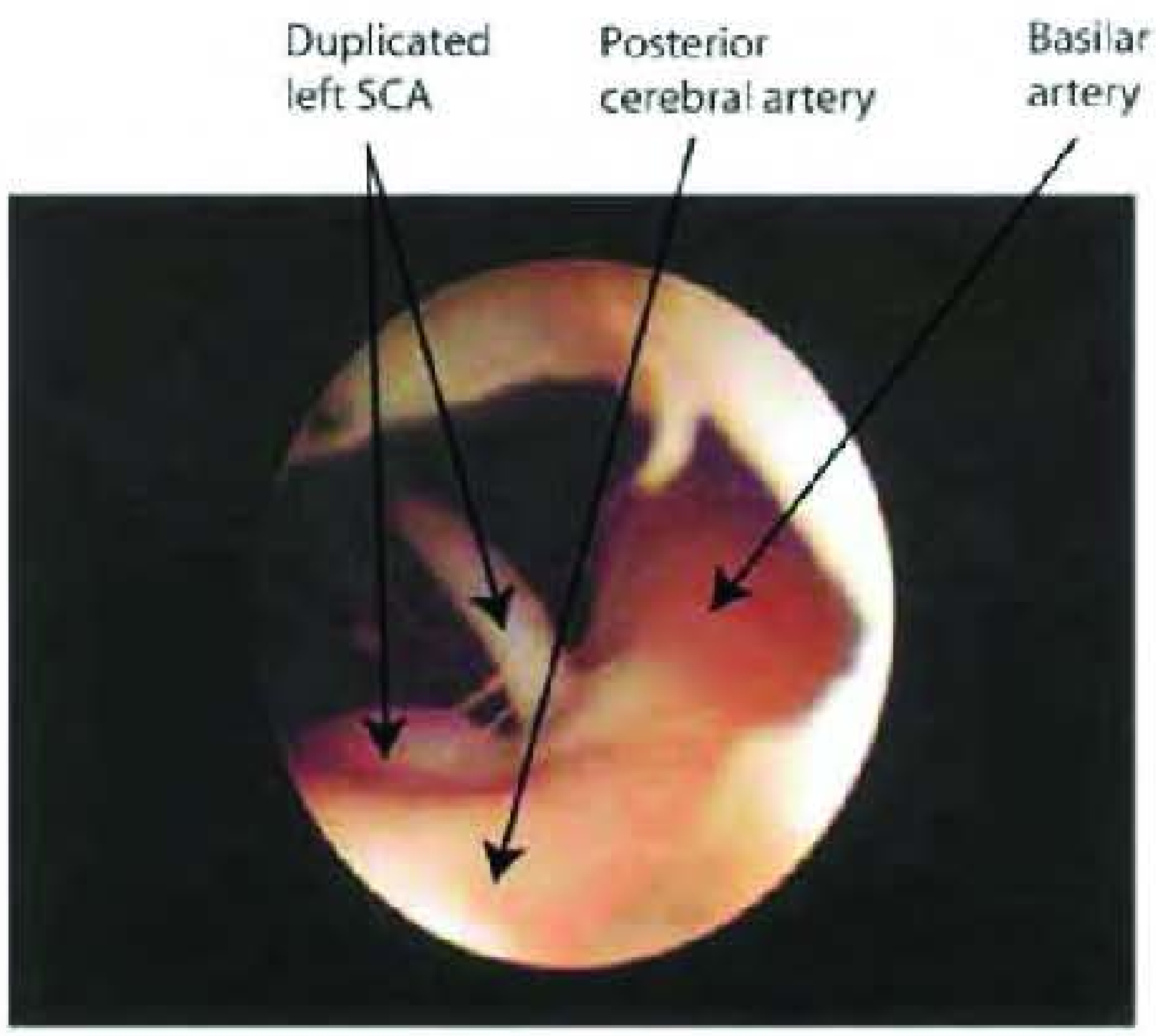


FIGURE 42–15 High-power view of the basilar artery, left P1, and left bifurcated superior cerebellar artery.

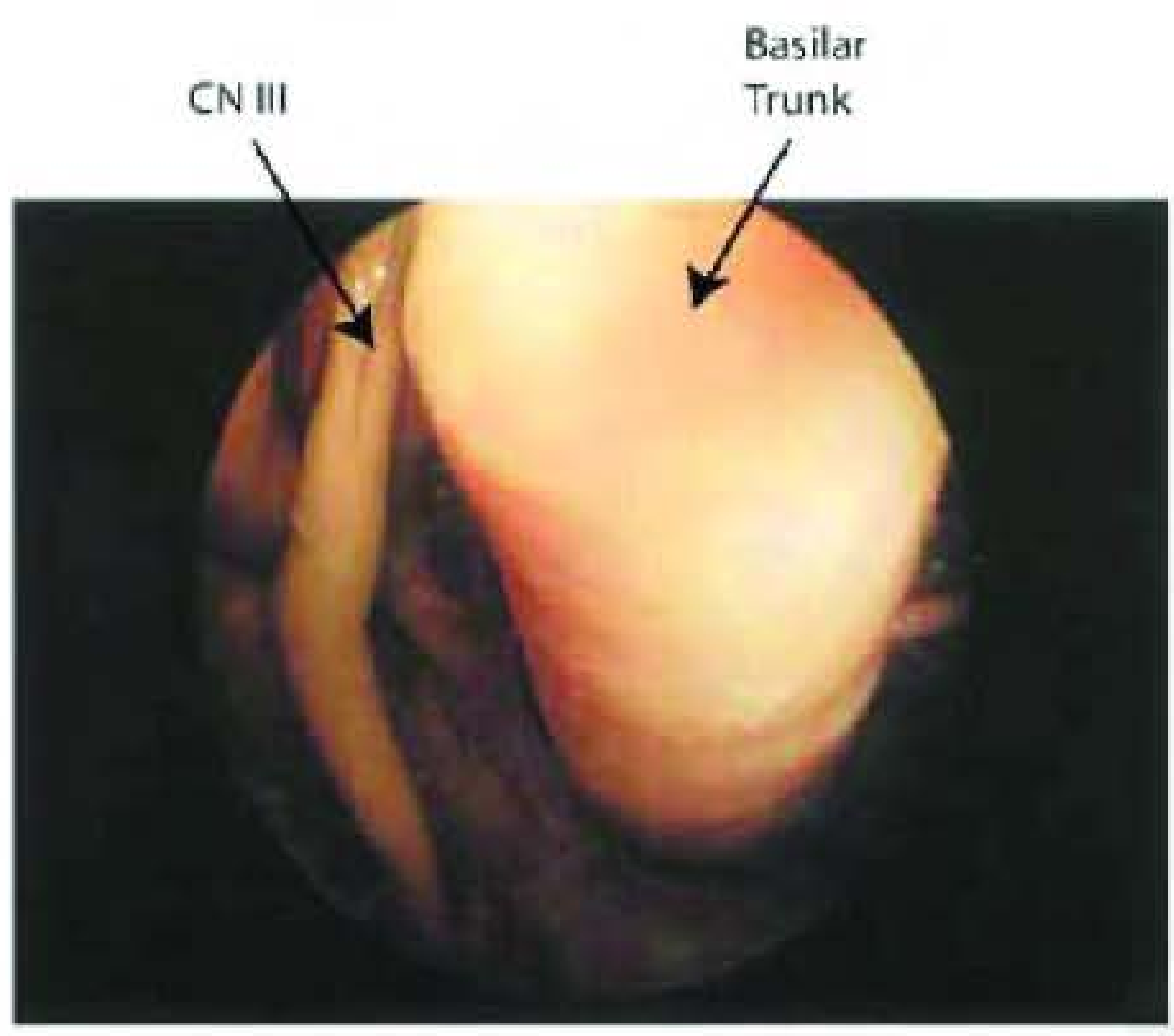


FIGURE 42–16 A 70-degree endoscope is passed through the fenestration visualizing the basilar artery and the right third cranial nerve (CN III).

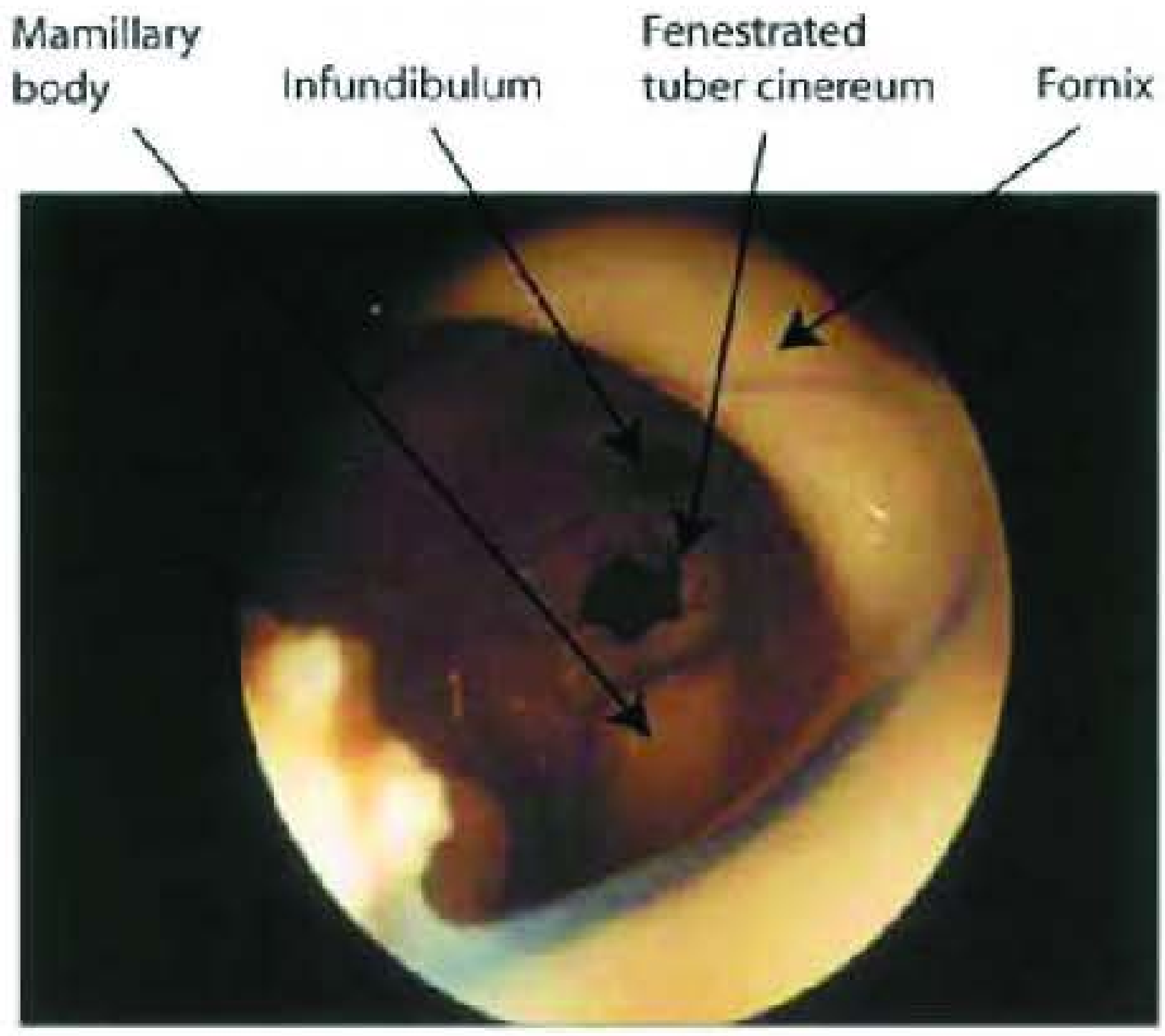


FIGURE 42–17 Transforaminal panoramic view of the fenestrated floor of the third ventricle. The fornix has not been injured during this procedure.

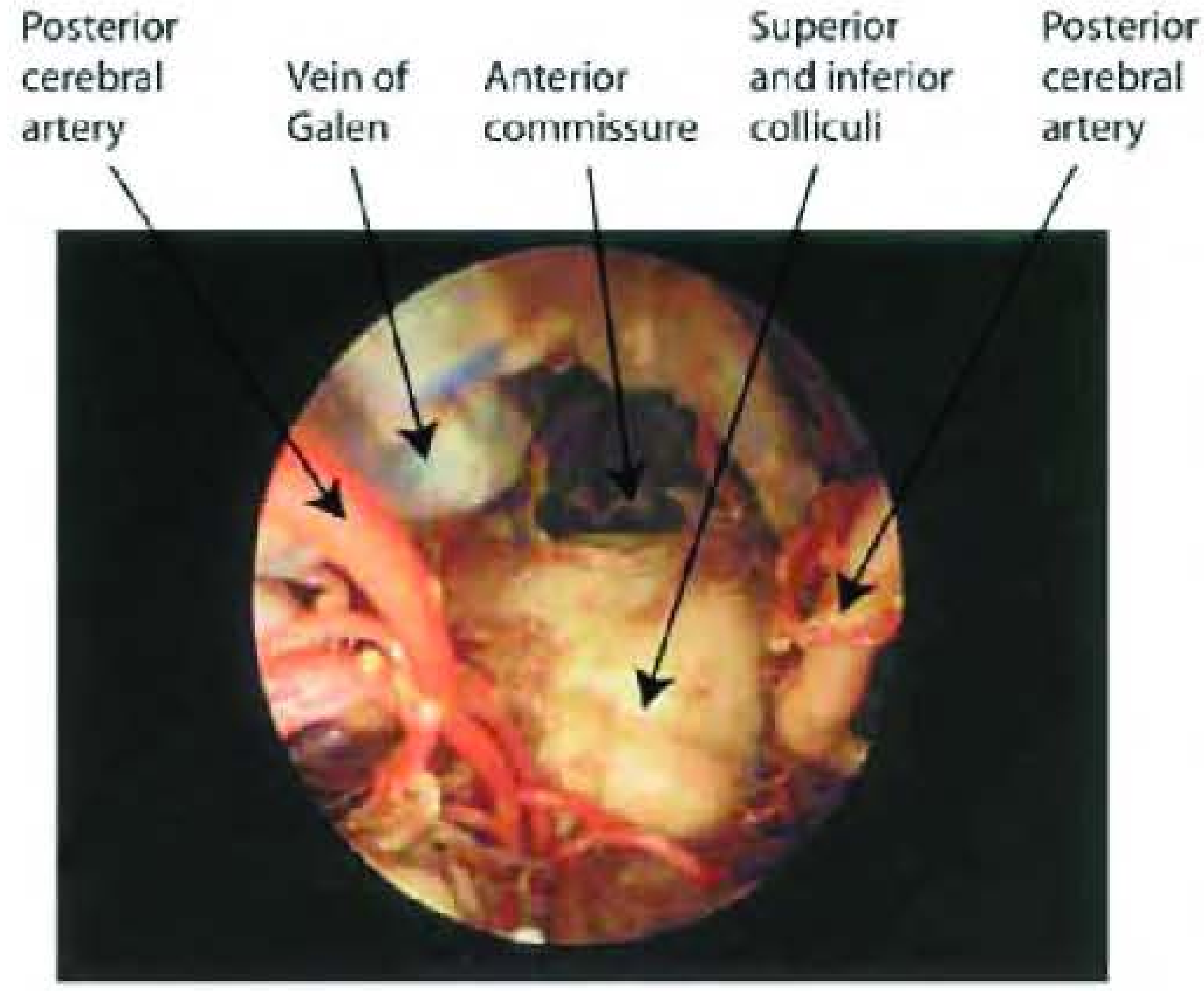


FIGURE 42–18 Posterior view of the collicular plate. The pineal gland has been resected leaving open the posterior wall of the third ventricle. The galenic venous complex is seen superiorly.

The paired internal cerebral veins that lie in the velum interpositum course posteriorly. They course along the curve of the stria medullaris and along the superolateral surface of the pineal body. The union of the two forms the great vein of Galen above or posterior to the pineal and near the inferior surface of the splenium.

The third ventricle also can be entered posteriorly as described in Chapter 16 (Figs. 42–18–42–20). The galenic venous complex and pineal gland are major anatomic structures to be identified via this approach.

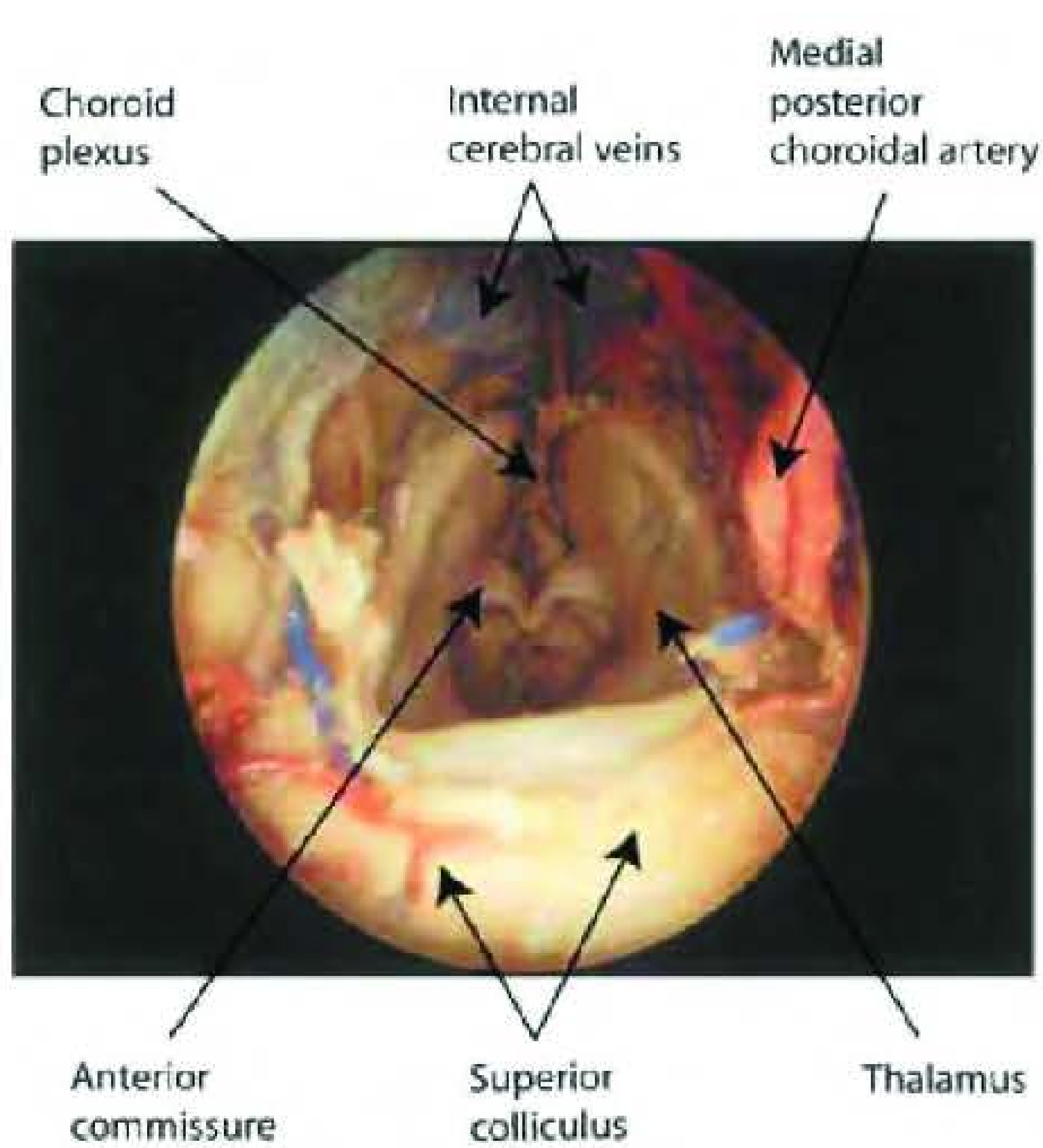


FIGURE 42–19 Through the open wall of the posterior third ventricle, the anterior and posterior commissures, internal cerebral veins, choroid plexus hanging from the roof, and foramen of Monroe can be visualized.

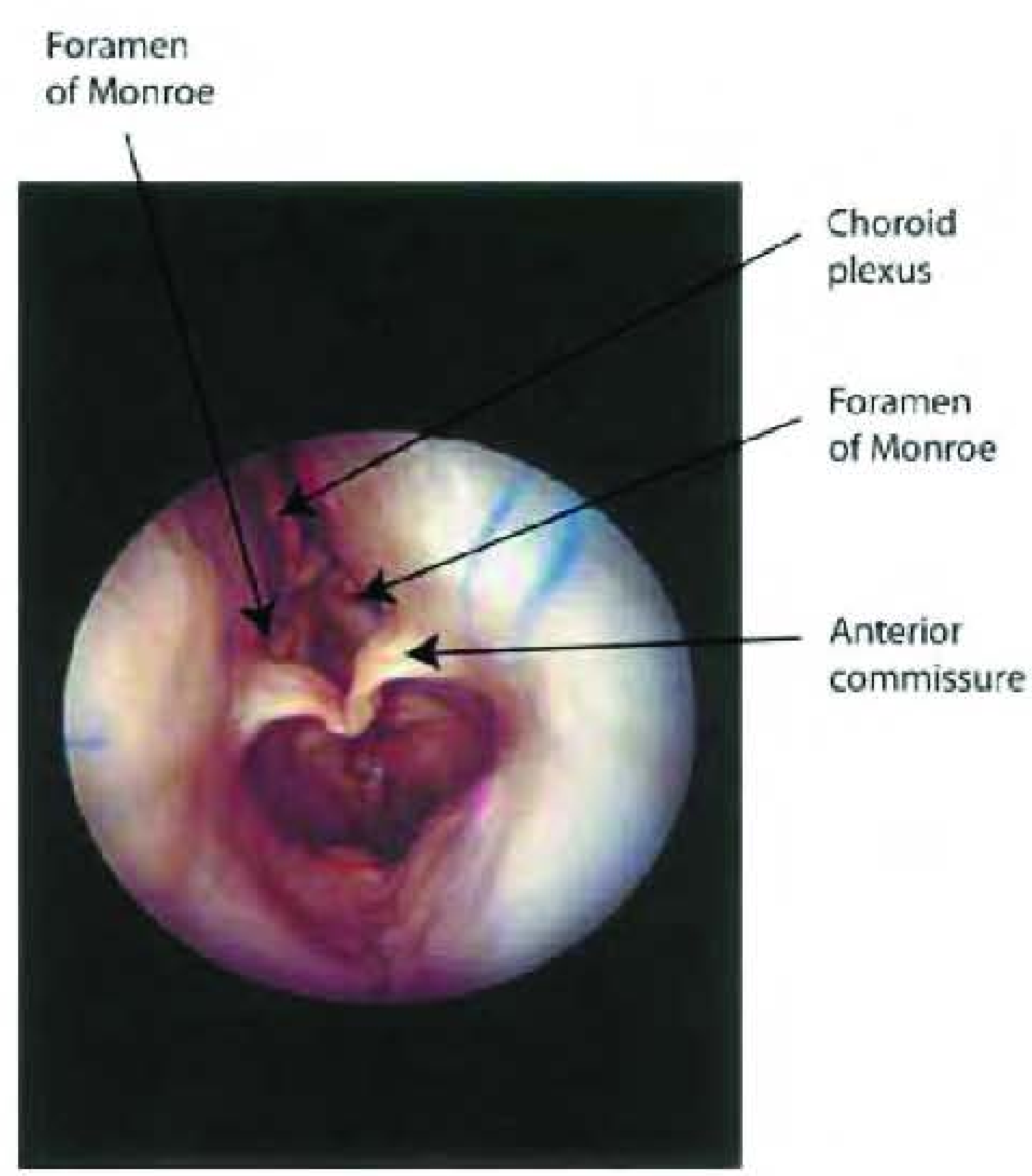


FIGURE 42–20 With a 70-degree endoscope within the third ventricle, the anterior commissure and foramen of Monroe are seen.

PITFALLS, PEARLS, CONSIDERATIONS

- Venous injury
- Injury to the fornix
- Optic nerve/chiasm injury
- Hypothalamic injury

SUGGESTED READINGS

Cohen AR. Endoscopic ventricular surgery. *Pediatr Neurosurg.* 1993;19:127–134.

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Chapter 43

ENDOSCOPIC THORACIC SYMPATHECTOMY

Ernest Senz, Carlos Acevedo, Anthony Caputy

INDICATIONS FOR APPROACH

- Hyperhidrosis
- Reflex sympathetic dystrophy

POSITIONING AND SKIN INCISION

The procedure is done with the patient under general anesthesia with a double-lumen endotracheal tube in position. The patient is placed in the right or left lateral decubitus position with the ipsitateral upper extremity abducted. Alternatively, the patient may be placed in the supine, crucifixion position if a bilateral procedure is to be performed. Three portals, one for the endoscope in the midaxillary line around the fifth or sixth intercostal space and two for working ports in the anterior and posterior axillary lines around the third or fourth intercostal space, are required for the procedure.

SURGICAL TECHNIQUE

Following placement of the thoracoscopic ports, the ipsilateral lung is collapsed and gently retracted to afford visualization of the spinal column, rib heads, and vessels. A dissection is made between the parietal and visceral pleura to identify ribs 2 to 4 with their associated neurovascular bundles. Rostra My, the dissection is limited by the subclavian artery. Underneath the artery, a fat pad that is related to the position of the first rib is visualized. On the lateral aspect of the vertebral bodies, the sympathetic chain can be identified (Figs. 43–1 and 43–2). It lies over the heads of the ribs and under the pleura.

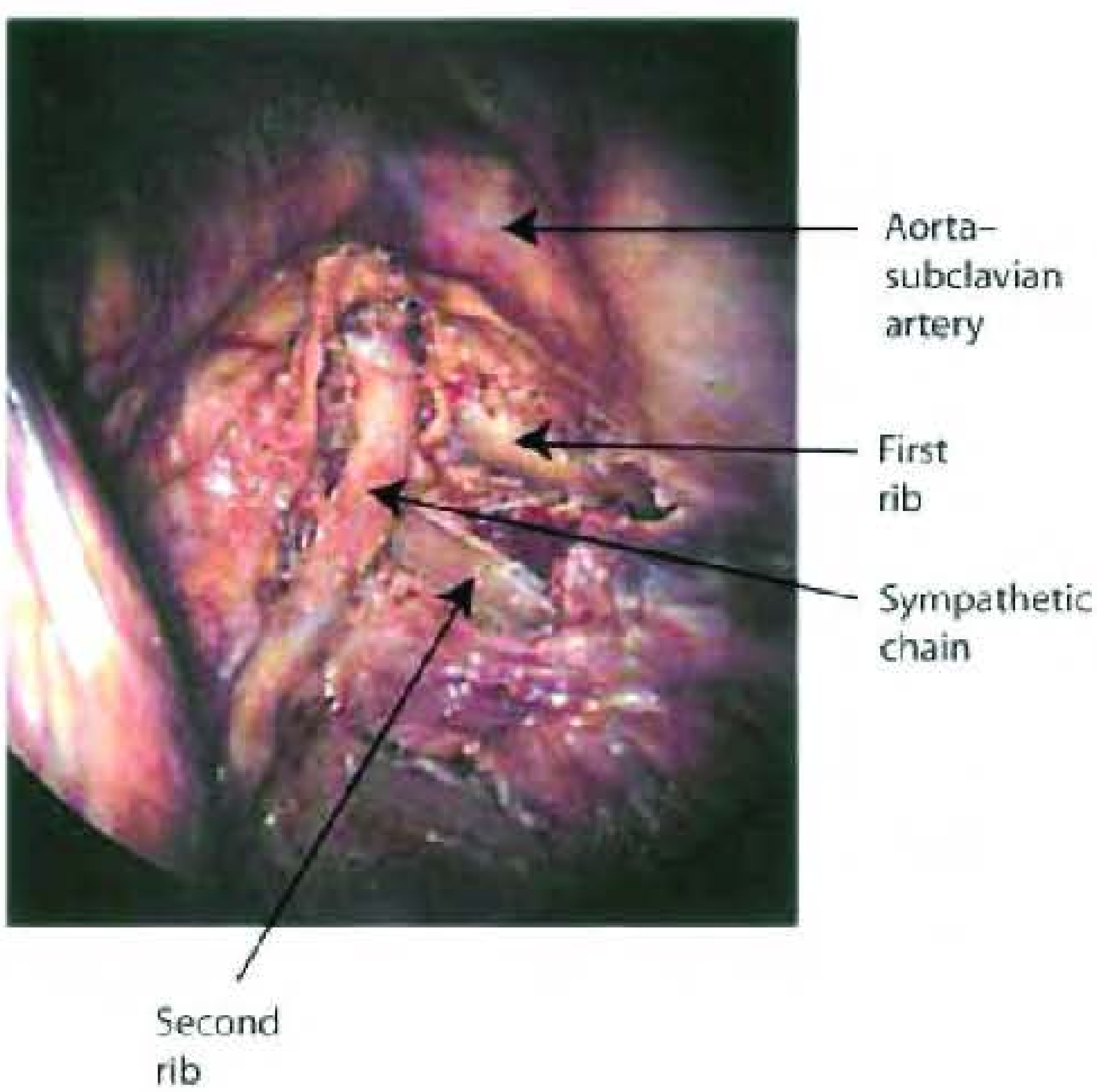

FIGURE 43–1 The aorta is seen with the subclavian artery coursing toward the apex of the hemithorax. The sympathetic chain has been dissected over the exposed first and second ribs.

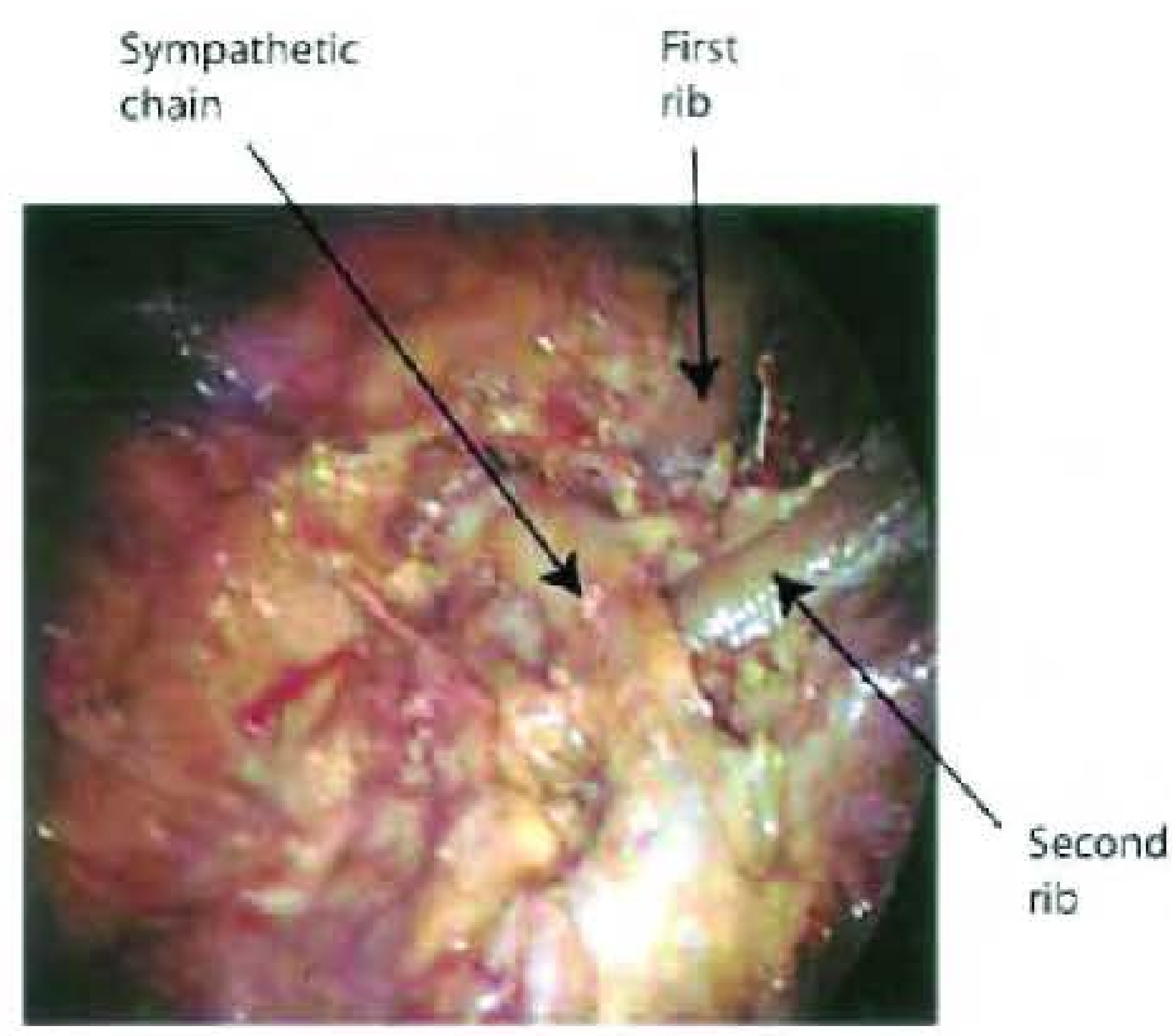

FIGURE 43–2 High-power view of the sympathetic chain overlying the exposed first and second ribs.

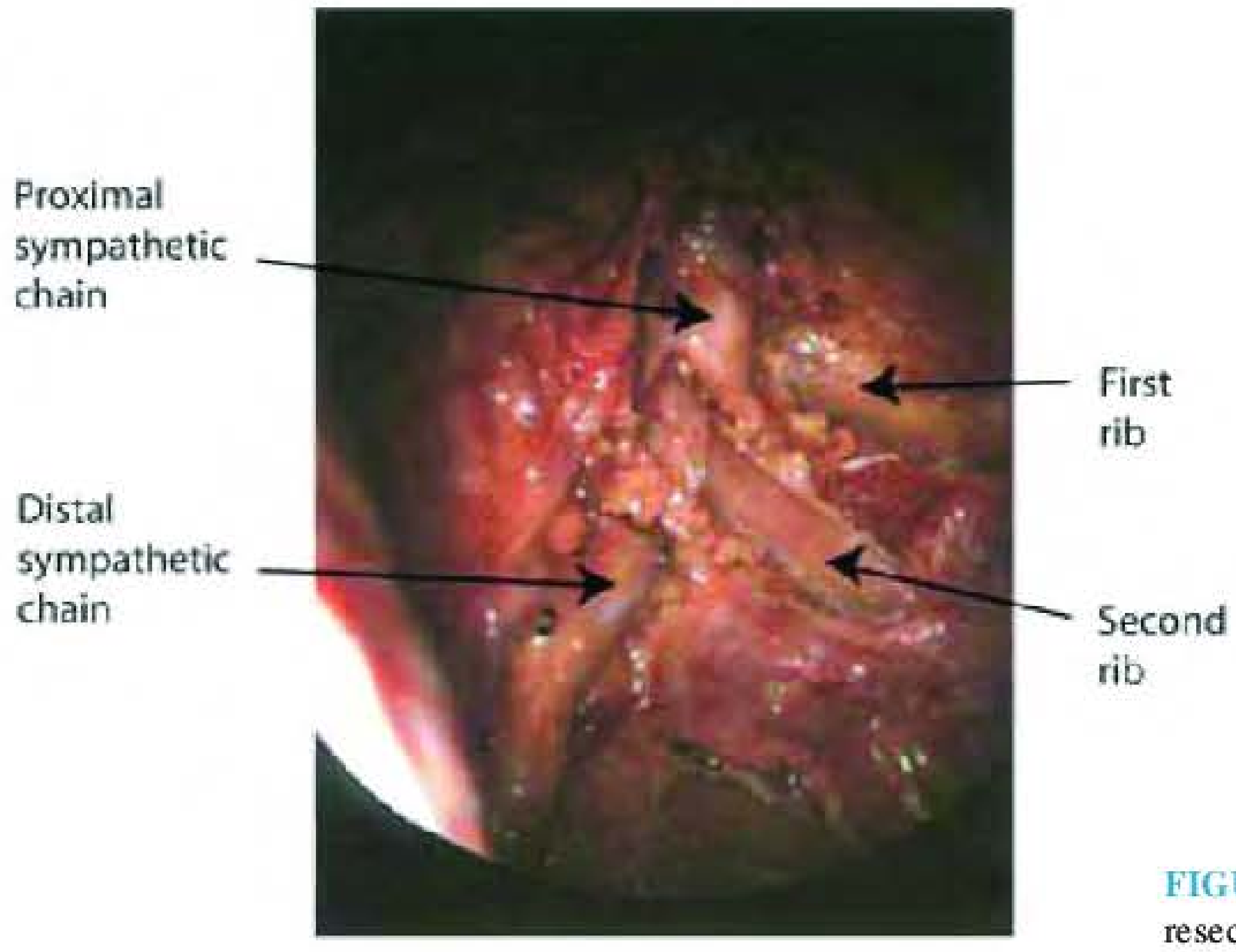

FIGURE 43–3 A segment of the sympathetic chain has been resected at the level of the second rib.

At least one segment of the chain should be resected, typically involving T2 through T4. This avoids injury to the distal stellate ganglion and the risk of a Horner's syndrome. An incision is made over the pleura and extended rostrally keeping the plane of dissection just under the chain in order to avoid intercostal vessels beneath. The segment to be resected then is isolated with cautery or metal clips, resected, and sent to pathology (Fig. 43–3). After verifying hemostasis, chest tubes are placed, and the wound is closed in two layers.

Pitfalls, Pearls, Considerations

- Horner's syndrome
- Lung injury
- Vascular or thoracic duct injury

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Note: Page numbers followed by *f* and *t* represent figures and tables respectively.