Pituitary Surgery: Transsphenoidal Approach

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THE TRANSSPHENOIDAL APPROACH for sellar tumors has evolved significantly since it was described initially during the first decade of the 20th century. The approach currently incorporates technological advancements and refinements in patient selection, operative technique, and postoperative care. Although many of these innovations are considered indispensable, the operative technique, as performed by contemporary neurosurgeons, is not standardized. This variability is a reflection of surgeon's preference, the lessons of experience, and the bias inherent in neurosurgical training. The methods and preferences described herein embody the distillation of an experience gained from 3900 transsphenoidal operations.

KEY WORDS: Pituitary adenoma, Surgical technique, Transsphenoidal surgery

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Almost a century ago in 1907, the transnasal transsphenoidal approach to lesions of the sella turcica was first introduced successfully by Herman Schloffer, a Viennese surgeon. This approach has since been adopted and modified by various European surgeons and by Harvey Cushing, who introduced the sublabial incision. It has undergone a series of significant evolutionary steps, notably the use of fluoroscopic guidance by Gerard Guiot and the introduction of the operating microscope by Jules Hardy. These developments facilitated the concept and feasibility of selective adenomectomy, establishing the standard by which transsphenoidal surgery has been practiced for the past three decades (4). Current (2001–2002) data from the Neurosurgery Residency Review Committee indicate that 19% of primary brain tumors treated in academic centers in the United States are operated transsphenoidally.

A number of important innovations have been introduced during recent years. These include various forms of neuronavigational guidance (3), intraoperative magnetic resonance imaging (MRI), transsphenoidal endoscopy (1), gamma knife radiosurgery, technical maneuvers to deal safely with recurrent pituitary tumors, reconstruction of the cranial base, improved methods of hemostasis, and the development of extended transsphenoidal cranial base approaches (5, 10, 13).

In this article, we review these quintessential details of the transsphenoidal technique. We outline nuances that we think are important to optimizing outcome and maximizing safety as distilled from the experience of the senior author (ERL) with 3900 transsphenoidal operations.

PREOPERATIVE CONSIDERATIONS

The overwhelming majority of sellar lesions are approachable transsphenoidally. The transsphenoidal approach has a number of iterations, including the endonasal rhinoseptoplastic, transnasal septal displacement, transnasal endoscopic, and sublabial transseptal approaches (2). Important considerations regarding the specific approach to the sphenoid are the size of the nose and nostril, the presence of septal deviation or perforation, a history of septal surgery, and a history of sinus disease or infection.

POSITIONING

Careful positioning of the patient is critical. In our practice, the patient is comfortably supine with the right shoulder at the upper right-hand corner of the operative table (*Fig. 1*). The patient is placed in a semirecumbent, reclining, or lawn-chair position, with the operative site above the level of the heart to allow for free drainage of blood from the region of the sella and the sphenoid sinus. Venous air embolism is not a major concern. The advantage of this position is that venous pressure is reduced, therefore bleeding is reduced;

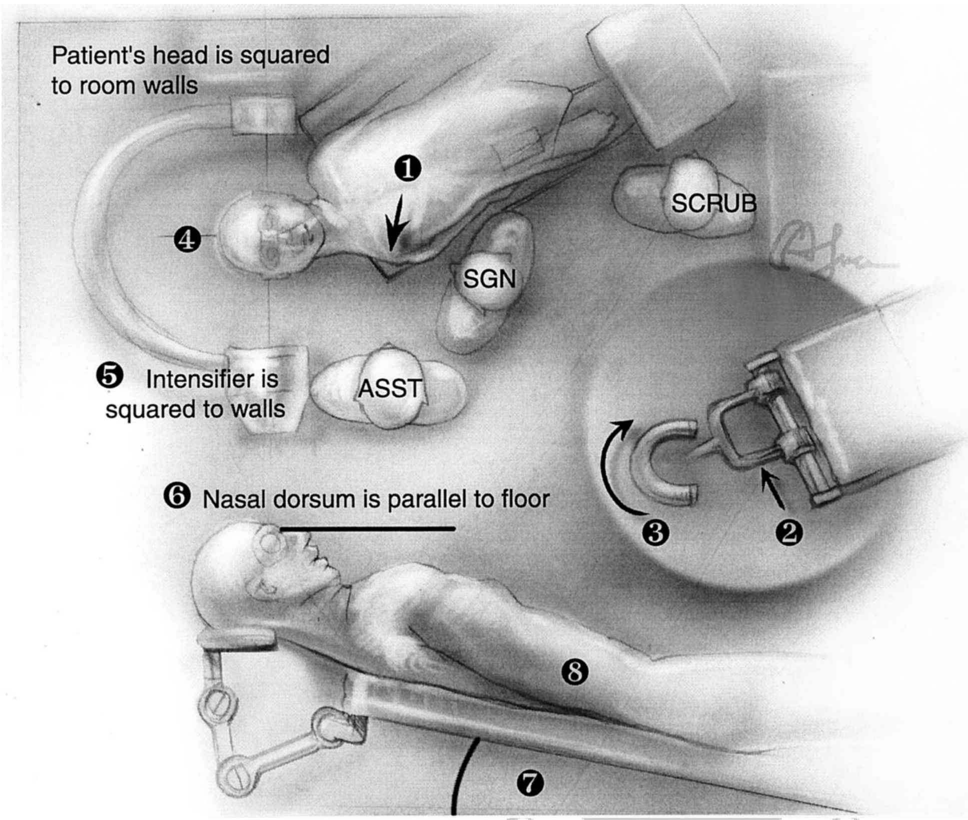

FIGURE 1. *Patient positioning and surgical team.* 1, *the patient's right shoulder is positioned in the top right-hand corner of the operative table.* 2, *the headrest frame is positioned to the far left.* 3, *the horseshoe headrest is rotated so that the patient's head is oriented toward the surgeon.* 4 *and* 5, *the patient's head is oriented at a right angle to the walls of the room to facilitate lateral intraoperative videofluoroscopy on the draped patient.* 6, *the head is positioned so that the trajectory is toward the sella. This is most easily accomplished by positioning the neck such that the dorsum of the nose is parallel with the floor.* 7, *the beach-chair position is used with the table angled approximately 20 degrees.* 8, *the patient's right hand is carefully positioned in an unobtrusive manner under the buttocks.* SGN, *surgeon;* ASST, *assistant.*

the bleeding that occurs runs out of the surgical field and into the recesses of the sinuses. Although a dry field is always an advantage, this is of particular importance when using the endoscope and dealing with microadenomas, and it is invaluable in patients with Cushing's disease. The diminished bleeding also makes routine packing of the oropharynx unnecessary. The alternative position, with the surgeon at the head of the table operating from above on a supine patient, lacks the advantage of gravity lessening the bleeding and can be more difficult when endoscopic approaches are planned.

The thorax should be at 25 to 30 degrees of elevation to facilitate intraoperative air injection through a lumbar catheter when necessary. With the head supported by a Mayfield horseshoe headrest, the head is laterally flexed 20 degrees, approximating the left ear toward the left shoulder. For most patients, the ability to make minor adjustments in head position is preferable to rigid fixation in pins. The operative table is positioned so that the patient's head is parallel to the walls of the room (*Fig. 1*). This facilitates accurate lateral imaging and orients the midline of the patient to the geometry of the operating room. The head and the microscope are positioned such that the standing surgeon's view into the nose will be directed at the sella. In general, this can be accomplished by positioning the patient's head so that the bridge of the nose is parallel to the floor (*Fig. 1*). A slight tilt of the table toward the surgeon is the key to providing an optimal position that allows the surgeon to operate standing straight instead of leaning over, which can be uncomfortable, especially during protracted procedures. This tilt is also an advantage in treating a patient with cervical spondylosis whose neck is not readily flexed laterally.

Every effort is made to achieve an approximation of this ideal position, because strict adherence to this positioning standardizes the angle of approach to the sella and helps to secure confidence regarding location of the midline.

Because the patient's head is not fixed to the operative table, the surgeon can subtly manipulate head position intraoperatively to obtain a wider view of the operative field and the cavernous sinus region without having to adjust the microscope.

SURGICAL APPROACHES

Transnasal Septal Displacement Approach

The transnasal septal displacement procedure or "septal pushover" is currently our approach of choice for most patients, particularly for reoperative transsphenoidal procedures, in children, and in patients with Cushing's disease. It provides for speedy exposure and closure (*Fig. 2C*) (8, 14). A small L-shaped mucosal incision is fashioned by use of a vertical incision posterior and parallel to the junction of the bony and cartilaginous septi and then anteriorly parallel to the attachment of the cartilaginous septum to the maxilla. The septum, with both layers of mucosa attached, is deflected to allow entry into the sphenoid sinus. The temporary nasal packs (fingers of rubber gloves filled with gauze), which realign the septum, generally are removed either the night of surgery or early in the morning of postoperative Day 1.

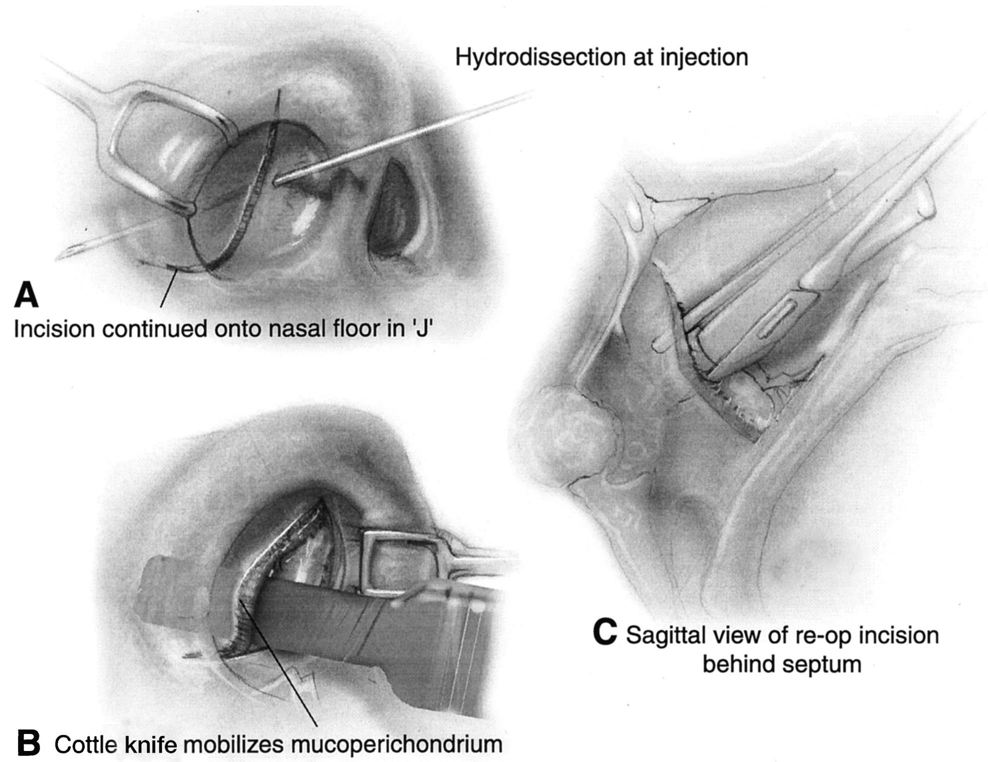

FIGURE 2. *Endonasal endoscopic approach (*A *and* B*, submucosal endonasal approach;* C*, septal displacement approach).* Re-op*, reoperation.*

Transnasal Endoscopic Approach

This approach can be used as the primary mode of tumor removal by use of a direct anterior sphenoidotomy, although its advantages remain debatable. Nonetheless, the endoscope can be effectively used as an adjunct to the standard approaches and provides views of the sella and suprasellar regions at angles not afforded by standard exposures (*Fig. 2*).

The use of the endoscope is facilitated by the placement of a table-mounted endoscope holder on the left-hand side of the operative table to free both hands of the surgeon. An additional Mayo stand is placed at the surgeon's left to support the endoscope tray; loops of the fiberoptic and camera cords also are maintained in this area. The endoscope is usually introduced into the left nostril and advanced along the middle turbinate to the anterior wall of the sphenoid. The sphenoid ostium is opened after it is palpated by a blunt dissecting instrument. The anterior wall of the sphenoid is opened widely with angled punches. A small segment of the posterior nasal septum is usually resected to augment exposure. Arterial bleeding may be encountered in the inferolateral portions of the sphenoidotomy as a result of disruption of the sphenopalatine artery. Monopolar or bipolar suction cautery may be used to control hemorrhage in this circumstance.

The endoscope is then fitted onto the table-mounted endoscope holder and inserted into the left sphenoidotomy defect. The shaft of the endoscope can be positioned into the nose through a plastic working channel that allows for removal and reinsertion without damage to the surrounding mucosa. On the right, a small self-retaining nasal speculum may be placed to allow for insertion of instruments. Alternatively, all manipulation can be performed through one nostril. Exposure of the sellar dura is performed with the identical instruments used in standard transsphenoidal approaches.

Sublabial Approach

Although it was once the most common corridor of access, the sublabial approach is now used only in procedures for which endonasal exposure is inadequate (*Fig. 3*). These include extended anterior cranial base procedures, in patients with small nasal apertures, and in pediatric patients in whom the nose is too small to accept a standard-sized speculum. It is also used for large tumors that are inadequately visualized through the endonasal approach, particularly those with lateral extension into the cavernous sinus or extensive involvement of the clivus. We have not found it necessary to enlarge the nasal piriform bony orifice, as advocated by some surgeons.

The nasal spine is carefully preserved, because the nasal spine and the incisors can assist in identifying the midline anteriorly. The tendency during an approach from the right is usually to drift across to the left. It is crucial to be confident in identifying the midline keel of the vomer and maintaining the superior aspect of the rostrum of the sphenoid.

EXPOSING THE PITUITARY FOSSA

After the position and trajectory of the transsphenoidal speculum are confirmed via fluoroscopy or image guidance, the sphenoid sinus is opened. Overzealous spreading of the speculum can cause maxillary, sphenoidal, or optic foramen fractures and may cause permanent facial numbness in Divisions I and II of the trigeminal nerve and damage to the lacrimal ducts.

It is critical to appreciate the compartmentalization of the sphenoid sinus to facilitate complete exposure of the pituitary fossa. Removing the sphenoid sinus mucous membrane may prevent the development of postoperative mucocele.

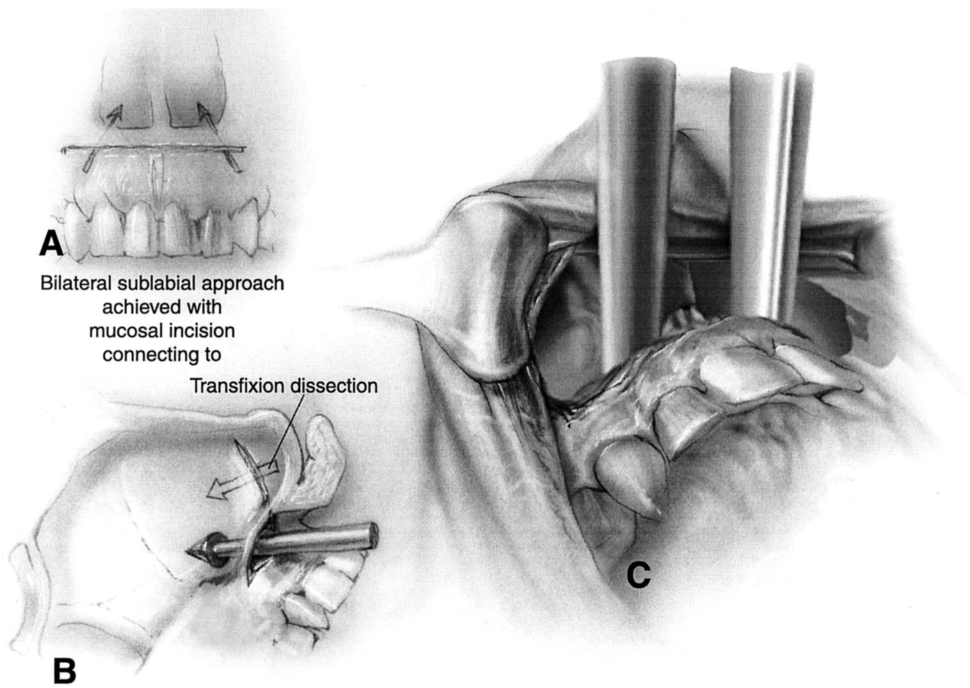

FIGURE 3. *Sublabial approach.* A *and* B, *anterior and lateral conceptualization of trajectory to sella turcica.* C, *nasal speculum inserted.*

TUMOR REMOVAL
(see video at web site)

Sellar Exposure and Intra-capsular Removal of Tumor

Wide exposure of the pituitary fossa facilitates tumor removal in both micro- and macroadenoma surgery. The sellar floor should be opened widely to expose the anterior limit of the left and right cavernous sinus as well as the inferior border of the superior intercavernous sinus (*Fig. 4*). The microscope is adjusted to an objective distance of 350 to 375 mm, with the magnification set so that the sella fills the entire field. This focal length provides an adequate working space for both hands and instruments.

Before the dural incision is made, imaging studies should be reviewed and the position of the carotid arteries noted. Many surgeons routinely puncture the dura with a 25-gauge needle before opening the dura with a No. 11-type blade. The identification of vascular flow voids on MRI scans makes this maneuver unnecessary in most cases. For typical adenomas, the dura is cauterized and then opened. It is important to remember that the sellar dura has two layers, and dissection between them may precipitate bleeding, particularly in patients with microadenomas and specifically those with Cushing's disease.

An obstacle that is infrequently encountered is an intercavernous sinus that transversely bisects the sella. In such circumstances, the dural opening can be accompanied by brisk bleeding that impedes the remainder of the procedure. Although an option may be to create a smaller dural opening, such a decision may compromise complete tumor removal. Instead, the dura is opened with the intent of removing a generous window of dura. The dural incisions are made so that the sinus is skeletonized, and small surgical clips then can be placed across the remaining dural leaves that contain the sinus. The remainder of the dura can then be safely incised and removed. Although most surgeons begin with oblique cruciate incisions creating four small dural flaps, we usually excise a rectangular window of uncauterized dura, which we study histologically for invasion by tumor.

Before any attempt is made to remove tumor, a right angle dissector is used to define the subdural plane around the margin of the dura. This maneuver separates and mobilizes the tumor from the underlying dura at the outset; this procedure is made much more difficult if it is attempted after tumor resection has been initiated.

Portions of macroadenomas should be removed sequentially. In general, the surgeon should remove the inferior and lateral aspects of the tumor before the superior aspect. This allows the suprasellar extension of the tumor to descend into the operative exposure. The preferred instrument is a 45-degree-angle ring curette. Care should be taken to obtain as much tumor as possible for laboratory analysis. Initial removal of the central and superior parts of a macroadenoma will prematurely deliver the redundant diaphragma into the operative field, obscuring the remaining tumor, making further resection difficult, and increasing the likelihood of causing a cerebrospinal fluid (CSF) leak. Removal of the lateral portions of tumors, particularly those entering the cavernous sinus, should be performed gently using blunt ring curettes to avoid damage to the carotid artery and cranial nerves. This is a technique that is developed with experience. Although decompression of the intrasellar portion of the tumor frequently permits the remaining suprasellar extension to prolapse into view, injection of 10 ml of air or saline via a lumbar catheter often will deliver the remaining suprasellar portions into the sella. Air contained within the expanded suprasellar cistern may be visualized by use of video fluoroscopy to confirm the completeness of tumor resection. If no lumbar drain is in place, a forced Valsalva maneuver often will suffice. As an alternative, bilateral jugular vein compression can help deliver the suprasellar tumor extension. After tumor removal, hemostasis is obtained by tamponade consisting of Gelfoam (Upjohn Co., Kalamazoo, MI) and cottonoid patties, and bone or cartilage harvested from the nasal septum is tailored to reconstruct the sellar floor. Reconstruction is an essential part of the terminus of the procedure because it facilitates future reexploration and may prevent the occurrence of a symptomatic secondary empty sella syndrome (11, 12).

Hemostasis

Because of the narrow corridor of the endoscopic, endonasal, or sublabial transsphenoidal approach, excessive bleeding can lead to prolonged operation time, increased technical difficulty, and problems with both tumor resection and identification of normal pituitary gland; on occasion, an operation must be prematurely aborted. During transsphenoidal pituitary surgery, the common forms of hemostasis are modified because of the nature of the surgical field. The narrow approach hampers the use of standard bipolar cautery. We also use monopolar or bipolar suction cautery for dural bleeding. Bone wax pressed into place with micropatties is used when necessary at the bony sphenoid and sellar margins, and Gelfoam is used on the tumor bed and for mild to moderate bleeding from the cavernous sinuses, together with gentle pressure, cottonoid patties, and patience.

Despite these techniques, prodigious or persistent bleeding can occur. We have used a new and effective hemostatic agent, a sterile mixture of a gelatin matrix and thrombin component called FloSeal (Fusion Medical Technologies, Inc., Fremont, CA), which is safe and biocompatible.

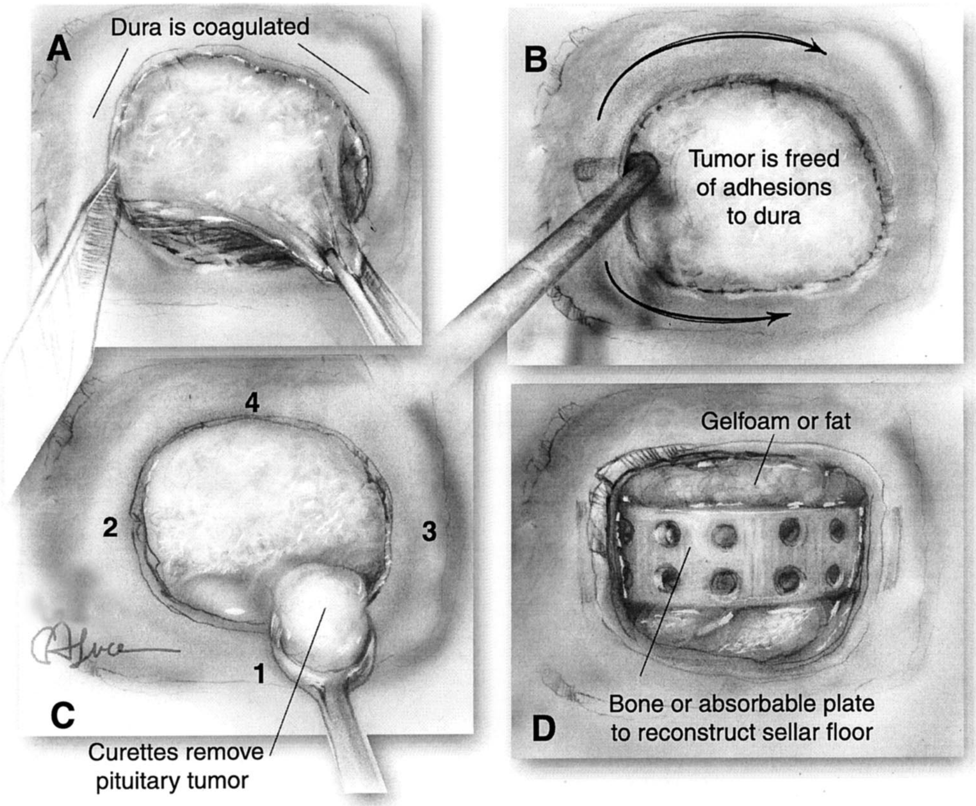

FIGURE 4. *Resection of tumor.* A, *dural incision.* B, *subdural plane developed.* C, *sequential removal of tumor.* D, *reconstruction of sellar floor.*

EXTRACAPSULAR RESECTION OF MIDLINE ANTERIOR CRANIAL BASE LESIONS
(see video at web site)

Transsellar/Transdiaphragmatic Approach

The extracapsular dissection of midline lesions extending from the pituitary fossa is possible through a standard transsphenoidal approach (5, 7). This technique, however, is reserved for cases in which the presence of the tumor has expanded the volume of the sella. After the complete removal of intrasellar tumor as described above, violation of the diaphragm, detaching it initially at the lateral aspect of the tuberculum sellae, is performed intentionally to gain access to the exterior aspects of the tumor capsule. Once identified, the lesion is gently brought into the field of view; the planes between the optic nerves, chiasm, and infundibulum are identified and developed.

Planum Resection/Supradiaphragmatic Approach

Exposure of the dura of the anterior fossa, the intercavernous sinus, and the sella allows for improved visualization of midline suprasellar anatomy (*Fig. 5*). Weiss (13) described and illustrated the approach in 1987. In 1997, Mason et al. (10) also described this technique in a series of patients with ectopic adrenocorticotropic hormone-secreting pituitary adenomas. The same method, however, also may be used to remove midline lesions extending from the pituitary fossa to the suprasellar cistern and into the anterior fossa. A lumbar catheter is inserted after induction. A sublabial/rhinoseptoplastic approach is used to maximize exposure of the sphenoid sinus. The dura of the sella turcica is exposed; the bone overlying the intercavernous sinus, the tuberculum sellae, and the anterior fossa floor is then removed with a high-speed drill and bone punches. Frameless stereotactic technology may be used to verify the adequacy of bone removal along the floor of the anterior fossa. Specific long, bayoneted instruments (straight and angled bipolar forceps, alligator scissors, and punches) that accommodate the depth of dissection are essential for this surgery. The dura of the sella is opened to reveal the underlying tumor. After complete resection of the intrasellar component of the mass, the intercavernous sinus is coagulated by use of bipolar cautery and divided between small titanium

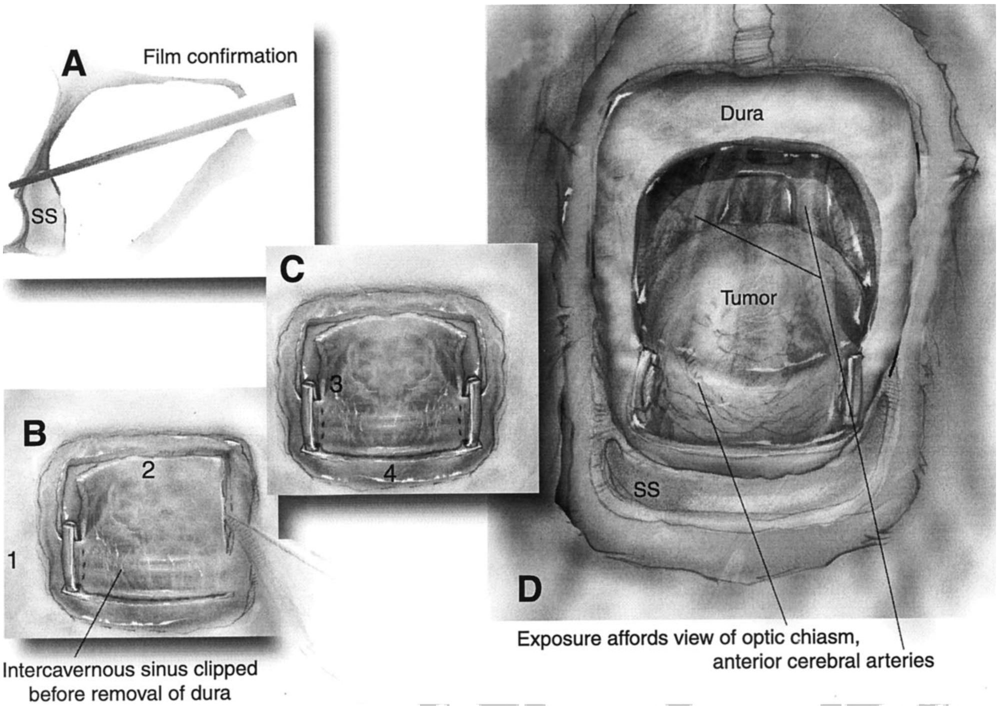

FIGURE 5. *Planum resection/supradiaphragmatic approach.* A, *videofluoroscopic confirmation of trajectory.* B *and* C, *dural incision and sectioning of intercavernous sinus.* D, *view of anterior cranial fossa contents.* SS, *sphenoid sinus.*

clips. Opening of the dura of the anterior fossa then exposes the chiasmal and suprasellar cisterns. Internal decompression of the lesion facilitates the visualization of the tumor capsule and surrounding anatomic structures. The optic nerves, chiasm, anterior communicating artery complex, infundibulum, and basilar bifurcation are routinely exposed via this approach. Dissection, however, risks injury to the blood supply of the optic nerves. In this region, they are supplied by branches of the superior hypophysial and ophthalmic arteries.

A lumbar drain is maintained for at least 72 hours postoperatively. Postoperative CSF leakage and meningitis are potential complications; broad-spectrum antibiotics are administered during the postoperative period. There are multiple advantages of this approach. It enables the surgeon to work along the axis of the tumor and the optic nerves, and the surgeon can observe the tumor face without obscuration by the chiasm or carotid. The exposure is at least as wide as that of the lamina terminalis approach, although it is far less invasive, and it negates the necessity for retraction. The position of the chiasm is not a deterrent, and an enlarged sella is not a prerequisite.

SPECIAL SURGICAL CONSIDERATIONS

Cushing's Disease

It is vital that the diagnosis of Cushing's disease is absolutely secure before transsphenoidal surgery is recommended. The technique used for Cushing's disease varies, and several specific modifications are required. First, it is important to recognize that sellar imaging in Cushing's disease can be negative or misleading, and inferior petrosal sinus sampling lateralizes correctly in only 60 to 70% of cases. The search for the responsible lesion involves a careful and systematic dissection of the sellar contents, hence the importance of optimal operating conditions. Subtle changes in tissue color, texture, or the contour of the gland aid in identifying an adenoma and distinguishing it from the normal gland and Crooke's hyalinization. The adenomatous tissue can often be multifocal or diffuse, and multiple adenomas can occur.

If no adenoma is evident after the dura is opened, careful subdural dissection with Hardy dissectors may reveal softening characteristic of tumor. If this maneuver is not successful, the gland is incised horizontally, and repeat subdural dissection may allow a tumor within the gland to extrude through the incision. Failing this, excisional biopsies from within the substance of the gland are performed, beginning with the central mucoid wedge. If an adenoma is not evident in the resected material, the lateral wings of the gland are carefully inspected and resected as necessary. If no tumor is recognized, then the posterior pituitary is carefully explored and abnormal tissue is excised. Even when a microadenoma is detected and removed, it is prudent to explore the remaining "normal" gland for additional abnormalities.

In the adult patient in whom an adenoma cannot be identified by this point, and for whom fertility is not an issue, a subtotal hypophysectomy is generally performed, leaving only a stump of residual anterior lobe tissue attached to the stalk. In all of the prior dissection, every effort has been made to avoid the superior aspect of the gland and any distortion of, or traction on, the pituitary stalk. If careful examination of the resected tissues still fails to reveal an adenoma, both cavernous sinuses must be evaluated. If an adenoma is not discovered at this stage, the surgeon must consider the rare possibility of a supradiaphragmatic tumor nodule. Given the additional operative risks of a diaphragmatic breach, a transdiaphragmatic exploration would not be contemplated without clear imaging evidence pointing to such a possibility. We give patients with Cushing's disease prophylactic aspirin therapy postoperatively and mobilize them as soon as possible because they have a propensity for deep vein thromboses.

Acromegaly

In acromegaly, bone is thicker, blood vessels are larger, carotids more tortuous, distances greater, and anesthesia and intubation problematic. Again, surgical and anesthetic experience cannot be overemphasized. Postoperatively, we use nasopharyngeal breathing trumpets regularly in patients with severe acromegaly to prevent respiratory difficulty and sleep apnea syndrome.

Repair of CSF Leaks

It is recognized that intraoperative CSF leaks are common during the course of intrasellar exploration and tumor resection. Even during the removal of microadenomas, CSF may leak into the sella turcica because of openings in arachnoid folds that prolapse through a congenitally absent or deficient diaphragmatic orifice. An effective strategy for dealing with such leaks has been developed (9). Once an intraoperative leak has been confirmed or is suspected, a fat graft is obtained from the right lower quadrant of the patient's abdomen. We no longer collect tissue from the thigh because of the increased discomfort this causes, and we consider fascia lata to have no advantage over use of fat alone. The fat is first bathed in chloramphenicol solution (1 g diluted in 100 ml of normal saline), then swiped across cotton, allowing minute and barely visible wisps of cotton to cling to the fat; the cotton is thought to engender a foreign body inflammatory reaction that participates in establishing a seal. The fat grafts are rolled in Avitene powder (Davol, Inc., Cranston, RI), then placed within the sella and sphenoid sinus. Care must be taken not to overpack the sella with the fat graft. It is advantageous to buttress the intrasellar graft with a piece of bone or cartilage, as part of reconstruction of the sellar floor, preferably by placing it across the sellar floor extradurally. Bioabsorbable plates (MacroPore, San Diego, CA) can be carefully tailored to occlude the cranial base defect when suitable allograft bone or cartilage is not available. Nasal packing is removed on postoperative Day 1 or 2. Lumbar drains are used rarely, and postoperative CSF leaks remain uncommon. Lumbar drains are not used specifically so that CSF leaks may be diagnosed early. When a leak is encountered, immediate reexploration for repacking of the sella and reconstruction of the sellar floor is our policy. In the absence of a CSF leak, the sella is packed with Gelfoam, and the sphenoid sinus is left free of foreign material.

Reconstruction of the Sellar Floor

As a general principle, some type of solid repair of the sellar floor is fashioned in nearly all cases. As mentioned above, this is especially important when a CSF leak has occurred and an intrasellar fat graft has been placed. The support provided by a solid sellar floor almost certainly adds to the security of the seal. In most instances, a portion of the septal bone or vomer fashioned in the shape of a small parallelogram suffices. In some situations, particularly with reoperations or in patients with Cushing's disease, local bone is insufficient for the repair. In such circumstances, bioabsorbable plates may be molded to reconstruct the floor of the sella and anterior fossa. Use of this technique is essential to maintain the position of the fat graft and to minimize the incidence of postoperative CSF rhinorrhea in addition to the temporary support provided by postoperative nasal packs. The aim is not only to reconstruct the sellar floor but also to obliterate dead space. In the case of Rathke's cleft cysts, it is wise not to pack the sella or reconstruct the sellar floor if possible; this strategy prevents symptom recurrence.

Frameless Stereotactic Guidance

Frameless computed tomography or MRI stereotaxy provides accurate information regarding trajectory and the midline and is especially helpful in revision surgery (3, 6) when anatomic landmarks are lost or distorted. In our experience, its use in determining extent of resection is limited. The disadvantages include the performance of an otherwise unnecessary preoperative imaging study and increased operative time and cost. It must be emphasized that frameless stereotaxy depends on how and where the fiducials are placed and co-registered to obtain mean fiducial errors acceptable for a corridor which can be as narrow as 5 mm in the case of "kissing carotids." For pituitary surgery, this theoretically allows the surgeon to work within a 1- to 2-mm zone of accuracy.

Recently introduced intraoperative fluoroscopic stereotactic guidance systems, such as FluoroNav (Medtronic Sofamor Danek, Inc., Memphis, TN), have eliminated the necessity for additional imaging studies. This technology is currently used to facilitate the placement of instrumentation in spinal surgery. After intubation and standard positioning of the patient, frontal and lateral videofluoroscopic x-rays are obtained with the patient in a radiolucent horseshoe headrest. The images are calibrated and stored on the video monitors. The fluoroscope is removed before surgery begins. The surgeon can refer to the stored images throughout the operative procedure and visualize the position of instruments in real time. There are several benefits of this mode of stereotaxy over frameless stereotactic computed tomography or MRI. It provides the same useful information regarding midline and trajectory and does not incur added cost to the patient for an otherwise unnecessary computed tomographic or MRI scan. Because the images are obtained intraoperatively, radiology-related scheduling conflicts are eliminated. Finally, after the images are obtained, the bulky fluoroscope is removed from the operating room to provide more freedom to the operative field.

POSTOPERATIVE CARE

Monitoring for Diabetes Insipidus

All patients are weighed daily using the same scale, and the specific gravity of their urine is checked every 4 hours after surgery (9). Although Foley catheters and intensive care unit protocols are not used routinely in these patients, their fluid input and output are strictly monitored. Generally, patients are treated with desmopressin if their fluid balance is unmatched, their serum sodium level is increasing, and they are experiencing inadequate rest at night. An attempt is made to treat with a single dose of desmopressin instead of initiating a daily regimen. It should be noted that patients with acromegaly often have brisk physiological diuresis after surgery, and early treatment with desmopressin should be avoided.

Corticosteroid Withdrawal

All patients, except those with Cushing's disease, receive perioperative hydrocortisone, 50 mg every 6 hours, to mitigate the stress of surgery. The last perioperative dose of hydrocortisone is given on the morning of postoperative Day 1. During the mornings of postoperative Days 2 and 3, serum cortisol levels are assessed. In general, hydrocortisone replacement treatment is given to patients whose cortisol levels are 8 nmol/L or less. Patients who are already receiving corticosteroid replacement preoperatively are tapered gradually to their replacement dose during their hospitalization. Patients with Cushing's disease are managed differently because they do not require and are not given perioperative hydrocortisone. Serum cortisol levels are obtained every 6 hours postoperatively at 0600, 1200, 1800, and 2400 hours. These patients are monitored closely by trained nurses and residents for clinical signs of adrenal insufficiency, including malaise, nausea, tachycardia, hypotension, and hypothermia. In general, patients do not exhibit these signs until 24 to 36 hours postoperatively. If hypocortisolemia does not develop, consideration is given to prompt surgical reexploration.

The patients who need cortisol most critically are those who present with pituitary apoplexy. Patients with hypopituitarism may not effectively absorb orally administered corticosteroids postoperatively, and it may be worthwhile to consider parenteral administration if patients are deficient. When a patient is unwell during the postoperative period, the condition usually is caused by cortisol deficiency or sodium imbalance, although less frequently, it may be attributable to early signs of postoperative meningitis.

CONCLUSION

The refinements of the transsphenoidal approach discussed herein illustrate the current techniques used by the senior author (ERL) in the treatment of patients with sellar lesions. The methods described include the choice of the surgical approach, the nuances in performing them, and the integration of the recent advances in transsphenoidal surgery. Although some of the advances are technical and others are conceptual, all are helping to usher transsphenoidal surgery to new frontiers of efficacy and safety.

It is important, however, to recognize that the strength of a neuroendocrine unit depends on an integrated team approach to patients with pituitary lesions. This requires close collaboration among the surgeon, endocrinologist, pathologist, anesthetist, radiotherapist, resident, and nurse, and it will be reflected in the unit's results.

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Acknowledgment

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COMMENTS

This description of operative technique for the surgical treatment of pituitary tumors is an excellent compendium of various adjuncts to the transsphenoidal approach most commonly used for these lesions. The insights and technical nuances presented represent a distillation of Dr. Laws' cumulative experience in nearly 4000 cases, and it should be mandatory reading for every neurosurgical resident and practicing neurosurgeon who performs these operations. I fully agree with the concepts and protocols described, which I also use in my practice. On occasion, I have found intraoperative magnetic resonance imaging using a low-field-strength PoleStar magnet (Odin Medical Technologies, Yokneam, Israel) to be helpful, especially for tumors with anterior or lateral suprasellar components. Although I prefer the microscope to the endoscope for transnasal procedures (owing to the better image resolution and depth perception afforded by the former), for certain lesions, the endoscope can provide better visualization of the lateral and anterosuperior aspects of the sphenoid sinus. Image-guided endoscopy with computer-generated virtual images of tumor and neurovascular structures (1) may facilitate endoscopic resections.

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Cleveland, Ohio

1. Mayberg MR, LaPresto E, Randall R: Stereotactic endoscopic navigation in the treatment of sellar and parasellar lesions. Presented at the 2002 Annual Meeting of the American Association of Neurological Surgeons, Chicago, Illinois, April 6–11, 2002.

The authors provide a detailed description of preoperative anatomic indications and considerations for transsphenoidal microsurgery. They discuss positioning, preoperative preparation, and the various approaches (sublabial, transnasal, endoscopic, etc.). They also discuss at length the technique of sellar exposure and tumor removal. They give special tips concerning various hypersecreting pituitary tumors. They discuss the extended transsphenoidal approach and the closure techniques.

We position the patient supine, with the operating table in a lounge-chair position and the patient's knees at the level of the heart. We agree that the bridge of the nose should be parallel to the operating room floor. However, in patients with considerable suprasellar tumor extension, we prefer to have the head and neck slightly extended so as to have a better line of vision into the suprasellar space. We prefer the use of a three-point fixation clamp to a horseshoe headrest, because we think it provides more safety. Thus, instead of moving the head, we rely on liberal intraoperative rotations of the operating table to adjust for vision. We also prefer the use of frameless stereotaxy for intracranial navigation over televised fluoroscopy, for many of the reasons that the authors mentioned in their report and especially considering that intracranial navigation provides for both vertical and horizontal orientation. The operative time has been considerably shortened since we began using external anatomic landmarks as fiducials. This has allowed us to obtain the preoperative protocol StealthStation (Medtronic Sofamor Danek, Inc., Memphis, TN) magnetic resonance imaging any time before the day of surgery.

We do not use any intrathecal injection techniques to deliver the suprasellar tumor component into the sella. Our technique for removal of a pituitary macroadenoma is very similar to that of the authors; the tumor is decompressed before separation of the tumor from the dura of the sella floor and the cavernous sinuses. The redundant intrasellar tumor portion is then resected before the suprasellar space is entered. The suprasellar tumor is first decompressed and then resected from the lateral to midline. We think that the critical moment in the operation is the recognition of the arachnoid membrane of the diaphragma sellae as it appears laterally where the arachnoid reflects onto the dural ring of the diaphragma sellae. This may require experience, because the arachnoid may be covered by a thin layer of residual normal anterior pituitary and thus may be mistaken for tumor tissue. Once the arachnoid membrane of the diaphragma sellae has been identified as such, further tumor separation along the tumor-arachnoid interface eventually delivers the suprasellar tumor component into the sella. We do not hesitate to apply gentle traction against the tumor while dissecting it away from the arachnoid, using microsuction with perforations at the tip or with microloop curettes. This is an excellent review of various surgical techniques designed to approach the sphenoid sinus and sella and execute removal of a pituitary adenoma.

Ivan S. Ciric
Evanston, Illinois

Laws et al. provide an overview of the transsphenoidal treatment of intrasellar lesions. I agree with their opinion that the transsphenoidal approach has evolved over the decades, but my routine surgical approach differs somewhat from theirs.

For the past 3 years, I have used the *direct* transnasal transsphenoidal approach originally described by Griffith and Veerapen in 1987 (1). This involves placing a long, thin nasal speculum directly to the ostium of the sphenoid sinus using the operating microscope from the beginning of the approach. The opening into the sphenoid sinus is then carried to the opposite side, and the nasal septum is retracted toward that opposite side. Although I occasionally use an endoscope to view selected aspects of the operative field, for the most part the operating microscope with true three-dimensional vision is far superior for both the approach and tumor resection. I do not spray or inject the nose, and I do not use any preparation other than the skin of the fat donor site.

I prefer to have the C-arm of the fluoroscopy unit underneath the patient so that one of the surgeons can stand at the head of the patient directly opposite the other surgeon. This allows excellent three-dimensional vision with most diploscopic microscopes and also allows easier initial placement of the speculum from the head of the patient. This setup also separates the surgeons and relieves crowding. I tend to use a pin fixation device because the entire procedure is performed with the operating microscope. Patients are discharged the day after surgery.

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1. Griffith HB, Veerapen R: A direct transnasal approach to the sphenoid sinus: Technical note. **J Neurosurg** 66:140–142, 1987.

This article is an excellent review of transsphenoidal approaches to sellar and parasellar lesions. The authors are extraordinarily qualified to write such an article with such a vast experience. We may have variances in minor aspects of the techniques, but overall this is an excellent summary.

I agree with the authors that most transsphenoidal approaches can be performed transnasally. I usually make the initial incision in the nasal mucosa more posteriorly, at the junction of the cartilaginous and bony septum. I prefer a sublabial approach for most patients with Cushing's disease, patients with very small nostrils, and those whose tumors have a very vertical suprasellar extension. The angle toward the front of the sella is more horizontal via the transnasal than the sublabial approach. I do not routinely coagulate the dura before opening it. Coagulation tends to shrink the dura and cause more epidural bleeding. I prefer to coagulate the edges after the dura is opened only if bleeding occurs. My incision for the sublabial approach is smaller than that depicted in the article. If the incision is carried to the incisors rather than the canines, there is still adequate room for a speculum and the incidence of tooth numbness is lessened. The submucosal dissection can be performed entirely through this incision without increasing the incidence of septal perforation, if care is taken to stay in the correct plane and not force the nasal speculum in too early.

I do not think the endoscopic procedure offers significant benefit, but it can be used as an adjunct to the standard microscopic procedure. The operative time is usually less than 90 minutes, and patients routinely leave the hospital on the second postoperative day and occasionally on the first postoperative day. Nasal complaints are few.

Kalmon D. Post
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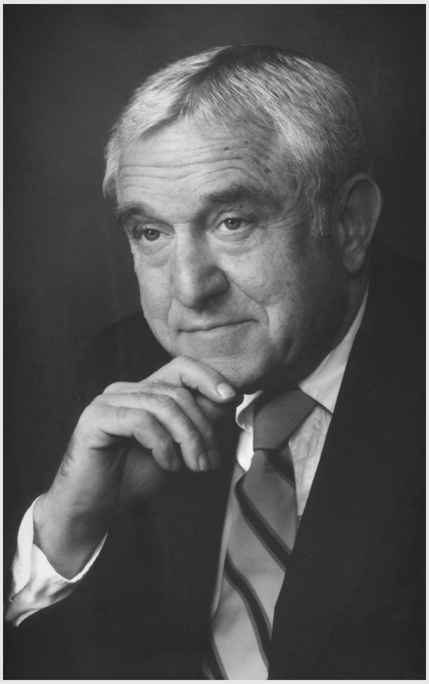
OBITUARY
THEODORE KURZE (MAY 18, 1922—MAY 10, 2002)

I met Theodore Kurze while I was a junior resident at the public university with the private hospital. He was professor and chief of neurosurgery at the private university with the public hospital, one of our many dichotomies.

It takes an extraordinary mind to accomplish the obvious. Seven years earlier, in 1957, Dr. Kurze had made the straightforward and brilliant decision that could have been made by many neurosurgeons but wasn't, to pull the binocular dissecting microscope across the hall from the laboratory to the operating room. He rapidly built a corpus of microneurosurgical procedures. During the same period, he, along with multiple colleagues, developed (or helped to develop) several operative approaches to acoustic neuromas (vestibular schwannomas). It was several years before he published his work, and he did so only when prodded by others, especially by Robert W. Rand of the University of California, Los Angeles, who coauthored multiple publications that were based on Dr. Kurze's work. He did not write much, although he wrote very well. This was a second dichotomy between us.



Dr. Kurze also was extremely verbal and could discuss neurosurgery, pain, general surgery, medical ethics, philosophy, and multiple segments of the world of ideas lucidly and in depth. For instance, for many years, he gave the lecture on abdominal pain to the third-year medical students in the Department of Surgery at the University of Southern California (USC). I remember William Hunt, then chair of the Department of Neurosurgery at Ohio State University, telling me that Dr. Kurze as a visiting professor had given the most articulate, and indeed the best, neurosurgical lecture he had ever attended—no slides, just chalk and a blackboard—on how to remove an acoustic tumor. Probably a third dichotomy.

To return to the beginning of our association, we were introduced through Robert Rand, who was in some ways Dr. Kurze's professional Boswell. Ted Kurze and Bob Rand were operating on acoustic tumors at both medical schools and at one or more private hospitals. The procedure took many hours. It became my privilege, at the end of the long day, to close the incisions. At that time, a unilateral horseshoe incision was used, which was complicated and tedious in both the opening and closure. General and specific discussions-in-depth of the case accompanied this last phase of the procedure, the closure. I learned a lot, not just technically but philosophically, about cerebellopontine angle tumors and many other things. Both Kurze and Rand treated me as a peer rather than as a serf. I learned a lot. (I repeat myself deliberately.)

Theodore Kurze was of medium build and height, with unruly hair, a strong nose in a frequently wryly smiling face, a distinctive voice like that of a 1930s or 1940s movie star, and good coloring. He moved well, even when close to death. (I last visited him just 6 weeks before he died.) He had been an excellent lacrosse player. He was able to become the center of attention in conversations without ever being aggressive. He had great ideas, substantive perceptiveness, and a talent for drawing people into whatever was being discussed. He truly loved his residents and taught them thoroughly and elegantly. I never heard him say a bad word about anyone, even people who I knew had treated him unfairly. As my residency drew to a close, he offered me a job. I came very close to accepting it but did not want to raise my children in southern California.

Theodore Kurze died on May 10, 2002, just short of his 80th birthday. He was born in Brooklyn, NY, on May 18, 1922, the son of Theodore and Emma Kurze, and grew up on Long Island. He was educated at Washington College, Chestertown, MD, and Long Island Medical College (M.D., 1947). He completed a rotating internship at St. Monica's Hospital, Phoenix, AZ, and began his neurosurgical studies in Los Angeles, which were interrupted for 2 years by military service. Upon his return, he completed general surgical and neurosurgical training at Los Angeles County General Hospital. From 1959 to 1987, Dr. Kurze was on the medical faculty at USC. He was professor and chair of neurological surgery there from 1963 to 1979, during which time he trained a number of superb neurosurgeons. In addition to the application of the microscope to neurosurgery, he developed microsurgical instruments and a surgical headlight and worked successfully in the development of diagnostic ultrasonography for use in neurosurgery.

After he retired as chairman at USC, Dr. Kurze practiced in Pasadena, CA, before moving to New York City, where he worked at Beth Israel Hospital as the neurosurgical director of the Health Insurance Plan of New York. He subsequently went to Pittsburgh for 2 years, where he worked with Michael Groff on a virtual reality system for teaching neurosurgical techniques. He taught philosophy at Washington College, his alma mater, where he received an Honorary Doctor of Science degree, and then returned to southern California. He led an active life, traveling, sailing, hiking, and learning new things with his wife, Joan.

Dr. Kurze was the author of numerous articles, books, chapters, and invited papers. He was a visiting professor at many institutions. He was a fellow of the American College of Surgeons and a member of the AANS, the American Academy of Neurological Surgery, the CNS, the Society of Neurological Surgeons, and the H.L. Mencken Society. He was president of the Los Angeles Society of Neurology and Psychiatry and the Southern California Neurosurgical Society. He is survived by four children from his first marriage: Janet Kurze of Rock Creek, OR; Peter Kurze of San Luis Obispo, CA; Carol Nicholson of Baltimore, MD; and Heather Kurze of South Pasadena, CA; as well as eight grandchildren and his wife, Joan.

The usual moment of inertia that prevails when something good and new is developed was shorter than average with regard to microneurosurgery because the young professionals saw the need and the promise in these techniques. Dr. Kurze's was for me the most stimulating mind I have ever known in neurosurgery. We remained in close contact over the years, always to my benefit and that of my thinking. More than any other neurosurgeon, he changed our field. Because of the application of the surgical binocular microscope to neurosurgery, morbidity and mortality rates dropped significantly. It became possible to see, treat, and share information about small abnormalities. We could see things never seen before and do things never done before. This meant that normally sensitive human beings could, for the first time, practice neurosurgery. Thus, a different type of resident came into our field.

Kurze never received the accolades he deserved. I frequently wonder what might have evolved had we worked together.

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