SURGICALLY TREATED TUBERCULUM SELLAE AND DIAPHRAGM SELLAE MENINGIOMAS: THE IMPORTANCE OF SHORT-TERM VISUAL OUTCOME

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OBJECTIVE: The visual outcome in patients with tuberculum and diaphragm sellae meningiomas treated with microsurgery was evaluated. Prognostic and diagnostic values of short- and long-term postoperative visual outcome and etiology for postoperative visual deterioration are discussed with special attention.

METHODS: Clinical data for 30 surgically treated patients with tuberculum and diaphragm sellae meningiomas were reviewed retrospectively. The mean duration of the follow-up period was 75.9 months (range, 12–151 mo). Mean tumor diameter and volume was 25.9 mm (range, 16.3–63.3 mm) and 12.4 cm^3 (range, 2.3–125.6 cm^3). A visual impairment score was used to assess the short-term (≤2 wk after surgery) and the long-term (>6 mo after surgery) postoperative visual outcome. Various predictive factors for visual outcome were tested statistically.

RESULTS: Complete resection was achieved in 23 out of 30 (76.7%) patients. Average preoperative, short- and long-term visual impairment scores were 48.2, 43.4, and 40.9, respectively. Favorable visual outcome was achieved in 80% of patients in the short term and 70% in the long term. Short-term postoperative aggravation of visual function was an ominous sign of further aggravation or at least of little hope for recovery, whereas there was a tendency to improve in the long term if short-term postoperative visual function showed favorable outcome. Recurrence or regrowth of tumor fully was responsible for late deterioration of visual function. No significant prognostic factor for visual outcome could be found.

CONCLUSION: Short-term postoperative visual outcome was a strong indicator of permanent visual outcome after surgery for tuberculum sellae and diaphragm sellae meningiomas.

KEY WORDS: Diaphragm sellae, Meningioma, Tuberculum sellae, Visual outcome

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Meningiomas arising from the tuberculum and diaphragm sellae cause insidious visual loss by optic nerve or tract compression. The extent of visual deficit is the single most important reason for the surgical treatment, and visual outcome is the major concern after surgery. During recent decades, marked advances have been made in the development of microsurgical techniques, and a dramatic improvement of surgical results for suprasellar meningiomas with respect to morbidity and mortality has been reported (1, 7, 12). There have also been many reports detailing visual outcome after surgery (3–5, 7–10, 12, 13, 15). However, many of these studies are limited by the inclusion of tumors of heterogeneous origin under the vague classification of suprasellar meningioma. Thus, accurate analysis of surgical outcome and related prognostic factors for tuberculum and diaphragm sellae meningioma, which should be distinguished from other meningiomas of neighboring origin from an anatomic point of view, has been difficult (8). To evaluate visual outcome after microsurgery and related prognostic factors for tuberculum and diaphragm sellae meningiomas, we have reviewed our experience of 30 patients. The importance of short-term visual outcome and the possible mechanism of visual deterioration are discussed.

PATIENTS AND METHODS

From 1991 to 2003, a total of 54 patients were diagnosed as having tuberculum or diaphragm sellae meningiomas after surgery. Of them, 30 patients with available result of detailed sequential visual function test were included in this study. Patients with total blindness in both eyes more than 1 year before the operation or with tumors that originated from nearby structures such as limbus and planum sphenoidale were excluded. A careful review of clinical records and radiological analysis was made retrospectively. The mean age was 45 years (range, 26–67 yr), and the male-to-female ratio was 1:4. The mean follow-up period was 75.9 months (range, 12–151 mo).

Preoperative imaging studies included magnetic resonance imaging in all patients and conventional angiography in 23 patients. The mean tumor diameter and volume were 25.9 mm (range, 16.3–63.3 mm) and 12.4 cm^3 (range, 2.3–125.6 cm^3). The laterality of dominant involvement of optic apparatus by tumor was right in 13 and left in 11 in preoperative magnetic resonance imaging. The other six patients showed no directional preponderance of growth pattern. A coincidental rate between laterality of tumor growth and symptomatically affected eye was 76.7% (23 out of 30). Conventional angiography exhibited vascular supply of the tumor by internal carotid artery in 13 patients, external carotid in four, and both in one. Five patients showed avascularity of the tumor.

Microsurgery was performed via a unilateral pterional approach in 26 patients and an interhemispheric approach in four patients. In the pterional approach, the tumor was accessed from the side on which the vision was worse. Anterior clinoidectomy or optic canal unroofing was not performed because extensive optic canal extension of the tumor was not observed in radiological examinations and operative findings. This was sufficiently confirmed by gentle, blind curettage along the optic canal. The gross total rate was 76.7% (23 out of 30). Intraoperative findings revealed that tumors originated from tuberculum sellae in 21 cases and diaphragm sellae in nine. All tumors were histologically benign (meningothelial in 26 cases, transitional in four).

All patients presented with visual deterioration as their chief complaint. The mean duration of their symptoms was 8.5 months (range, 1–48 mo). For the measurement of visual acuity, best-corrected Snellen visual acuity at the 5 m distance in 200 lux of light was used. Change in visual acuity was defined as visual acuity change by one or more Snellen lines. Any improvement or deterioration among blind, light perception, and finger counting were deemed to reflect no functional changes in visual acuity. Goldmann perimetry also was performed for the evaluation of visual field defect. Visual impairment score (VIS), the guideline of the German Ophthalmological Society, was used to analyze the visual status of the patients, used by Fahlbusch and Schott (4), who originally applied it to evaluate the surgical outcome of tuberculum sellae and planum sphenoidale meningiomas. A VIS is provided by adding the scores in specific tables given for visual acuity and visual field defect, respectively. The score ranged from 0 (best) to 100 (worst). Visual status was sequentially evaluated in the preoperative period, the postoperative short-term period (≤2 wk), and the postoperative long-term period (>6 mo). The results of visual outcome were also grouped into "favorable" if VIS improved (lower score) or was unchanged and "unfavorable" if it worsened (higher score). The authors tested multiple variables as a predictive factor for visual outcome. Patients with aggravated postoperative visual outcome actively were treated by maintaining optimal blood pressure and blood viscosity, as well as steroid therapy, to reduce any possible risk factors for optic nerve ischemia or edema.

Statistical analyses were performed using SPSS software (version 10.5; SPSS, Chicago, IL). For analyzing predictive factors; a χ^2 test was used for parametric comparisons. Statistical significance was accepted at P values less than 0.05.

RESULTS

The clinical data from the present series are summarized in *Table 1*, and detailed visual examination results are shown in *Table 2*. In terms of preoperative visual field defect, 17 patients were involved in only one eye, 11 patients in both eyes, and the remaining two patients experienced no field defect. Among the monocular involvement pattern of visual field defect, temporal hemianopia was the most common (n = 7) and inferior hemianopia was the next (n = 5). Other patients of monocular involvement and binocular involvement of visual field defect showed diverse pattern. Therefore, we could hardly find any correlation between the postoperative visual outcome and the preoperative visual field defect pattern. However, there were interesting results when we analyze the visual field defect and visual acuity simultaneously using VIS. The average VIS was 47.9 preoperatively, 43.4 in the postoperative short-term period, and 40.9 in the postoperative long-term period. The favorable visual outcome rate was 80% (24 out of 30) in the postoperative short-term period and dropped to 70% (21 out of 30) at follow-up more than 6 months. Short-term visual outcome strongly predicted long-term outcome (*Table 3*) (P = 0.005; positive predictive value, 83.3%; negative predictive value, 83.3%). If the immediate postoperative visual status was favorable, there was a tendency to improve afterward. On the other hand, if the vision became worse immediately after surgery, there was little hope for recovery in spite of any medical treatment. Recurrence of the tumor was solely responsible for late deterioration after initial favorable visual outcome, as observed in four (13.3%) patients. The intervals from initial surgery to late deterioration of vision were 100, 96, 42, and 42 months, respectively. Three patients had to be reoperated for the recurrent tumor, and one patient had undergone gamma knife radiosurgery. A single patient showed a unique clinical course of initial deterioration followed by late recovery of VIS. This was caused by surgically-induced permanent contralateral optic nerve injury that masked gradual improvement of ipsilateral visual function. Operative findings and imaging studies of two of the five

TABLE 1. Summary of clinical data[a]

Patient no.	Sex/age	Origin	Follow-up	Tumor feeder	Optic nerve	Resection	VIS				Tumor control
							Preop	Postop ST	Postop LT	Result	
1	F/51	TS	36	ICA	L compression	STR	35	35	35	No change	Stable
2	F/63	TS	144	Avascular	R compression	NTR	68	58	52	Improved	Stable
3	F/44	TS	72	Avascular	R encasement	GTR	22	13	6	Improved	Stable
4	F/31	TS	12	Avascular	L compression	GTR	17	6	0	Improved	Stable
5	F/26	TS	18	Avascular	L compression	GTR	38	30	15	Improved	Stable
6	F/63	TS	151	Avascular	B compression	GTR	100	100	90	Improved	Stable
7	F/39	TS	48		R compression	GTR	40	8	2	Improved	Stable
8	F/46	TS	21		L compression	GTR	94	73	59	Improved	Stable
9	F/34	TS	108		R compression	GTR	57	44	27	Improved	Stable
10	F/35	TS	89	ECA	R compression	GTR	40	35	33	Improved	Stable
11	F/44	TS	42	ECA	L compression	GTR	20	6	0	Improved	Stable
12	M/50	TS	89	ICA	B compression	GTR	61	37	35	Improved	Stable
13	F/39	TS	45	ICA	L compression	STR	15	8	0	Improved	Stable
14	F/48	TS	65	ICA	L compression	GTR	12	6	2	Improved	Stable
15	F/46	TS	70	ICA	B compression	GTR	100	77	67	Improved	Stable
16	F/40	DS	15	ICA	R compression	GTR	90	82	57	Improved	Stable
17	F/47	DS	12	ICA	B compression	GTR	94	80	50	Improved	Stable
18	F/55	DS	39	ICA	R compression	STR	20	6	0	Improved	Stable
19	M/67	DS	120	ICA	R compression	STR	47	44	32	Improved	Stable
20	M/45	DS	46	ECA	R compression	GTR	43	17	3	Improved	Stable
21	F/61	TS	26	ICA	L compression	GTR	50	50	60	Late deterioration	Recurrence
22	F/42	TS	150		L compression	NTR	27	20	42	Late deterioration	Recurrence
23	M/42	DS	145		L compression	GTR	13	9	100	Late deterioration	Recurrence
24	F/35	DS	149	ICA and ECA	B compression	GTR	96	80	96	Late deterioration	Recurrence
25	F/56	TS	84		R compression	NTR	73	100	100	Immediate deterioration	Stable
26	M/42	TS	114		R compression	GTR	37	100	100	Immediate deterioration	Stable
27	F/46	TS	71	ICA	B compression	GTR	37	45	50	Immediate deterioration	Stable
28	M/42	DS	136	ICA	R encasement	GTR	30	47	47	Immediate deterioration	Stable
29	F/41	DS	145	ICA	L encasement	GTR	25	35	42	Immediate deterioration	Stable
30	F/42	TS	16	ECA	R compression	GTR	37	52	27	Late recovery	Stable

[a] VIS, visual impairment score; preop, preoperative; postop, postoperative; ST, short-term; LT, long-term; ICA, internal carotid artery; ECA, external carotid artery; R, right; L, left; B, bilateral; GTR, gross-total removal; NTR, near-total removal; STR, subtotal removal; TS, tuberculum sellae; DS, diaphragm sella.

patients who showed immediate postoperative deterioration of visual function revealed that the involved optic nerve was encased by the tumor supplied by feeders from the internal carotid artery. However, there was no difference in postoperative visual outcome either between tuberculum sellae and diaphragm sellae meningiomas or between complete and incomplete resection. Other variables such as age ($P = 0.657$), tumor size ($P = 0.571$), symptom duration ($P = 0.361$), and internal carotid artery encasement ($P = 1.000$) were shown to have insignificant predictive value for postoperative visual outcome.

DISCUSSION

The visual outcome of tuberculum sellae or diaphragm sellae meningiomas is a matter of concern in surgical treatment. The results of recently reported studies are summarized in *Table 4*. Although most of these studies reported acceptable visual outcomes after surgery, they are limited because a heterogeneous group of tumors was examined, the time of evaluation of visual status was unclear, and an appropriate method of reflecting the essential status of vision that simultaneously assessed the visual acuity and visual field was lacking. In the present study, the authors focused on the visual outcome after the surgical resection of meningiomas whose origin was confined to the tuberculum sellae and diaphragm sellae using VIS as a tool for sequential evaluation.

In analyzing surgical results including visual outcome, tuberculum sellae and diaphragm sellae meningiomas should be distinguished from other anterior cranial fossa meningiomas, such as those of planum sphenoidale, clinoid, or medial sphenoid wing origin. This is because tuberculum or diaphragm

TABLE 2. Preoperative and short-term and long-term postoperative visual acuity and visual field examination results in detail[a]

Patient no.	Preoperative			Postoperative short-term			Postoperative long-term		
	Visual acuity		Visual field defect	Visual acuity		Visual field defect	Visual acuity		Visual field defect
	L	R	L R	L	R	L R	L	R	L R
1	FC	1.0		FC	1.0		FC	1.0	
2	0.4	0.02		0.4	0		0.4	0	
3	1.0	0.16		1.0	0.4		1.0	0.5	
4	0.16	1.0		0.5	1.0		1.0	1.0	
5	HM	0.7		0.4	0.32		0.4	0.7	
6	HM	0		0.1	0		0.2	0	
7	0.8	FC		1.0	0.7		1.0	0.8	
8	0.02	0.16		0.1	0.16		0.2	0.16	
9	0.2	0.4		0.4	0.5		0.4	0.5	
10	1.0.	0		0.8	0		0.9	0	
11	0.2	1.0		0.5	1.0		1.0	1.0	
12	0.7	0.02		0.8	0		0.8	0	
13	0.32	1.0		0.4	1.0		1.0	1.0	
14	0.32	1.0		0.5	1.0		0.8	1.0	
15	0.02	LS		0.4	LS		0.32	0	
16	0.1	HM		0.2	LS		0.36	LS	
17	0.2	FC		0.2	0.02		0.32	0.1	
18	1.0	0.2		1.0	0.5		1.0	1.0	
19	0.63	HM		0.63	HM		0.8	0.02	
20	1.0	0.01		1.0	0.7		1.0	0.7	
21	0.02	0.5		0.02	0.5		0.2	0.2	
22	0.16	0.8		0.2	0.8		LS	0.63	
23	0.4	1.0		0.63	1.0		0	0.16	
24	0	0.1		0	0.2		0	0.1	
25	0.2	0.04		HM	0		HM	0	
26	1.0	0.2		0	0		0	0	
27	0.1	0.63		0.02	0.63		0.02	0.5	
28	0.5	0.32		0.5	LS		0.5	LS	
29	0.1	1.0		0.05	0.8		HM	0.63	
30	0.8	0.02		0.5	0.2		0.5	0.4	

[a] FC, finger count; HM, hand movement; LS, light sense.

sellae meningiomas elevate the anterior visual pathways, whereas others press the optic nerves and chiasm down or backward as they grow (8). Because the inferior surface of the optic nerve and chiasm receives its blood supply from superior hypophyseal arteries that arise from the supraclinoid segment of the internal carotid artery, surgical dissection of the tumor from the inferior side of the optic apparatus is a more formidable procedure than removal of tumors above the optic apparatus (10). Immediate postoperative deterioration and progressive aggravation of vision, as shown in the present series, reflects the high possibility of direct vascular insult to the optic apparatus during surgery rather than simply transient neural edema. Therefore, the process was almost irreversible despite meticulous medical therapy. The importance of postoperative short-term visual outcome, which has a powerful predictive value for permanent outcome, as shown in the present study, is related to this difficult situation. It is also indicated that the risk is even more serious when the tumor has a vascular supply from the internal carotid artery and encases the optic nerve (*Table 1*). Thus, more attentive dissection of the tumor from the inferior surface of the optic nerve or chiasm is needed in such cases. It has been proposed that the identification and preservation of the optic cistern is important during surgery because it provides a protective plane for the optic apparatus and perforating vessels (4, 15). There are several reports supporting the observations of the current study. Chicani and Miller (3) mentioned that worsening of vision after surgery likely is to be permanent on the basis of their experience. Puchner et al. (12) emphasized that renewed visual deterioration after some initial recovery is highly indicative of tumor recurrence, as seen in the present series, without exception.

TABLE 3. Postoperative short-term and long-term visual outcomes and their relationships

Visual outcome		Long-term (>6 mo)		*P* value
		Favorable	Unfavorable	
Short-term (<2 wk)	Favorable	20	4	0.005
	Unfavorable	1	5	

Evaluation of the visual status of patients with surgically treated tuberculum or diaphragm sellae meningioma is a complicated problem. Both visual acuity and visual field should be assessed simultaneously, and the period of examination is important because gradual recovery of visual function after surgery is usual. This phenomenon of gradual recovery was observed in other studies as well as in the present series (6, 12, 14, 15). The VIS provided a way to quantify the patient's exact visual status by adding the visual acuity score and the visual field defect score for any combination in both eyes (4). Although a similar scoring system has been proposed by Rosenstein and Symon (14), VIS is found to be more simple and practical. Except for specific situations, VIS matched the clinical course exactly and provided an accurate predictive value. Serial assessment of VIS may also be helpful in detecting tumor recurrence.

Many authors have proposed possible prognostic factors for visual outcome in surgical treatment of tuberculum sellae meningiomas or other suprasellar meningiomas. Fahlbusch and Schott (4) mentioned that young age and short symptom duration are good prognostic factors for visual outcome. Goel et al. (5) proposed symptom duration in addition to preoperative visual function, anterior cerebral artery encasement, and tumor size as valuable prognostic factors. Zevgaridis et al. (15) suggested prognostic factors such as age, symptom duration, preoperative visual function, and arachnoid membrane intactness. Margalit et al. (10) emphasized the importance of optic nerve encasement, tumor size, and preoperative visual function. However, all the candidates for prognostic factors for visual outcome failed to show significance in the current study except for the strong connection between postoperative short-term visual outcome and long-term visual outcome. This, in other words, implies that surgical manipulation is the most important factor in determining the fate of vision.

There were several reports asserting the beneficial effects of optic canal unroofing, including anterior clinoidectomy for tumors involving the optic nerve (2, 10). This is an ideal approach when there is not enough space to remove a tumor without too much handling of the optic nerve, even when the optic canal extension of the tumor is not prominent (10). However, the current study showed acceptable tumor control rates of 96.7% with a total removal rate of 76.7% without any additional bone work around the optic canal. This result is comparable with a postoperative long-term follow-up study of tuberculum sellae meningioma performed by Ohta et al. (11), who reported a total removal rate of 63.6% in 33 patients with an overall recurrence rate of 24.2% in 10.7 years. Moreover, Margalit et al. (10), who emphasized the significance of early decompression of the optic nerve within the bony canal, only found a similar visual outcome to the present study. Therefore, routine optic canal decompression for tuberculum sellae or diaphragm sellae meningioma is recommended to be reserved for occasions in which the tumor shows extensive optic canal extension of the tumor in preoperative magnetic resonance imaging.

TABLE 4. Recent studies dealing with visual outcome in patients with tuberculum sellae or diaphragm sellae meningiomas[a]

Series (ref. no.)	No.	Origin	Visual outcome after microsurgery		Prognostic factor
			Favorable rates (%)	Evaluation time	
Puchner et al., 1998 (12)	50	PS, TS, DS, ACP	52/76	ST/LT	UM
Zevgaridis et al., 2001 (15)	60	PS, TS, DS, ACP, MSW	65	UM	Age, symptom duration, arachnoid membrane intactness, preoperative visual function
Fahlbusch and Schott, 2002 (4)	47	PS, TS	80	UM	Symptom duration, age
Goel et al., 2002 (5)	63	TS	70	UM	Preoperative visual function, symptom duration, ACA encasement, tumor size
Jallo et al., 2002 (8)	23	TS, DS	81	UM	UM
Margalit et al., 2003 (10)	50	TS,DS, ACP, MSW, CS	80 (V/A) 82 (V/F)	UM	Tumor size, preoperative visual function, optic nerve encasement
Chicani and Miller, 2003 (3)	18	SS	80/72	ST/LT	Preoperative visual function, symptom duration

[a] PS, planum sphenoidale; TS, tuberculum sellae; DS, diaphragm sellae; ACP, anterior clinoid process; MSW, medial sphenoid wing; CS, cavernous sinus; SS, suprasellar; ST, short-term; LT, long-term; UM, unmentioned; ACA, anterior cerebral artery; V/A, visual acuity; V/F, visual field.

CONCLUSION

This study suggests that the short-term postoperative visual outcome is strongly correlated with the permanent visual outcome in tuberculum and diaphragm sellae meningiomas. The surgical insult is presumed to be the single most important factor for visual outcome, and thus favorable visual outcome is secured by cautious surgical manipulation around the optic nerve. However, routine optic canal decompression is not always necessary for this purpose.

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COMMENTS

This is a well-written article that contains a large series of meningiomas of the tuberculum and diaphragm sellae, but it differs from other studies that also include meningiomas of the planum sphenoidale. The authors report on 30 patients; in 23 (76.7%) of these patients, complete resection was achieved. Late visual deterioration was found in four patients with recurrent tumor. The authors found that short-term postoperative visual outcome was a significant prognostic factor for permanent visual outcome after surgery. In addition to the pre- and postoperative visual impairment score and their surgical results, the authors presented the patients' demographic data, size, and volume of the meningioma and vascularization pattern. They also discussed their results with regards to previously published, relevant literature.

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The authors have evaluated the relationship between the initial postoperative visual outcome and the long-term postoperative visual disability after surgery for tuberculum and diaphragma sellae meningiomas. The authors have clearly shown that the short-term postoperative visual outcome is strongly correlated with permanent visual results for these tumors, and I agree that surgical "insult" is the single most important factor in determining the visual outcome for these tumors.

There is no doubt that meticulous surgical technique is the most essential element in determining outcome after surgery, with particular care being taken to preserve vascular supply to the undersurface of the optic nerve and optic chiasm. The authors reported that these tumors need to be distinguished from other anterior cranial fossa meningiomas, such as those arising from the planum sphenoidale, in which the optic apparatus is often depressed, and the vascular supply arising from the superior hypophyseal arteries that supply the undersurface of the optic chiasm. Optic nerves are relatively protected during resection of the tumor.

This is a useful study that confirms that clinical experience in the treatment of these tumors, and the early visual assessment is often, but not always, an indication for long-term visual outcome.

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