

Surgical Indications of Exploring Optic Canal and Visual Prognostic Factors in Neurosurgical Treatment of Tuberculum Sellae Meningiomas

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Abstract

Background: Tuberculum sellae meningiomas (TSMs) present a special symptom because of the adherence and compression to the optic nerve, optic artery, and the chiasm. A significant number of patients with TSMs appear visual deficits. This study aimed to investigate the surgical indications of exploring the optic canal and visual prognostic factors in the neurosurgical treatment of TSMs.

Methods: Totally 21 patients with TSM, who were operated from September 2007 to August 2011 in the Department of Neurosurgery, Tongren Hospital were enrolled in this study. Results of orbital computed tomography (CT) and magnetic resonance imaging (MRI), visual acuity, Goldmann visual field test, orbital color Doppler flow imaging (CDI) test in these patients were retrospectively analyzed.

Results: Visual deficit and optic canal involvement (OCI) were detected in all the 21 patients. Fourteen patients had bone proliferation within the area of the optic canal. After the operation, visual outcomes were improved in 13 patients, unchanged in 7 patients, and deteriorated in 1 patient. All the 21 patients performed orbital CDI test preoperatively, the results showed that if the peak systolic velocity (PSV) of central retinal artery (CRA) value was ≤ 8 cm/s, the visual outcome would be better.

Conclusions: The surgical indications of exploring optic canal in TSM cases included: (1) The neuroimaging evidences of OCI (CT and/or MRI); (2) PSV of CRA in orbital CDI test was ≤ 8 cm/s; (3) visual acuity was below 0.1; (4) visual field deficit. The PSV of CRA in CDI test could be a prognostic factor for visual outcomes of TSMs.

Key words: Meningioma; Surgical Management; Tuberculum Sellae; Vision

INTRODUCTION

Tuberculum sellae meningiomas (TSMs) present a special symptom because of the adherence and compression to the optic nerve, optic artery, and the chiasm. A significant number of patients with TSMs appear visual deficits. In recent articles, the optic canal involvement (OCI) was reported, the incidence of which ranges from 8% to 100%.^[1-5] Sade and Lee reported that OCI is very common in TSM (77.4%), and it correlates well with preoperative visual status.^[6]

In this study, we intended to find another visual prognostic factor of TSM by comparing the blood flow of central retina artery (CRA) pre- and post-operatively, and following up the outcomes of optic nerve decompression in TSM cases. Furthermore, we discussed the surgical indications of exploring optic canal.

METHODS

Patients

Totally 21 patients with TSM, who were operated from September 2007 to August 2011 in the Department of Neurosurgery, Tongren Hospital were retrospectively analyzed. All the 21 patients were followed up from 4 to 46 months (14.9 months in average). They were evaluated by

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neuro-ophthalmologists and radiologists before the operation to determine whether the tumors invaded into the optic canal and to predict the location of OCI. The characteristics of patients with TSM in this study were shown in Table 1.

Pre- and post-operative examinations

All of the patients had performed the following examination preoperatively including: Orbital computed tomography (CT) and magnetic resonance imaging (MRI), visual acuity, Goldmann visual field test, orbital color Doppler flow imaging (CDI) test (CRA; peak systolic velocity [PSV] value). All of the patients had orbital CT and MRI, and visual acuity test postoperatively. Only 12 patients had visual field tests, and 10 patients had CDI test after surgery because the patients were treated by different doctors.

Operational protocol

The sub-frontal or sub-frontal temporal craniotomies were performed in this study. The operations were performed in the poor eyesight sides (21 sides). If the tumor was smaller than 2 cm in diameter, sub-frontal approach was performed; if the tumor was larger than 2 cm in diameter, sub-frontal temporal approach was required to gain more space to obtain better exposure of the tumor. After craniotomy, we decompressed the optic roof from the epidural space, and then the optic nerve was explored and the tumor was resected subdural. If the patient had big frontal and sphenoidal sinus, the main concern of postoperative complication was cerebrospinal fluid (CSF) leakage. We performed multi-layer hard dural

reconstruction: The artificial cerebral dura mater patch was in the bottom, free temporal myofascial flap was on the dura mater patch and water-tight sutured with hard dura, and the pedicled galea flap was on the top. If the patient still had CSF leakage postoperatively, then lumbar drainage was performed for a week, and the CSF leakage was recovered. In this study, only 5 patients had transient CSF leakage. Three of them recovered by keeping lying in bed for 5 days, and 2 of them recovered by 7 days of continuous lumbar drainage.

Postoperative outcomes

The postoperative visual outcome was reported as improved, unchanged, or deteriorated. Visual acuity and field outcomes were assessed separately, and improvement in one of these evaluations was necessary to qualify as a visual improvement. The preoperative orbital CDI tests (PSV values of CRA) were compared with visual outcomes [Tables 2 and 3].

Statistical analysis

Values were analyzed using the Chi-square test with SPSS for Windows, Release 11.5.0 (SPSS Inc., IL, USA). A $P < 0.05$ was considered statistically significant.

RESULTS

Fourteen patients had bone proliferation within the area of the optic canal [Figure 1]. Visual deficit and OCI were detected in all 21 patients [Figures 2 and 3]. The presence of OCI was strongly correlated with the preoperative visual deficit. After the operation, visual outcomes were improved

Table 1: Characteristics of patients with tuberculom sellae meningiomas in this study

Patient number	Age (years)	Gender	OCI	Hyperostosis of OC	Operation side	Visual acuity (Snellen notation)						Follow-up (months)	Visual outcome
						Preoperation		Postoperation		Follow-up			
						OD	OS	OD	OS	OD	OS		
1	58	Female	1	1	Right	NLP	0.1	NLP	0.1	HM	0.1	4	1
2	57	Female	1	1	Right	CF/1 m	0.3	CF/1 m	0.3	0.1	0.3	12	1
3	65	Female	1	0	Left	NLP	0.01	CF/0.1 m	0.05	CF/0.1 m	0.06	23	1
4	33	Male	1	1	Left	0.2	0.03	0.6	0.07	0.6	0.07	42	1
5	31	Female	1	1	Right	0.1	1	0.1	1	0.2	1	46	0
6	48	Female	1	1	Right	CF/0.3 m	0.1	0.05	1.2	0.05	1.2	7	1
7	53	Female	1	1	Right	CF/0.2 m	CF/0.2 m	0.05	0.05	0.05	0.05	7	1
8	45	Male	1	0	Left	CF/1 m	NLP	0.03	NLP	0.03	NLP	10	1
9	44	Male	1	0	Right	NLP	0.5	NLP	0.5	NLP	0.8	16	1
10	43	Female	1	0	Right	HM	0.05	NLP	0.1	NLP	0.1	18	1
11	65	Female	1	1	Left	0.6	0.04	0.7	0.3	0.7	0.3	22	1
12	58	Female	1	0	Left	CF/1 m	HM	CF/1 m	HM	0.03	CF/0.5 m	11	1
13	33	Female	1	0	Right	LP	0.8	LP	0.8	LP	0.8	12	0
14	46	Female	1	0	Left	CF/0.5 m	CF/1 m	CF/0.5 m	CF/1 m	CF/0.5 m	CF/1 m	13	0
15	25	Female	1	1	Right	0.6	1.2	0.6	1.2	0.6	1.2	5	1
16	45	Female	1	1	Left	CF/0.15 m	0.2	CF/0.15 m	0.2	CF/1 m	0.2	6	0
17	52	Female	1	1	Right	1.2	1	1.2	1	1.2	1	13	0
18	72	Female	1	1	Left	1	LP	1	LP	1	LP	10	0
19	44	Female	1	1	Left	1	0.2	1	NLP	1	NLP	5	-1
20	54	Female	1	1	Right	HM	0.4	NLP	0.4	NLP	0.4	11	0
21	57	Female	1	1	Right	LP	0.8	LP	0.8	0.02	0.8	19	1

NLP: No light perception; LP: Light perception; HM: Hand moving; CF: Counting fingers; OCI column: 1 – Positive; Hyperostosis of OC: 1 – Positive, 0 – Negative; Visual outcome: 1 – Increased, 0 – Unchanged, -1 – Deteriorated; OCI: Optic canal involvement; OC: Optic canal; OD: right eye; OS: left eye.

Table 2: Preoperative CRA orbital CDI test and visual outcome of patients in this study

Patient number	Preoperation PSV value of CRA in orbital CDI test		Visual outcome
	OD	OS	
1	6.2	7	1
2	6.5	14.4	1
3	6.2	10.5	1
4	12.4	9.7	1
5	9.2	11.5	0
6	4.3	7.5	1
7	9.2	8.7	1
8	6.7	6.1	1
9	4.6	6.8	1
10	5.1	7.2	1
11	7.1	5.1	1
12	14.7	13	1
13	10.7	8.1	0
14	10.8	9.6	0
15	5.4	8.3	1
16	5.8	9.1	0
17	10.7	9.3	0
18	15	8.2	0
19	8.6	8.3	-1
20	8.1	9.7	0
21	9.7	10.6	1

Visual outcome: 1 – Increased, 0 – Unchanged, -1 – Deteriorated. CRA: Central retinal artery; CDI: Color Doppler flow imaging; PSV: Peak systolic velocity, OD: right eye; OS: left eye.

Table 3: Visual outcomes of patients in this study (n)

Variables	Improved	Unimproved	χ^2	P
Preoperative orbital Doppler test (CRA, PSV value)			6.390	0.024
≤8 (n = 10)	9	1		
>8 (n = 11)	4	7		
Preoperative visual acuity (Snellen notation)			3.592	0.133
≤0.1 (n = 19)	13	6		
>0.1 (n = 2)	0	2		

CRA: Central retina artery; PSV: Peak systolic velocity.

in 13 patients, unchanged in 7 patients and deteriorated in 1 patient. The improved and unchanged case number was 20/21.

All of the 21 patients had CRA Doppler test preoperatively. We compared the CRA result as a variable in the visual outcome, the results showed that when the PSV value of CRA was ≤8 cm/s, the visual outcome was better than when PSV value of CRA was >8 cm/s ($P = 0.024$).

Among 19 of 21 patients whose visual acuity was below 0.1 in at least one eye preoperatively, visual outcomes were improved in 13 patients, unchanged in 5, and deteriorated in 1 postoperatively. Preoperative visual acuity was not statistically related with the postoperative visual outcome ($P = 0.133$) [Table 3].

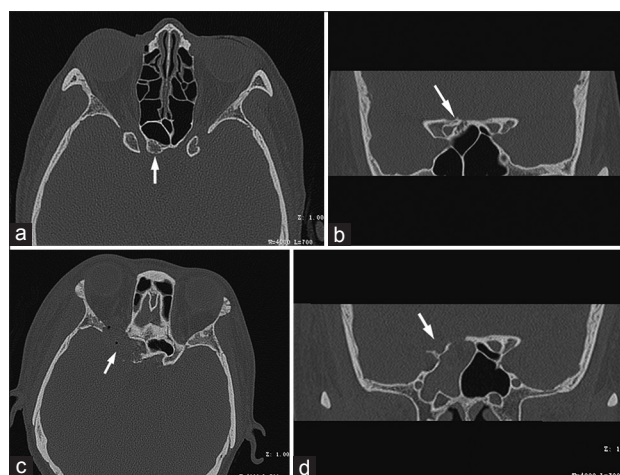


Figure 1: The optic canal computed tomography scan: Preoperative axial (a) and coronal (b) positions. White arrow showed the bone proliferation in the optic canal area. Postoperative axial (c) and coronal (d). White arrow showed the unroofing optic canal, and the anterior clinoid was resected.

DISCUSSION

Optic canal involvement

In this study, 21 patients with TSMs had extension into the optic canal; those were confirmed by the operation. Among the 21 patients, 14 patients had bone proliferation in the optic canal area. OCI may be appreciated in preoperative MRI, and optic canal CT scan could also find the hyperosteo-geny of the optic canal. Meningioma tends to affect the bone to be grown where it is located. The optic canal could be narrowed because of the pathological growth of the great wing of sphenoid. Arai *et al.*^[7] emphasized that the presence of preoperative visual disturbance implies the need for optic canal unroofing. If OCI was suspected in TSM, the optic canal exploration and decompression should be done during the operation.^[6] Puchner *et al.*^[8] emphasized the need to remove tumor growth in the medial aspect of the optic canal to achieve the best long-term visual results up to the time of their report. Depending on the extent and exact localization of the tumor origin, the bony origin was also drilled, and blood supply to the tumor via basal bony structures was interrupted to the extent possible without undue retraction of dural structures.^[9] Tumor recurrence is a serious long-term threat to a good outcome.^[8,10-12] The missing of OCI in TSM may result in unimproved or deteriorated postoperative vision, and/or higher recurrence of the tumor and the Simpson Grade I or II resection will not be achieved.

TSMs can extend into the optic canal unilaterally or bilaterally. In Al-Mefty's series,^[13] 13 cases of bilateral OCI were reported in among 45 patients who were found with anterior and middle fossa meningioma. In this group of patients, we preferred to do the boney decompression and exploring of the optic canal at the lower visual acuity side. In this study, we found 100% of cases with OCI, and the difference between unilateral and bilateral OCI was not discussed. It was due to the small number of cases. While

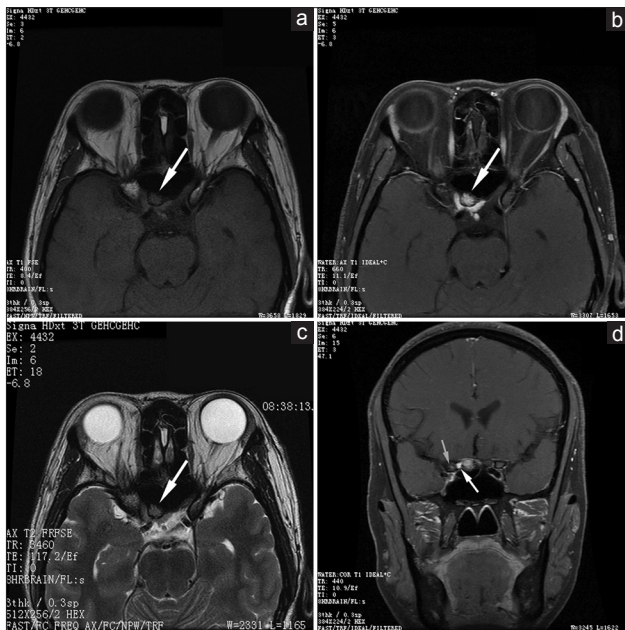


Figure 2: The orbital magnetic resonance imaging scan: T1 axial (a), T1 axial with contrast (b), T2 axial (c), T1 coronal with contrast (d). White arrow showed the optic canal involvement of tuberculum sellae meningioma. Gray arrow showed the optic nerve.

the number of patients was increasing, there might be new findings of OCI in TSMs.

Peak systolic velocity of central retinal artery

CDI to evaluate the hemodynamics of the orbital vasculature has been in use since the early 1990s. It has proved useful in the assessment of a number of orbital and ophthalmic disorders, including carotid cavernous fistula, orbital tumors, thyroid eye disease, vascular lesions (such as occlusive vasculopathy of the retina and ischemic lesions of the optic nerve head and orbit) and glaucoma.^[14] PSV of CRA shows the blood flow status of CRA, which indicates the blood supply of retina. In the OCI cases of TSMs, the tumor encasement of optic nerve might decrease the PSV of CRA during the CDI test, which might be one of the reasons of visual deterioration.

Study of Kahn showed the minimized value of normal PSV of CRA in CDI was about 8 cm/s.^[14] Especially in the study of Kahn, in which they collected 90 cases of healthy Taiwanese. The mean PSV of CRA was 12.48 ± 4.03 cm/s.^[14] In our study, we compared the visual outcome between the groups, one of which PSV of CRA was lower than 8 cm/s, and the other, higher than 8 cm/s. We found that, before the operation, if the PSV value of CRA was ≤ 8 cm/s, the visual outcome after surgery was more likely improved ($P = 0.024$, Table 3). The abnormal low PSV value of CRA indicated poor blood supply of optic nerve and retina. In the low PSV of CRA cases, poor blood supply might be the main reason of visual deterioration. And after decompressing the optic nerve, the blood supply was getting better, and the visual outcome might be improved. In previously published literatures^[4,9,15,16] the timing of optic canal decompression is still a subject of debate. In this study, we thought preoperative

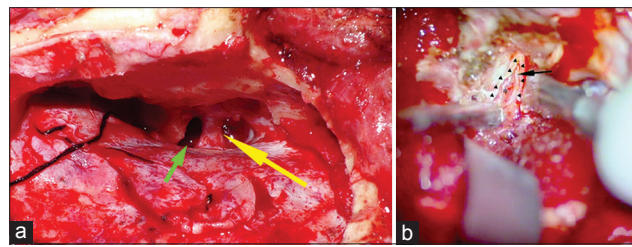


Figure 3: Pictures of operation. (a) Showed the epidural scene of operation. The yellow arrow indicated the unroofing of the optic canal. The green arrow indicated proliferation bone was resected; (b) Showed the subdural scene of operation. * indicated optic canal involvement tumor; black arrow indicated the optical canal segment of optic nerve, which was compressing by the optic canal involvement tumor from the lower and inner side; the black triangles indicated the edge of optic nerve sheath, which was cut open.

PSV of CRA ≤ 8 cm/s was another enhancing indication of exploring optic canal.

Visual deterioration

Previous articles reported that preoperative visual functions,^[15,17-20] duration of visual deterioration before surgery,^[3,18-22] and tumor size^[15,19,21,22] were factors influencing postoperative visual functions. Margalit *et al.*^[15] reported in their study, which had 50 cases of parasellar meningiomas involving optic nerves (including 16 TSMs), visual outcomes were influenced by preoperative visual function, tumor size, and optic nerve encasement. All of the patients in our study had visual deterioration preoperatively. One of the reasons is that our hospital is the biggest ophthalmology center in North China, and most patients come here with a chief complain of visual deterioration. We compared the visual outcome between the groups which preoperative had visual acuity higher than 0.1 and lower than 0.1 in Snellen notation. After statistical analysis, it turned out that the preoperative visual acuity was not related to the visual outcome after surgery ($P = 0.133$, Table 3). It was a little different from common sense. But, the study of Nozaki *et al.* drew the same conclusion.^[16] From another point of view, the small number of TSM patients without visual deterioration in our study might affect the statistic result.

Relationship between visual field test and tumor location

In 1945, Hans Goldmann invented the first arc perimeter. His dynamic vision checking method by hand, which could measure the difference of retinal light sensitivity, is still valuable in the clinical application. Most of the patients had Goldmann visual field test before the operation in this study. And the result of the visual field test identified the tumor location and direction of OCI. Because of the visual field and retina have an inverted and reversed relationship, as Figure 4 was shown, the visual field test showed us the upper and outer visual field deficit of right eye, and this indicated that the optic nerve was compressing from the lower and inner direction around the optic canal area [Figure 3b]. It was confirmed by CT and MRI scans [Figures 1 and 2]. By using this evaluation, we could predict the location of the tumor within the optic canal, and cut it on purpose.

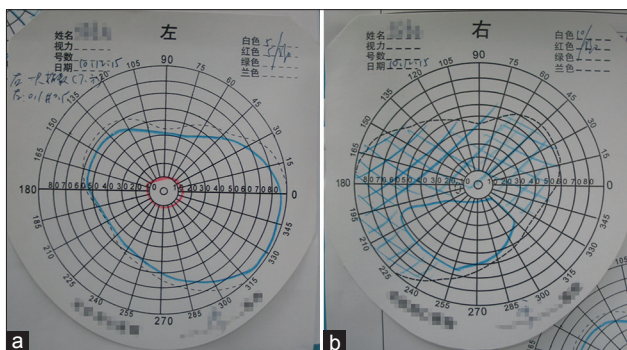


Figure 4: The preoperative Goldmann visual field test: Left side (a) was normal, right side (b) was a deficit in upper and outer visual field.

In conclusion, the surgical indications of exploring optic canal in TSM cases included: (1) Neuroimaging evidences of OCI (CT and/or MRI); (2) PSV of CRA in orbital CDI test was ≤ 8 cm/s; (3) visual acuity was below 0.1; (4) visual field deficit.

Exploring optic canal was the skull base technique which could accomplish Simpson I level resection in this area. Through this, the recurrence rate decreased, and the visual outcome was becoming better. A visual field test was also an indication of OCI location, and also guidance for the operation. The PSV of CRA in CDI test showed the blood flow situation of CRA. Moreover, it could be a prognostic factor for visual outcomes of TSMs.

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Conflicts of interest

There are no conflicts of interest.

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