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Microsurgical Management of Tuberculum Sellae Meningiomas by the supraorbital keyhole eyebrow approach: Surgical Outcome

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The aim of this study was to evaluate (surgical) visual outcomes in patients treated via supraorbital keyhole eyebrow incision approach.

Data from 14 patients with TSMs (Tuberculum Sellae Meningioma) who underwent microsurgical treatment by a supraorbital keyhole eyebrow skin incision between September 2006 and September 2013 were retrospectively collected and analyzed. Patients were analyzed on the basis of clinical, radiological, and surgical factors that appeared to affect the outcome. To quantify the extent of ophthalmological disturbances Visual impairment score was used to analyze visual acuity and visual fields, which range from 0 (best) to 100 (worst). Change in visual function was assessed as the main outcome.

The mean age of the 10 women and 4 men enrolled in the study was 56.50years (range, 42~74 years). The presenting symptom was asymmetrical visual loss in 71.4% of the patients. And examination revealed decreased visual acuity (Snellen notation) in 100% and impaired visual fields (Goldmann perimetry) in 58.3 % (7/12 cases, central scotoma and temporal anopia n=1, classical bitemporal hemianopia n=4, incongruent homonymous hemianopia n=2 , 2 cases data N/A) of the patients. Simpson grades I resection via a supraorbital keyhole eyebrow skin incision approach, were achieved in 100% of the patients.

Quality of life was assessed according to Karnofsky scale and was 86.67 (range: 70~100). The mean follow-up duration was 51.73 months (range: 27~91 months).No recurrent tumors were observed during this period.

According to the findings of this study, this approach provides a pleasing cosmetic outcome and also decreases brain manipulation while minimizing the likelihood of procedure-related morbidity. A favorable visual outcome was observed in most of the patients in the late postoperative period.

Key words: Meningioma, prognostic factors, tuberculum sellae, and visual outcome

Tuberculum sellae meningioma (TSM) arises from the tuberculum sellae, chiasmatic sulcus, limbus sphenoidale and diaphragma sellae; and it grows in a subchiasmal position[13]. TSMs are situated near important structures such as the pituitary stalk, major arteries, optic nerve and optic chiasm. TSM comprise 3% to 10% of all intracranial meningiomas. [2,9,15,16,22,25,27,28,34]

TSMs tend to dislodge the optic chiasm backwards, the optic nerves laterally and superiorly[6], commonly extend into both optic canals and cause visual impairment due to displacement of or adherence to the optic apparatus.[10,12]

Dandy[32], and Cushing and Risenhardt[14] published the first reports on this topic. Since then, a great number of series have been reported with a mortality ranging from 0%-30%[11, 26] and improvement of visual function in 25%-80% [2,26]. Patients experiencing worsening of preoperative visual function have been reported in recent articles ranging from 10-20%.[15]

Materials and Methods

All the patients with TSM who were treated in Third Affiliated Hospital of Sun Yat Sen University from September 2006 to September 2013 were included in this study. Meningiomas primarily originating from the dura of the olfactory groove, Planum Sphenoidale, anterior clinoid process or diaphragm sellae, Neurofibromatosis type 2 or malignancies were excluded. Information about clinical history, signs, surgical approach and outcome were obtained retrospectively.

Preoperative MRI scans were performed in all patients to plan surgical strategy and to obtain the following information: the primary location of the tumor; relationship between the tumor, the optic nerve, and the internal carotid artery (ICA); involvement of the optic canal and orbit; and presence of hyperostosis, unilateral or bilateral involvement of the optic nerve. Mean tumor volume was measured using the greatest horizontal and vertical diameters in the axial plane and the greatest diameter in the sagittal plane.

Visual impairment score (VIS; described in the German Ophthalmological Society guidelines) was used to analyze visual acuity and visual fields, which range from 0 (best) to 100 (worst). Snellen visual acuity at 5m was assessed, and ability to see one or more Snellen lines was defined as a meaningful change in visual acuity.

Tumor extension into the optic canal was assessed by Preoperative MRI and intraoperative inspection. Tumor consistency was defined as 'Soft', 'Moderate' and 'Firm'; when most of the tumor could be aspirated, when half of the tumor could be aspirated, and when most of the tumor could not be aspirated with a suction tube or low-power Cavitron ultrasonic surgical aspirator (CUSA; Valleylab, Boulder, CO, USA) respectively. Epidemiological and clinical information for patients undergoing surgical resection of Tuberculum Sellae meningioma is summarized in Table 1.

The operation was performed via supraorbital keyhole approach through eyebrow incision for all TSM cases.

Total no. Patients	14
Sex (n)	
Male	4
Female	10
Age (years; range)	56.50 (42~74 years)
Symptom duration (months; range)	21.0 months (3~71 months)
Follow-up duration (months; range)	51.73 months (range: 27~91 months)
Eyes tested (n)	
Both	4
Right	1
Left	5
None	4

Tumor origin (n)	
TSM	14
Tumor volume (cm^3)	10.6213 cm^3 (0.015–39.9)
Pathology (WHO grade; n)	
Grade 1	14
Grade 2	0
Grade 3	0
T2 signal intensity (n)	
High	12
Isointense	2
Low	0
Optic canal involvement (n)	1
Calcification (n)	0
Arterial encasement (n)	1
Optic nerve adhesion (n)	7
Peritumoral edema (n)	1
Arterial encasement (n)	1
Hydrocephalus (n)	1

Table 1: Epidemiological and clinical information for patients undergoing surgical resection of Tuberculum Sellae meningioma.

TSM = Tuberculum sellae meningioma, WHO= World Health Organization

Statistical analyses

We assessed several variables to identify predictive factors for improved clinical outcome and visual function. Comparison of categorical variables between the two was performed using chi-square test and paired t-test; a P value of ≤ 0.05 was considered significant. Statistical analyses were performed using SPSS software (version 21.0; IBM, SPSS, Chicago, IL, USA).

Result

There were 14 patients (10 female and 4 male; mean age, 56.57years; (range: 42~74). Mean tumor volume was 10.61 cm3 (range: 0.015~39.9 cm3). The T2 signal intensity was classified as ‘‘high’’, ‘‘Isointense’’, or ‘‘low’’, and there were 12, 2 and 0 cases in each class respectively. The tumors had adhered to the optic nerve in 7 cases, optic canal involvement in 1 case, Peritumoral edema in 1 case, hydrocephalus in 1 case and major arterial encasements were observed in 1 case. **(Figure 1), (Figure 2)**

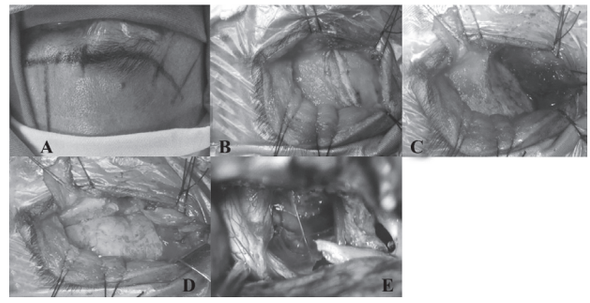

Figure 1: Intraoperative photographs of procedure supraorbital keyhole approach through eyebrow. (A) Skin incision is planned along the eyebrow. (B-C) the muscular and skin flaps have been retracted with silk sutures. (D) A single burr hole is made below the superior temporal line and posterior to the keyhole, and then a small supraorbital craniotomy is formed. (E) The dura is opened with base along the orbital rim.

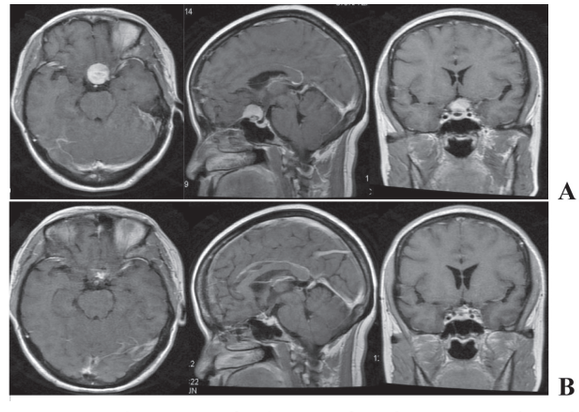

Figure 2: MRI of 42-year female presented with headache and decrease in vision. (A) Preoperative MRI (B) Post-operative MRI showing complete resection via supraorbital keyhole approach through eyebrow incision.

The mean patient age was 56.50years (range, 42~74), and there were 10 female and 4 male in this case series. The mean follow-up duration was 51.73 months (range: 27~91 months).The clinical outcomes are summarized in Table 2. Many variables that potentially affect clinical outcomes have been reported in the literature, and we analyzed the significance of these factors according to clinical outcome. With respect to outcome, 3 patients were classified as ‘‘excellent’’, 3 as ‘‘good’’, 7 as ‘‘fair’’, and 1 as ‘‘poor’’. The criteria used to evaluate the clinical outcome are outlined in Table 3. Intraoperative tumor consistency

Factor	No. cases				P-Value
	Excellent	Good	Fair	Poor	
Symptoms Duration					
<6 months	2	1	4	0	0.015
>6months	1	2	3	1	
Age					
< 60 Years	3	3	3	0	0.014
> 60 Years	0	0	4	1	
T2 Signal Intensity					
High	2	2	7	1	0.308
Isointense	1	1	0	0	
Low	0	0	0	0	
Calcification					
Yes	0	0	0	0	
No	3	3	7	1	
Optic canal involvement					
Yes	0	0	1	0	
No	3	3	6	1	
Adherence to optic nerve					
Yes	1	2	3	1	0.530
No	2	1	4	0	
Major arterial encasement					
Yes	0	1	0	0	0.336
No	3	2	7	1	
Hydrocephalus					
Yes	0	0	0	1	0.003
No	3	3	7	0	
Intraoperative tumor consistency					
Soft	0	0	0	0	0.691
Moderate	0	0	1	0	
Firm	3	3	6	1	
Very firm	0	0	0	0	
Extent of resection					
Total	3	3	7	1	0.143
Sub total	0	0	0	0	

Table 2. Tuberculum Sellae Meningioma Clinical outcomes

(P = 0.691), T2 signal intensity (P = 0.308), Optic canal involvement (P = 0.691), tumor adherence to the optic nerve (P = 0.530), Peritumoral edema (P =0.691) and major arterial encasement by the tumor (P = 0.336) were not significant predictors of clinical outcome. Symptom duration of less than six months (P = 0.015) and age less than 60 year (P = 0.014) were related to improved clinical outcome. Hydrocephalus (P = 0.003) was associated with poor clinical outcome.

In the immediate post- operative period and, preferably, on discharge visual outcome analysis was performed for 14 patients. Examinations of visual outcome (both visual acuity and fields) were conducted for 28 eyes in 14 patients. The average VIS was 50.25 preoperatively. In two cases, the data were missing, so these patients were excluded. On discharge, absolute visual acuity was improved in 12 eyes (42.85%), and stayed the same in 2 eyes (7.14%). A favorable visual outcome was observed for 50% of patients in the immediate postoperative period (7/14; 6 improved and 1 stable outcomes) and 83.3% of patients in the late postoperative period (10/12; 8 improved and 2 stable outcomes; 1 patients did not come for follow up and 1 patient died post-surgery). Postoperative deterioration of visual acuity was observed in 2 of 12 cases (16.66%).

Worsening of vision in both eyes was not observed in any patients. Visual acuity continued to improve or persisted throughout the follow-up period in the patients who benefited from treatment. Post-surgery visual field deficits were also improved or stable in 10 cases. Visual acuity was preserved in 20 eyes (preoperative visual acuity, 0.5–1.0), and deteriorated or was lost in 4 eyes (visual acuity, 0.1 or less).

Favorable final visual outcome was expected, if the immediate postoperative visual status was favorable, ($P < 0.05$). Hydrocephalus was the only variable that had a statistically significant relationship with visual outcome: it was associated with a poor visual outcome ($P = 0.003$). There were no other clinical or radiological factors that were significant predictors of immediate or late visual outcome (all $P > 0.05$, data not shown). In the immediate postoperative period, 1 stable patient ultimately improved.

Quality of life was assessed according to Karnofsky scale and average was 86.67 (range: 70~100).

Outcomes	Definition
Excellent	Total Resection; visual improvement without complications
Good	Total Resection or tumor control with radiosurgery after subtotal resection; improved or favorable visual function without life threatening Complications
Fair	Total Resection and favorable visual function with life-threatening complications
Poor	Post-operative deterioration

Total Resection= Simpsons Grade I or Simpsons Grade II

Table 3. Classification system for final clinical outcomes

Discussion

Preoperative evaluation of Oculomotor, neurological, and endocrinological function were carried out. The imaging modality of choice for accurate diagnosis is multiplanar, contrast-enhanced MRI. Determining tumor size, the tumor's anatomic relationship to neighboring neurovascular structures, and the location of the ICA and the ACA-complex in relationship to the meningioma were the primary goals of preoperative evaluation. Peritumoral edema and tumor calcification were the indicator of firm nature of the tumor although it's uncommon in TSM. The ability of meningiomas to invade can also be related to the Peritumoral edema, and it can influence the risk of recurrence.30

It has been recommended that the optic canal should be opened in order to remove small pieces of residual tumor since residual tumors in the optic canal can also be a source of tumor recurrence 4, 23. High rates of complete tumor resection could be achieved without increasing morbidity, in recent microsurgical series, including the present series, 10,18,19,29. In our series, extension into the optic canal was relatively uncommon (2 of 14 patients by preoperative radiological examination and/or intraoperative inspection). Optic canal unroofing was performed in 2 of these patients. Fahlbusch and Schott 10 reported recurrence in only 2.1% of patients with complete tumor removal. In our experience, tumor location, and whether the ICA and ACA-complex were completely encased were the factors on which the successful complete resection depended.

In recent surgeries that were conducted microsurgically, the visual improvement rate post- surgical resection was 25-80% in suprasellar meningiomas 13,15,10. There is a clear relationship between surgical approach and technique with postoperative visual outcome 18,28. In our experience, the size of the tumor and, the duration of symptoms and degree of visual deterioration can also influence postoperative visual outcome. Better visual outcome in patients with tumors <3cm than those with tumor >3cm was reported by Rosenstein and Symon 31. In patients surgically treated for TSMs 10–40% of visual deterioration was previously reported. 10,15,18,33 .Arai et al. 3 emphasized the need for optic canal deroofing in the presence of preoperative visual disturbance. Minimizing direct manipulation and or trauma to the optic nerves and avoiding injury to the blood supply of the optic apparatus is the key to preserve visual function.19

. In our series, Immediate Postoperative, visual acuity was improved in 12 eyes (42.85%) and unchanged in 2 eyes (7.14%). and 83.3% of patients in the late postoperative period (10/12; 8 improved and 2 stable outcomes; 1 patients did not come for follow up and 1 patient died post-surgery). Postoperative deterioration of visual acuity was observed in 2 of 12 cases (16.66%). No patient experienced worsening of vision in both eyes. Thus, postoperative optic nerve function can likely be improved by the combination of decompression, optic canal unroofing, and total tumor resection.

Visual outcomes were unfavorable if adhesion of the tumor to the optic nerve and arterial encasement was present, but these relationships were not significant 4,20.

Except, Hydrocephalus no other clinical or radiological factors tested were significant predictors of short-term or long-term visual outcome. In our study, the long-term visual improvement rate was 83.3%.

Sometimes, tumor vascular supply comprises of small branches of the ACA 1 Therefore, early identification of the ACA-complex during surgery is necessary. The optic nerves are secured within the optic canal, and the most common site of compressive injury to the nerve is the falciform ligament. It is advisable to release the falciform ligament before optic nerve manipulation, to minimize the chance of optic nerve injury. Notably, in our cases, there were 7 cases with tumor adhesions within the optic canal and there, the tumor could be removed easily.

As mentioned above, in much of the literature adverse visual and surgical outcomes are major concerns. Potential prognostic factors for visual outcomes has been proposed by many authors including short symptom duration, preoperative visual status, arterial encasement, tumor size, optic nerve encasement, tumor consistency and appearance on T2-weighted images 7,10,12,13,17,20,21,35. Similarly, in our series the finding suggested that symptoms duration less than 6 months (P = 0.015) and age less than 60years (P = 0.014) were likely to improve the clinical outcomes 7,12,13,20,21,35. This finding suggests that surgical manipulation may be the most important factor in determining the visual outcome.

Conclusion

Supraorbital approach provides a pleasing cosmetic outcome and also decreases brain manipulation while minimizing the likelihood of procedure-related morbidity. Minimizing direct manipulation and or trauma to the optic nerves and avoiding injury to the blood supply of the optic apparatus is the key to preserving visual function. Postoperative improvement of visual function after surgical removal of TSM can be expected in most cases. Patients below 60 years and with symptoms less than 6 months and absence of hydrocephalus have a better prognosis. Hence surgical removal should be attempted as soon as visual disturbances occur. We also recommend that improving visual function in the contralateral eye should be the main concern in patients with unilateral severe visual impairment.

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