



Management of Large Medial Sphenoid Wing Meningiomas: A Series of 178 Cases

Büyük Medial Sfenoid Kanat Menenjiyomlarının Yönetimi: 178 Olguluk Bir Seri

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ABSTRACT

AIM: The aim of this study was to evaluate our treatment and outcome in patients with large medial sphenoid wing meningiomas (SWMs).

MATERIAL and METHODS: Data from 178 patients with large medial SWMs treated was collected and analyzed retrospectively. Most of patients underwent microsurgical resection under electrophysiological monitoring and Doppler probe. Radiation therapy was administered in 64 patients with residual tumor and malignant pathology.

RESULTS: Total resection of the tumor was achieved in 118 of 178 cases (66.3%), subtotal in 60 of 178 (33.7%) at the time of initial surgery without serious surgical complications except 2 patients with ptosis. Postoperative vision improved in 84 patients (87.5%), remained unchanged in 8 (8.3%) and deteriorated in 4 (4.2%). The progress free survival (PFS) and Karnofsky performance score (KPS) between patients with gross total resection (GTR) and patients with subtotal resection (STR) followed by radiation therapy (RT) had no significant difference.

CONCLUSION: Surgery still remains a principal treatment option for SWMs. Good craniotomy techniques, proper hemostasis and optimal surgery strategy are critical to improve resection rate and elevate prognosis. Likewise, it is expected that STR with adjuvant RT can provide satisfactory results in case of total removal impossible.

KEYWORDS: Meningiomas, Sphenoid wing, Microsurgery, Radiotherapy

ÖZ

AMAÇ: Bu çalışmanın amacı geniş medial sfenoid kanat menenjiyomlu (SKM) hastalarda tedavimizi ve sonuçlarımızı değerlendirmektir.

YÖNTEM ve GEREÇLER: Büyük medial SKM olarak tedavi edilen 178 hastanın verileri toplandı ve retrospektif olarak analiz edildi. Hastaların çoğuna elektrofizyolojik izleme ve Doppler probu altında mikrocerrahi rezeksiyon uygulandı. Rezidüel tümör ve malign patolojisi olan 64 hastada radyoterapi uygulandı.

BULGULAR: İlk cerrahiyle 2 hastada gelişen pitüizis dışında ciddi bir cerrahi komplikasyon olmadan 178 olgudan 118'inde (%66,3) total rezeksiyon ve 60'ında (%33,7) subtotal rezeksiyon elde edildi. Postoperatif olarak görme 84 hastada (% 87,5) iyileşti, 8'inde (% 8,3) değişmedi ve 4'ünde (% 4,2) kötüleşti. Gros total rezeksiyon (GTR) ve radyoterapinin (RT) takip ettiği subtotal rezeksiyon (STR) olan hastalar arasında progresyonsuz sağkalım (PFS) ve Karnofsky performans skoru (KPS) açısından anlamlı bir fark yoktu.

SONUÇ: SKM'ler için cerrahi hala temel bir tedavi seçeneğidir. Rezeksiyon oranını artırmak ve prognozu yükseltmek için iyi kranyotomi teknikleri, uygun hemostaz ve optimal cerrahi strateji önemlidir. Aynı şekilde, total eksizyonun mümkün olmadığı durumlarda adjuvan RT ile birlikte STR'nin tatmin edici sonuçlar sağlaması beklenmektedir.

ANAHTAR SÖZCÜKLER: Menenjiyomlar, Sfenoid kanat, Mikrocerrahi, Radyoterapi

INTRODUCTION

Meningiomas are the most common tumors of the sphenoid wing (11). Medial sphenoid wing meningiomas (SWMs) are presumed to represent 10% of all supratentorial meningiomas (2). The principal aim of surgical management is maximal resection with minimal resulting neurological deficits, but complete and safe resection is still a major neurosurgical challenge. Although there have been recent advances in cranial base exposures, microsurgical techniques and

neuroimaging, postoperative outcomes remain unfavorable over the long term (19). Patients with medial SWMs frequently present with minimal functional impairment, for which surgery or other therapies can be the best aim to preserve, as well as return to work and preoperative level of activity. High mortality, permanent neurological deficits and incidence of poor outcomes after surgery have forced many neurosurgeons into favoring subtotal or partial resection with adjuvant radiotherapy (RT) (12). Preoperative

evaluation directly affects the surgical exposure, goal and outcome. Good craniotomy technique and tumor resection strategies are critical in preserving neurovascular structures, and raising tumor resection rate. We retrospectively present our experience in 178 patients with large medial SWMs and analyze patient's outcomes.

PATIENTS and METHODS

Patient Characteristics

This study consisted of 178 patients with large medial SWMs. These procedures were performed by the same neurosurgeon at the west china of hospital. Female preponderance was observed with 125 women (70.2%) compared with 53 men (29.8%). Mean age was 44.2 years (ranging from 21 to 72 years). 84 tumors were on the right side and 94 were on the left. The number of patients experiencing clinical symptoms was as follows: visual disturbances, 96 (53.9%); headache, 26 (14.6%); seizures, 13 (7.3%); amblyopia, 12 (6.7%); intracranial hypertension, 10 (5.6%), with 6 cases of Foster-Kennedy syndrome; blepharoptosis, 9 (5.1%) hemiparesis, 3 (1.7%); facial hypesthesia, 3 (1.7%); proptosis, 3 (1.7%); diabetes insipidus 2 (1.1%); hypopituitarism, 2 (1.1%); emotional disturbance, 2 (1.1%). The major clinical symptoms and signs of the 178 patients are shown in Table I.

Preoperative Evaluation

All patients underwent through a neurological examination before surgery. Ophthalmologic test consisted of patient's visual acuity and field for both eyes. Glucocorticoid was detected in 3 patients because the tumor was adhered to hypothalamus and/or pituitary stalk. Computed Tomography (CT) scans with thin cuts through the cranial base revealed delineation of osseous anatomy and were helpful in identifying areas of bony hypertrophy, intratumoral calcification and enostosis (Figure 1). T1- and T2-weighted three- dimensional MRI could determine the relationship of tumors with neighboring structures, the extent of the tumor, and encasement or compression of the optic apparatus (Figure 2A,B). Isointensity or hypointensity on T2-weighted MRI indicated firm meningioma (Figure 3A,B). In another 132 patients CT angiography (CTA) or MR angiography (MRA) was performed to visualize encasement of the internal cerebral artery (ICA) and its branches. Digital subtraction cerebral angiography (DSA) was performed in 13 patients with giant tumors embolized with Onyx embolic agent using superselective catheterization of the feeding arteries from the external cerebral artery (ECA). Mean tumor diameter was 6.3 cm (range 4.2–11.9 cm). Calcification was present in 19 cases, peritumoral edema in 167, and the shift of midline in 122 and compression to cerebral ventricle in 107. The majority of tumors showed sharply demarcated margin. The shape of the tumors was round (122 cases), flat (14), lobulated (3), and irregular (11). Infiltration into the unilateral cavernous sinus was present in 105 cases, optical canal involvement in 27 with 6 further extending into the orbital wall or orbital compartment. Hyperostosis of the sphenoid wing was present in 13 patients.

The extent of tumor resection was classified according to the Simpson classification (22):

Grade I- total tumor resection with excision of infiltrated dura;

Grade II- total tumor resection and coagulation of dural attachments;

Grade III- gross total tumor resection without excising dural attachments or extradural extensions;

Grade IV- subtotal tumor resection.

GTR including simpson grade I and II resection, was defined as no intraoperative evidence of residual tumor and no evidence of contrast-enhancing tumor on postoperative MRI. When either of these criteria was not satisfied, the extent of tumor removal was classified as STR. Our patients almost underwent immediate and follow-up MRI to evaluate the extent of tumor

Table I: Major Clinical Symptoms in 178 Patients with Medial SWMs

Clinical Presentation	No. Patients (%)
Visual disturbances	96 (53.9)
Headache	26 (14.6)
Seizures	13 (7.3)
Ambiopia amblyopia	12 (6.7)
Intracranial hypertension	10 (5.6)
Blepharoptosis	9 (5.1)
Hemiparesis	3 (1.7)
Facial hypesthesia	3 (1.7)
Proptosis	3 (1.7)
Diabetes insipidus	2 (1.1)
Hypopituitarism	2 (1.1)
Emotional disturbance	2 (1.1)

Values represent number of patients and percentages (in parentheses) of total.

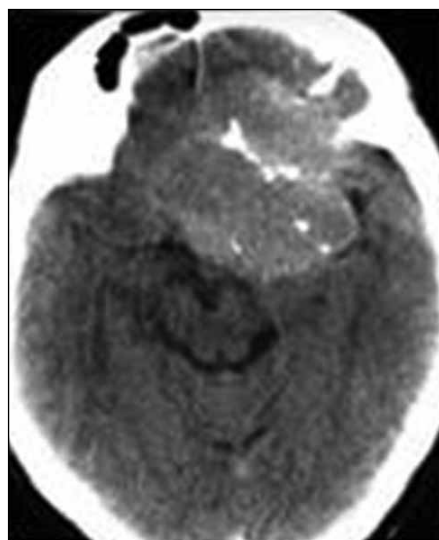


Figure 1: Preoperative CT shows a giant mass at the anterior and middle skull base with calcification.

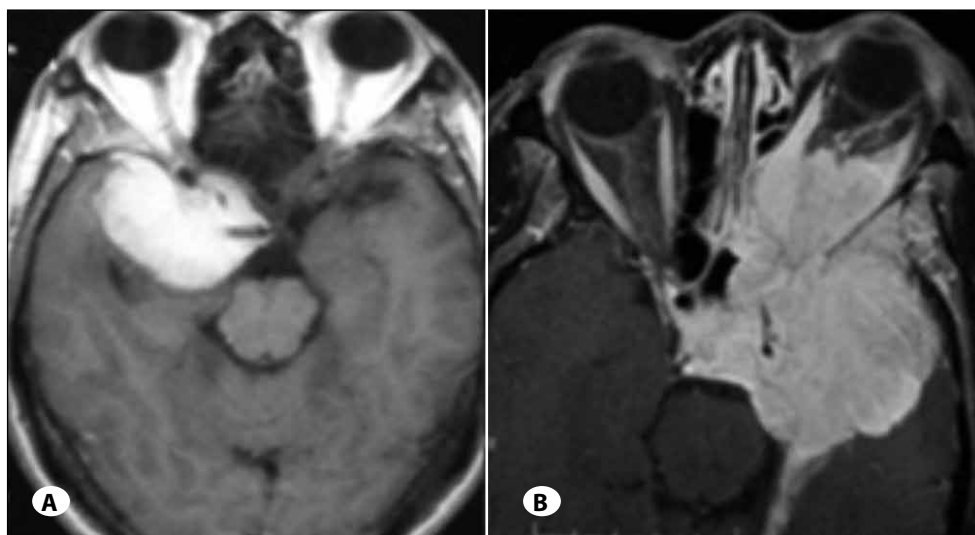


Figure 2: **A)** Axial MRI with contrast displays the right SWM compressing the lateral wall of the right optic nerve, **B)** The flat SWM encasing of the left optic apparatus and sellar region.

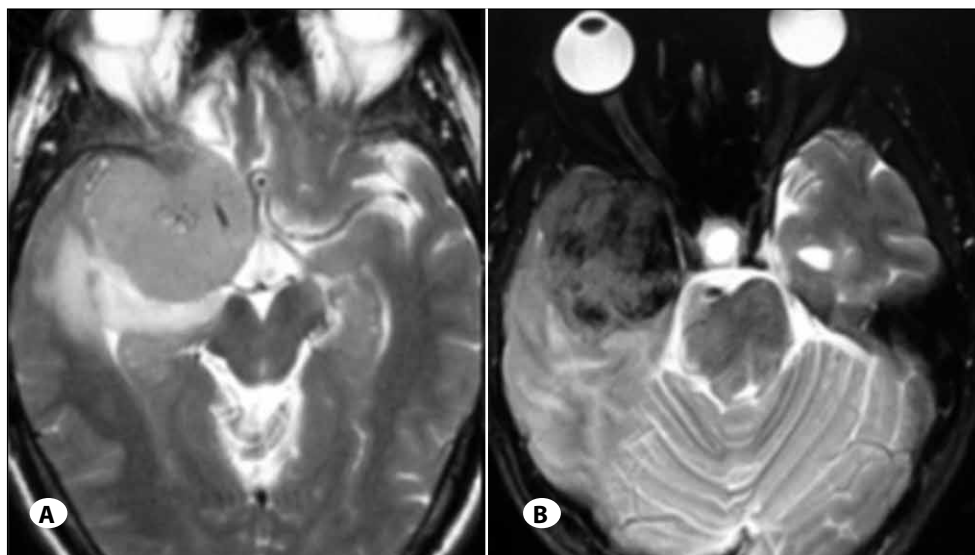


Figure 3: **A)** Axial T2-weighted MRI demonstrates a meningioma with isointensity and hypointensity. **B)** At the right sphenoid wing.

resection and recurrence or progression three months after initial surgery. Functional outcomes were based on the KPS scale definitions rating criteria. The patients who had high KPS (80-100), able to carry on normal activity; no special care needed (4). KPS was evaluated in all patients preoperatively and also could follow-up.

Operative Technique

After general anesthesia, the patient was placed supine with the head rotated from 30 to 60 degrees to the contralateral side of the approach and the head of the bed elevated approximately 15°. The scalp incision of transzygomatic pterional approach was made 0.5cm inferior to the zygomatic arc and 0.5cm anterior to the tragus, and then frontally curved behind the hairline. The incision was in a three-quarter bicoronal fashion for amplified frontotemporal approach. The subfascial dissection was made to expose the orbital rim anteriorly and the zygomatic arc inferiorly. An

Table II: Approaches in 178 Patients

Approach	Number
Pterional	37
Modified pterional	37
Transzygomatic pterional	31
Amplified frontotemporal	73

amplified frontotemporal osteotomy was to fully expose the tumors extending across the midline. Pterional or modified pterional craniotomy was made along the skull base. Different approaches for tumor resection were listed in Table II. The size and shape of bone flap rely on the location and extension of the mass. A few techniques of reducing blood loss in especially dealing with the sphenoid wing were as follows: (a) drilling away the outer plate, diploe and partial inner plate of bone flap, and the sphenoidal crest; (b) then breaking off

the lamellar of the inner plate after finishing bone window; (c) grinding the bleeding sphenoidal crest up to the clinoid process by using a minimal high-speed drill as soon as possible. The dura was elevated off the floor of the middle fossa under the surgical microscope after devascularizing of basal blood supply from ECA. Cerebrospinal fluid was released under microscope from lateral fissure. Microvascular Doppler probe and cavitron ultrasound surgical aspirator (CUSA) were implied and intraoperative electrophysiological monitor with stimulation electrodes used side by side to judge the relation between the tumor and the nerves. It should be kept in mind that nerves and large vessels should be preserved at any times. We initially reduced tumor size by either central debulking or segmental resection, and then dissociated tumors from encased arteries, and severely compressed or encased nerves with the aid of dissector, bipolar coagulation and microscissor. In our series, all patients with preoperative visual

acuity and field disturbance underwent direct exploration of the intracranial segment of optic nerve when tumor mass effect was not seen around the nerve (Figure 4). The infiltrated bone was maximally drilled away. The zygomatic arc and the bone flap with its masseter attachment were placed by use of titanium miniplates. The average estimated volume of blood loss was 350 ml during the whole operation.

RESULTS

The degree of tumor excision was determined on both intraoperative assessment and postoperative MRI performed within 24-48 hours. None of the 178 patients died of surgery. Simpson grade I + II resection was respectively achieved in 20 and 98 patients, and grade III+ IV in 40 and 20 because of tumor invasion of the cavernous sinus or /and firmly adherent to or encasement of the ICA and/or optic apparatus. In the same situation, tumor with hyperintense on T2-weighted was generally removed easier than those with isointensity or hypointensity (Figure 5). Among the patients with preoperative visual disturbance, postoperative vision improved in 84 patients (87.5%), remained unchanged in 8 (8.3%) and deteriorated in 4 (4.2%). Preoperative other symptoms gradually relieved after surgery. New-onset postoperative seizures developed in 9 patients and were well controlled by medical therapy. Postoperatively permanent oculomotor nerve palsy appeared in three patients except one that disappeared one week later. Two young patients experienced long-term apathy indifference. RT was used in 48 patients with residual tumors conformed as WHO grade I meningiomas. Total dose of 54 Gy was introduced for benign meningiomas, and 60 Gy for atypical and malignant tumors. Patients were followed up from 9 to 60 months (median, 42 months). The progress free of residual tumor on the fifth-year postoperative MRI was considered as indicative of radiotherapy (Figure 6A-D). The PFS of patients with GTR (Figure 7A-F) was present in 81 patients (79.4%), the PFS of patients with subtotal resection (SRT) + RT detected in 37 (78.1%) in WHO grade I meningiomas in Table III. They were not strongly correlated ($X^2=0.011, p>0.05$). Postoperative 94.9% patients with GTR compared with preoperative 90.7%

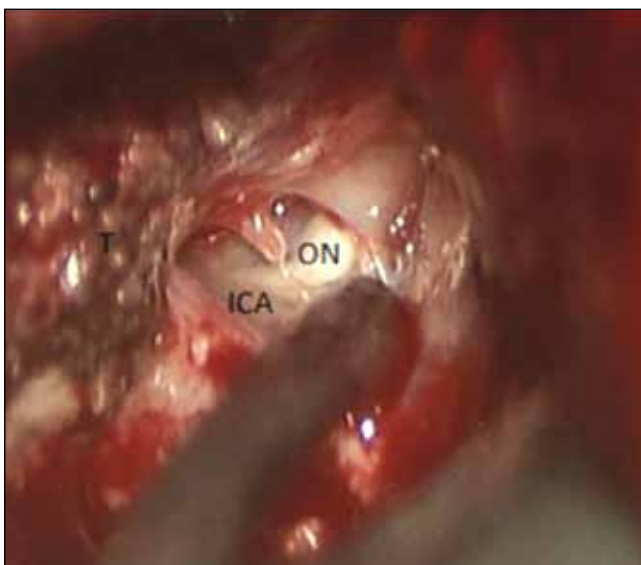


Figure 4: Intraoperative photography shows the left optic nerve after opening of the falciform ligament and the partial optic nerve sheath. **ON** indicates optic nerve; **T**, tumor.

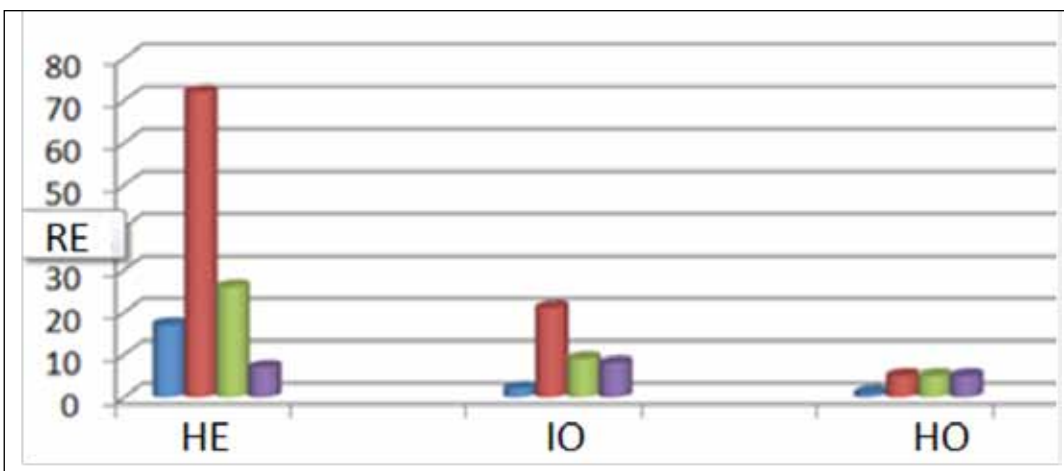


Figure 5: Relationship between resection extent and T2 Simpson grade I Simpson grade II Simpson grade III Simpson grade IV **RE**= resection extent; **HE**=hyperintense; **IO**=isointensity; **HO**=hypointensity.

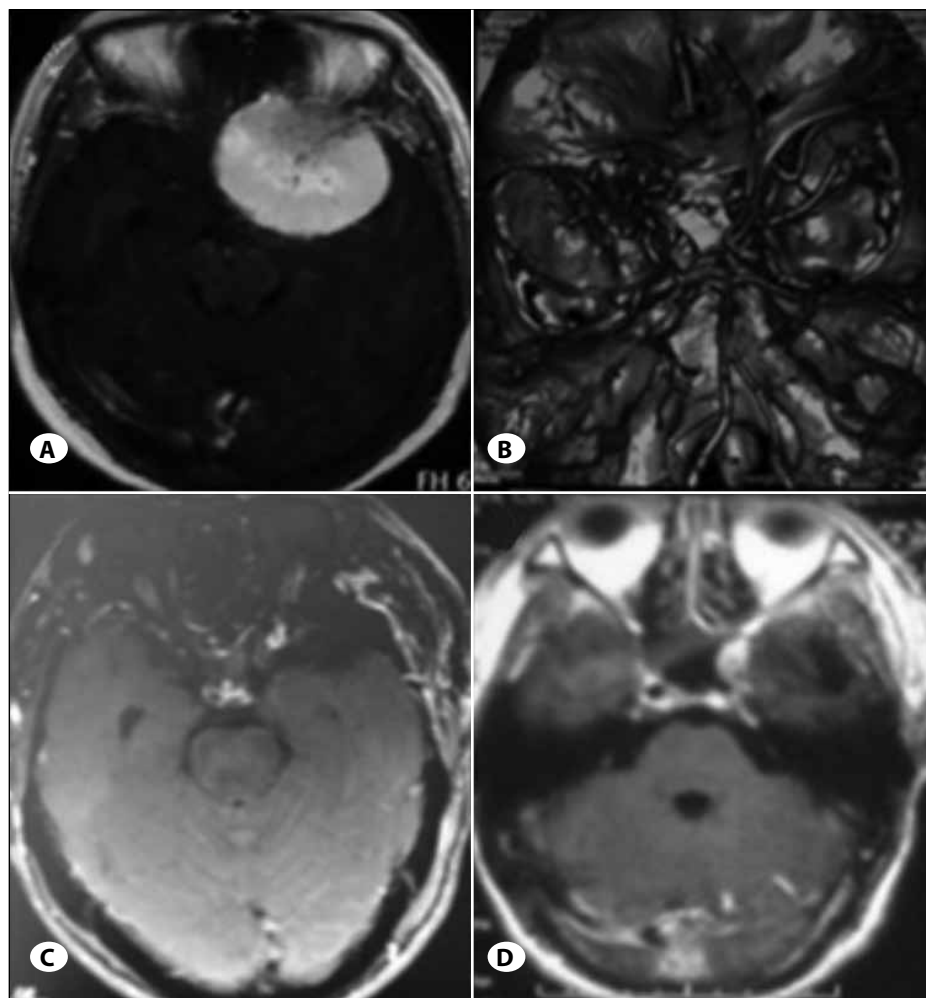


Figure 6: **A)** Preoperative axial contrast enhanced MRI displays the left medial SWM extending into suprasellar region, **B)** CTA abundant blood supply of the tumor, ACA and MCA displacement, **C)** the residual tumor in the left cavernous sinus three month later, **D)** the residual tumor had no significant progress after postoperative radiation 54 month.

had a normal life (KPS: 80–100). By contrast, postoperative 96.7% patients with STR+RT compared with preoperative 85.0% got the same KPS. The KPS of patients between GTR and STR +RT after management had no statistical difference ($X^2=0.068$, $p>0.05$) in Table IV.

DISCUSSION

Medial SWMs accounting for around 50% of all sphenoid wing meningiomas, are located at the medial sphenoid ridge, a 1 cm a small bony structure, where the cavernous sinus, optic nerve, and cranial ICA are closely bound (20). They grow slowly, become very large when diagnosed. Advances in neuroimaging, improved microsurgical techniques and cranial base exposures, successfully removing tumors previously considered as unresectable is possible nowadays (18). However, safe and complete resection still remains surgically challenging procedures. Radical resections may contribute to avoid or delay tumor recurrence (8). Neuropraxia and severe complications possibly follow the attempt on blind GTR because of tumor’s adhesion or/ and invasion to the cavernous sinus and optic apparatus. The primary goal of surgery was maximal removal of tumor and reduction of

morbidity and mortality (6). We accomplished total resection in our two cases whose permanent deficit of cranial nerve after the surgery occurred initially. Therefore, we intentionally performed extensive subtotal resection in high-risk areas to avoid additional neurological deficits after that.

Table III: PFS of Medial SWMs Between GTR and STR+RT (WHO Grade I Meningiomas)

Variables	GRT	SRT+RT
No. of patients	102	48
No. of PFS	81 (79.4%)	37 (78.1%)
Mean time of FU (m)	34.6	37.3

m= month, FU= follow-up

Table IV: Long-Term Functional Outcome in GRT and SRT +RT (KPS: 80-100)

Treatment	Pre-N	Post-N
GRT	107 (90.7%)	112 (94.9%)
SRT+RT	51 (85.0%)	58 (96.7%)

Pre-N = preoperative number, post-N= postoperative number.

Imaging finding involving CT, CTA, MRI, MRA and DSA are important in preoperative planning. The role of MR image allows a study of the vascularization, infiltration, extension, limits and relationships with surrounding structures. A general idea of the texture and extent of the tumor can be achieved by analysis of signals on preoperative T2-weighted images that almost suggest the tumor's consistency. The tumor with isointensity or hypointensity relative to grey matter on T2-weighted sequences often indicates that safely

dissecting off the hard tumor from the intimate relation with vital structures is not easy, and any attempt to achieve a GTR is dangerous. In our series, Tumors with subtotal resection were mostly those tumors with isointensity or hypointensity on T2-weighted MRI, and those tumors in close proximity to important structures.

Multiple surgical approaches have been developed to attack these formidable lesions. It is well known that the

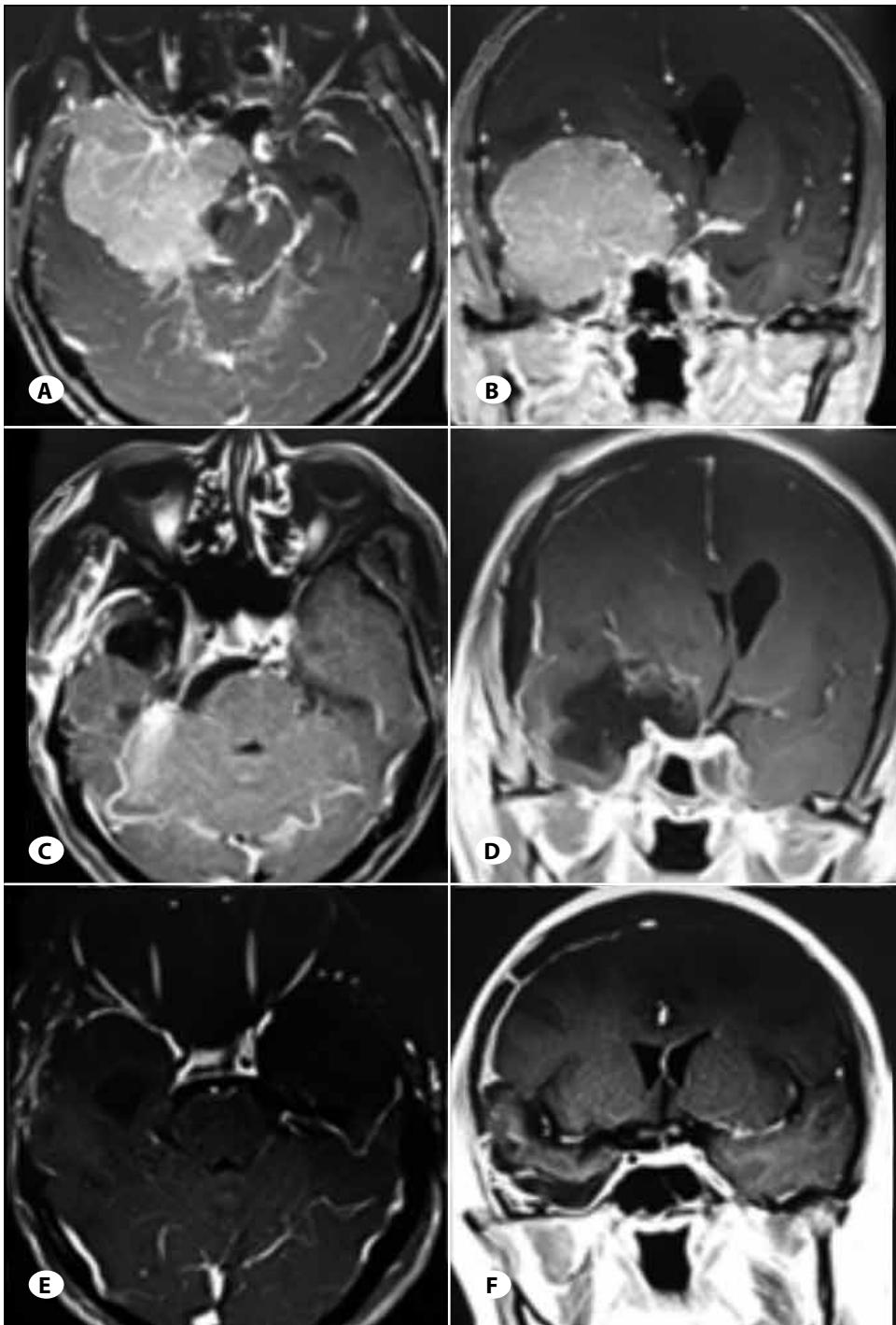


Figure 7: A, B) Preoperative axial and coronal view of T1-weighted with contrast MRI shows the right SWM extending into sellar region, C, D) Total tumor removal three months after surgery, E, F) No tumor recurrence 60 months postoperatively.

correct operative approach is very important for removal of a complicated tumor such as medial SWMs. The choice of approach was dictated by the size, location and extension of the tumor. If the medial parts of the tumors were located in the anterior and middle cranial fossae and extended across the midline, amplified frontotemporal craniotomy should be adopted to receive a good medial view of the suprasellar region. Ample working space like fronto-orbito-zygomatic approach was provided to detach tumor from optic apparatus and ACA without removal of the orbital rim and zygomatic arch so supraorbital nerve and artery were intact. Its advantage compared with conventional fronto-orbito-zygomatic craniotomy is to shorten the time, lower damage and induce facial shape influence. Pterional approach should be managed for patients whose tumors extended laterally and superiorly. Modified pterional approach should be performed for patients with tumors extending anteriorly or posteriorly. Transzygomatic pterional approach might be better for tumors mainly invading the middle skull fossae. When the tumor invaded the cavernous sinus, STR should be performed to avoid damaging the cranial nerves and vessels in the cavernous sinus.

The surgical difficulties are the following: (i) large tumor size; (ii) tumor consistency; (iii) cavernous sinus infiltration; (iv) involvement of cranial nerves and vessels; and (v) abundant blood supply (13). Large medial SWMs are highly vascularized from the ECA and ICA. Intraoperative bleeding is another major concern especially when meningiomas lie on the wall of the cavernous sinus (7). Tumor can obtain blood supply from internal carotid branches inside the cavernous sinus, which usually are difficult to be embolized preoperatively. In our series, minimum blood loss was achieved through the correct operative approach where early interruption of the dural blood supply was done. Heavily bleeding may sometimes be encountered, even onset of incision of scalp. A few techniques of controlling blood loss before resection of the tumor, especially dealing with the sphenoid wing, make it easy to expose tumor, which would directly shorten operation time, enhance the chance for total tumor resection and improve the results of operation. The chances of radical removal sometimes are hampered by the involvement of the vessels and nerves whose exact locations remain unknown to the neurosurgeon, so the risk of intraoperative neurovascular injury persists. It is important to visualize the relationship between the tumor and the neurovascular structures, so the ICA and its branches should be monitored by Doppler before resection of tumors. Most of the soft tumor could be aspirated with a suction tube or CUSA in order to decrease vascular impairment. The severe adhesion to the optic apparatus and ICA as well as its branches indicates that it is unfeasible to divide the tumor even with microscissor. Postoperative outcomes displayed that the patients involved in our study had a favorable preservation of the neurovascular structures after the microsurgical treatment assisted by intraoperative electrophysiological monitoring. It is imperative in all cases for protection of the important cranial nerves in the skull base.

High recurrence after complete excision of meningiomas made many neurosurgeons frustrated (4). RT is another choice in treating residual tumors and has proven beneficial for patients with incompletely resected meningiomas (1, 5). Furthermore, it has been used for high surgical risk areas (16, 17). For benign meningiomas, adjuvant RT reduces tumor progression in subtotal resected tumors (23). As shown in Table III and Figure 6(A-D) in our series, the application of single daily doses of 1.8–2.0 Gy up to a total dose of 54 Gy has proved effective in patients with incomplete resection of meningiomas (WHO grade I) by improving 5-year PFS to be same extent as complete surgical resection. Meningiomas that have recurred once, tend to recur soon (15), so additional radiation treatment for patients with subtotal resection should be accomplished. Some reports on meningioma treatment indicate much better results with postoperative radiotherapy than with surgery alone. The 5-year PFS rate is 77% to 88% with surgery and RT is 43% to 59% with surgery alone (9, 12, 21). Microscopic surgery followed by RT has provided a better prognosis in some literatures reported. In the present series, patients with adjuvant RT after STR reached postoperatively a high KPS with tumor progression free in the regular follow-up. Defying resection might cause serious deterioration of patient's life quality when the involved structures included the critical structures like the cavernous sinus. All the patients with WHO grade I meningioma almost maintained a long-term acceptable level after STR followed by subsequent RT. Both pure surgery and RT after operation offer a choice for pretherapeutic consideration of patients with large medial SWMs in order to optimize patient's outcome (14).

Visual acuity and field disturbance was the main cause for referral. Despite the improvement of microsurgical techniques and refinement of microsurgical tools in the past few years, the outlook for visual recovery in patients with medial SWMs have been quite pessimistic after surgery (2, 3). Significant visual improvement in 71%, and only a minority of patients recovering to normal vision were reported (24). The key to preserving visual function is to minimize direct manipulation or trauma to the optic nerves and interference to the blood supply of the optic apparatus (10). If the arachnoid membrane was not recognizable, dissection of tumor from the optic apparatus would be dangerous. In patients whose decompression or encasement of optic apparatus was not visible during procedure, but visual disturbance existed preoperatively, all underwent direct exploration of intracranial segment of optic nerve. With respect to their visual outcome, the overwhelming majority of them achieved a good visual result. According to our experience, visual outcome after tumor resection tended to remain unchanged in those patients whose preoperative duration and degree of visual deterioration were long and severe.

CONCLUSION

Surgery still remains a principal treatment choice for large medial SWMs though GTR is a major neurosurgical challenge. Pursuing a GTR of the tumor should not be a unique target

of the surgery because patient's life quality and functional outcome after surgery should be a prior concern. STR with adjuvant RT provides an option that gives excellent results for residual tumor.

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