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Efficacy of Pterional Approach in Surgical Management of Meningioma En Plaque

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ABSTRACT

Background: One-third of brain malignancies are meningioma. Cushing established meningioma en plaque (MEP) as a flat, soft dura mater tumor. It invades bones, causing hyperostosis. The tumors are called MEP, or spheno-orbital meningiomas (SOM). SOM invades the sphenoid wing and can spread to the orbit, infratemporal fossa, and cavernous sinus, which makes surgery to be more difficult. Hyperostosis may compress the optic and other cranial nerves. Proptosis, eyesight impairment, and cosmetic abnormalities are also caused by hyperostosis. Full resection improves proptosis and visual issues. Thus, the surgical technique is critical.

Objectives: This study aimed to investigate the outcome of ten patients treated by microsurgical resection through pterional approach.

Patients and methods: This retrospective study included 10 cases of hyperostosis and proptosis-characterized plaque meningioma. We assessed the surgical procedure, technique, resection extent, and postoperative outcomes.

Results: All participants were women, except for one was male. Participants had a mean age of 45.4 years. All 10 patients had proptosis as their main symptom. Two had headaches and retro-orbital pain, while three claimed vision impairment. Pterional was utilized in all instances. Total tumor resection occurred 5 times, subtotal 3 times, and partial 2 times. Seven patients had proptosis improvement, two had partial improvement, and one had no change after three months. Cerebrospinal fluid leak, infection, hydrocephalus, and visual impairment occurred separately after surgery.

Conclusions: To achieve effective surgical resection and clinical improvement of proptosis, the lateral and superior orbital walls must be drilled, and any intra-orbital soft tissue components were removed. However, complications such as hyperostosis development on the infra-temporal fossa or medial orbital wall, tumor invasion of the cavernous sinus, or tumor attachment to orbital muscles preclude complete excision.

Keywords: Pterional approach, Surgery, Meningioma en plaque, Spheno-orbital meningioma.

INTRODUCTION

Meningiomas of the spheno-orbital area are a complicated kind of brain tumor characterized by hyperostosis of the sphenoid wing and direct involvement of the orbit [1, 2].

Previously, researchers classified these tumors as orbital secondary tumors, coming from the sphenoid wing bone's dura [2, 3, 4]. Furthermore, a particular periorbital component distinguishes these tumors, according to further pathological examination [5, 6]. In terms of the incidence of meningiomas, this place is regarded as the third most typical [7, 8, 9]. To tell them apart, SOM can be identified by the way they grow, which is based on radiographic features rather than histological features [1, 10, 11].

Sphenoid wing meningiomas may affect the cavernous sinus and the sella turcica [12, 13], with the potential to propagate and spread to other parts of the body. Secondary orbital cavity involvement may occur via the superior orbital fissure, the optic canal, or the bone [15, 16, 17, 18]. However, the path of tumor spread is still unknown in most cases of invasive tumors. We anticipate an intraorbital invasion in between 39 and 50% of sphenoid wing meningiomas [1, 7, 19]. At any given time, spheno-orbital localization is present in about nine percent of all cerebral meningiomas [20, 21].

There is a significant invasion of the orbit, accompanied by extensive bone infiltration. The degree of hyperostosis can occasionally be disproportionate to the size of the tumor or the soft tissue component, which is usually restricted. This can pose significant challenges for surgical procedures[5, 16, 22].

Effective excision has always been difficult due to the substantial involvement of the dura mater, bone, and orbit in SOM. This has resulted in a recurrence rate that may reach 35 to 50%. Studies have demonstrated that surgical intervention is not a feasible treatment for persistent tumor-associated proptosis, leading to the recommendation to steer clear of this condition [23-26]. As is the case with the majority of meningiomas, the majority of patients diagnosed with SOMs are females [7, 18, 26].

The chief symptoms that manifest themselves often include proptosis, vision impairment, and frequent retro-orbital pain [9, 18, 25]. Patients who are experiencing a recurrence of SOMs frequently have involvement of the optic nerve [1, 10, 11]. This study's objective was to investigate the outcomes of ten patients who had microsurgical resection procedure utilizing the pterional approach.

PATIENTS AND METHODS

Study design: We conducted retrospective research at the Department of Neurosurgery at Beni-Suef University Hospital on ten patients diagnosed with SOM between February 2021 and March 2023.

Exclusion criteria: Absence of proptosis. Patients with clinoidal meningiomas, cavernous sinus meningiomas with secondary orbital involvement, main optic nerve sheath meningiomas, and non-hyperostotic sphenoid wing meningiomas. In addition,

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recurrence that has been handled in the past using strategies other than pterional was not included.
The expansion of the soft tissue tumor into the orbit accompanied the hyperostosis and proptosis was observed in every examined patient.

Methods: We collected and analyzed the following data: patients' demographics, preoperative clinical state, radiographic evaluation, surgical technique, amount of resection, and clinical results. We performed preoperative magnetic resonance imaging (MRI) on each patient. We performed a computed tomography (CT) scan on each patient prior to the surgical procedure to determine the extent of bone involvement, the degree of hyperostosis, and the involvement of the orbital walls and infratemporal region.

Four kinds of orbital tumors were recognized based on their size and location (Table 1):

1- Lateral and superolateral (5 cases).
2- Medial and infero-medial (2 cases).
3- Orbital apex (2 cases).
4- Diffuse (1 case).
5- One out of the 10 cases was recurrent case.

Table (1): The tumor's extent and placement in the orbit.

Tumor's extent and placement in the orbit	Number
Lateral and superolateral	5
Medial and infero-medial	2
Orbital apex	2
Diffuse	1

The surgical technique: In terms of surgical technique, the sphenoid ridge was drilled using the traditional pterional method in every instance [27]. To make the reattachment process easier, a pterional craniotomy was performed as an initial treatment. This was followed by drilling of a portion of the orbital roof and the excision of the orbital rim using a Gigli saw in a beveled shape. Drilling was done on both the lateral orbital wall and the orbital roof in each instance. It also de-roofed the superior orbital fissure. A high-velocity drill was utilized to puncture every bone in the hyperostotic area. If the tumor was present during the surgery, extradural drilling of the anterior clinoid process was performed. A pterional craniotomy was done at first therapy to facilitate the reattachment process. Following this, a section of the orbital roof was drilled, and the orbital rim was removed using a beveled Gigli saw. In each case, the orbital roof and the lateral orbital wall were drilled. The superior orbital fissure was likewise de-roofed. Each bone in the hyperostotic region was punctured using a high-velocity drill. The anterior clinoid process was extradural drilled if the tumor was present during the procedure.

After the osseous treatment was completed, the dura mater was sliced, and the medial border of the mass, which contained the optic nerve and the carotid artery, was examined before the soft tissue component of the tumor was excised. The Simpson Grading System [28] was used to objectively evaluate the tumor excision. Following the full excision of the tumor, the most significant issue encountered during the closure phase was attaining the adequate hermetic dural closure and suturing. Because the orbital rim was retained in all cases, the drilled orbital roof and lateral wall were not restored.

Ethical consideration: The Neurosurgery Department Council of Beni-Suef University gave its approval. After receiving all of the information, each participant signed their permission. The Helsinki Declaration was followed throughout the course of the investigation.

Statistical analysis

The collected data were coded to improve data processing and then entered twice into Microsoft Access. The data were analyzed using SPSS Inc.'s SPSS software version 22.0 on Windows 7. Basic descriptive analysis of qualitative data was done utilizing numerical values and percentages, with arithmetic means used to quantify central tendency and standard deviations to analyze the dispersion of quantitative parametric data. P value ≤ 0.05 was considered significant.

RESULTS

Our research included 10 participants. All patients were females, with the exception of one instance, the age range spanned from 34 to 60 years, with a mean age of 45.4 years. Proptosis was the predominant clinical symptom, seen in all cases. Additionally, there were signs such as vision impairment in three cases, headache and retro-orbital discomfort in two individuals, and temporal fossa swelling in two instances. One example had restricted ocular mobility, while another patient experienced convulsions (Table 2).

Table (2): The clinical presentation.

Clinical presentation	Number of patients	Percentage %
Proptosis	10	100
Vision impairment	3	30
Headache and retro-orbital discomfort	2	20
Temporal fossa swelling	2	20
Restricted ocular mobility	1	10
Convulsions	1	10

Regarding orbital pathology and involvement, all patients showed hyperostosis on radiographic examination, with only four cases indicating tumor soft tissue extension into the orbit. Two cases showed involvement of the cavernous sinus. Degree of tumor excision: Intraoperative monitoring and postoperative CT or MRI tests indicated that a seemingly complete tumor excision was accomplished in five of ten patients. This group comprised four cases of Simpson grade I and one example of grade II, since it was challenging to precisely delineate the extent of the dural resection in some instances. Simpson grade III resection was achieved in three individuals, whereas grade IV was attained in two instances. The evaluation of tumor resection extent based on intraorbital site type indicated that an apparently full resection was accomplished in all lateral or superolateral lesions. Conversely, most diffuse orbital cancers had partial excisions. The superior orbital fissure was the most prevalent location of residual tumor in partial resections (Table 3).

Table (3): The degree of tumor removal based on Simpson grading.

Simpson grading	**Number of patients**	**Percentage %**
Grade 1	4	40
Grade 2	1	10
Grade 3	3	30
Grade 4	2	20

In seven instances, proptosis was completely resolved, two cases exhibited moderate improvement, and one case showed no change at the three-month postoperative follow-up. None of the patients exhibited enophthalmos throughout the follow-up period. Visual impairment improved in one out of three individuals with preoperative visual decline (Table 4).

Table (4): Fate of proptosis after 3 months from surgery

Degree of improvement	Number of patients	Percentage %
Complete improvement	7	70
Moderate improvement	2	20
No improvement	1	10

One patient had significant deterioration of visual acuity owing to traction from a tumor fragment that was highly adhered to the optic nerve.

One patient had conservative treatment for a postoperative cerebrospinal fluid (CSF) leak, whereas the second patient later experienced late postoperative hydrocephalus that required a ventriculoperitoneal shunt.

Three individuals had temporary ocular (V1) hyposthesia, which resolved within three months. Oculomotor nerve deficits were the most prevalent neurological complications in four individuals post-operatively, despite the cavernous sinus not being accessed, with three patients experienced remission within three months. The involvement of the trigeminal and oculomotor nerves may be resulted from the thermal and mechanical effects of drilling the hyperostotic lesser sphenoid wing and anterior clinoid.

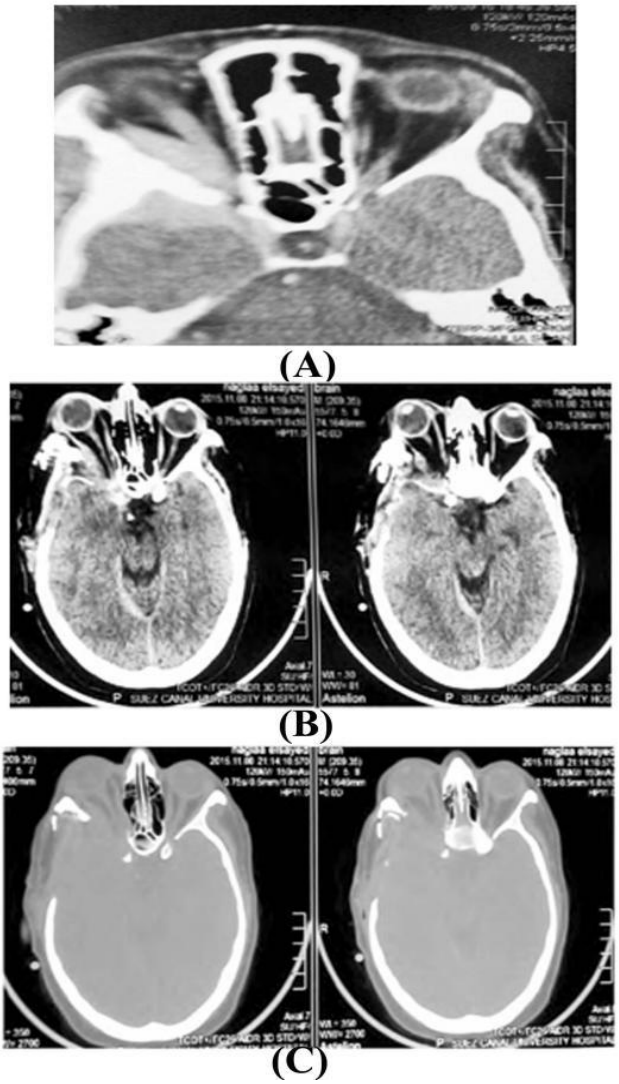

Figure (1): Axial CT film shows right superolateral SOM (A). Axial CT soft and bone window films showed extent of bony work and optic canal decompression (B and C).

DISCUSSION

Even though SOM with hyperostosis only account for 2–9% of meningiomas, they nonetheless make it difficult for neurosurgeons to do complete excision [1, 7]. Even though the tumor's soft tissue component is often minimal, complete excision is made more difficult by the hyperostotic bone's expansion into the orbit, possible invasion of the cavernous sinus, and extension into the infra-temporal area [12, 18, 26]. The primary difficulty is that the goal of surgery is not only to remove all of the soft tissue from the intracranial tumor, but also to remove hyperostotic

bone that contains meningioma cells in its Haversian canals, which represent a significant recurrence location [11, 23, 26]. Addressing the patients' proptosis and/or ocular problems is another crucial goal [15, 21]. Since the hyperostotic bone is frequently the source of the visual involvement, excision of the meningioma alone may not always be enough to accomplish this [19]. This usually happens when the optic foramen and/or optic canal narrow and the anterior clinoid is hyperostotic [22].

Several surgical techniques have been described for SOM resection. Fronto, orbito, zygomatic and pterional are the most well-known. We reviewed the literature on the small orbitozygomatic (OZ) method (modified OZ) and found no additional benefits from the orbital rim osteotomy. In cases of SOM, this is not required even if it does increase the vertical angle since the soft tissue component was minor and superficial, and the excision of the intra-orbital section may be accomplished without an orbital rim osteotomy [1, 8, 15].

Jesus and Toledo [4] found that drilling of the marginal tubercle without OZ craniotomy is enough to improve angles of exposure and getting direct access to the hyperostotic bone in the lower sphenoid and middle cranial fossa. **Oya *et al.*** [22] claimed that because the OZ method divides the orbital rim from the periorbita, it may result in enophthalmos. They claimed that if the periorbita was not separated from the orbital rim, there would be no need to recreate the orbit.

Optic nerve decompression was performed in all patients exhibiting visual problems as well as in a few chosen cases when the tumor was large and nearly completely removed. Drilling the optic canal's ceiling and lateral walls allowed for this. Toledo used frontotemporal craniectomy with orbital decompression for all their cases [8]. **Terrier *et al.*** [29] employed a frontotemporal technique with extradural excision of the invaded or hyperostotic bone using high-speed drills and rongeurs. **Oya *et al.*** [22] said that they were using the modified Dolenc approach with extradural bone drilling. In our series, all cases were done via pterional craniotomy with extradural bone drilling. **Sandalcioglu *et al.*** [30] did osteotomy of both upper and lateral orbital ridges to excise the lesion in 81.2% of their MEP cases.

The degree of SOM resection varies. The gross total resection in the investigations by **Schick *et al.*** [24] and **Mirone *et al.*** [4] reached 60 82%. Only 50% of cases with hyperostosis and 15% of patients with extension into the orbit had gross complete resection, according to previous studies like those reported by **Jaaskelainen *et al.*** [31].

In several studies, symptom alleviation was the primary objective of surgery instead of the complete and gross removal of the tumor. This was the case with **Ringel *et al.*** [32], where 60% of the sub-totally resected tumors remained stable whereas 24% of their patients had entire resection.

In our research, we were able to accomplish entire resection in 50% of instances, subtotal resection in 30% of cases, and partial resection in 20% of cases. Tumor tissue adhesion to the orbital musculature, infratemporal extension of the hyperostotic bone into the pterygoid plates, and soft tissue extension into the cavernous sinus were the primary factors limiting gross complete resection. Regarding the rebuilding of the drilled superior and lateral orbital walls following surgical excision of the tumor, the neurosurgical community is still divided. Reconstruction, according to several authors, is required to reduce the incidence of pulsatile exophthalmos. However, it is believed that such restoration is unnecessary if the orbital floor and orbital borders are not drilled out [24, 32].

Regarding our study, we didn't reconstruct the lateral wall or orbital roof. In all studies we reviewed, most of the patients were women [4, 12, 19]. We found the same regarding sex as all our patients were women except of one patient.

Li *et al.* [33] found that the mean age of MEP cases was 45.5 years. This is what we found in our series it was 45.4 years. The mean age was 48.3 years in a series of 37 patients studied by **Oya *et al.*** [22].

Li *et al.* [33] found that all cases in their series presented with proptosis and this is like what we found in our results. **Oya *et al.*** [22] found that five of his 39 patients did not have proptosis.

The research by **Jesus and Toledo** [4] found that out of six participants, two (or 33.3% of the total) had visual impairment.

Honeybul *et al.* [25] reported the same results. Five people out of fifteen (33.5%) showed a decrease in vision. Three of our patients (30%) showed signs of vision impairment, which is consistent with these results. In their study, **Oya *et al.*** [22] found that 53.8% of patients had obvious preoperative visual abnormalities. Among the MEP patients studied, headaches affected 24.3%, according to **Li *et al.*** [33], in our study two people, or 20% of the total sample size of ten, reported headaches and retro-orbital pain.

Jesus and Toledo [4] reported that 16% of patients had a headache. In their study, **Honeybul *et al.*** [25] found that 46.7% of the patients had headaches. **Parker *et al.*** [8] recorded one seizure episode among six MEP patients. Also in our study we had one case 10% complained from convulsions.

Matias *et al.* [34] found that 89% of their cases were of WHO grade 1 meningioma. In a study by **Sandalcioglu *et al.*** [30] they confirmed that all their cases were WHO grade 1. Histopathological examination of all specimens in our study revealed grade 1 meningiomas

Very important goal for surgery is to improve visual acuity. **Scarone *et al.*** [23] documented that visual symptoms improved in 85% of their patients. **Cannon *et al.*** [35] reported 16.6% improvement. **Oya *et al.*** [22]

achieved 66.7% improvement of visual acuity in their MEP patients and we got similar result as visual symptoms improved in one of our three patients with preoperative visual impairment

Following SOM resection, there are a variety of postoperative consequences as trigeminal damage, hemiplegia, ophthalmoplegia, facial numbness, hematomas, and deterioration of eyesight [13].

A ventriculo-peritoneal shunt was necessary to treat the late postoperative hydrocephalus that two of our patients had, whereas another patient experienced a postoperative CSF leak that was treated conservatively. In our study, three individuals experienced trigeminal nerve damage, which showed up as V1 distribution hypoesthesia. However, all of the cases were transient, and by three months after surgery, they had entirely recovered. Third nerve palsy was permanent in one case.

Visual deterioration has been reported in many literatures. In the study by **Honeybul *et al.*** [25] 26.6% of cases experienced visual deterioration after surgery. **Oya *et al.*** [22] reported no (0%) postoperative visual worsening in their MEP cases. In our series, one patient experienced severe visual deterioration.

We studied our patients for 15 months in relation to recurrence, with the exception of two cases tracked for 12 months. During the 24-month follow-up period, **Schick *et al.*** [24] recorded recurrence rate of 10.4%. In our series, there was no recurrence in the five cases that have been excised totally. One of our cases that has been done subtotally showed an increase in tumor size after 1year.

Jaaskelainen and colleagues [31] reported that the documented mortality rate following the excision of SOMs was approximately 6%. According to published research, the main cause of death is a vascular insult. We did not encounter any instances of mortality during our review. However, it is probable that we will identify reported incidents with a more extensive research group.

Follow-up was performed every three months for 15 months, and then annually after that, in all instances where complete resection was accomplished, including the hyperostotic bone. Instead of providing adjuvant radiation to patients with remaining hyperostotic bone, we decided to monitor them. Only when a tumor remains in the cavernous sinus are patients at our institution were sent for radiosurgery therapy among people in general who have WHO classifications II or III.

CONCLUSIONS

The removal of all available hyperostotic bone, excision of any intra-orbital soft tissue components, and adequate and careful drilling of the lateral and/or superior orbital walls are all important factors in the complete resection and regression of proptosis. Extending the hyperostosis into the inferior orbital walls, medial orbital walls, or infra-temporal fossa are factors that make complete excision challenging. Furthermore, tumor adhesion to the orbital muscles or expansion into the cavernous sinus are acknowledged obstacles to complete excision. When complete excision of the tumor is not feasible, the primary goal of surgery is still to cure the proptosis by decompressing the optic nerve and the hyperostotic orbital walls.

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