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Optimizing the pterional approach in medial sphenoid wing meningioma: a detailed morphometric study on anterior clinoidectomy and its effect on operability score

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Abstract

Background Medial sphenoid wing meningiomas are best treated through pterional craniotomy, as pterional craniotomy provides wide and multidirectional exposure of the anterior and middle cranial fossa. Anterior clinoidectomy can increase the exposure potential. To delineate the role of anterior clinoidectomy (AC) in the standard pterional craniotomy approach through the evaluation of operability score measures (manoeuvrability arc, depth of surgical field, and surgical angle of attack). All patients with inner sphenoidal wing meningioma who underwent microsurgical excision between February 2022 and October 2023 were enrolled in the study. Preoperative and postoperative imaging studies (MR contrast studies and 3D thin-slice CT scans of the brain) were performed to determine the tumour size, extent, and pattern of optic canal involvement by comparing pre- and postoperative operability score parameters.

Results Twenty-five patients met our inclusion criteria: 2 males (8%) and 23 females (92%). The mean age (SD) was 49.08 ± 6.42 years, with an age range of 39–60 years. The preoperative visual manifestations were as follows: eight patients (32%) had mild visual impairment, five patients (20%) had moderate visual impairment, six patients (24%) had severe visual impairment, and five patients (20%) had blindness. There was a significant positive correlation between the operability score and extent of resection (gross total resection was correlated with a higher operability score) ($r = 0.301$, $n = 25$, $p = 0.005$).

Conclusions A well-planned manoeuvrable arc allows neurosurgeons to perform surgery with precision, ultimately impacting surgical outcomes and the potential for complete tumour removal with minimal patient morbidity.

Keywords Operability score, Pterional, Optic, Sphenoid wing meningioma

Background

Sphenoid ridge meningiomas account for 14% of all meningiomas, with a higher incidence in females. These tumours can be categorized as either medial, originating from the medial third (including the anterior clinoid), or lateral, arising from the lateral two-thirds of the ridge. Invasive meningiomas can lead to hyperostosis, extending around the pterional territory and sometimes infiltrating the entire region up to the midline of the skull base, known as "en plaque" [1, 2].

Microsurgical excision of these tumours is challenging due to their proximity to critical neurovascular structures such as the internal carotid artery (ICA), middle cerebral artery (MCA), and optic nerve. Addressing the mass effect and optic nerve compression requires precise dissection and decompression [3].

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In Egypt, there are limited statistical data on the prevalence of sphenoid ridge meningiomas, although a significant number of patients are treated each month. However, the lack of precise patient numbers and limited resources, such as neurophysiological monitoring and neuronavigation, pose potential risks to surgical outcomes. Surgeons often opt for pterional craniotomy to provide broad and multidirectional exposure of the anterior and middle cranial fossa. This approach has been modified to address lesion-specific challenges and reduce surgical complications. Previous modifications have involved less bone removal and specific approaches to lesions, with anterior clinoidectomy (AC) being performed when additional access is needed. Various techniques for anterior clinoidectomy have been utilized to enhance manoeuvrability, the angle of attack, and the depth of field during pterional craniotomy, reducing the need for brain retraction [4, 5].

Surgical morphometric parameters, including the manoeuvrability arc (MAC), depth of the surgical field (SF), and surgical angle of attack (SAA), play a crucial role in determining the feasibility and safety of the standard pterional approach. These measurements are essential for selecting the most appropriate surgical approach for optimal safety and efficacy [6].

Our study aimed to delineate the role of anterior clinoidectomy (AC) in optimizing the pterional approach for the surgical management of inner sphenoidal wing meningioma through the evaluation of operability score parameters, including the manoeuvrability arc, depth of surgical field, and surgical angle of attack, via the standard pterional approach.

Methods

Patient population and study design: this single-centre retrospective cohort study was conducted at our tertiary centre and included all patients with sphenoidal wing meningioma who underwent microsurgical excision between February 2022 and October 2023.

The inclusion criteria were patients over 18 years of age with a confirmed radiological diagnosis of inner sphenoid wing meningioma (ISWM) and evident optic nerve compression, as well as postoperative radiographic measurements of frontotemporal craniotomy (FTC) between 25 and 30 cm^3. The exclusion criteria included patients with other parasellar lesions and FTC sizes outside the 25–30 cm^3 range.

The research being a retrospective in type; patients' data were retrieved from medical record following IRB approval and so there is no human subjects participated in the research.

Preoperative visual assessments were conducted by an independent ophthalmologist, with visual acuity assessment as the dependent variable. Visual field and fundus examinations were used for pre- and postoperative evaluations. Postoperative CT scans with 3D reconstruction were reviewed for patients who underwent craniotomy and microsurgical excision of the ISWM, with only patients within the 25–30 cm^3 FTC range selected for further analysis of operability score parameters. Radiological evidence of AC was reassessed in the selected patient group, further subclassifying them into those with the pterional approach with anterior clinoidectomy (PAAC+) and those without (PAAC−).

DICOM viewer software was utilized to measure the size of the craniotomy using the 3D module. Subsequent measurements of the SF, MAC, and SAA were taken using both soft and bone windows, focussing on the ipsilateral optic nerve as the region of interest.

The extent of microsurgical resection (EOR) was evaluated using the Simpson grading scale [7]. Grades I and II were considered gross total resection (GTR), while grades III and IV were classified as subtotal resection (STR). The visual assessment data were analysed and appropriate statistical methods were applied to correlate AC as an independent categorical variable with EOR and optic nerve decompression as dependent continuous numerical variables.

Initial patient data including age, sex, occupation, history of medical or surgical problems, and presenting symptoms, were collected during full history taking. Neurological assessment involved a thorough examination of each patient for cranial nerve deficits and other neurological impairments preoperatively. Preoperative and postoperative imaging studies, such as MR contrast studies and 3D thin-slice CT models of the patient's cranial anatomy, were conducted to determine the tumour size, extent, and pattern of optic canal involvement. This allows the surgical team to simulate different approaches and anticipate potential obstacles, as well as perform morphometric analysis of the approach, including manoeuvrability arc, depth of surgical field, and surgical angle of attack.

Grading surgical difficulty and optimizing preoperative planning were made possible by assigning a numerical score (operability score) to each variable within the classic pterional approach, considering the anterior clinoid process (ACP) and optic nerve as the target (Figure 1). According to Table 1, the operability score method involves giving each variable a value of 0 or 1 [8].

A full ophthalmological assessment, including visual acuity, visual field testing, ocular motility, and fundoscopy, were conducted preoperatively and postoperatively. Intraoperative strategy and data involved microsurgical techniques utilizing an operative microscope and micro

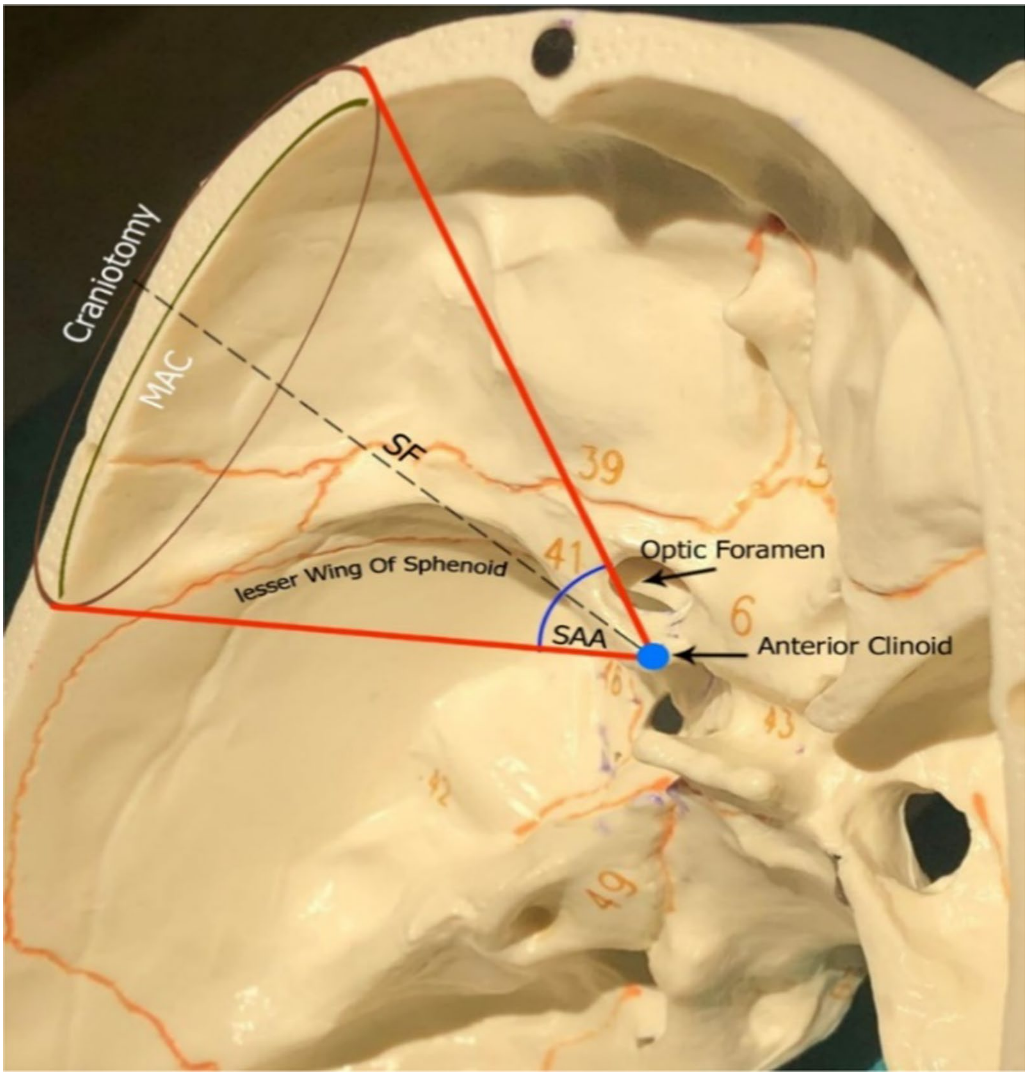

Figure 1 Schematic illustration of the skull model describing pterional approach craniotomy with the anterior clinoid as a target point and measurement of operability score parameters (MAC, SAA, and SF)

Table 1 System of the OS variables for the pterional approach

Variables	Score 0	Score 1
Depth of the surgical field (SF)	> 5 cm	≤ 5 cm
Surgical angle of attack (SAA)	< 60°	≥ 60°
Manoeuvrability arc (MAC)	< 45°	≥ 45°

SF depth of the surgical field, *SAA* surgical angle of attack, *MAC* Manoeuvrability arc

instruments to enhance visualization and precision within the defined manoeuvrability parameters.

Surgical procedure: "The standard pterional approach" was in all cases. The patient was placed in the supine position with the knees flexed and the head of the table elevated approximately 15–20°. The head was immobilized in a skull clamp, turned (20–45°) away from the side of the approach, and moderately hyperextended to allow the frontal lobes to fall away from the floor of the anterior cranial fossa. This position facilitates gravity-assisted retraction of the brain. A curvilinear skin incision was made starting above the zygoma and extending just behind the hairline, following the contour of the temporalis muscle. The muscle was mobilized as anteroinferiorly as possible to reveal the pterion. A bone flap was created using a high-speed drill, usually outlining the sylvian fissure, which is generally at the pterion. The anteromedial aspect of the craniotomy may violate the frontal sinus, so this bony area should be carefully inspected. A high-speed drill was used for the removal of hyperostotic bone from the lesser and greater sphenoid wings (Figure 2).

Good exposure of the lateral wall of the orbit and the anteroinferior part of the greater sphenoid wing was achieved. Then, the remaining part of the bone was elevated. Drilling of the pathological bone of the sphenoid wings and roof of the orbit continued. The optic canal was opened to decompress the optic nerve, and if there was orbital infiltration, the tumour in the orbit was followed and removed. Anterior clinoidectomy and removal of the bony optic canal was performed extradurally and the falciform ligament was opened using a high-speed diamond-burr microdrill (Figure 3).

Unlocking the superior orbital fissure and cutting the meningo-orbital band allowed better exposure of the anterolateral skull base. Dissection and decompression of the optic apparatus involved tumour exposure and removal of the intradural part of the tumour, devascularization, internal debulking, and resection. Brain retraction can be avoided with adequate brain relaxation, which is achieved by partial drainage of cerebrospinal fluid (CSF) through a lumbar catheter or through an opening made in the arachnoid cisterns. A pericranium dural graft was used to close the dura with the aid of fibrin glue in some cases.

The collected data were analysed using the Statistical Package for Social Science (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0 Armonk, NY: IBM Corp.). Pearson's product moment correlation coefficient is a measure of the linear relationship between two variables that have been measured on interval or ratio scales. A p value < 0.05 was considered to indicate statistical significance.

Results

There were 25 patients who met our inclusion criteria: 2 males (8%) and 23 females (92%). The mean age (± SD) was 49.08 ± 6.42 years, with an age range of 39–60 years. All patients with medial sphenoidal wing meningioma underwent radiological evaluation to delineate the tumour-optic relationship and tumour extension. The tumour was confined to the sphenoid wing with no extension in 14 patients, extended to the lateral orbital wall in three patients, extended to the middle cranial fossa in three patients, and extended into both the extraconal and intraconal regions in two patients, and only one patient had extension into either the intraorbital and middle cranial fossa or infratemporal fossa or extraconal region.

The surgical approach used in all patients was the standard pterional approach (fronto-temporal

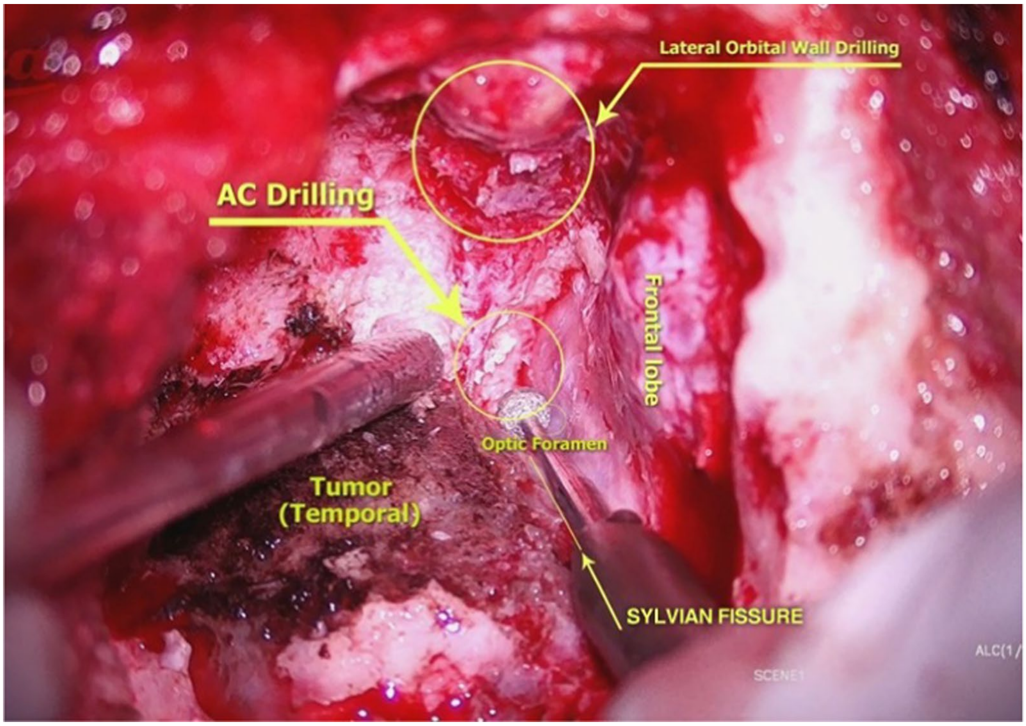

Figure 2 Intraoperative photo during the pterional approach demonstrating AC drilling and exposure of the optic foramen, lateral orbital wall, frontal lobe and tumour

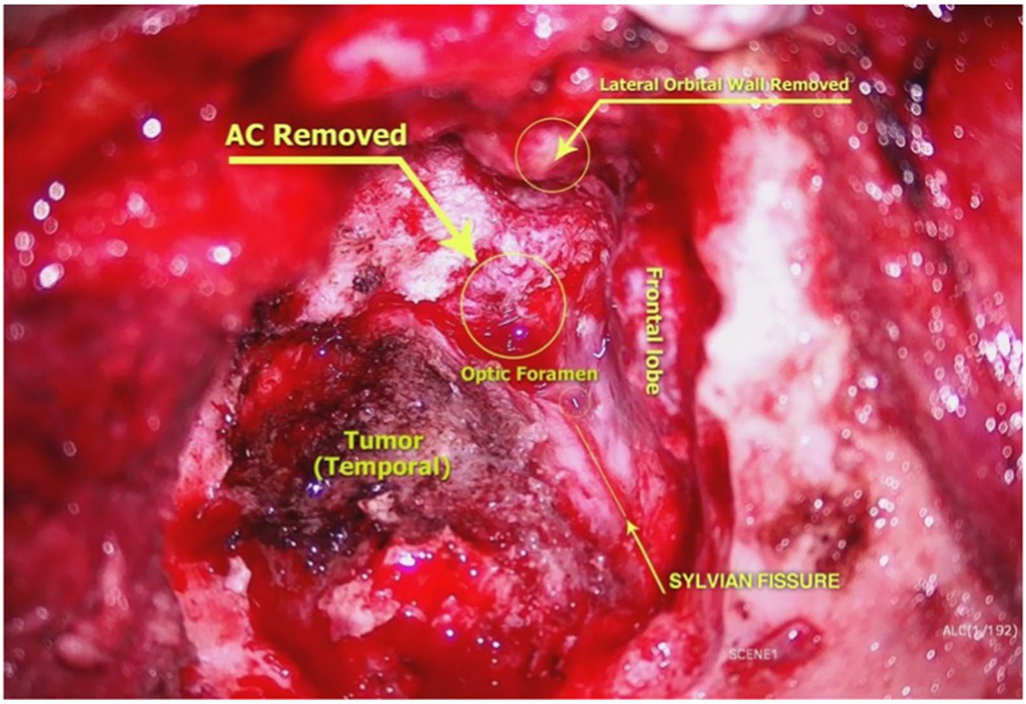

Figure 3 Intraoperative photo during the pterional approach demonstrating AC removal, optic foramen exposure, lateral orbital wall removal, frontal lobe and tumour

craniotomy). The patients were then subclassified into two groups (11 patients with PAAC+ and 14 patients with PAAC−) (Table 2).

The preoperative visual presentation of the patients in the studied group was stratified according to the World Health Organization report on vision [9] and included eight patients (32%) with visual impairment category 0 (no or mild), five patients (20%) with category 1 (moderate), six patients (24%) with category 2 (severe), five patients (20%) with category 3 (blindness), and only one patient (4%) with category 4 (blindness) (Table 3).

Postoperative radiological evaluation of surgical outcomes revealed that 19 patients (76%) underwent gross total resection (GTR) and 6 patients (24%) underwent subtotal resection (STR). Postoperative complications were encountered in the whole sample and included incomplete ophthalmoplegia in six patients, CSF collection in one patient, CSF leakage in one patient, visual deterioration in one patient, and wound infection in one patient.

The depth of the surgical field (SF) in the PAAC+ group (mean 41.94 mm; SD 6.77 mm) and in the PAAC− group (mean 54.27 mm; SD 6.77 mm). Differences in SF were found to reach statistical significance (*p* value 0.03). The MAC was greater in the PAAC+ group (mean 49.41°; SD 6.82°) than in the PAAC− group (mean 37.01°; SD 3.56°). Differences in MACs were found to reach statistical significance (*p* value 0.04). The SAA in the present study was calculated considering the anterior clinoid process (ACP) as the target point. SAA was greater in the PAAC+ group (mean 90.30°; SD 16.18°) than in the PAAC− group (mean 36.68°; SD 4.67°). Differences in SAAs were found to reach a strong statistical significance (*p* value of 0.01), reflecting an actual advantage in the PAAC+ group. The mean SF, MAC and SAA values are reported in Table 4.

According to the OS, the manoeuvrability area (MA) is considered the cross-sectional area of the surgical corridor at its narrowest point; in the pterional approach, it corresponds to the surgical window defined by the optic nerve and ICA, which is the working channel towards the optico-carotid cistern. For SF, the assigned score was 0 if the SF was greater than 5 cm and 1 if it was less than 5 cm. For MAC, a calculated value of more than 45° was assigned a score of 1, and for those calculated of less than 45°, the assigned score was 0. For an SAA wider than 60°, the assigned score was 1, and for an SAA less than 60°, the assigned score was 0. The sum of the three scores assigned to the single variables calculated for both single variants corresponded to the overall OS. OS ranges from a minimum of 0 to a maximum of 3. Table 5 shows the different geometrical parameters of the operability score measured in the study group. Figures 4, 5 show the measurements of the operability score parameters for PAAC+ and PAAC−.

Table 2 Demographics, lesion criteria, and surgical parameters of the studied patients

	Patients ($n = 25$)
Age (years)	Mean ± SD: 49.08 ± 6.42 years; range: 39–60 years
Sex	
• Male	2 (8%)
• Female	23 (92%)
Lesion extension	
• No extension	14
• Lateral orbital wall	3
• Extraconal + intraconal	2
• Middle cranial fossa	3
• Intraorbital + middle cranial fossa	1
• Infratemporal fossa	1
• Extraconal	1
Surgical approach	
• Anterior clinoidectomy	11
• No anterior clinoidectomy	14
Surgical outcome (extent of resection)	
• Gross total resection	19
• Subtotal resection	6
Complications	
• CSF collection	1
• CSF leak	1
• Wound infection	1
• Visual deterioration	1
• Incomplete ophthalmoplegia	2
• No complications	19

Numerical data was expressed by using mean ± SD. (SE), non-numerical data was expressed by using no. (%)

Pearson product–moment correlation was performed to determine the relationship between surgical outcome (extent of resection) and the operability score for the pterional approach used for the excision of inner sphenoid wing meningioma (ISWM). There was a significant positive correlation between the operability score and extent of resection (gross total resection was correlated with a higher operability score) ($r = 0.301$, $p = 0.005$) (Table 6).

There was a strong, positive correlation between the operability score and the PAAC+ group rather than the PAAC− group, as the PAAC+ group was significantly correlated with a higher operability score ($r = 0.938$, $p = 0.005$) (Table 7).

Regarding the relationship between visual outcome and OS in both the PAAC+ and PAAC− groups, of the 13 patients who experienced visual improvement, 8 were in the PAAC+ group (OS 3 in 7 patients and OS 2 in 1 patient). Five patients were in the PAAC group (OS1 in two patients, OS2 in two patients, and OS3 in one patient). Eleven patients did not improve and had a stationary course; 9 of them had an OS of zero (one patient in the PAAC+ group), and two had an OS of 1 (all in the PAAC+ group). Unfortunately, only one patient deteriorated (with an OS of zero and a decrease in the PAAC− group) (Table 8).

Table 9 shows the detailed visual outcomes stratified according to preoperative visual status categories correlated with the approach used (whether PAAC+ or PAAC−) and postoperative visual status.

Discussion

Surgery for medial sphenoid wing meningioma involving optico-carotid compression remains a challenge for modern neurosurgery due to the difficulty of surgical exposure and the need for a selective approach related to skull base demolition.

Skull base tumours can be approached from many different trajectories. Proper selection of the optimum approach for a specific lesion is a matter of debate in neurosurgery, initiating the main drive of research in the field to develop variable approaches aimed at ensuring the safety and efficacy of the surgeon's manoeuvres.

Advances in skull base surgery, extensive microsurgical anatomical orientation, and the development of innovative surgical instruments and radiological tools have led to the rapid development of modern microscopes and

Table 3 Preoperative visual presentation of the studied group

Category	**Visual impairment**	**Presenting visual acuity**		**The affected eye**
		Worse than	**Better than**	
0	No or mild		6/18	8 (32%)
1	Moderate	6/18	6/60	5 (20%)
2	Severe	6/60	3/60	6 (24%)
3	Blindness	3/60	1/60	5 (20%)
4	Blindness	1/60 with light perception		1 (4%)
5	Blindness	Irreversible blindness with no light perception		0 (0%)

Table 4 Variables of the operability score calculated for patients who did or did not undergo anterior clinoidectomy

	PAAC+	PAAC−	*P* value
SF			
Mean	41.94 mm	54.27 mm	0.03
Range	34–55 mm	39–66 mm	
SD	6.77 mm	6.77 mm	
SAA			
Mean	90.30°	36.68°	0.01
Range	55–120°	30–44°	
SD	16.18°	4.67°	
MAC			
Mean	49.41°	37.01°	0.04
Range	45–66°	30–43°	
SD	6.82°	3.56°	

PAAC+ pterional approach with anterior clinoidectomy, *PAAC−* pterional approach without anterior clinoidectomy, *AC* anterior clinoidectomy, *MAC* manoeuvrability arc, *SAA* surgical angle of attack, *SD* standard deviation, *SF* depth of the surgical field

Table 5 Operability score parameters in the studied group

Patient	PAAC+	SAA (°)	MAC (°)	SF (mm)	OS
1	Yes	84.21	47.54	50.42	2
2	Yes	90.23	66.33	35.54	3
3	Yes	81.94	45.22	34.31	3
4	No	38.99	35.75	55.32	0
5	No	44.32	40.25	48.67	1
6	No	37.25	39.63	49.89	1
7	Yes	65.63	46.43	55.66	2
8	No	30.51	30.52	54.55	0
9	No	40.13	35.34	55.33	0
10	Yes	70.82	47.22	36.46	3
11	Yes	92.56	45.15	34.87	3
12	Yes	106.52	45.56	40.22	3
13	No	38.93	35.45	45.11	1
14	No	30.45	32.31	56.16	0
15	No	37.62	37.23	66.33	0
16	Yes	95.27	55.22	41.45	3
17	Yes	80.32	46.76	43.36	3
18	No	31.93	36.12	60.51	0
19	No	30.15	35.15	55.67	0
20	No	38.46	40.52	39.34	1
21	No	32.54	41.34	57.33	0
22	No	40.78	43.22	60.34	0
23	Yes	105.64	49.63	45.38	2
24	Yes	120.26	48.53	43.75	3
25	No	41.53	35.31	55.24	0

PAAC+ pterional approach with anterior clinoidectomy, *SAA* surgical angle of attack, *MAC* manoeuvrability arc, *SF* depth of surgical failure, *OS* operability score

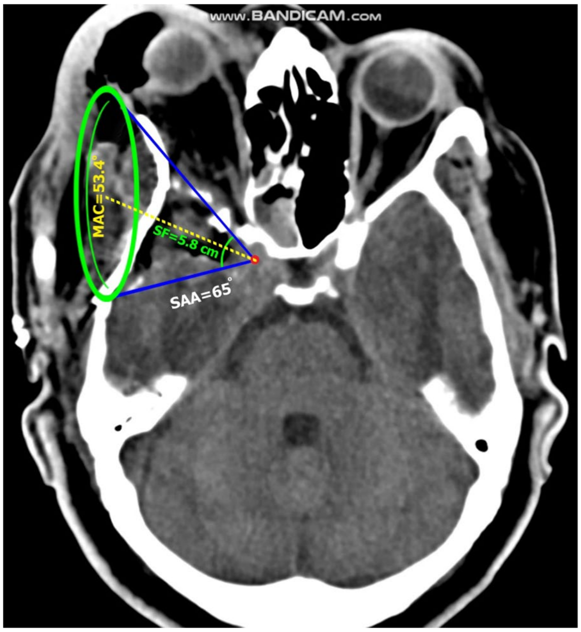

Figure 4 Postoperative non-contrast CT scan of the pterional approach with anterior clinoidectomy "PAAC+", showing measurements of operability score parameters (MAC, SAA, SF)

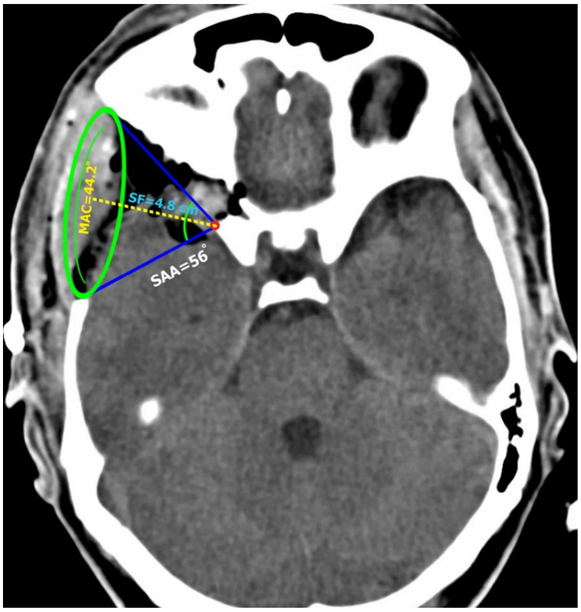

Figure 5 Postoperative non-contrast CT scan of the pterional approach without anterior clinoidectomy "PAAC−", showing measurements of operability score parameters (MAC, SAA, SF)

endoscopes. These changes have paved the way from more invasive and destructive to minimally invasive selected approaches according to careful preoperative planning [1].

Table 6 Correlations between the surgical score and extent of resection

OS	GTR	STR	Total	Test of significance
0	6	4	10	$r=0.301$ $p=0.005$*
1	3	1	4	
2	3	0	3	
3	7	1	8	
	76%	24%		

OS operability score, *GTR* gross total resection, *STR* subtotal resection, *n* number of patients, *p p* value, *r* Spearman correlation coefficient

*Statistically significant

Table 7 Correlation between anterior clinoidectomy and the operability score

OS	PAAC+	PAAC−	Test of significance
0	0	10	$r=0.938$ $p=0.005$*
1	0	4	
2	3	0	
3	8	0	

OS operability score, *PAAC+* pterional approach with anterior clinoidectomy, *PAAC−* pterional approach without anterior clinoidectomy, *n* number of patients, *p p* value, *r* Spearman correlation coefficient

*Statistically significant

Table 8 Correlations between the operability score and visual outcome

OS	No.	Improved	Stationary	Deteriorated	Test of significance
0	10	0	9	1	$r=0.748$ $p=0.005$*
1	4	2	2	0	
2	3	3	0	0	
3	8	8	0	0	
		13	11	1	

OS operability score, *n* number of patients, *p p* value, *r* Spearman correlation coefficient

*Statistically significant

The concept of operability has been thoroughly analysed in the literature and was first described by Yasargil et al. The qualitative assessment of tumour operability depends on three variables: patient variables (age, general and clinical conditions, previous treatment), lesion variables (location and number of lesions, composition, size, vascularization), tumour characteristics (growth pattern, benign/malignant lesion, oedema, presence of hydrocephalus), and surgeon variables (surgeons' personal skills). Yasargil further clarified that tumour operability was greatly increased in the pterional approach by sphenoid wing drilling, resulting in significant implementation of the surgical cone [8, 10].

The concept of the working cone was first presented by Sindou et al. when approaching central skull base lesions. It offers multiangle visualization of the selected target according to its anatomical location, morphology, and neurovascular and clinical characteristics [11]. These ideas were expanded upon by Gonzalez et al. who defined operability as the capacity to carry out surgical procedures on a specified area [6].

Filipce et al. used an endoscope and a microscope to examine the extent of the working area and concluded that endoscope-assisted microscopic approaches were the best way to look around corners and guarantee an optimal 3D view [12]. Salma et al. [13] proposed a qualitative scoring system to compare the exposure obtained by pterional and supraorbital craniotomy.

As first described by Gagliardi and colleagues the concept of the operability score (OS) summarizes all the analysed variables mentioned above by applying geometrical concepts in the surgical preoperative evaluation of the lesion. These key geometrical points are easy to apply and include the depth of the surgical field (SF), which represents the length of the major axis of the surgical corridor. It is assessed by measuring the distance between the manoeuvrability area and the target. The surgical angle of attack (SAA) corresponds to the angle of incidence of the surgical corridor towards an area of interest. The wider the angle is, the more comfortable the approach. The manoeuvrability arc (MAC) consists of the maximal degree of manoeuvrability of surgical instruments around a target and is intrinsically influenced by the width of the surgical cone [8, 14].

A morphometric analysis of OS parameters likely involves the use of preoperative imaging to measure these parameters for surgical planning. This helps in understanding the spatial relationships and confines within which the surgeon will work, leading to safer and more effective tumour resection. In neurosurgery, the concept of a manoeuvrability arc refers to the range of motion allowed for surgical instruments within the confines of the surgical field. The manoeuvrability arc is crucial because it dictates how freely the surgeon can move and manipulate instruments to reach the target point while minimizing disruption to surrounding structures.

When approaching an inner sphenoid wing meningioma, which is intimately related to the critical neurovascular bundle (optico-carotid), the manoeuvrability arc becomes especially important. The arc must be wide enough to provide the surgeon not only with visual access but also with the ability to use various tools safely and effectively, such as scalpels for cutting, suction devices

Table 9 Correlations between visual outcome and preoperative visual status and AC

Category	Visual impairment	The affected eye	PAAC+	Visual outcome					
				Improved		Stationary		Deteriorated	
				PAAC+	PAAC−	PAAC+	PAAC−	PAAC+	PAAC−
0	No or mild	8	4	4	1	0	3	0	0
1	Moderate	5	2	2	1	0	2	0	0
2	Severe	6	1	1	3	0	2	0	0
3	Blindness	5	3	1	0	2	1	0	1
4	Blindness	1	1	0	0	1	0	0	0
5	Blindness	0	0	0	0	0	0	0	0
Total		25	11	8	5	3	8	0	1

PAAC+ pterional approach with anterior clinoidectomy, *PAAC−* pterional approach without anterior clinoidectomy

for removing blood and CSF and instruments for dissecting tumour tissue [2, 3, 15].

A well-planned manoeuvrability arc allows the surgeon to optimize the angle of attack on the meningioma, facilitating complete resection where possible and reducing the risk of intraoperative complications [5, 13].

The pterional approach is the most common approach used for surgery for inner sphenoid wing meningioma. The pterional approach may sometimes be combined with anterior clinoidectomy, which involves removing the anterior clinoid process, to improve the manoeuvrability arc and allow for better access to the meningioma [5, 16].

Authors have already described the pterional approach technique with or without AC variants to approach the ISWM, postulating the role of the AC in increasing the operability and visualization of the opticocarotid bundle [16].

In the present study, the authors comparatively analysed both variants of the pterional approach to define the putative actual advantage provided by the AC in performing a frontotemporal approach to the medial sphenoid wing region. In our study, of the 25 patients, 11 PAAC− patients had an OS of zero, 3 had an OS of 1, and none of the remaining patients had an OS of 2 or 3, in contrast to the PAAC− patients. None of the patients had an OS of zero or 1, 8 patients had an OS of 3, and 3 had an OS of 2, reflecting a better operability score in patients with ISWM when a standard frontotemporal craniotomy was performed combined with anterior clinoidectomy.

The mean depth of the surgical field (SF) was 41.94 mm in the PAAC+ group and 54.27 mm in the PAAC− group (+6.77 mm). Better operability scores (OS 2, OS 3) could be achieved with a lower depth of the surgical corridor owing to the feasibility of manipulation and minimizing the effect of blurring with overmagnification.

SAA was greater in the PAAC+ group (mean 90.30°; SD 16.18°) than in the PAAC− group (mean 36.68°; SD 4.67°). Our results showed that anterior clinoidectomy offers better exposure to the opticocarotid apparatus, thus widening the surgical angle of attack (*p* value 0.01). Obtaining a wider SAA resulted in a better operability score.

In our study, we found that maximal degrees of manoeuvrability of surgical instruments around a target and better manipulation of microinstruments were correlated with better operability score results (OS 2, 3). This principle was measured using the manoeuvrability arc (MAC), which is influenced by the width of the surgical corridor. Our results showed that the MAC was greater in the PAAC+ group (mean 49.41°; SD 6.82°) than in the PAAC− group (mean 37.01°; SD 3.56°), reflecting the ease and feasibility of manipulation among the PAAC+ group.

GTR was achieved in 7 out of 8 patients with an OS of 3, 3 of which had an OS of 2, and 3 out of 4 with an OS of 1, while STR was achieved in 4 out of 10 patients who underwent STR of the tumour, indicating the feasibility of resection and the ability to achieve GTR with higher OS values.

In terms of visual improvement as an indicator for adequate optic nerve decompression, all patients with OS 3 and OS 2 showed improvement in visual outcome compared to OS 1, which showed a 50% improvement. Nine out of the 10 patients with an OS of zero showed a stationary course, reflecting the ease of access and manoeuvrability associated with higher OS values. The three patients in the PAAC+ group who did not improve and had a stationary course despite two of them having an OS of 2 can be explained by longstanding compression leading to ischaemic changes in the optic nerve [17, 18].

Limitations

Our study has several limitations, including its retrospective nature. The study only analysed a single approach with one variable (AC or not), and it did not compare two different approaches for the same lesion (target point). As the study was retrospective, surgeries were performed by many surgeons with different levels of surgical expertise, which may have affected the extent of resection of the tumour.

Conclusion

This morphometric study provides a detailed analysis of the impact of anterior clinoidectomy on the pterional approach for medial sphenoid wing meningiomas. Our results suggest that anterior clinoidectomy, while technically demanding, can significantly enhance surgical exposure and improve the overall operability score in these challenging cases.

Anterior clinoidectomy has many advantages when added to pterional approach:

- Wider operative corridors: this allows for better visualization and manipulation of instruments, particularly in the optico-carotid region.
- Improved trajectory for tumour resection: this is especially crucial for tumours with medial or superior extension towards critical neurovascular structures.
- Reduced brain retraction: minimizing brain retraction potentially leads to fewer postoperative complications.
- Improve total operability score.
- Facilitate achieving optic nerve decompression

However, the decision to perform an anterior clinoidectomy should be made on a case-by-case basis, carefully weighing the potential benefits against the inherent risks associated with this procedure. Factors such as tumour size, location, and relationship to surrounding structures should be meticulously evaluated.

Further studies with larger patient cohorts and long-term follow-up are warranted to validate these results and establish standardized guidelines for incorporating anterior clinoidectomy in the surgical management of medial sphenoid wing meningiomas.

Abbreviations

SD	Standard deviation
AC	Anterior clinoidectomy
ISWM	Inner sphenoid wing meningioma
ICA	Internal carotid artery
MCA	Middle cerebral artery
FTC	Frontotemporal craniotomy
EOR	Extent of resection
ACP	Anterior clinoid process
CSF	Cerebrospinal fluid
SAA	Surgical angle of attack
SF	Depth of surgical field
OS	Operability score
MAC	Manoeuvrability arc
CF	Counting finger
HM	Hand movement
PL	Perception of light
STR	Subtotal resection
GTR	Gross total resection
PAAC+	Pterional approach with anterior clinoidectomy
PAAC−	Pterional approach without anterior clinoidectomy

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Author contributions

The corresponding author (MS) on behalf of all co-authors certify that all co-authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by MS, AM, AS, AAM, MO. The first draft of the manuscript was written by MS, AAM, AS, MO and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The research protocol was approved by the ethical Committee "Mansoura Faculty of Medicine Institutional Review Board", the committee's date (Jan 13th, 2024), and reference number (R.24.05.2643). The research being a retrospective in type; patients' data were retrieved from medical record following IRB approval and so there is no human subjects participated in the research.

Consent for publication

Not applicable.

Competing interests

The corresponding author (MS) on behalf of all co-authors certify that they have no affiliation with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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