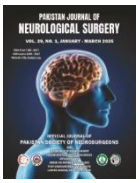

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Original Research

Institutional Experience of Microsurgical Clipping for Anterior Circulation Aneurysms with Mini Pterional Craniotomy: A Cosmetic and Pivotal Innovation

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ABSTRACT

Objective: To examine the functional outcome, complications, and aesthetic results with the mini pterional craniotomy for microsurgical clipping for anterior circulation aneurysms.

Material & Methods: This study was conducted at Neurosurgery Unit II of Punjab Institute of Neurosciences Lahore by a single neurosurgical team with 10 years of experience in vascular neurosurgery. A total of 107 patients who fulfilled the inclusion criteria were included in the study. Mini pterional craniotomy was performed in all the selected patients. Data was analyzed for age, gender, location of the aneurysm, and Modified World Federation of Neurological Surgery grade (WFNS) (pre-op, post-op at 3 months). Data was also analyzed for post-op complications along with a subjective assessment of wound scars by patients according to a modified cosmesis scale.

Results: Out of the total 107 patients, 64 (59.8%) were female while 43 (40.2%) were male. Aneurysm was located at the anterior communicating artery in 58 (54.2%) patients and at MCA in 39 (36.4%). The pre-op WFNS grade was 1 in 52 (48.5%) patients and grade 2 in 25 (23.3%) patients. The WFNS grade recorded at 3-month post-op follow-up was grade 1 in 66 (61.6%) patients and grade 2 in 11 (10.2%) patients. Seven (6.5%) patients developed hydrocephalus, 5 (4.6%) got meningitis and 4 (3.7%) developed neurological deficits.

Conclusion: Mini pterional craniotomy has proven itself as a safe and effective surgical procedure. It can be applied to a variety of aneurysmal locations and has a low rate of complications and good outcomes.

Keywords: Mini-pterional craniotomy, Temporalis muscle atrophy, Aneurysm, WFNS grading scale, Modified Cosmesis scale.

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INTRODUCTION

A cerebral aneurysm is a dilatation arising from a weakened area in the wall of an artery in the brain.[1] Anterior communicating artery (ACoA) is the most common location of the anterior cerebral circulation followed by the peripheral portion (A2) of the anterior cerebral artery. Aneurysmal walls hold little supporting connective tissue, this predisposes these vessels to the development of aneurysms. Aneurysms frequently arise in areas where there is a curve in the parent artery, in the angle between it and a branching artery.[2]

The apex of branch points which endure the maximum hemodynamic stress in a vessel are the usual locations of saccular aneurysms on major cerebral arteries. 85-95% of aneurysms occur in the carotid system, with the following 3 most common locations; ACoA: 30%, PComA: 25%, and middle cerebral artery (MCA): 20%. 5-15% of aneurysms occur in the posterior circulation. The most common presentation is a rupture in the subarachnoid space.

The optimal treatment for an aneurysm depends on multiple factors, some are related to the patient and some are related to the health facility and surgeon such as patient age and comorbidities, anatomy of aneurysm, and associated vasculature, the ability of the surgeon and the availability of treatment options. The surgical gold standard is microsurgical clipping, where a surgical clip is placed across the neck of the aneurysm to exclude the aneurysm from circulation without occluding normal vessels.[4]

The pterional craniotomy, modified pterional craniotomy, and mini pterional craniotomy are the most used approaches in vascular neurosurgery. The efficient and safe exposure for the desired surgical target requires simultaneous consideration of all operative goals to address the surgical target, understanding of the patient's unique anatomy, and the surgeon's technical expertise. Pterional craniotomy is the workhorse approach among cranial operative corridors. It is a highly versatile skull base approach that affords excellent exposure of the anterior cranial fossa, the circle of Willis, and the interpeduncular region.[5]

One of the most frequently encountered complications of Pterional craniotomy is temporal muscle atrophy. Temporal muscle atrophy can occur due to damage to either of the following, damage directly to muscle fibers, muscle blood supply, and nerve supply. Surgical outcomes can be improved by applying modification and improvement in neurosurgical techniques and instrumentation during the procedure.[6]

For the reduction of pterional craniotomy size and its related complications numerous different techniques have been recommended. However, each technique has its pros and cons and some do not decrease the magnitude of temporal muscle injury, and some do not provide comparable surgical exposure. In this study, we tried to introduce some alternative approaches to minimize these drawbacks such as the ministerial craniotomy. The ministerial craniotomy provides a similar microsurgical window with a significantly shorter incision, less muscle dissection, and a smaller craniotomy flap. An advantage over the pterional craniotomy is that ministerial craniotomy reduces the risk of the iatrogenic opening of the frontal sinus, consequently minimizing the risk of cerebrospinal fluid leakage and postoperative infection[7,8,9]. The primary goal of this study is to interpret the cosmetic effect of mini pterional craniotomy according to the cosmesis scale and Neurological outcome based on WFNS grade at 3 months along with complications.

MATERIALS & METHODS

Study Design & Setting

This was a quantitative study carried out at Neurosurgery Unit II, Punjab Institute of Neurosciences Lahore from January 2023 to November 2024 after the approval from the

Institutional Review Board (NO.1714/IRB/PINS/2024). After applying the inclusion and exclusion criteria, 107 patients were included in the study. Informed consent was taken from all the participants and data was collected on the proforma.

Inclusion Criteria

The inclusion criteria for this study are patients aged between 18 and 65 years, of both genders, who have been diagnosed with subarachnoid hemorrhage (SAH) caused by a ruptured aneurysm in the anterior circulation. Participants must be within two weeks post-ictus (onset of hemorrhage).

Exclusion Criteria

The exclusion criteria include patients with medical co-morbidities that make them unfit for surgery, those with an aneurysmal configuration that is unsuitable for clipping, and individuals with a WFNS (World Federation of Neurosurgical Societies) grade 5, indicating severe impairment and poor prognosis.

Surgical Procedure

A mini-personal craniotomy was employed which is a surgical procedure that involves creating a small opening in the skull to access the intracranial components with a skin incision of 6-11 cm and bone flap of 3 cm width and 4.5 cm length.

Modified Cosmesis Scale

A modified Cosmesis scale was used as follows for the assessment of the Cosmesis outcome. A total score of modified cosmesis scale = 10, favorable cosmesis scale result = 8 and above, and unfavorable cosmesis scale result = <8.

Surgical Technique

The mini-personal craniotomy was conducted with the patient lying supine and the head elevated by 10°-15° to ensure it remains above heart level. The neck was in an extension position to enhance gravitational influence on venous drainage and enhance the surgeon's exposure angle directly to the operative field. The head rotation laterally depends on the aneurysm's position and for each surgery angle of lateral rotation was decided according to the aneurysm's position and anatomy. Skin incision draws 1 cm above the base of the zygomatic arch approximating the frontal edge of the hairline. Skin incision in curved line towards the mid pupillary line on the same side. Interfacial dissection is carried out, and the muscle flap is retracted posteriorly and caudally. The pterion is fully exposed, and an osteotomy hole is created beneath the temporal line, just superior to the frontozygomatic suture. The osteotomy starts beneath the superior temporal line and curves downwards towards the pterion as it reaches the stephanion, incorporating it into the bone flap. Skull bone separated from underlying dura mater. This flap contains a small section of the temporal bone and frontal bones. The sphenoid ridge is drilled until the meningo-orbital artery is visible at the superior orbital fissure. The entire craniotomy region is situated beneath the temporal muscle (Figures 1-2).

In the traditional pterional craniotomy, the size of the craniotomy extends beyond the limits of the temporal muscle, necessitating significant dissection and retraction of the muscle. The dura is incised in a semilunar manner, with the base oriented toward the sphenoid wing. The areas that become visible include the inferior frontal gyrus, the Sylvian fissure, and the superior temporal gyrus. This approach allows for access to the ipsilateral crural cisterns, interhemispheric space, chiasmatic region, and the bilateral optic and carotid arteries, while postoperative CT scans

indicate a typical restoration of anatomy (Figure 3).

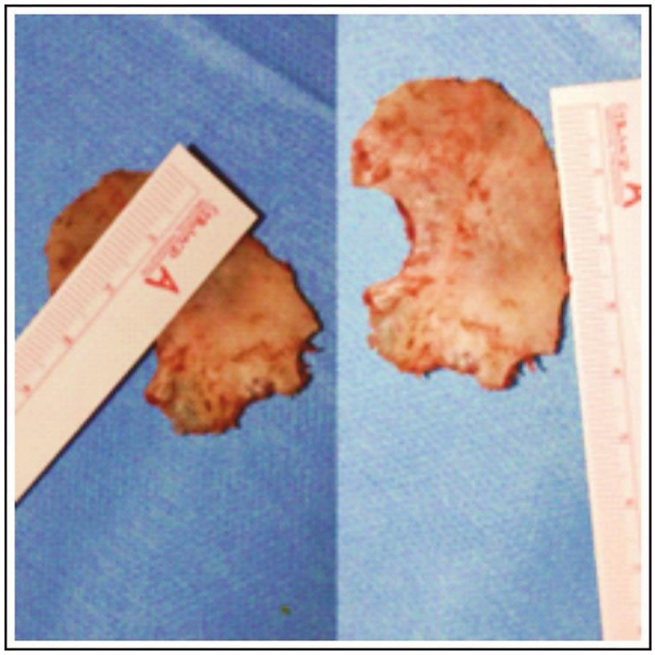

Figure 1: Mini Pterional Craniotomy (Picture was taken with consent).

Figure 2: Post-op Wound (Picture was taken with consent).

Data Analysis

Data was entered and analyzed using SPSS version 26. Variables such as the location of aneurysms, pre-operative, post-operative WFNS grade, and cosmesis scale outcome concerning favorable and unfavorable outcome frequency were assessed in Tables 1 and 2. The paired samples analysis was applied to Pre-WFNS and Post-WFNS scores.

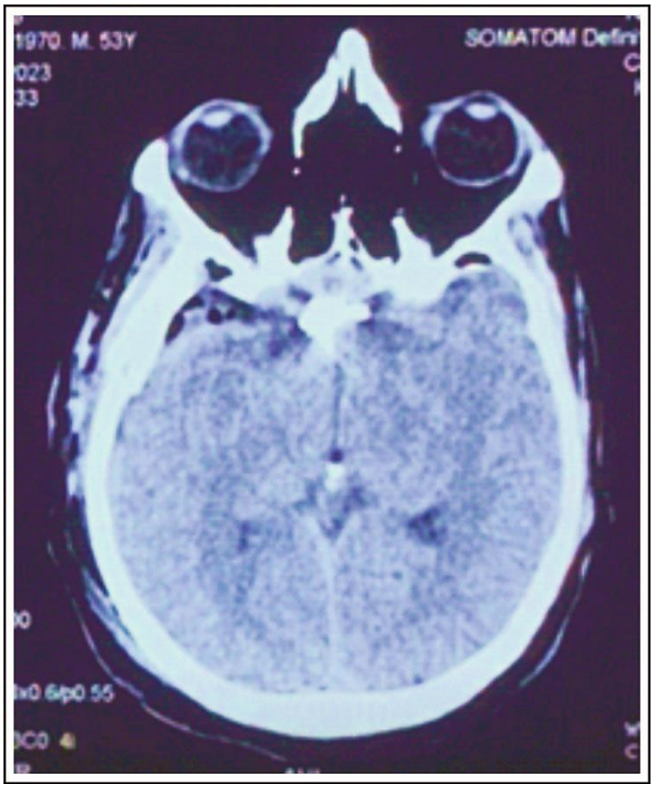

Figure 3: A-comm aneurysm clipped with Mini Pterional Craniotomy (Picture was taken with consent).

RESULTS

Data was analyzed in descriptive statistics regarding gender distribution, location of the aneurysm, pre-op WFNS grade, post-op WFNS grade at 3 months, cosmesis grade at 3 months, and complications.

Mean Age & Gender

Out of the total 107 patients, 64 (59.8%) were female while 43 (40.2%) were male with a mean age of 48 years.

Location of aneurysms, pre-operative, post-operative WFNS grade, and cosmesis scale outcome concerning favorable and unfavorable outcome frequency were assessed in Tables 1 and 2. The paired samples analysis applied on Pre-

WFNS and Post-WFNS scores reveals a high correlation of patients with the batter WFNS score pre-operatively had batter WFNS score procedure as well. These findings were consistent with poor WNFS scores as well. In Table 3 these correlations are significant as ($p < 0.001$). In Table 4 Binomial test was applied to a total of 98 alive patients the proportion of favorable outcomes (79/98) is significantly higher than the hypothesized equal distribution (50% favorable vs. 50% unfavorable), with a highly significant p-value of 7.13×10^{-10} (highly significant). This suggests that the intervention is strongly associated with a higher rate of favorable cosmetic outcomes. A p-value of ≤ 0.05 was considered statistically significant.

Table 1: *Aneurysm Locations.*

Location	Frequency (%)
Anterior communicating artery	58(54.2%)
Middle cerebral artery	39(36.4%)
Posterior communicating artery	06(5.6%)
Internal carotid bifurcation	4(3.7%)
Total (n)	107(100%)

Aneurysm Location

Out of the 107 patients, the aneurysm was located at the anterior communicating artery in 58 (54.2%) patients and at MCA in 39 (36.4%) (Table 1).

Table 2: *WFNS Grades.*

WFNS Grade	Pre-operative Frequency (%)	Post-operative Frequency (%)
1	52(48.5%)	66(61.6%)
2	25(23.3%)	11(10.2%)
3	17(15.8%)	13(12.1%)
4	13(12.1%)	08(8.4%)
5	0	09(8.4%)
Total (n)	107(100%)	107(100%)

WFNS Grade Comparisons

The pre-op WFNS grade was 1 in 52 (48.5%) patients, grade 2 in 25 (23.3%), and grade 3 in 17 (15.8%) patients. The WFNS grade recorded at 3-month post-op follow-up was grade 1 in 66 (61.6%) patients, grade 2 in 11 (10.2%) and 3 in 13 (12.1%) patients (Table 2).

Patients with the batter WFNS score pre-operatively had batter WFNS score pot-procedure as well. These findings were consistent with poor WNFS scores as well. In Table 3 Pearson's correlation coefficient demonstrated with "r" value of 0.938 very close to 1, indicating a strong positive linear correlation. The paired samples analysis reveals a high correlation ($p < 0.001$) between Pre-WFNS and Post-WFNS scores, indicating consistency between the two measures.

Table 3: *Pre and post-WFNS Correlation.*

	N	Correlation (r)	P Value
Pre-WFNS & Post-WFNS	107	0.938	0.000

Table 4: *Cosmesis Outcome.*

Grading according to the Cosmesis scale	Frequency (%)	Binomial Test P value
Favorable outcome	79(80.6%)	
Unfavorable outcome	19(19.3%)	7.13×10^{-10}
Total (n)	98(100%)	

Cosmesis Scale Outcome

9 patients died due to which they were excluded from the cosmesis interpretation. According to the cosmesis scale, 79 (80.6%) patients had favorable outcomes while 19 (19.3%) patients had unfavorable outcomes. Binomial Test p-value: 7.13×10^{-10} (highly significant) (Table 4).

Table 5: *Complications.*

Complications	Frequency (%)
Hydrocephalus	7(6.5)
Meningitis	5(4.6)
Neurological deficit	4 (3.7)
Wound infection	3(2.8)
CSF leak	1(0.9)
Total (n)	20(100)

COMPLICATIONS

Seven (6.5%) patients developed hydrocephalus, 5 (4.6%) got meningitis and 4 (3.7%) developed neurological deficits (Table 5).

DISCUSSION

The primary goal of surgery for intracranial aneurysms is to separate the aneurysm from circulation, thereby reducing the risk of re-bleeding while preserving neurological function. In 1975 mini pterional craniotomy by Yaşargil et al, was a great advancement in surgical outcomes, which involved reduced exposure of the frontal and temporal lobes. Minimally invasive techniques offer minimized surgical trauma, lower costs, decreased levels of pain, shorter surgical durations, decreased hospital stay, and improved cosmetic results compared to traditional craniotomies.

Minimally invasive procedures are now becoming the standard of care worldwide because of patient preference, better cosmesis, and psychological aspects of having a bigger unsightly scar. A decrease in incision size in mini pterional craniotomy technically reduces the risk of postoperative CSF leakage due to smaller dura and skin opening, avoiding unnecessary exposure of the frontal lobes.

In our study, 58 patients were clipped through ministerial craniotomy for proximal anterior cerebral artery aneurysm and 39 patients underwent clipping for MCA aneurysms that were up to the bifurcation. Proximal Acom aneurysms usually get adequately exposed with ministerial craniotomy with a lesser risk of conversion to a full pterional craniotomy, however, MCA aneurysms up to the bifurcation of MCA which require proper sylvian fissure split distally can be trickier to deal with due to limited exposure. Despite this, we were able to avoid switching to conventional pterional craniotomy and were able to satisfactorily deal with all aneurysms including MCA bifurcation ones while remaining within the limits of mini pterional craniotomy.

To enhance visibility, the temporalis muscle is typically entirely separated from the temporal fossa. Nevertheless, this approach may result in specific drawbacks, such as functional and cosmetic issues. Additionally, it could cause changes in mandibular function, persistent pain, and facial weakness from damage to the frontal branch of the facial nerve.[11,12,13,14]

In our study, 52(48.5%) patients were in WFNS grade 1 before the surgery, and 66 (61.6%) patients with WFNS grade 1 at a 3-month follow-up after surgery. There were 13(12.1%) patients with poor WFNS grade 4 before surgery and 09(8.4%) patients had post-op poor WFNS grade 5 after surgery. The paired samples analysis reveals a high correlation ($p < 0.001$) between Pre-WFNS and Post-WFNS scores, indicating consistency between the two measures and these results are comparable to the other studies.[11]

The cosmesis outcome was measured by the modified cosmesis scale in which the aesthetic scale was scored from 1 to 5 for the input from both the patient and doctor. In the scoring system “1” was marked as a very dissatisfied or least acceptable result and “5” was very satisfactory for both patient and doctor.

In our study, 79(80.6%) patients expressed favorable cosmesis outcomes, and 19 (19.3%) had unfavorable cosmesis outcomes. In Leonardo's study, the favorable cosmesis result was in 19 (79%) patients which is comparable with our study. In Leonardo's study, the cosmesis results of conventional pterional craniotomy were only 13(52%) with a satisfactory outcome. In our study, the unfavorable outcome was 19(19.3%). A binomial test was applied to a total of 98 alive patients the proportion of favorable outcomes (79/98) is significantly higher than the hypothesized equal distribution (50% favorable vs. 50% unfavorable), with a highly significant p-value. This suggests that the intervention is strongly associated with a higher rate of favorable cosmetic outcomes. Post-procedure complication

frequency is comparable with the previous studies.[11]

We worked to improve the outcomes of the mini pterional craniotomy for aneurysm clipping by modifying the surgical method, including shortening the skin incision, preserving the temporal muscle, and minimizing the craniotomy size. By reducing the length of the incision, we were able to decrease skin numbness in the surgical area, and the smaller scars contributed to better cosmetic results.

CONCLUSION

Mini Pterional craniotomy has proven itself as a safe and effective surgical procedure. It can be applied to a variety of aneurysmal locations and has a low rate of complications and good outcomes.

RECOMMENDATIONS

Mini Pterional Craniotomy is an acceptable technique to improve the cosmesis and functional outcome of patients with clipable anterior circulation aneurysms.

LIMITATIONS

To infer results and prove their implications we need to conduct comparative studies with longer follow-ups.

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Additional Information

Disclosures: No conflict of interest.
Institutional Ethical Review Board: The study complies with the ethical review board requirements.
Human Subject: Consent was obtained by all patients/participants in the study.
Conflict of Interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following.
Financial Relationship: All authors have declared that they have no financial relationship at present or within the previous three years with any organizations that might have an interest in the submitted work.
Other Relationships: All authors have declared that no other relationships or activities could appear to have influenced the submitted work.
Data Sharing Statement: For data sharing interested researchers can contact the corresponding author.

AUTHOR'S CONTRIBUTION

Sr.	Author Name	Author Contribution
1.	Usman Ahmad Kamboh	Introduction & Study design.
2.	Muhammad Irfan Sheikh	Discussion.
3.	Hassan Ali Khosa & Zain Saleh	Data analysis & interpretation of results.
4.	Muhammad Ashfaq & Muhammad Rizwan Khan	Literature review and referencing.
5.	Muneeb Khaliq	Data collection.
6.	Syed Shahzad Hussain Shah	Editing and quality insurer.