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Morphometric measurements of anterior clinoid process in relation to parasellar osseous structures and their clinical significance

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Abstract---This study is to analyze the morphometry of anterior clinoid process (ACP) and the surrounding parasellar structures which is important for the surgeries related to cavernous sinus, ICA, and basilar artery. A cross-sectional study has been done on 77 adult human dry skulls among North Indian population. The length, width, thickness of ACP and distance between ACP to OS, distance between two ACPs, distance between PCPs, distance between ACP to PCP were measured using digital vernier caliper. The mean and standard deviation was calculated and paired t-test was applied for the comparison. The mean length and width and thickness of ACP was 8.72±0.94 mm, 8.13±1.16 mm and 1.10±0.44 mm on right and 8.57±0.91mm, 8.05±1.24 mm and 1.40±0.41mm on left side. The average distance between the ACP tip to OS and ACP and PCP tip was 6.01±1.11mm and 8.79±1.49mm on the right and 5.90±0.99mm and 8.47±1.49mm left side. The mean distance between the ACP tip and PCP tip was 20.10±2.36 mm and 12.63±2.03 mm respectively. We did not find any significant difference of morphometric parameters between the right and the left side. The anatomical knowledge of these structures and its variation will help surgeons to plan surgery around the parasellar region.

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Keywords---morphometry, anterior clinoid process (ACP), optic strut (OS), posterior clinoid process (PCP).

Introduction

The access of parasellar region and cavernous sinus during neurosurgical procedures possess great challenges for the surgeons. The osseous structures surrounding the parasellar region are anterior clinoid process (ACP), middle clinoid process (MCP) and the posterior clinoid process (PCP)[1,2]. The anterior clinoid process are the bony projections presents on the medial end of lesser wing of sphenoid bone and connects the body of sphenoid to the lesser wing by two roots – anterior and posterior root (optic strut)[3-5]. Anterior root of the anterior clinoid process forms the roof and posterior root forms the floor of the intracranial part of optic canal, whereas the base of the anterior clinoid process forms a part of lateral wall of optic canal[6-8]. The anterior clinoid process (ACP), optic strut (OS) and the surrounding parasellar structures are very important as they are closely related to the nerves, vessels, glands, and part of base of brain like optic nerve, ophthalmic artery, internal carotid artery, cavernous sinus, pituitary gland, basilar artery and interpeduncular fossa[9,10].

Anterior clinoid process and optic strut are often removed for the treatment of tumours such as meningiomas, and aneurysm in the parasellar and suprasellar region by pterional approach[4]. Anterior clinoidectomy along with removal of roof and floor (OS) of optic canal exposes the optic nerve and ophthalmic vessels and dural ring for mobilization of internal carotid artery (ICA)[11-15]. For the treatment of tumors in the parasellar region and aneurysm of internal carotid artery, upper part of basilar artery the detail knowledge of the morphometry of parasellar region is required[12,15]. These informations will give an idea about the location of paraclinoid or intracavernous aneurysm[8]. So, it is important for the neurosurgeons to verify dimension and variations of ACP and associated parasellar structures. This study is designed to focus on the morphometry of the anterior clinoid process and associated bony structures of the parasellar region and observe if any significant difference present between the right and the left side.

Material And Method

The present study conducted on 77 adult dry skulls from medical colleges of North India during January 2020- july2021. Ethical clearance was taken from the Institutional ethics committee. Total 85 adult dry skulls of both the sexes were reviewed, out of which 8 were excluded due to damage in parasellar region or in the middle cranial fossa. Rest 77 skulls were analysed. Bilaterally, these skulls have normal parasellar morphology. The morphometric parameters were measured with the help of digital vernier calliper and the measurements were taken three times for each parameter and the average was taken (figure 1). Single researcher took all the measurements to reduce the intraobserver bias. The following measurements were taken in adult human dry skulls (figure 2,3) –

- Length of ACP: maximum distance from its base to tip.
- Width of ACP: maximum distance at its base
- Thickness of ACP
- Distance between tip of ACP to optic strut (OS)
- Distance between tip of ACP to tip of PCP (posterior clinoid process)
- Distance between both the ACP tips
- Distance between both the PCP tips

The data were tabulated in Microsoft excel sheet – mean, standard deviation of each parameter was calculated and comparison were done using t-test. The p-value of <0.05 were considered statistically significant.

Figure 1. Showing the parameters measured by vernier caliper

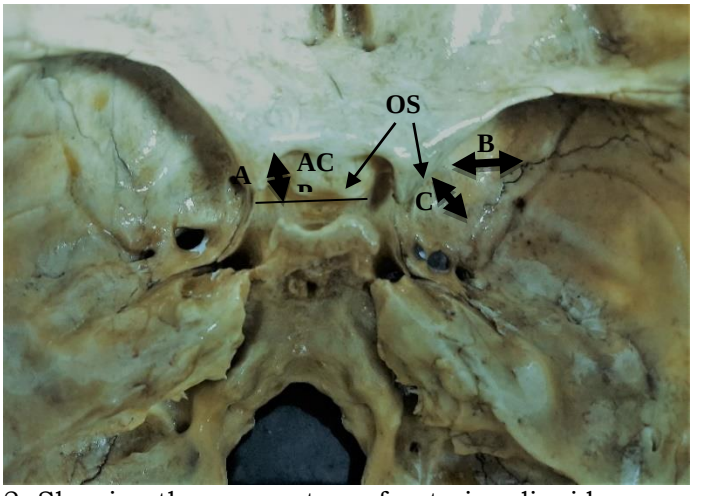

Figure 2. Showing the parameters of anterior clinoid process (ACP)

A) Length of ACP
B) Width of ACP
C) Distance between ACP to OS
ACP – anterior clinoid process

OS – optic strut

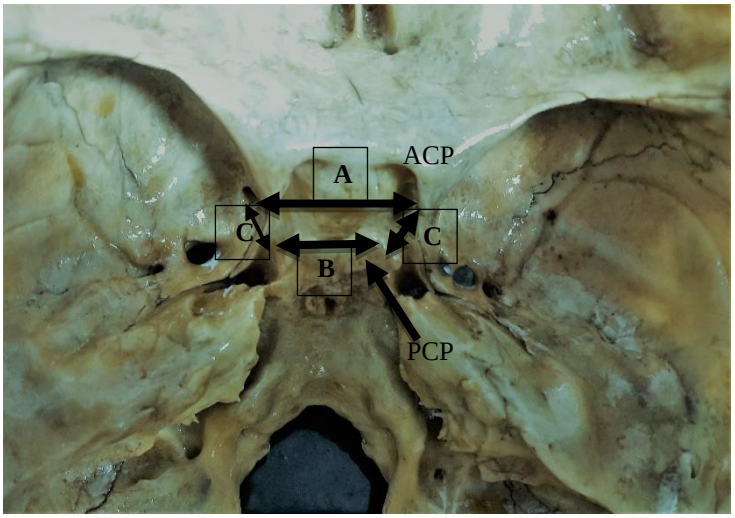

Figure 3. Showing the morphometric parameters of the osseous structures in the parasellar region. (A) Distance between the tips of anterior clinoid process (ACP)

(B) Distance between the tips of posterior clinoid process (PCP)
(C) Distance between ACP to PCP
ACP – anterior clinoid process
PCP – posterior clinoid process

Result

Table 1
Morphometric parameters of anterior clinoid process (n=77)

Parameters		Mean (mm)	SD (mm)	Range (mm)	p-value
Length	Right	10.39	2.14	5.9 – 15.4	>0.05
	Left	10.28	2.22	5.3 – 14.9	
Width	Right	9.78	2.01	5.9 – 14.6	>0.05
	Left	9.72	2.12	5.3 – 14.7	
Thickness	Right	2.62	0.61	0.3 – 2.9	>0.05
	Left	2.95	0.57	0.3 – 2.9	

Table 2
Morphometric Parameters of parasellar osseous structures (n=77)

Parameters		Mean (mm)	SD (mm)	Range (mm)	p-value
Distance between tip of ACP to OS	Right	6.91	1.93	3.1 – 12.4	>0.05
	Left	6.83	1.82	3.3 – 12.7	
Distance between ACP tip to	Right	10.64	2.74	2.2 – 15.6	>0.05
	Left	10.47	2.79	2.9 – 15.6	

PCP tip					
Distance between ACP tips		22.87	3.67	13.6 – 28.9	
Distance between PCP tips		14.47	3.29	8 - 25	

SD – standard deviation; ACP – anterior clinoid process; PCP – posterior clinoid process; OS – optic strut

A total of 77 adult dry skull were analysed. Different parameters of ACP and the osseous structures around the parasellar region were measured. The mean, standard deviation (SD), and range of all the parameters of anterior clinoid process (ACP) are calculated and shown in table 1. The parameters for the distance between the ACP tip to OS, distance between ACP tip to PCP tip, distance between both ACP tips and PCP tips are shown in table 2. There were no statistically significant difference noted between the right and left side of all the parameters of anterior clinoid process ($p>0.05$) shown in table 1. We have also observed that no significant difference present between the right and left side of distance between ACP – OS and ACP – PCP tips (table 2). The mean distance between ACP tips is 22.87±3.67mm and PCP tips is 14.47±3.29mm respectively. We have also noted that the mean of right side of all the parameters are little higher as compared to left side (table 1 and 2).

Discussion

The sellar, suprasellar and parasellar region are related to major anatomical structures like pituitary gland, internal carotid artery, cavernous sinus with its content, optic nerve and ophthalmic artery[16,10]. For the safe surgical operation in the area involving lesion in suprasellar, sellar and parasellar region, appropriate exposure of that area is needed which is very challenging due to presence of bony prominences around that area[16]. Anterior clinoid process is connected to the body of sphenoid by two roots which is forming the roof (anterior root) and floor (posterior root or optic strut) of optic canal[17].Anterior clinoid process is related to anterior part of cavernous sinus and the internal carotid artery[18]. For better exposure of cavernous sinus in case of tumor, internal carotid artery in case of ICA aneurysm, optic nerve and ophthalmic artery in case of neuromas and meningiomas in that region, anterior clinoidectomy is needed along with the removal of optic strut[18]. So, the knowledge about morphometry of anterior clinoid process and the associated osseous parasellar structures is important for safe surgical exposure as well as for prevention of the preoperative and postoperative complications[19].

In our study we have found that the length, width, and thickness of anterior clinoid process (ACP) on the right side was higher as compared to the left side. Similar result was found by Lee HY et al.[3] in Korean population, they have found that the length and width of ACP on the right side as 9.26±1.43mm and 9.97±1.58 mm whereas on the left side it was 9.09±1.67mm and 9.29±1.39mm, and thickness on the right side and left side were 5.44±1.02mm and 5.19±1.12mm respectively. Their length and width were slightly lower than our value but thickness was much higher as compared to our values and they have

also found statistically significant difference between right and left side but we did not find any significant difference between the right and the left side.
Dhakal A et al[16] found the length, width, and thickness of ACP on the right side as 9.88±1.36mm, 8.72±1.50mm and 5.21±1.83mm whereas on the left side as 10.30±1.47mm, 8.73±1.71mm and 5.33±1.60mm respectively. They did not find any significant difference between right and left side like our study. Sibuor W et al.[20] had conducted a similar study on Kenyan population, and found the length, width and thickness of ACP on right side as 11.12±2.83mm, 10.52±2.68mm and 5.38±2.11mm and on left side as 10.72±2.77mm, 10.34±2.69mm and 5.47±1.95mm respectively and no significant difference observed between right and left side. These findings are similar with our study.

Our study is in concurrence with the study done by Natsis K et al.[21] in Greek population but the length and thickness of ACP was higher and the width of ACP was lower as compared to our study, and they have also found significant difference between the right and left side of width of ACP but we did not find any significant difference in all the parameters of ACP. Our study also concurred with the study by Dagtekin A et al.[19] in the population of Turkey, but their parameters for the length and width was much lower as compared to our values and the thickness was much higher as compared to ours. Similar study was also done by Neslihan B et al.[22] but their values for length, width and thickness for all the parameters are much higher than our values. Our values of all the parameters are different from their values may be because of the different population and different age groups (table 3).

Table 3
Comparison of different parameters of anterior clinoid process in present study with the previous studies

Parameters of ACP		Natsis K et al.[21]	Dagtekin A et al.[19]	Neslihan B et al.[22]	Present study
Length	Right	11.43±2.33	9.7	11.5±1.9	10.39±2.14
	Left	11.66±1.70	9.6	11.4±1.8	10.28±2.22
Width	Right	9.02±1.67	7.3	12.4±1.7	9.78±2.01
	Left	9.63±1.71	7.2	12.3±2.5	9.72±2.12
Thickness	Right	5.91±1.63	5.5	4.4±1.2	2.62±0.61
	Left	5.92±1.48	5.3	4.2±1.2	2.95±0.57

We have also measured the different morphometric parameters of osseous structures around parasellar region. We have measured the distance between ACP tips to optic strut (OS), distance between ACP to PCP tip in right and left side and not found any significant difference between the right and the left side. We have also measured the distance between ACPs and the average was 22.87±3.67mm and the average distance between PCPs was 14.47±3.29mm. In a study by Dsouza A et al.[10] in South Indian population the mean distance between ACP and OS was 13.46mm on right and 13.84mm on left side in male whereas 13.28mm on right and 12.85mm on left side in females. Our values are much lower than their values.

In a study by Dhakal A et al.[16] the distance between ACP-PCP tips is lower than our values but the average distance between ACP tips and PCP tips are lower as compared to our values, and they did not find any significant difference between the right and left side which is similar to our study. Our study concurred with the study by Natsis K et al.[21] but their values for the ACP-PCP distance are higher than our values and distance between ACP tips and distance between PCP tips are much lower than our values. Our study also concurred the studies by Lone M et al.[7] and Dagtekin A et al.[10] but their values for all the parameters in parasellar region are lower than our values (table 4)

Table 4
Comparison of different parameters of parasellar structures in present study with the previous studies

Parameters		Dhakal A et al.[3]	Natsis K et al.[5]	Lone M et al.[18]	Dagtekin A et al.[19]	Present study
Distance between ACP-PCP tips	Right	8.17±3.49	4.94±1.60	4.2±2	7.7	10.64
	Left	8.43±3.06	4.92±1.31	4.3±2.1	7.5	10.47
Distance between ACP tips		24.41±2.32	25.51±2.42	22.9±1.3	24.1	22.87
Distance between PCP tips		20.01±3.23	16.25±2.29	-	13	14.47

A study by Neslihan B et al.[22] found that distance between ACP tips was 25.8±2.7mm and the distance between ACP-PCP was 10.7±2mm in right and 10.4±2.1mm in left side and these values are higher than our values. Most of the previous studies are from outside India and few are from southern and eastern part of India but our study was conducted on the population of North India. Most of the previous authors had only measured the parameters of anterior clinoid process but we have also measured the parameters of different bony landmark around the parasellar region which will be more reliable for the surgeon to safely approach the area during anterior clinoidectomy. So, the detailed knowledge about the morphometry of anterior clinoid process along with optic strut and associated bony landmark will be helpful for the neurosurgeons.

Conclusion

All neurosurgeons working on suprasellar and parasellar region should carefully study the anatomical description of anterior clinoid process, optic strut and the other bony landmark around the parasellar region, especially before performing surgery on meningioma and aneurysm in that area. We did not observe any significant difference between the right and left side in all the parameters of ACP as well as other structures. The average value on the right side was more as compared to the left side in all the parameters of anterior clinoid process. This information might help the neurosurgeon and radiologists in management of pathological condition of that region.

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