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GAINING IN WORKING LENGTH ON INTERNAL CAROTID ARTERY AND OPTIC NERVE FOR NEUROSURGEONS AFTER ANTERIOR CLINOIDECTOMY: A MORPHOMETRIC STUDY

Neurosurgery

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ABSTRACT

Anterior clinoidectomy is a key procedure during exposure of parasellar tumors and clipping of paraclinoid aneuryms. By doing anterior clinoidectomy, neurosurgeons gaining working length on vital structures like internal carotid artery and optic nerve, so that they can achieve proximal control on ICA, or mobilize optic nerve for tumor removal and optic nerve decompression. In this study, we measured the size of bony anterior clinoid process, then the length of ICA and optic nerve before and after anterior clinoidectomy. We found that, 50% more working length on ICA and 100% on optic nerve are available to neurosurgeons by doing extradural anterior clinoidectomy.

KEYWORDS

Anterior clinoid process, internal carotid artery, parasellar tumors, paraclinoid aneurysms.

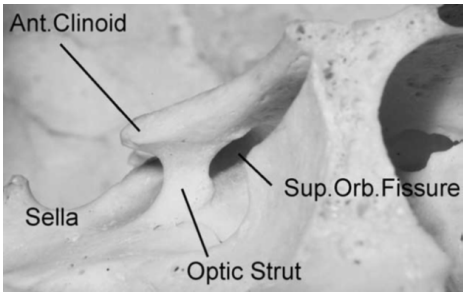
INTRODUCTION:

Anterior clinoidectomy is an essential technique when removing parasellar tumors or clipping paraclinoid aneurysms.

Due to the deep location of the ACP and the complexity of the anatomical structure around it, anterior clinoidectomy requires precise knowledge of the anterior and middle skull base neuroanatomy.

Dolenc (1) introduced the extradural technique of complete anterior clinoidectomy. The purposes of this study is to compare the measurement visible to the surgeon in the length of optic nerve and the internal carotid artery (ICA) before and after extradural anterior clinoidectomy and to measure the height and basal width of the ACP in South indian population.

Microsurgical anatomy around the anterior clinoid process;



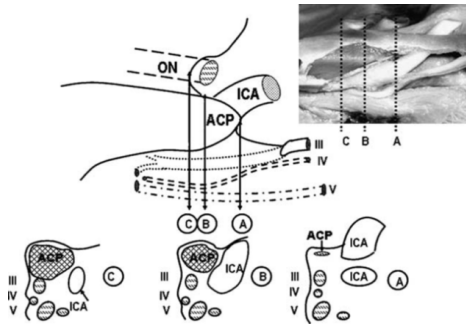
PICTURE 1: Lateral view of right para-sellar area of the dry bone specimen. The anterior clinoid process locates posterior end of the minor wing of the sphenoid bone. The optic strut is a bridge between the body of the sphenoid and the anterior clinoid process. The superior orbital fissure situates between the minor and major wing of sphenoid. Ant.Clinoid: anterior clinoid process; Sup.Orb.Fissure: superior orbital fissure.

The anterior clinoid process is a bony structure, which locates posterior tip of the lesser wing of the sphenoid bone. The ACP is located at the medial end of the lesser wing of the sphenoidale bone. This bony projection is connected to the body of the sphenoidale bone by two roots. The superior root forms the roof of the OC and continues as the JS. The optic strut forms inferior root. The strut divides the optic canal medially and the superior orbital fissure laterally. The anterior clinoid process has the internal carotid artery medially and the superior orbital fissure and cavernous sinus inferiorly.

The thickness and the pneumatization of the process are variable. The tip of the process points postero-medially. In some cases, the tip of the process elongates postero-inferiorly and attaches the body of the sphenoid. It is called the middle clinoid process. The internal carotid artery passes the bony canal, which is created by the anterior and middle clinoid process. The anterior clinoid process is surrounded by the periostium.

The free edge of the tentorium leads to the tip of the anterior clinoid process. The dura matter of the anterior cranial base covers it superiorly. The lateral surface is facing to the tip of the temporal fossa. The Falciform extends medially from the ACP across the ON, to the posterior border of the jugum sphenoidale. This dural fold covers several millimeters of the ON before the proximal opening of the optic canal.

The dura that extends medially off the upper surface of the ACP forms the DDR (upper dural ring, fibrous ring, Perneczky's ring, and the true dural ring) around the ICA. The proximal dural ring (PDR) separates the C5 segment of the ICA from the oculomotor nerve. DDR forms a complete ring around and fuses with the adventitia of the ICA. The DDR is firmly adherent to the dorsolateral aspect of this vessel. Hence, blunt dissection of the DDR can lead to the tearing of the adventitia of the ICA. The C5 segment of the ICA extends from the PDR to the DDR and lies immediately below the ACP. The DDR is a landmark for the end of the C5 segment and the beginning of the ophthalmic (C6) segment. The Proximal dural ring loosely surrounds the ICA.



PICTURE 2: Schematic drawing of the lateral view of the left anterior clinoid process (ACP), showing the relationship between the ACP and cranial nerves from an inferolateral aspect. Three imaging coronal planes sectioning at three differential levels of the ACP are shown, with three small schematic drawings demonstrating the relationships between the ACP and cranial nerves III, IV, and V at three different levels. Key: (A) First coronal plane at the level of the tip of ACP. (B) Second coronal plane at the junction point of the medial edge of ACP and the posterior edge of the roof of the optic canal. (C) Another coronal plane at level of the centre point on the posterior bony edge of the roof of the optic canal. ACP, anterior clinoid process; ICA, internal carotid artery; ON, optic nerve; III, oculomotor nerve; IV, Trochlear nerve and V, trigeminal nerve.(Fig -6)

AIMS AND OBJECTIVES:

The purposes of this study are:

- to investigate the dimension of the ACP,
- to quantify the improved exposure of the parasellar space and
- to measure the improvement in the exposed length of structures,

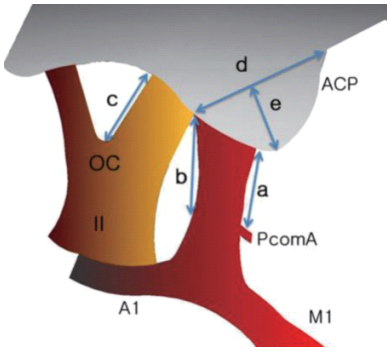
particularly internal carotid artery and optic nerve available to the neurosurgeon after extradural anterior clinoidectomy.

MATERIALS AND METHODS

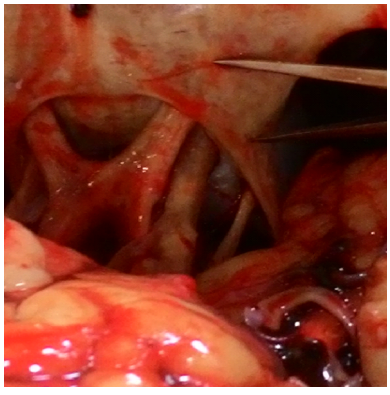
Thirty (18 males 12 females) south Indian cadavers from forensic science department mortuary kept on freezer were examined for a total of 60 ACPs removed. Specimens were placed on a handmade headrest and positioned for a frontotemporal approach. A large frontotemporal approach was performed. Microanatomical dissections were performed with a surgical loop(zeiss 3.5). Parts of frontal and temporal lobe were removed for precise measurement. All data were calculated by using scientific caliper in units of mm. All measurements were made by a single investigator.

Measurement before anterior clinoidectomy:

For convenience during the investigation, the frontotemporal lobes were partially removed. According to the **Bouthillier et al.(2)** classification of the ICA, the C6 (ophthalmic) segment of the ICA was measured. The lateral length of the C6 segment (a), from the most proximal visible point where it was covered by the ACP to the origin of the posterior communicating artery (PcomA), was measured. The medial length of the C6 segment (b), from the most proximal visible point covered by the superior root of the ACP to the medial ICA point opposite to the origin of PComA, was measured. The length of the optic nerve (c) from the optic chiasm (OC) to the falciform ligament was examined. The basal width of the ACP (d), which is a projected line that extends laterally from the lateral edge of the optic canal to the apex of the angle formed by the sphenoid ridge and the lateral aspect of the ACP, was measured intradurally. The height of the ACP (e), from its base to the tip of the process perpendicularly, was also recorded.



PICTURE 3



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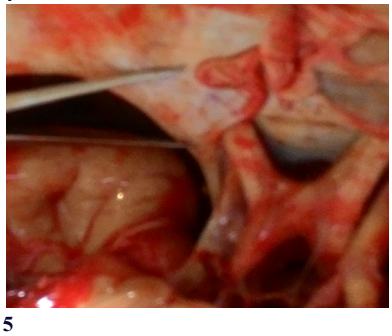


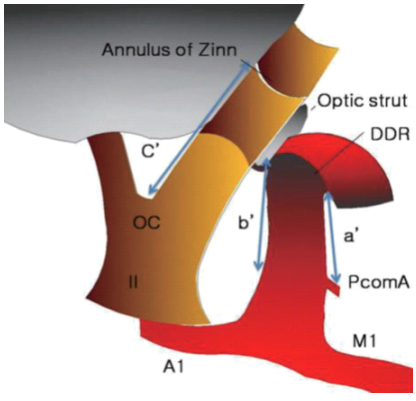
PICTURE 5

Extradural anterior clinoidectomy

After a large frontotemporal craniotomy, the dura covering the anterior cranial fossa was elevated from the orbital roof and the sphenoid ridge toward the ACP, after which the sphenoid ridge was drilled with a high-speed drill. The frontotemporal dural fold could be visualized and incised. After the peeling of the meningeal layer of the cavernous sinus and the dura over the ACP, the fully exposed ACP was removed using the drill .The remnant bone particles were removed with a rongeur.

Measurement after anterior clinoidectomy

A posterior orbitectomy and unroofing of the optic canal were done. The distal dural ring was incised with care and the optic sheath was opened along the lateral margin of the optic nerve until the cranial nerve (CN) III was encountered. After an extradural anterior clinoidectomy and orbitectomy, the distal dural ring (DDR) and the optic strut were well visualized. Next, the distances between these structures along the ICA medially and laterally were measured. The length of the lateral C6 segment of the ICA from the DDR to the origin of the PcomA was recorded (a'). Then, we measured the length of the medial C6 segment of the ICA from the DDR to the point on the medial side of the ICA corresponding to the level of the PcomA origin (b'). The length of the optic nerve from the OC to the annulus of Zinn was then measured ©')



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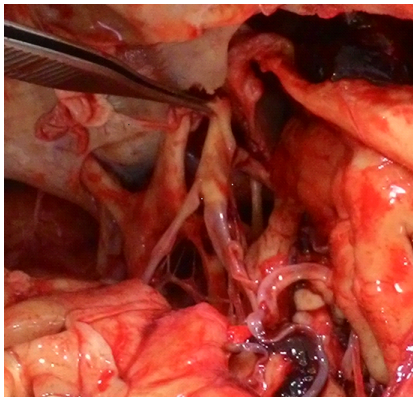
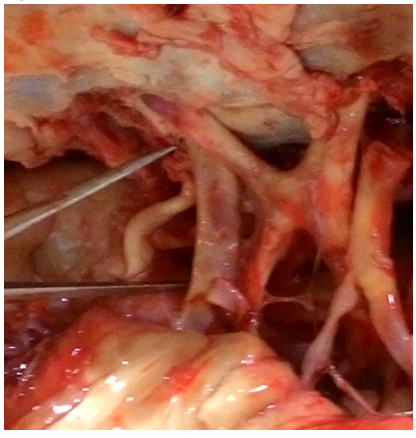


PICTURE 7



PICTURE 8

RESULTS;
Intradural dimension of the ACP;

The ACP had an inverted triangular shape and its end was medially projected. Intra-dural basal width of ACP measurements ranged from 7.6mm to 14.0mm with an average of 10.38mm and heights of ACP ranged from 5.0 to 5.9 with an average measurement of 7.21mm (Table-1).

Table 1. Dimension of anterior clinoid process

	Right side(n=30) (range)	Left side(n=30)(range)	Total(n=60)
WIDTH(mm)	10.37(7.6-14.0)	10.39(8.0-13.8)	10.38
HEIGHT(mm)	7.21(5.0-8.9)	7.21(5.9-8.8)	7.21

Measurement of optic nerve and ICA with anterior clinoid process;
Before exta-dural removal of ACP, the mean length of C6 segment of ICA lateral side (a) is 4.56 mm and a medial side length(b) is 6.76mm.

The mean length of the optic nerve from the optic chiasm to the margin of the optic canal (c) is 9.07mm. (Table-2)

Table-2 Dimensions before removal of ACP

	Right(n=30)	Left(n=30)	Total (n=60)
C6 lateral segment*	4.56(3.3-6.0)	4.57(3.1-6.4)	4.56
C6medial segment*	6.81(5.3-8.2)	6.71(5.4-8.0)	6.76
Optic nerve	9.05(7.8-10.6)	9.1(8.3-11.7)	9.07

*Bouthillier's classification of the internal carotid artery

Measurement after anterior clinoidectomy;
After an extra dural clinoidectomy, following measurements are taken,The extended mean length of lateral aspect (a') and medial aspect (b') of C6 segment of ICA are respectively 6.76mm and 10.03mm. which showed a 49%to 50% extension of each distance.

The mean length of optic nerve from optic chiasm to annulus of zinn after removal of ACP is 18.04mm,which is 98.5% extension of optic nerve exposure (Table-3).

Table-3 Dimension after removal of ACP

	Right(n=30)	Left(n=30)	Total(n=60)	Extention Rate (%)
C6 lateral segment*	6.81(5.8-8.6)	6.71(5.8-8.7)	6.76	49%
C6 medial segment*	10.01(8.2-11.7)	10.05(8.3-11.7)	10.03	50%
Optic nerve	18.06	18.02	18.04	98.50%

DISCUSSION
The ACP is a bony projection of the lesser sphenoid wing, and it is connected to the sphenoid body by two roots, a superior and an inferior root. The superior root forms the roof of the optic canal, and continues as the planum sphenoidale. The inferior root forms the lateral and ventral walls of the optic canal and connects to the lesser wing. The ACP is normally composed of a thin shell of cortical bone and an inner trabecular bone.

According to a study of dry skull by **Lee et al.(3),** the means of the ACP width and height are 9.63 mm and 9.18 mm, respectively. In a Korean study, Compared with Lee's study using a dry skull, their measurement was made with fresh cadaver under surgical view intradurally reveals the ACP10.82mm and height are 7.61mm, respectively. Our measurements in un embalmed fresh cadavers showing almost same results from the **Korean study(4).**

Many articles have been published about intradural and extradural anterior clinoidectomy **(5,6,7,8,9,10,11)** and we performed an extradural anterior clinoidectomy. In addition, several articles about the anatomy of the paraclinoid and cavernous sinus regions exist along with the surgical approaches through which these regions were exposed **(12,13,14).** Since **Dolenc(1)** described the extradural anterior clinoidectomy procedure, numerous modifications have been made. Anterior clinoidectomy is a technically difficult but invaluable component of surgery for a variety of anterior and middle-skull base pathologies. Anterior clinoidectomy has been used widely during the clipping of paraclinoid aneurysms and removing of parasellar tumors, including meningiomas originating at the ACP, the medial sphenoid wing, or the optic canal. In the above cases, the tumor could extend to the optic canal or the optic nerve may be stretched over the tumor surface. As a result, the ACP needs to be removed to ensure an expanded space for manipulation. With the removal of the DDR of the ICA and the opening of the optic sheath, the operator gains an expanded view of the aforementioned area, after which mobilization can be gained as regards the ICA and ON for neurovascular protection. Several studies on the advantages of anterior clinoidectomy have been conducted, The purpose of our cadaveric study was to quantify the extended exposure of ICA, and ON in the parasellar region in south Indian adults. By means of anterior clinoidectomy, we found mean increases of 49% on the C6 segment of the ICA, both medially and laterally. Mean exposure of the ON increased by 99%. Another study conducted in Korean population by **Hyun-Woo Lee et al (4)** gives almost same percentage of increased dimensions of these structures after removal of ACP. These increases in surgical exposure can offer numerous advantages, such as less traction of normal structures and sufficient exposure of pathogenic lesions. A study by **Hwang et al (15)** showed almost a 150% increased exposure of ICA, a two-fold increase of ON and an opticocarotid triangle (OCT) exceeding 300% by means of an extradural anterior clinoidectomy. As traction of the ICA could be influenced by subjective factors, we did not check the OCT, but we measured medial and lateral sides of ICA, respectively. Other results were similar to our data. In a study of **Andaluz et al. (89),** the exposure of the ICA increased by 60% and 112% in terms of the lateral and medial lengths, respectively. The exposure of the optic nerve was increased by nearly 150% in terms of the length. These results were different from ours, and different anatomical features according to race may have been a factor in measured differences.

CONCLUSION;
Anterior clinoidectomy is a difficult procedure with limited indications. This study was focused on the morphometrical benefits obtained by extradural anterior clinoidectomy in south Indian population. With the removal of the ACP, workable length of the C6 segment of the ICA, by neurosurgeon can be increased by approximately 49% and the optic nerve length can be nearly doubled.

This technique is an essential part of neurosurgeon's skill for treating pathological lesions around anterior clinoid process.

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