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Trans-Ciliar supraorbital eyebrow Approach for Skull Base Lesions; A Cadaver Study

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ORIGINAL ARTICLE

Trans-Ciliar supraorbital eyebrow Approach for Skull Base Lesions; A Cadaver Study

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Abstract

Background: ***Supraorbital ridge resection was appropriate for resectioning olfactor groove meningiomas, sellar and parasellar tumors, craniopharyngiomas, and anterior communicating aneurysms.***

Aim and objectives: ***To understand the anatomy and angles for the skull base through the trans-clear approach on the cadavers and how we can use this information on the patients at the operative theatre to improve the outcome and avoid complications.***

Patients and Methods: ***This prospective analytical research enrolled four cadavers at the Mortuary in Anatomy Department and Microscopic Neurosurgical Unit of the Faculty of Medicine, Al-Azhar University. Five adult cases with skull base de novo tumors are scheduled for surgical intervention.***

Results: ***Severe cerebral atrophy with firm consistency and collapse in vascular structures were identified in each of the cadaveric heads fixed with formalin. The distances between the frontozygomatic suture and target structures are measured.***

Conclusion: ***The study findings demonstrated successful visualization of the medial and anterior regions of the anterior cranial fossa. The endoscopic "supraorbital keyhole" technique can be employed to easily dissect the arteries of the Circle of Willis, which is situated on the same side as the craniotomy. Aneurysms in the anterior circulation and lesions in the anterior skull base, particularly those in the middle, can be surgically treated easily.***

Keywords: Trans-Ciliar Approach; Skull Base Lesions; Cadaver Study

1. Introduction

A pituitary tumor was initially resected via supraorbital ridge resection by Frazier in 1913.[1] A supraorbital approach was initially proposed by Jane et al. in 1982 for the resection of craniopharyngiomas, sellar and parasellar tumors, olfactor groove meningiomas, and anterior communicating aneurysms.[2] Perneczky and coworkers made further improvements to the supraorbital keyhole craniotomy procedure by using a ciliary incision, which they precisely described.[3,4,5]

For anterior cranial base access, numerous microsurgical techniques are currently being developed. [6]

Significantly low rates of complications have been observed when orbitofrontal, unilateral, or bilateral subfrontal, peritoneal, and orbitozygomatic approaches were utilized. Neuroimaging, neuroendoscopy, and neuronavigation methods, on the other hand, have emerged as a recent development in neurosurgery that has enabled surgeons to customize minimally exposed, less invasive surgical approaches for patients.[7] The following were cited as disadvantages of Classical approaches with broad exposures: Brain retraction of a significant degree, surgical dissection that is unnecessarily wide, temporal muscle dissection of some degree despite the absence of temporal bone resection necessity, and unfavorable cosmetic outcomes. [6]

Anterior skull base endoscopic techniques have increased in popularity over the past two decades due to advancements in endoscopes featuring enhanced optical and illumination qualities and the manufacturing of new endoscopic instruments. The endoscopic endonasal transsphenoidal approach is a significant alternative to the microsurgical transseptal transsphenoidal approach.

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Endoscopy provides superior illumination., a considerably wider operative view during surgery, increased magnification, and the capability to "see around the corner". [8, 9]

It is now possible to do more extensive surgery on pathologies in the anterior cranial base thanks to modifications in the endoscopic endonasal transsphenoidal method.[9] But these "extended" methods can lead to major complications, such as fistulas of cerebrospinal fluid or complications during secondary surgery due to significantly disturbed anatomy.[9] The supraorbital keyhole technique has gained popularity in treating injuries to the anterior skull base and aneurysms in the anterior circulation. It is minimally invasive and has a low risk of complications.[5, 10]

Many clinical research studies have been published recently concerning utilizing microscopic, endoscopic, or endoscopy-assisted microscopic supraorbital keyhole approaches to treat lesions in the middle and anterior skull bases. Furthermore, extensive research has been conducted on the microsurgical anatomy surrounding the supraorbital keyhole approach.[11] Nevertheless, very few cadaveric investigations have focused on the endoscopic morphology of the anterior skull base.[12]

This work aimed to better understand the anatomy and angles of the skull base through a trans-ciliar approach on the cadavers and how we can use this information on the patients at the operative theatre to improve the outcome and avoid complications.

2. Patients and methods

This prospective analytical study enrolled four cadavers at the Mortuary in Anatomy Department and Microscopic Neurosurgery Unit of the Faculty of Medicine, Al-Azhar University, and five adult patients with skull base de novo tumors scheduled for surgical intervention in the Neurosurgery Department of Al-Azhar University hospitals from October 2022 to September 2023. All participants were medically and radiologically evaluated. All participants received ethical committee approval and written informed consent before enrollment in the study.

In order to be eligible for participation in this research, the inclusion criteria were five cases: adults with skull base de novo tumors. CT and MRI with contrast were used to confirm skull base de novo tumors. Criteria that were excluded in the study: children, skull base recurrent tumors, skull base tumors needing only an endoscopic transnasal approach, like pituitary microadenoma, and skull base non-neoplastic lesions.

Before surgery, a comprehensive medical history was recorded, and general and neurological examinations were conducted.

Surgical technique for the cadavers:

The incision in the skin measures 5 centimeters. The cut is performed at the upper boundary of the eyebrow, maybe inside the crease of skin above the eyebrow (supraciliary). The supraorbital notch acts as the medial limit for the incision. Course: The incision line placement is slightly higher above the eyebrow. Ending point: The incision concludes at the edge of the eyebrow's tail and can be prolonged up to 1 cm in a sideways orientation. The dissection of subcutaneous tissue is accomplished by making incisions in the soft tissues parallel to the skin incision. The task must be performed with a margin of 3 cm above the orbital ridge. It is imperative to conserve the supraorbital neurovascular bundle. The frontalis muscle is cut following the orientation of its muscle fibers and in alignment with the skin incision. The temporal fascia and muscles are exposed to allow for a prolonged approach. The dura of the frontal lobe is exposed via the utilization of a fronto-basal keyhole. Expanding this aperture to encompass the larger wing of the sphenoid bone extracranially allows one to access the temporal pole's dura and Sylvian fissure. Certain cadavers exhibit a frontal sinus that exceeds the supraorbital notch.

Consequently, extracting the posterior wall of the frontal sinus is essential while performing a craniotomy. The craniotomy landmarks are specific anatomical points utilized as reference points throughout the surgical craniotomy procedure. Medially, the frontal sinus or the supraorbital notch is observed if it is located to the side of the notch. Laterally, the keyhole is observed. Superiorly: Positioned up to 3 cm above the supraorbital ridge. Inferiorly: the orbital rim (unless an orbital osteotomy is required). The dura is incised in a C-shaped manner. Exposure inside the dura mater; Parenchymal structures: If necessary, the frontal and temporal lobes can be exposed. Arachnoidal layers: carotid cistern, optic cistern, and, if necessary, the proximal Sylvian fissure. Cranial nerves: The optic nerves, which can be either ipsilateral or contralateral, connect to the optic chiasm. Arteries: ipsilateral and contralateral internal carotid artery, ipsilateral posterior communicating artery (PcomA), ipsilateral and contralateral anterior cerebral artery, anterior communicating artery (AcomA), and ipsilateral middle cerebral artery (MCA).

It was noted that orbiting roof drilling requires sufficient maneuverability to provide efficient working conditions. Observing deep structures such as the diaphragm sellae, infundibulum, basilary tip, proximal sections of the bilateral PCA, and the PCommA proved challenging without an endoscope.

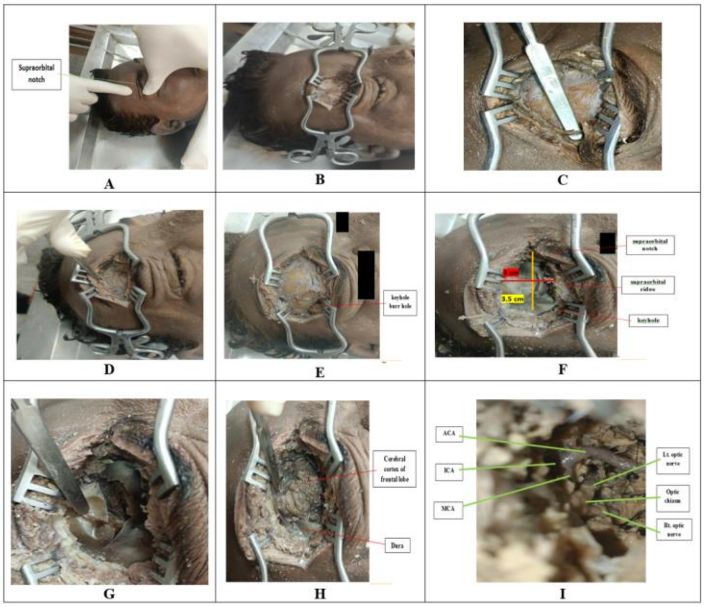

Figure 1: Showed (A): Skin incision (5 cm). (B): dissection of subcutaneous tissue. (C): Preservation of supraorbital neurovascular bundle (D): Dissection of frontalis and temporalis muscles. (E): keyhole burr hole. (F): After craniotomy with intact dura. (G): C-shape opening of the dura. (H): Cerebral cortex of the frontal lobe. (I): Internal structures.

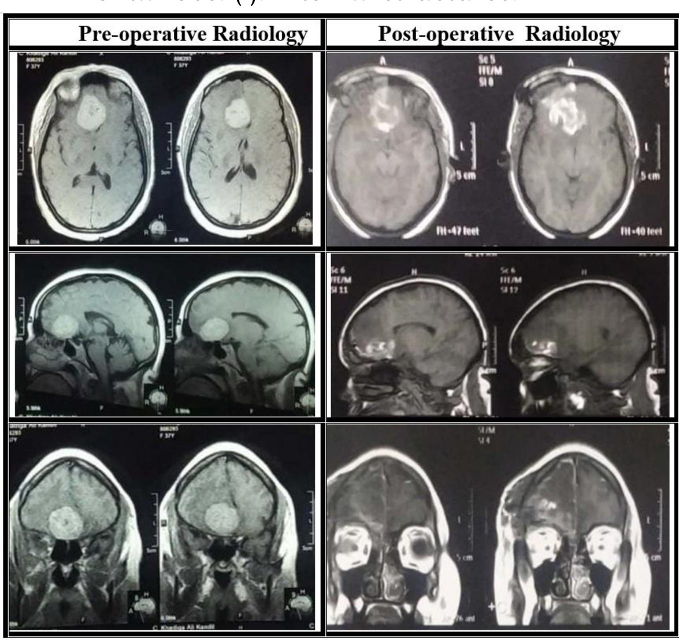

Figure 2: Pre and post-operative radiology for live case.

3. Results

The skin incision measured a typical length of 5 cm. The craniotomy had a width of 3.5 cm and a height of 3 cm. Reluctantly, the frontal sinus was opened in 2 out of 4 craniotomies due to its considerable size, which exceeds the supraorbital notch. If the frontal sinus were to open during this live operation, it would be necessary to remove the mucus membrane of the frontal sinus and obliterate its space and foramen by a bud of fat or muscle. All of the formalin-fixed cadaver heads exhibited severe cerebral atrophy characterized by firm consistency and collapse in vascular structures.

Table 1. The distances between the frontozygomatic suture and target structures

CADAVER NUMBER	ICA BIFURCATION MM	OPTIC CHIASM MM	ICA BIFURCATION – OPTIC CHIASM DISTANCE (MM)
1	66	70	11
2	63	67	10
3	54	60	8
4	52	55	9

Table 2. Comparison between Trans-Ciliar approach in both live and the cadaveric cases

	LIVE CASES	CADAVERIC CASES
POSITION	Can processing as we need by May's field.	Can't processing as we need because all body of the cadaver is stiffness
SKIN INCISION	Easy	Easy
SUBCUTANEOUS TISSUE DISSECTION	Easy	Easy
PRESERVATION OF SUPRAOPTIC NERVE AND BLOOD VESSELS	Easy	Easy
FRONTALIS AND TEMPORALIS MUSCLES DISSECTION	Easy	Easy
PERIOSTEAL DISSECTION	Easy	Hard as the periosteam is adherent to skull bone
CRANIECTOMY OF SKULL BONE BY CRANIOTOMY AND DRILL	Easy	Easy
THE FRONTAL SINUS WAS OPENED RELUCTANTLY	2 cases, so we remove the mucus membrane of the frontal sinus and obliterate its space and foramen by bud of fat or muscle	2 cadavers as large frontal sinus that exceed the supraorbital notch
OPENING THE DURA	Easy	Easy
ELASTICITY OF THE BRAIN CORTEX AND TISSUE	Soft	Very firm
ILLUSTRATION OF ANTERIOR AND MIDDLE CRANIAL FOSSA	Easy	Can do that after excision part of the frontal lobe as the consistency of the cadaveric bone is very firm
ILLUSTRATION OF OPTIC CHIASM AND OPTIC NERVES	More easy	Can do that after excision part of the frontal lobe as the consistency of the cadaveric bone is very firm
ILLUSTRATION OF ICA, ACA AND MCA	More easy	Can do that after excision part of the frontal lobe as the consistency of the cadaveric bone is very firm
HEMOSTASIS	Easy	Can't do that as the

		blood in cadavers is clotted
CLOSURE OF THE DURA	Easy	Can't do that as the dura is friable
REPOSITION OF BONE FLAB	Easy	Easy
CLOSURE OF THE FRONTALIS MUSCLE	Easy	Hard as the frantalis muscle in cadavers is friable
CLOSURE OF THE SECATEURS TISSUE	Easy	Hard as the secateurs tissue n cadavers is friable
CLOSURE OF SKIN	Easy	Easy

4. Discussion

Several neurosurgical techniques have been devised to treat lesions in the frontotemporal region of the skull. The techniques encompass orbitozygomatic, frontal, personal, bifrontal, frontotemporal, and other variations.[13]

The advancement of these methodologies, commencing with Dandy's frontotemporal "microsurgical approach," proceeding to Yasargil's microsurgical personal approach, and ending in the supraorbital keyhole approach executed via an eyebrow incision, has supplied neurosurgeons with the requisite visibility to approach various pathologies in a secure manner.[13]

Not only was the purpose of "keyhole" surgery to create a small opening, but also a small incision and craniotomy. By employing this technique, adequate access was ensured to skull base lesions while trauma to surrounding tissues, such as the dura, skin, bone, and, notably, the brain, was minimized.[14]

A diminished opening within a blood vessel could impede the attainment of adequate vascular regulation in the context of vascular lesions while preventing harm to surrounding structures. Subfrontal and supraorbital craniotomies can be performed considerably more efficiently when a rigid rod-lens endoscope is used with the surgical microscope. Greater illumination at greater depths, improved focus, and enhanced visibility are all characteristics of the endoscope. For instruments to be maneuverable utilized during a bimanual surgical technique, a craniotomy opening of at least 1.5–2 cm is essential.[13]

We utilized nine cadaver heads preserved in formalin, sourced from the Anatomy Department's inventory at the Istanbul School of Medicine. The anatomical dissections were performed in the Microneurosurgery Laboratory, a department of Istanbul Medical School's Neurosurgery Department. Eighteen supraorbital keyhole craniotomies were conducted utilizing incisions made through the eyebrows. A 2 mm diameter rigid endoscope, measuring 26 cm in length, equipped with lenses of 0 and 30 degrees (made by Karl Storz Gmbh and Co., Tutlingen, Germany), was used.[15]

We utilized cadaver heads from the Anatomy Department inventory of the Faculty of Medicine at Al-Azhar University for our investigation. Four supraorbital keyhole craniotomies were conducted using open surgery, utilizing both a loop and an endoscope, through incisions made in the eyebrows. The measurements of the eyebrow incision, craniotomy size, and, if applicable, frontal sinus opening were documented.[15]

Critical intracranial structures of the anterior and middle cranial fossa, including the optic chiasm, optic nerve, ICA, ACA, and MCA, were taken into account in our research, along with the size of the craniotomy and the standard length of the eyebrow incision (5 centimeters).

The head was placed in a surgical posture with a 15-degree extension angle and a 20-degree lateral deviation from the approach side. The usage of palpation and marking facilitated the identification of the supraorbital notch. A skin incision was performed inside the region between the eyebrows, starting at the outside edge of the supraorbital notch and extending to the pterion. The temporal, frontal, and orbicularis oculi muscles were visible.[15]

In our study, we could not move the neck because of the stiffness of the cadavers, but we were using the loop for better exploration. The utilization of palpation identified the supraorbital notch and subsequently indicated. A skin incision was performed inside the region between the eyebrows, starting at the outside edge of the supraorbital notch and extending to the pterion. A temporal and frontal muscle, orbicularis oculi, was visibly exposed.

A periostal elevator cuts the temporal muscle straight across from the temporal line. An 11-blade knife cut the frontalis muscle parallel to the edge of the upper eyelid. Dissection was performed bluntly on the frontal and orbicularis oculi muscles.[15]

For our experiment, we used a sharp 11-blade knife to cut the frontalis muscle in a parallel line with the supraorbital boundary. Conversely, a periosteal elevator was angled vertically to the temporal line and utilized for blunt dissection of the temporal muscle. The frontal muscles and orbicularis oculi were also dissected bluntly.

The keyhole was created below the temporal line utilizing a high-speed drill and a 5-mm-diameter ball fluted bit. Craniotomy with a width of 2.2-3.0 cm and a height of 1.3-1.7 cm was performed.[15]

In our study, a surgical procedure involved creating an opening in the skull at a keyhole point below the temporal line using a Hudson brace drill. The craniotomy, 3.5 cm wide and 3.0 cm high, was performed, which was bigger than the previous study as we did not use the endoscope.

The skin incision exhibited a mean length of 3.68 ± 0.19 cm, spanning a 3.4 to 4 cm range. The craniotomy had an average width of 2.65 ± 0.23 cm, with a 2.2 to 3 cm range. On the other hand, it had a mean height of 1.43 ± 0.12 cm, with a range of 1.3 to 1.7 cm. A hesitant frontal sinus opening was observed during five out of eighteen craniotomies. The frontal sinus orifice measured less than one cm in three craniotomies. In one, it was between 1 and 2 cm, and in one, it exceeded 2 cm.[15]

In our study, we used the stand length of the skin incision (5 cm). The width of the craniotomy was 3.5 cm, whereas the height was 3 cm. The frontal sinus was opened with reluctance in two cadavers of our research because the frontal sinus was beyond the supraorbital notch. The dura was incised in a C-shaped manner, following the contour of the orbital roof. The drill was utilized to narrow the craniotomy's orbital roof and interior margins, allowing for broader working angles for the endoscope.[15]

In our investigation, the dura was incised in a C-shaped manner. In addition, we thinned the orbital roof and interior margins of the craniotomy utilizing a drill to provide a wider range of working surgical equipment. A 9 mm brain retractor was utilized to retract the frontal pole, and a 2 mm 0-degree endoscope was introduced intradermally into the anterior cranial fossa.

In our study, the frontal pole was not retracted as the formalin-fixed brain was very firm, so we did a partial frontal lobectomy to help visualize important intracranial structures of the anterior and middle cranial fossa, like the optic chiasm, optic nerve, ICA, ACA, and MCA.

A zero-lens endoscope allowed for visualization of the olfactory bulb, olfactory tract, both optic nerves at the Liliequist membrane, optic chiasm, optic canal, A1 and A2 segments of the anterior choroidal artery, ICA bifurcation, Acoma, MCA, and ACA. By employing 30-degree lens endoscopes, the seller, diaphragm, and infundibulum were visually examined. An observation was made of the superior and inferior trunks of the M2 segment distal to the MCA.[15]

In our study, we used a loop and an endoscope to look at the optic chiasm, the A1 segment of the ACA, both optic nerves at the optic canal, the ipsilateral ICA bifurcation, and the M1 segment of the MCA.

The following are the distances among the dura and the target structures at the craniotomy site: ICA bifurcation (mm) is Mean±SD 74.7±6; Optic chiasm (mm) is 76.2±5.4; and ICA bifurcationoptic chiasm (mm) is Mean±SD 11.3±1.9. [15]

In our study, the distance between the frontozygomatic suture and target structures is: ICA bifurcation (mm) is Mean±SD 58.75±6.75; Optic chiasm (mm) is 63±7; and ICA bifurcationoptic chiasm (mm) is Mean±SD 9.5±1.5.

4. Conclusion

The current work is a valuable source of information concerning the trans-ciliar approach to anterior cranial base surgery. In great detail, the surgical working area and dissection were described. Dissection and the surgical working area were described. The findings of this research endeavor exhibited accurate observation of both the medial and anterior cranial fossa. A straightforward procedure involves performing an endoscopic "supraorbital keyhole" dissection of the arteries of the Circle of Willis, which are located on the same side as the craniotomy. Aneurysms of the anterior circulation and lesions of the anterior skull base, particularly those in the midline, are easily opera.

Disclosure

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Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

There are no conflicts of interest.

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