Operative Technique

Three-step anterolateral approaches to the skull base

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ABSTRACT

Adequate intraoperative exposure of the brain is paramount to prevent unnecessary retraction of the brain parenchyma. Lesions in the anterior skull base, the middle fossa and even the upper part of the posterior fossa can be managed anterolaterally through the pterional approach, the orbitozygomatic approach and the transzygomatic approach. Although commonly discussed on a separate basis, these three procedures are here considered to belong in the same spectrum, which includes one, two or three step procedures depending on the case and the level of exposure required. Ten hemispheres were used to describe the surgical technique applied in a three-step anterolateral approach. The pterional approach provides adequate access to the frontal base and the Sylvian fissure, the circle of Willis and the optic nerves. Where access to the temporal base is needed, improved exposure can be afforded by sectioning the zygomatic arch and lowering the masseter muscle. The lateral orbital wall is sectioned to improve the vertical angle of approach and facilitate access to hypothalamic and posterior fossa lesions. The combination of three approaches into one procedure introduces a new perspective on this technique, one which makes them easier to understand and shows how craniotomy may be modified for optimal exposure, even while conducting the surgery.

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1. Introduction

The pterional or fronto-temporo-sphenoidal approach, which was first described by Yasargil, constitutes one of the most widely used approaches in neurosurgery, as it provides access to lesions at the circle of Willis, the sellar and parasellar regions, the base of the middle fossa, the sphenoid wing, and the temporal lobe [1].

This approach affords excellent brain exposure at the level of the anterior Sylvian fissure, and the frontal and temporal opercula; however, access to the floor of the middle fossa may be restricted by interposition of the zygomatic arch, which limits retraction of the temporal muscle. The zygoma can be resected thereby turning the pterional approach into a transzygomatic approach. This affords excellent access to the floor of the middle fossa and the lateral wall of the cavernous sinus, opens a good window to manage lesions at the interpeduncular cistern, and provides a better angle of view to the insula [2,3].

Removal of the zygoma permits a wider view in the pterional approach; however, lesions that are located farther, either medially or basally, as is the case when the hypothalamus is involved, or lesions that affect the posterior fossa and may require a deeper vertical view, will remain hidden. In order to approach these from the anterior region, a part of the lateral orbital wall needs to be removed so that the osteotomy can be widened, thus becoming an orbitozygomatic approach [4–6].

Over the last three decades, much progress has been made in the management of skull base lesions, on account of a practice which minimizes brain retraction based on greater bone removal. The orbitozygomatic approach represents the quintessence of this practice. Several authors have discussed this approach in one, two and three steps ever since it was initially described by Jane, Pellerin, Hakuba, and Al Mefty [7–10].

They all focus on these three approaches on a separate basis, that is, from a perspective that eventually complicates the surgical technique used. Here we intend to show that these three seemingly separate approaches are, in fact, part of one and the same procedure, and that by using certain reproducible simple maneuvers, they can be applied safely to enhance the angle of exposure. This group

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of approaches is jointly called “anterolateral approaches to the skull base”.

By using one approach that is inclusive of three variants (three in one), the procedure can be customized to suit each patient’s needs, the osteotomy can be conveniently widened when the previously planned approach proves inadequate, and these otherwise complex approaches become clearer for the training of neurosurgical residents.

2. Materials and methods

Five dry skulls and five formalin-fixed heads were used to demonstrate the technical features of this three-step approach.

3. Surgical technique

3.1. Common steps of the approach

The patient is positioned supine with the chest elevated 10–15 degrees so as to enhance venous return. Depending on the head rotation, a roll may or may not be placed under the ipsilateral shoulder. The head is turned contralaterally 0–60 degrees, depending on the region to be approached, with the malar eminence conveniently representing the highest point in the operative field. The neck extension, which lowers the vertex, helps to promote the force of gravity and separate the frontal lobe from the anterior skull base.

3.1.1. Skin incision

The incision starts at the level of the upper margin of the zygomatic arch, 1 centimeter anterior to the tragus, and extends behind the hairline up to the midline (Fig. 1A). Where necessary (as is the case when the three steps of the approach are conducted), the incision can be safely taken 1.5 centimeters inferior to the zygoma without risk of damaging the frontal branch of the facial nerve.

3.1.2. Flap dissection

A subgaleal dissection is performed to expose the fat pad above the temporal fascia. At this level, the incision is cut through the superficial fascial layer and the fatty tissue between the superior and inferior fascial layers to advance along the inferior fascial layer in order to protect the frontal branch of the facial nerve. As a second step, the orbital rim is exposed; with the pterional approach, exposure need not be taken as far as the zygoma or the zygomatic arch, which must be reached when the transzygomatic and the orbitozygomatic approaches are used (Fig. 1B, C, Fig. 2).

3.1.3. Reflection of the temporal muscle

The temporal muscle is elevated from the bone starting at the superior temporal line by means of retrograde dissection so as to prevent postoperative atrophy. For better cosmetic reconstruction, a part of the muscle may be kept attached to the bone.

3.2. Step 1: Pterional approach

Two burr holes are made for the craniotomy. The first hole or so-called “keyhole” (hole 1) is placed posterior to the frontozygomatic arch.
suture and inferior to the superior temporal line. The second burr hole is drilled just posterior to the sphenotemporal suture at the level of the temporal squama, and superior to the zygoma (hole 2). First, the dura must be dissected from bone. Then the craniotomy is performed, starting at the level of hole 2 and proceeding along the posterior line of the muscle reflection to extend past the upper limit. The craniotomy is then curved and extended to the frontal region above the orbital roof up to hole 1. Where a wider exposure of the middle fossa floor is required, the zygoma can be exposed (Fig. 1).

3.3. Step 2: Transzygomatic approach

The temporal bone is exposed and repositioned for exposure of the zygoma and the zygomatic arch. The zygomatic arch is then vertically sectioned into two parts – posteriorly and immediately anteriorly to the temporomandibular joint, where the orbital tubercle is the most important anatomical landmark, and anteriorly and immediately posteriorly to the union of the zygomatic arch and the zygoma. In this way, the released bone fragment and the masseter muscle, which is not separated from the zygoma, are mobilized inferiorly. Exposure of the base of the temporal fossa is achieved by drilling its lateral wall (Fig. 2).

3.4. Step 3: Orbitozygomatic approach

The periorbita is an anatomic continuation of the pericranium and must be dissected laterally to medially with extreme care. The supraorbital nerve must be released from its notch and, where there exists a foramen, this can be opened with Kerrison rongeurs. After the zygoma has been removed, the orbital rim and orbital roof are sectioned, starting 1 centimeter lateral to the medial frontal border of the craniotomy and then moving posteriorly by approximately 3 centimeters, with no need to access the superior orbital fissure. Finally, as a third step, the section is curved towards the inferior orbital fissure (Fig. 3).

4. Discussion

The pterional approach is routinely used to manage lesions in the middle and anterior fossae. First popularized by Yasargil, this approach consists of sectioning the Sylvian fissure for exposure of the vessels in the Sylvian cistern and the circle of Willis to reduce the distance between the surgeon's hands and the surgical site. Maximal bone removal, use of fissures and sulci, and minimal brain retraction are all essential principles in present day neurosurgical technique [11,12].

The addition of steps to the pterional approach affords a better angle of view without producing brain retraction. Here we describe how one approach can be transformed into another in a simple and dynamic way, thereby enabling customization of the osteotomy in a single surgical procedure.

The pterional approach can be turned into a transzygomatic approach by removing the zygomatic arch, that is, by adding one simple and quick step to facilitate access to the base of the middle fossa. This further step permits full visualization of the lateral wall of the temporal dura, as opposed to the pterional approach alone, where access is blocked by the temporal muscle [13].

Fig. 2. Step 2. After the craniotomy the dura covering the upper temporal and lower frontal surfaces can be seen, completing the first step (A). If a more basal approach is needed the temporal muscle can be repositioned, exposing the zygoma (B), then two cuts are made without detaching the masseter exposing the bone covering the temporal pole (grey shape) (C). After the new craniotomy is complete (D) a larger access to the floor of the middle fossa is obtained. (This Figure is available in color at www.sciencedirect.com.)
Contrary to other authors, we consider that the masseter muscle can be kept attached to the inferior margin of the zygomatic arch; the bone is sectioned as described, and mobilized downwards, thereby allowing the temporal bone to fill the space left with the osteotomy [2]. In this manner, a more functional reconstruction is achieved, one that preserves the attachment of an important muscle for mastication.

Complete exposure of the lateral aspect of the temporal dura mater is thus obtained, which is useful for extradural and cavernous sinus approaches. In addition, retraction of the temporal pole is minimized, thereby enhancing the view of the interpeduncular fossa [2].

The amount of zygoma to be removed varies depending on the author; we prefer to section the zygoma widely, so that the space left can hold the whole temporal is muscle, with utmost care in order to avoid entering the temporomandibular joint; other authors have described the removal of a fragment of the lateral orbital wall.Krish reported that drilling of the upper part of the zygoma without complete removal improves access and provides adequate exposure, thereby avoiding a new osteotomy [14]. We believe that sectioning the zygoma with 3 centimeters between bone margins, while keeping the attachment of the masseter muscle in place, is a simple, fast procedure that permits easy reconstruction and maximizes the approach to the middle fossa.

Where the disease process so requires it, a third step can be added to the procedure described above, turning the transzygomatic approach into a three-step orbitozygomatic approach. Section of the lateral orbital wall improves the angle of horizontal access, which is particularly useful when a transsylvian route is used, for instance, in the management of craniopharyngioma or hypothalamic hamartoma [15,16].

On the basis of the previously mentioned description, bone removal stops before reaching the superior orbital fissure and does not extend anteriorly to the zygomatic arch. Gonzalez et al. argue that further extension of the osteotomy towards the maxillary bone affords minimal widening of the surgical field [16]. Furthermore, extending the approach to the superior orbital fissure provides no significant enhancement of the view but requires retraction of the frontal lobe and involves a certain risk of damage to the structures along its course. We suggest shifting the angle by which the orbital roof is sectioned 1 centimeter before reaching the superior orbital fissure (fourth section) so that it is brought downwards to the inferior orbital fissure (fifth section). In this way, the orbital osteotomy is limited and excellent exposure is obtained; in addition, technical complexity, surgical time and risk of damage to nearby structures are reduced without sacrificing space in the surgical field.

The three-step anterolateral approach simplifies and combines three different procedures, thereby allowing customization of bone removal and temporal muscle retraction for each individual patient, with the purpose of maximizing bone removal and minimizing brain retraction.

Conflicts of Interest/Disclosures

The authors declare that they have no financial or other conflicts of interest in relation to this research and its publication.
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