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Mini-temporal approach as an alternative to the classical pterional approach for resective temporal region surgeries: Technical note

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Technical advance

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Abstract

Background

Classical pterional appoach for temporal surgeries may cause atrophy and dysfunction of temporalis, injury to the facial nerve, as well as unnecessary cortical exposure. As an alternative to the classical pterional approach for such surgeries, we hereby describe an mini-temporal approach which reduces these risks and proven to be practical in neurological surgeries.

Methods

In the mini-temporal incision design, the frontal end of the incision never surpassed the hairline at the level of temporal line, and a one-layer skin-galea-muscle flap was detached from the cranium, effectively avoiding the injuries of facial nerve. The surgical bone window was completely located underneath the temporalis muscle, allowing it to be completely repositioned postoperatively.

Results

We demonstrated the application of mini-temporal approach in a variety of temporal region tumors, which can be applied to complete successful resective surgeries while effectively reducing injuries to extra-temporal cortex, temporalis and facial nerve. There were no postoperative complications related to extra-temporal cortical damage, atrophy of temporalis or injury to the facial nerve.

Conclusion

The mini-temporal approach can effectively shorten the time of craniotomy and closure, decrease the size of bony removal, increase the restoration of temporalis during closure and lower the chance of facial nerve injury. Therefore, it improves cosmetic outcomes and reduces the risk of unintentional extra-temporal cortical injury, which fully embodies the minimally invasive principle in neurosurgery.

Background

Pterional craniotomy, one of the most commonly used procedurse in neurosurgery, has become a mainstream surgical approach and standard in evaluating alternative surgical techniques for the same anatomical target for many years [1–6]. It allows surgical exposure that minimizes brain retraction of the arterial circle of Willis, midbrain, temporal lobe, frontal lobe, supra- and parasellar regions, the orbit, cavernous sinus, and the superior orbital fissure [1, 3, 5, 6]. However, due to the complete dissection of the temporal muscle, pterional craniotomy may lead to functional impairment and aesthetics [1, 5, 6]. Damage to the temporal branch of the facial nerve and atrophy of the subcutaneous fat pad and the temporalis often result in craniofacial contour changes [1, 5, 7]. It is an inevitable trend for neurosurgery

to move away from the larger craniotomies to the smaller craniotomies [8]. Neurosurgeons are constantly challenging to minimize surgical approaches without compromising anatomical exposure. "One-size-fits-all" craniotomy is not rational, the surgeons should be allowed to adjust the approaches according to the features of the lesion and the anatomical characteristics neighboring the lesions, in order to best meet the interests of the patients.

In our clinical practice we have found that for temporal region surgeries, such as the popular anterior temporal lobectomy for either epilepsy or glioma surgeries, the classical pterional approach seems quite extensive with unnecessary exposures and lengthy procedures from craniotomy to closure. As an alternative, the mini-temporal approach has been practiced in our department for more than eight years, achieving good results in multiple aspects. The indications of this approach encompass epilepsy surgeries such as anterior temporal lobectomy and selective amygdalo-hippocampectomy, glioma surgeries involving mesial and lateral temporal lobe, extra-axial tumors located in the anterior temporal region or sylvian fissure, and small tumors in the middle cranial fossa.

Methods

Operative technique:

A) Patient is positioned in a supine position, with head rotated 45 degrees towards the opposite shoulder, and a curved incision is made within the hairline of the temporal region; **B)** Hook-shaped retractors are used to maximize bony exposure; **C)** Drills made in the root of zygomatic arch and the anterior and upper limits toward the the keyhole; **D)** Opening of the bone flap; **E)** Cutting open the dura and exposing the cortical areas as needed; **F)** Removal of the temporal lobe lesion; **G)** Complete restoration of the cranium; **H)** Complete restoration of the temporal muscles; **I)** Use a skin stapler to close the incision

The patient is positioned in a supine position, with head rotated 45 degrees towards the opposite shoulder, vertex tilted downwards to the floor. A curved incision is usually made in the temporal region (Fig. 1, 1A).

Retraction is very important since the exposure can be very small. Usually 2 to 3 hook-shaped retractors for the flap will be used. (Fig. 1, 1B) Drippings should be fixed tightly by the circulating nurses for sufficient retraction.

The bony exposures are mainly the temporal bone and the greater wing of the sphenoidal bone. The extents are: downwards:zygomatic arch root; upwards: one centimeter above the squamous suture; anterior: anterior extremity towards sphenoidal ridge after retraction (usually have a distance to the “keyhole”); and posterior: level of the external acoustic meatus (or more posterior according to position of the lesions). The classical craniotomy landmark, the keyhole, can seldom be reached in this approach. The first drill is usually at the root of the zygomatic arch. The second one, if necessary, is usually at the anterior and upper limit toward the direction of the keyhole. (Fig. 1, 1C) The craniotomies extent usually equals the exposure after the flap retraction, usually no extra bone should be removed after the bone flap

removal. (Fig. 1, 1D). For a trained doctor, the procedure usually takes about 20 minutes and greatly reduces the size of the bone window(Fig. 2).

The orange line indicates the incision for the mini-temporal approach; the green line indicates the incision for the classical pterional approach; the blue area represents the bone window of the mini-temporal approach; and the yellow area represents the bone window of the classical pterional approach.

After dura opening, the anterior extremity of the temporal lobe is hidden(Fig. 1, 1E). The sylvian fissure is usually sufficiently exposed with minimal exposure of the inferior frontal gyrus. With adjustment of the microscope angle, elevation of the patient's upper half, and with gradual lowering of the cerebral pressure during resection, the whole temporal lobe can be resected sufficiently and safely(Fig. 1, 1F). Dura closure can be performed easily, and complete restoration of the cranium can be done(Fig. 1, 1G). The temporal muscle can be completely restored and completely covers the bone window(Fig. 1, 1H). Finally, skin incisions were closed with a skin stapler(Fig. 1, 1I).

Results

Case illustrations:

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional review board and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants. Patients consented to the publication of their images.

The first patient was a 50-year-old woman who suffered seizure attack once. Magnetic resonance imaging (MRI) revealed a significantly enhanced mass in the right temporal lobe (Figure 3, 3A). We used the mini-temporal approach to access the tumor and perform resection of the tumor (Figure 3, 3B). Postoperative MRI showed complete resection of the tumor, and postoperative pathology showed meningioma of WHO grade I (Figure 3, 3C).

The second patient was 61-year-old female who suffered intermittent headche for 6 months. An enhanced lesion can be seen in the right temporal region (Figure 3, 3D). The mini-temporal approach was designed for performing "en bloc" resection of the tumor (Figure 3, 3E). The lesion was removed completely, and postoperative pathology showed a glioblastoma of WHO grade IV (Figure 3, 3F).

The third patient, who had numbness in the left side of the face for 4 months, showed a non-enhanced small lesion in the left temporal region (Figure 3, 3G). In the mini-temporal approach, the incision should

be as close to the hairline as possible to make the wound smaller (Figure 3, 3H). The lesion was removed completely, and postoperative pathology showed chordoma (Figure 3, 3I).

The fourth patient had blurred vision on the right eye. MRI showed a non-enhanced lesion in the left temporal lobe (Figure 3, 3J). the Mini-temporal craniotomy was designed slightly larger, and “en bloc” resection of the tumor was performed (Figure 3, 3K). Postoperative pathology revealed a astrocytoma of WHO grade II (Figure 3, 3L).

The last patient was 59-year-old male who suffered headche for half a month. An enhanced lesion can be seen in the right temporal region (Figure 3, 3M). The mini-temporal approach was designed for performing “en bloc” resection of the tumor (Figure 3, 3N). The lesion was removed completely, and postoperative pathology showed a glioblastoma of WHO grade IV (Figure 3, 3O).

As applied in a variety of tumor resections or open biopsy procedures, including meningiomas(A), gliomas(D, J and M), chordomas (G). The incisions were individually designed according to the tumor size and location and the patient's hairline (B, E, H, K, N). With a smaller incision and a bone window, most temporal lesions can be successfully removed (C, F, I, L, O).

Discussion

Classical pterional approach was first proposed by Krause in the late 19th century and the first performed by Dandy and Heuer to approach the hypophysis and optic chiasma [8]. In 1944, Dandy introduced the frontolateral craniotomy for the treatment of anterior circulation aneurysms, forming the basis of the classical pterional craniotomy. Kempe, Shepard and Swain further developed this procedure [8] and was greatly improved and popularized by Yasargil [5, 6]. Because of its versatility, this approach is widely used for approaching lesions in the circulation circle of Willis and the parasellar regions, as well as the frontal and temporal lobes. Although brain retraction is a commonly used technique in neurosurgery, it can lead to postoperative complications[9, 10]. The principle of pterional approach is to expose surgical targets in the basal cisterns by using a natural plane and space without severve brain retraction, thus leaving the brain undisturbed. Pterional craniotomy, however, requires complete dissection of the temporal muscles and often unnecessarily exposes large areas of the cortex that are unrelated to the site of the lesion.

New surgical techniques have been proposed to reduce the exposure of pterional craniotomy, reduce hospitalization and operative times, reduce tissue trauma, create a comfortable postoperative period, lower costs, and improve aesthetic and functional outcomes [1, 11-21]. Figueiredo et al. confirmed that the ascending branch of the anterior sylvian fissure as the posterior boundary of the craniotomy was able to achieve the same exposure range as the classical pterional approach[22]. The study showed that the surgical exposure area and the approach angles gradually increased with the progression of the sylvian fissure dissection toward the pars triangularis at the level of the anterior ascending ramus, and further dissection did not increase the exposure [22]. In mini-temporal craniotomy, the temporal lobe exposure will be larger than that of Figueiredo et al. to better expose both the temporal lobe and the

sylvian fissure region when approaching the arterial circle of Willis, which makes the en bloc resection of the temporal lobe tumors possible.

To protect arteries and nerves in the temporal region, it is necessary to dissect the muscle and periosteum together during the separation of the temporalis. Before surgeons began to intentionally protect the temporal branch of the facial nerve during craniotomy, frontalis muscle palsy occurred in 30% of patients who underwent scalp flap subgaleal elevation with separate temporalis separately elevation [7, 14, 23-25]. The loose areolar tissue between the galea and the superficial layer of temporal fascia is where the temporal branches to the frontalis muscle run [23]. Thus, the interfascial-subpericranial and subfascial-subpericranial techniques can retain innervation of the frontalis muscle [26]. In addition, with the development of plastic surgery and reconstruction and maxillofacial surgery, the understanding of the relationship between different fascia layers and nerves in the temporal region has also been improved [27-30]. The hairline at the temple is also comsidered a marker, and the area behind it is safe to dissect [31]. In the min-itemporal incision design, the frontal end of the incision never surpasses the hairline at the level of temporal line, and a one-layer skin-galea-muscle flap is detached from the cranium, effectively avoiding the injuries of facial nerve. Because the min-itemporal incision is usually small, the surgical bone window is completely located underneath the temporalis muscle, allowing it to be completely repositioned postoperatively. The cranium is usually milled in one piece with no extra bone removal, which commonly happens in the classical apporach, and the cranium can be restored intactly. Mini-temporal craniotomy does not extend to the frontal side of the skull, so the frontal sinus will not be invaded, reducing the possibility of postoperative cerebrospinal fluid leakage and infection. Mini-temporal incisions require less hair to be shaved, so fewer holes are required to be drilled and fewer temporalis to be separated. It can greatly reduce the time required for craniotomy as well as for closure.

Naturally, mini-temporal apporach has limitations. First, compared with the classical pterional approach, exposures of the temporal fossa, sphenoidal ridge and sylvian fissure are limited and it requires the surgeons to adjust the microscope to find the best angles. Second, when deep bony drilling in the surgical field is required, when brain edema or hematoma high intracranial occurs, or when fully dissection of the sylvian fissure is required for aneurysms, the mini-temporal approach, does not provide the same convenience and safety as the classical pterional approach. Therefore, the choice between mini-temporal and classical pterional approaches should be based on the anatomical positions and clinical/radiological features of the lesions.

Conclusion

Mini-temporal approach can effectively shorten the time of craniotomy and closure, decrease the size of bony removal and the chance of nerve injury, and facilitate the restoration of temporalis, thus improving cosmetic and functional outcomes and reduces the risk of unintentional cortical injury. This approach fully demostrates the minimally invasive principle in neurosurgery.

Declarations

Ethics approval and consent to participate:

This study was approved by the ethics review committee of Huashan Hospital. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional review board of Huashan Hospital and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards, and informed consent was obtained from all individual participants included in the study.

Consent for publication: Informed consent was obtained from all individual participants included in the study.

Availability of data and materials: The materials used and analysed during the current study available from the corresponding author on reasonable request

Competing interests:

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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Authors' contributions:

Conceptualization: Rui Feng, Jinsong Wu; Formal analysis and investigation: Nijiati Kudulaiti, Feili Liu; Writing - original draft preparation: Nijiati Kudulaiti, Feili Liu; Writing - review and editing: N. U. Farrukh Hameed, Rui Feng; Funding acquisition: Jinsong Wu; Resources: Peng Wang, Jie Zhang; Supervision: Jinsong Wu, Rui Feng. All authors read and approved the final manuscript.

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Figures

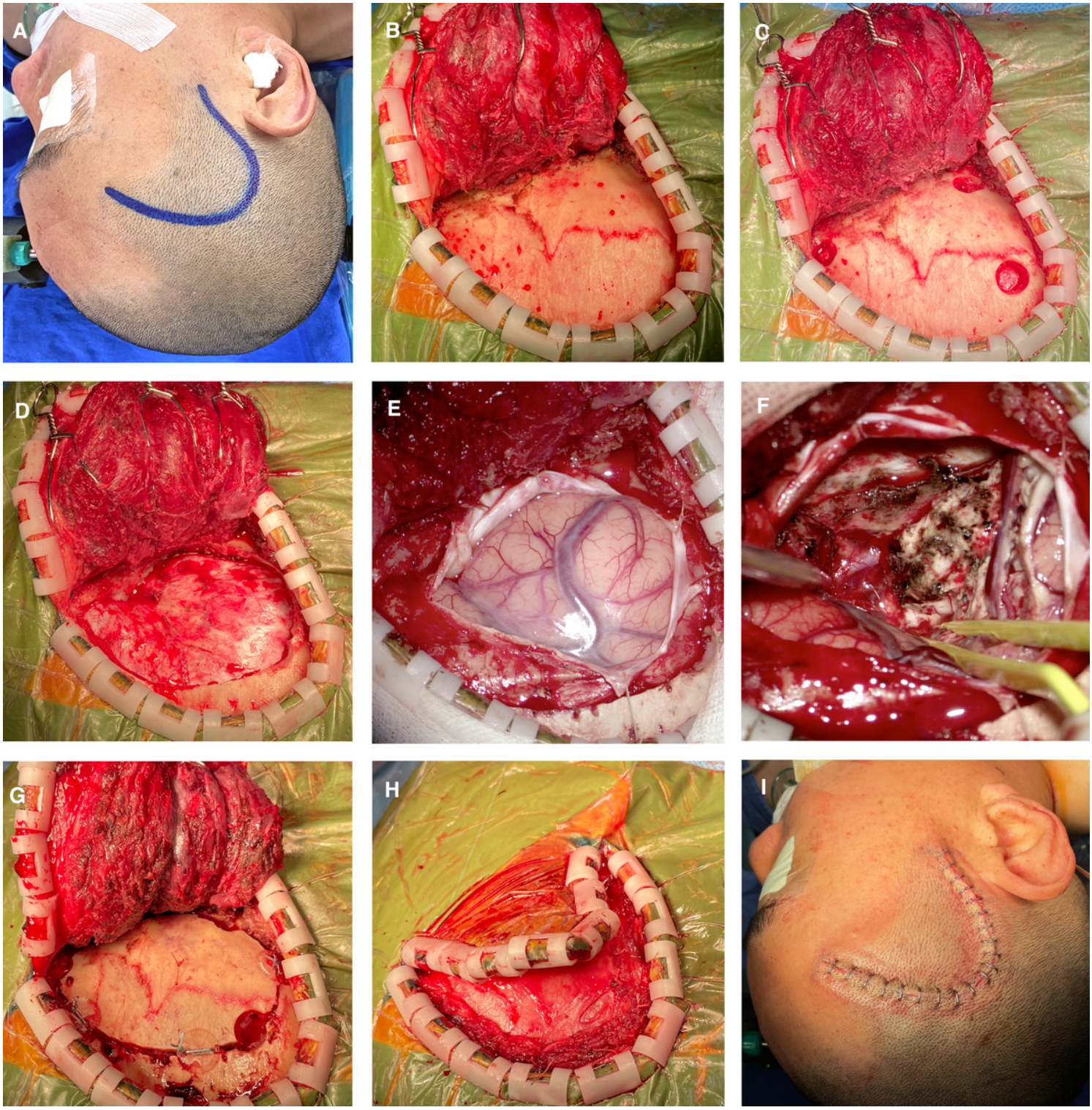

Figure 1

Craniotomy under the mini-temporal approach A) Patient is positioned in a supine position, with head rotated 45 degrees towards the opposite shoulder, and a curved incision is made within the hairline of the temporal region; B) Hook-shaped retractors are used to maximize bony exposure; C) Drills made in the root of zygomatic arch and the anterior and upper limits toward the the keyhole; D) Opening of the bone flap; E) Cutting open the dura and exposing the cortical areas as needed; F) Removal of the temporal lobe

lesion; G) Complete restoration of the cranium; H) Complete restoration of the temporal muscles; I) Use a skin stapler to close the incision

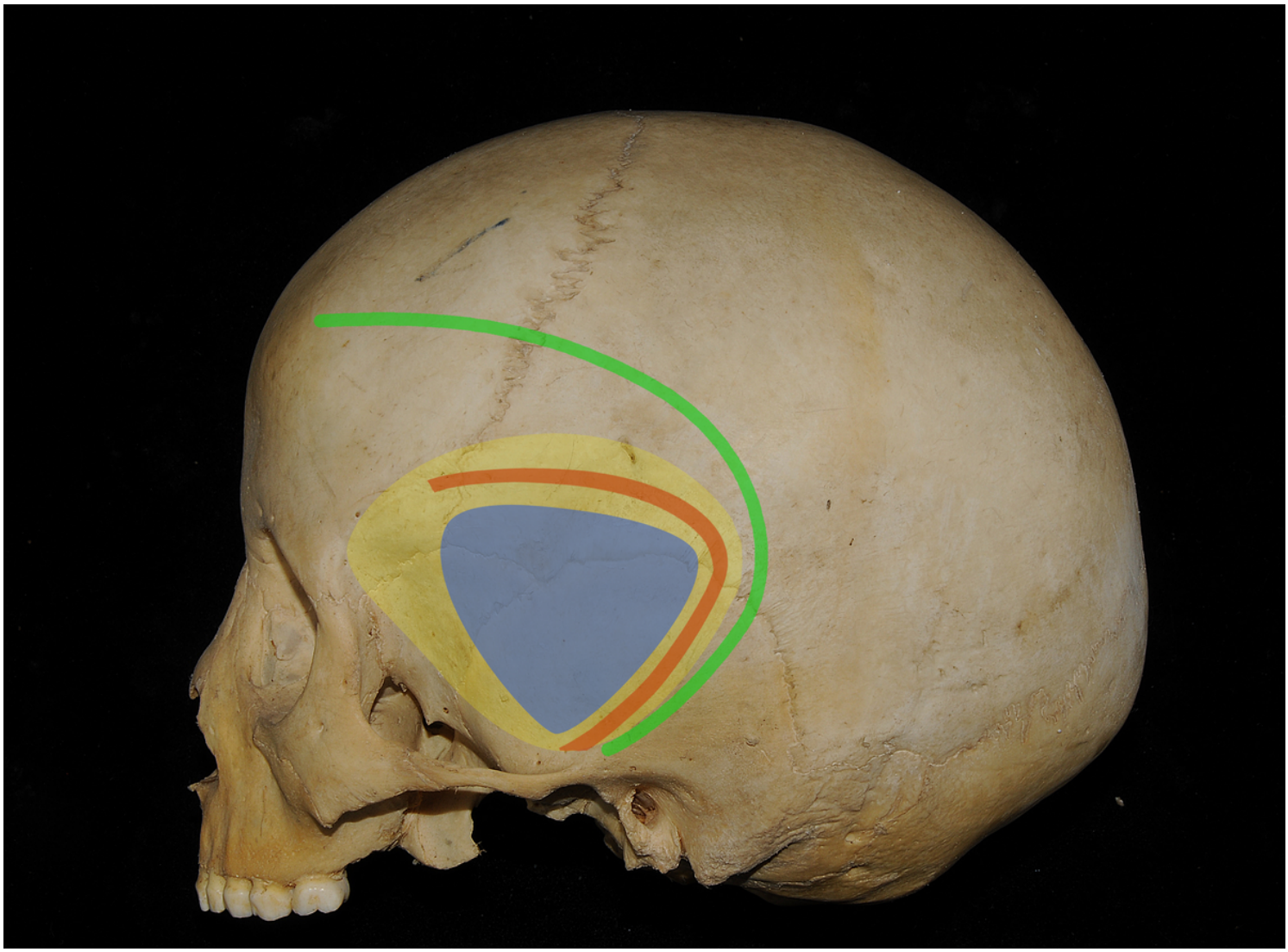

Figure 2

Comparison of incision and bone window size between the mini-temporal and classical pterional approaches

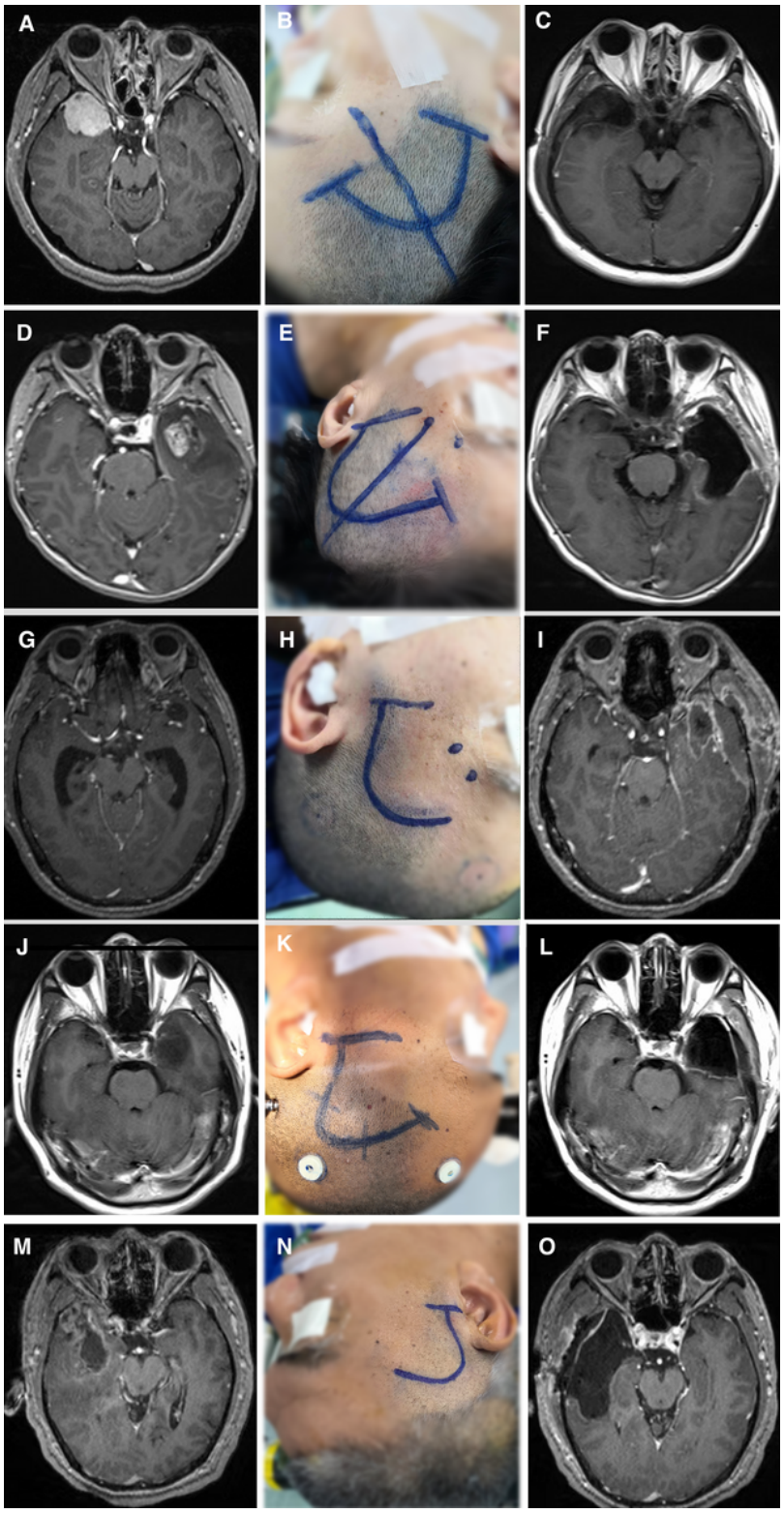

Figure 3

Illustration of the mini-temporal approach