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Cortical Thickness Parameters for Endoscopic Browlift Fixation

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Abstract

Background: Techniques for endoscopic browlift include bony fixation over the lateral frontal region and soft tissue fixation over the temporal region. Although bony fixation over the lateral frontal region is advocated universally, limited information exists about bicortical thickness in this area.

Objectives: The authors provide bicortical thickness measurements between the frontal midline and the most inferior temporal region to assist surgeons in identifying appropriate fixation planes.

Methods: Bicortical thickness was measured in the hemicraniums of 13 female cadavers, along the coronal planes that travel through the anterior border of the mandibular condyles and at the junction of the posterior mandibular condyles and the external auditory meatuses. Measurements began at the midline and coursed laterally at 1-cm intervals.

Results: Average cranial thickness along the frontal region ranged from 8.9 ± 2.4 mm to 6.4 ± 2.8 mm over the anterior coronal line and 8.8 ± 2.2 mm to 5.6 ± 1.8 mm over the posterior line. Average thickness along the temporal region ranged from 5.6 ± 2.8 mm to 2.8 mm ± 1.4 mm over the anterior coronal line and 5.1 ± 1.8 mm to 3.4 ± 1.4 mm over the posterior line. Minimum thickness was 3.7 mm and 1.3 mm over the frontal and temporal regions, respectively. There was no

: browlift procedures should include measurement of cortical thickness at various fixation points. Bony fixation over the temporal region should be avoided. Minimal bicortical thickness was observed in the lateral frontal region.

Keywords

cortical thickness   endoscopic browlift   facial surgery

Endoscopic browlifts can employ various fixation techniques over the frontal and temporal bone regions. Vectors of pull in the frontal region—and thus fixation positions—have been described in a range from 1 cm to 7 cm off the midline, as have landmarks such as vertical lines drawn through the lateral second and third brow peak positions.[1⇓⇓⇓⇓⇓⇓⇓⇓⇓⇓⇓⇓⇓⇓⇓⇓⇓⇓-19] Whether surgeons use miniplates, miniscrews, or cortical tunnels for fixation, the potential entry of surgical tools through the inner cortex is a primary safety concern for physicians and their patients. Despite the ongoing refinement of endoscopic browlift procedures, published articles exploring surgical safety through the measurement of cranial thickness over traditional fixation points are limited. Cranial thickness has been measured in North Korean individuals at various points on the frontal bone and squamous temporal bone, but the measurements do not correlate with the fixation points typically used for endoscopic brow elevation. In that study, frontal bone thickness was measured 1 cm above the supraorbital margin and 1.5 cm lateral to the

midline, at the midpoint of the frontal bone anterior to the coronal suture, and at the midpoint of the squamous part of the temporal bone.[20] The present study aims to determine bicortical thickness between the frontal midline and the most inferior temporal region in order to explore the potential for violating the inner cortical layer when drilling the cranium for bony fixation.

Methods

Twenty-six hemicraniums (13 left, 13 right) from adult female human cadavers were examined using computed tomography (CT) scans. The average age of patients was 50 years (range, 38-82 years). Cadavers were selected randomly and were excluded if the patient had brain or bony pathology or had been actively treated for osteoporosis. CT scans were obtained along the 2 coronal lines defined by (1) the anterior border of the mandibular condyle and (2) the junction of the posterior mandibular condyle and the external auditory meatus. The bicortical thicknesses of the skull along these anterior and posterior coronal lines were measured at 1-cm increments beginning at the frontal midline and extending laterally over the temporal bone. These coronal planes were selected because their span corresponds to potential fixation regions and because they are easily identifiable on coronal CT images. All descriptive results used for statistical analysis were expressed as mean and standard deviation values using Microsoft Excel (Microsoft Corp., Redmond, WA).

Results

The frontal and temporal junction was observed between 7 and 8 cm from the midline. A paired, 2-tailed Student t test showed no significant difference between left and right hemicranium at any measured location point ($P > .001$). As such, left and right hemicranial bicortical thicknesses were combined. Average cranial thickness along the frontal region ranged from 8.9 ± 2.4 mm to 6.4 ± 2.8 mm over the anterior coronal line and from 8.8 ± 2.2 mm to 5.6 ± 1.8 mm over the posterior coronal line (Table 1). Average cranial thickness along the temporal region ranged from 5.6 ± 2.8 mm to 2.8 ± 1.4 mm over the anterior coronal line and from 5.1 ± 1.8 mm to 3.4 ± 1.4 mm over the posterior coronal line. Minimum cranial thickness over the frontal region was 3.7 mm over the frontal region and 1.3 mm over the temporal region. Additional anterior and posterior coronal line bicortical thicknesses, standard deviations, and minimal values for the 26 hemicraniums are shown in Table 1. CT images appear in Figures 1⇓⇓-4.

Table 1.
Comparison of Anterior and Posterior Cranial Thickness (mm) Along the Midline and Paramedian[a]

	Anterior		Posterior	
	Average ± SD	Minimum	Average ± SD	Minimum
Midline	8.7 ± 1.3	6.4	8.3 ± 1.6	5.0
Paramedian				
1 cm	8.3 ± 1.6	5.3	8.6 ± 1.6	5.5
2 cm	8.5 ± 1.8	6.1	8.4 ± 2.1	4.3
3 cm	8.9 ± 2.4	5.5	8.8 ± 2.2	5.5
4 cm	8.8 ± 2.8	4.8	8.3 ± 2.7	4.5
5 cm	8.0 ± 2.8	4.3	7.7 ± 2.8	3.9
6 cm	7.3 ± 3.0	3.8	6.8 ± 2.7	4.0
7 cm	6.6 ± 3.1	3.7	6.0 ± 2.3	3.8
8 cm	6.4 ± 2.8	3.7	5.6 ± 1.8	3.7
9 cm	5.6 ± 2.8	2.0	5.1 ± 1.8	2.3
10 cm	4.1 ± 2.2	1.5	4.0 ± 1.7	1.9
11 cm	2.8 ± 1.4	1.3	3.5 ± 1.1	1.9
12 cm	3.4 ± 0.9	1.6	3.4 ± 1.4	1.9

Abbreviation: SD, standard deviation.

↵a Cranial thickness was measured along the coronal line that runs through the anterior condylar process and the junction of the posterior condylar and anterior external auditory meatus over the frontal and temporal bones. Bicortical thickness was measured at the midline and at 1-cm intervals along the above-described coronal lines.

Enlarge table

Figure 1.

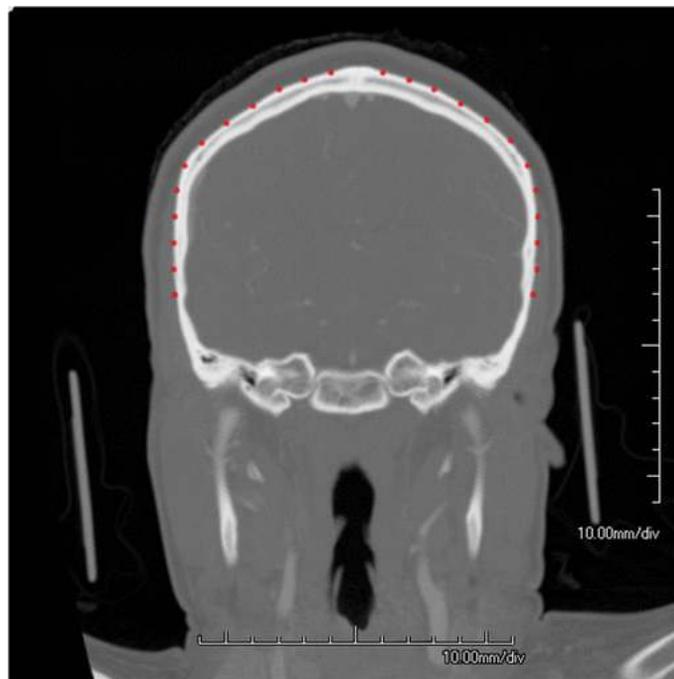Coronal slice of a CT scan along the anterior border of the mandibular condyle.

Figure 2.

Coronal slice of a CT scan along the junction of the posterior border of the mandibular condyle and the external auditory meatus.

Figure 3.
Coronal slice of a CT scan along the anterior border of the mandibular condyle, depicting the locations of the recorded measurements (red dots).

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Figure 4.
Coronal slice of a CT scan along the junction of the posterior border of the mandibular condyle and the external auditory meatus. The locations of the recorded measurements are indicated by red dots.

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Discussion

Walden et al[21] attempted to verify the safety of various endoscopic browlift techniques by using cortical tunnels, external screws, and Endotine forehead devices (Micro-Aire Surgical Instruments, Charlottesville, VA) on the craniums of 14 human cadavers. However, the 6 points of measurement were selected arbitrarily: 2 points were assigned 1 cm posterior to the anterior hairline perpendicular to the brow arch, and 4 points were assigned 3 cm posterior to the anterior hairline.[21] Because traditional fixation points vary in location from 1 to 3 cm posterior to the anterior hairline and extend from 1 to 7 cm off the forehead midline, the findings from that study were of limited value.[1⇓⇓⇓⇓⇓⇓⇓⇓⇓⇓⇓⇓⇓⇓⇓-18] Our study provides continuous bicortical thickness measurements along 2 coronal lines, which offers

insight for variable browlift fixation points depending on the desired effect on the brow, which may not always correspond with the brow arch vertical vector. We also used reproducible anatomical landmarks (the mandibular condyle and external auditory meatus) to define the positions of measurement rather than a variable landmark such as the anterior hairline.

Bony fixation for endoscopic browlifts is usually limited to the frontal area of the skull, and only soft tissue fixation is typically used at the deep temporal fascia because cranial thickness is believed to be thinner at the temporal bone.[16] Our findings confirm that deeper fixation methods in the temporal bone area can be harmful to patients because cranial thickness decreases as it extends laterally from the midline and approaches the temporal bone. Several documented endoscopic and nonendoscopic browlift procedures have used percutaneous microscrews with a 4-mm stopcock or an electric drill with a 4-mm guard to prevent violation of the inner cortical layer.[1⇓-3] Our average and standard deviation values suggest that 4-mm penetration into the cortical layer, along endoscopic fixation points placed from the midline to 6 cm both anteriorly and posteriorly, should be safe for paramedian incisions. However, our minimum values indicate that 4-mm penetration into the cortical layer has the potential to cause leakage of cerebrospinal fluid (CSF) within the expected safety region (Table 1).

Ramirez and Pozner[2] recommend using 4 or 5 incisions, including 2 paramedian incisions placed on a tangent line from the alar base through the lateral orbital rim. Fixation is completed immediately posterior and lateral to the paramedian incisions, using percutaneous screws of 1.5 mm in diameter and 12 to 18 mm in length, with a 4-mm stopcock. Temporal fixation is performed by securing the superficial temporal fascia to the temporal fascia proper, with the vector and pull based on aesthetic judgment.[2] Our findings suggest that the procedure described by Ramirez and Pozner poses little risk for violation of the inner cortex or for leakage of CSF.

Kikkawa et al[3] recommend 2 paramedian incision lines placed in line with the lateral limbus. According to their technique, incisions of 2 cm in length are placed 2 cm behind and perpendicular to the hairline. Temporal incisions are placed parallel to the hairline and in line with an imaginary line that extends from the nasal ala to the lateral canthus. Paramedian fixation is completed by drilling 1.3-mm diameter holes with a 4-mm stopped bit and placing titanium screws of 12 mm in length and 1.5 mm in diameter. Temporal fixation is completed by repairing the temporoparietal fascia and dermis of the advancing flap to the superficial layer of the deep temporal fascia with 3–0 polydioxanone mattress sutures with oblique tension.[3] Results from our study confirm that the surgical method of Kikkawa et al[3] is reasonable because the location of fixation points and the depth of penetration into the outer cortex lie within the safety parameters we have described.

The procedures described by Kikkawa et al[3] and Ramirez and Pozner[2] use screw fixation methods for endoscopic browlifts. However, our results are not limited to supporting only these methods of fixation. Although these procedures were selected because of their well-described methods, other methods of fixation have proven safe, such as Endotine systems and bicortical tunnels. Each fixation method may have its own advantages. Regardless, our goal is to complement various procedures with additional safety information, not to promote any particular method of fixation.

There have been only a few reports of intracranial penetration, some of which focused on the safety of cranial bone graft harvests.[22,23] Other studies of skull thickness compared genders and different ethnicities for the purposes of forensics and vehicular safety.[24,25] However, none of these had a study design similar to ours. The low number of reported cases of intracranial penetration may be attributable to the double resistance produced by the bicortical thickness of the cranium during drilling. Observation of the second resistance may be used to determine the location of the drill to halt further invasion of the cranium, preventing violation of the inner cortex. Although there are just a handful of reports of intracranial penetration, surgeons must safeguard against this unfortunate possibility. The development of a cortical tunneling tool that would limit tunnel depth to 4 mm would help physicians confidently avoid invading the inner cortex.

Knowledge of cranial thickness along endoscopic browlift fixation points has been limited. A limitation of the present study is that the data were collected only from female cadavers. Because male skulls tend to be thicker, additional studies will be needed to provide a more complete picture of skull thickness for both genders, along with appropriate surgical recommendations. Moreover, it is possible that skull thickness may vary according to ethnicity, which also suggests that further investigations may be required. Also, in general, we noted that older patients had narrower cortices than younger patients. However, a direct study would be needed to confirm any correlation between patient age and cortical thickness. Obviously, it would not be cost-effective to perform CT scans on every patient who undergoes an endoscopic browlift procedure. Ultrasonography may be a more economical alternative for measuring cortical thickness before endoscopic browlift procedures, but further studies would be required to evaluate the use of ultrasonography for this purpose.

Without sufficient anatomical information, physicians will not be able to definitively avoid violating the inner cortex during endoscopic browlift procedures. However, our study provides specific measurements of cranial thicknesses along fixation points for endoscopic browlift procedures, which should help reduce the possibility of violating the inner cortex.

Conclusions

An extremely important consideration in the safety of endoscopic browlift is the thickness of the outer cerebral cortex, which protects the inner cortex from being violated.

We examined cortical thickness along the anterior and posterior of the coronal line, for safety considerations, to determine whether bony fixation may violate the brain parenchyma. Our measurements show that browlift fixation along the midline, extending to 6 cm laterally, is safe for paramedian incisions. However, our minimal-thickness measurements indicate that, in some cases, cranial thickness may not be sufficient to permit safe drilling without violating the inner cortex—particularly at the routine bony fixation located 6 to 8 cm from the lateral frontal/parietal bone region. Whenever possible and practical, cortical thickness should be measured in advance of endoscopic browlift procedures to maximize patient safety.

Disclosures

Funding

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