Degree of Frontal Bone Exposure via Upper Blepharoplasty Incision: Considerations for Frontal Sinus Fracture

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Abstract

Objective. The upper eyelid blepharoplasty incision affords direct access to the frontal bone for skull base surgery and trauma reconstruction with a well-hidden scar. The goal of this study is to quantify frontal bone exposure that can be achieved with an upper eyelid blepharoplasty incision.

Design. Anatomic study with human cadaver heads.

Setting. UC Davis Medical Center.

Subjects/Methods. Fourteen human cadaver heads were used to perform 26 upper blepharoplasty approaches. Exposure was measured with virtual planning software to create virtual reference points at the midline of the superior orbital rim. Surgical navigation was used with a 3-dimensionally printed drill model to measure the maximum exposure achievable relative to the virtual reference point at 5 standardized angles.

Results. Mean ± SD exposures at medial 60°, medial 30°, 0°, lateral 30°, and lateral 60° were 16.1 ± 1.3 mm, 17.8 ± 1.3, 18.3 ± 1.4, 19.3 ± 1.9, and 20.9 ± 1.9, respectively. Significant differences were detected between exposures at 60° laterally and 60° medially and between exposures 60° laterally and 30° medially (P < .05).

Conclusions. The upper eyelid blepharoplasty incision provides direct surgical access to the inferior frontal bone. Access was greatest with far lateral extension (mean, 20.9 mm) and most limited with far medial extension (mean, 16.1 mm). Treatment of injuries above this level could be achieved with additional percutaneous incisions for screw placement.

Keywords

frontal sinus fracture, facial fracture, trauma, blepharoplasty

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Frontal sinus fractures account for 5% to 15% of traumatic facial injuries.¹ Anterior table fractures can result in aesthetic deformities, while injury to the posterior table and frontal sinus outflow tract can result in sinusitis, cerebrospinal fluid (CSF) leak, meningitis, and mucocele formation. There are several common surgical approaches to the frontal sinus. The frontal rhytid approach provides direct access with a well-hidden scar; however, paresthesias can occur. The endoscopic brow lift approach provides excellent cosmesis; however, access is limited to the superior region of the frontal bone, and percutaneous incisions are necessary for internal fixation.² The endoscopic transnasal approach has been used to treat injuries of the frontal recess as well as the anterior and posterior tables. Although it is technically demanding, there are no external scars.³-⁶ The “gull wing” brow incision provides direct access but carries the risk of paresthesias and poor cosmetic outcomes. The coronal incision has been considered the gold standard for management of frontal sinus fractures. It provides unparalleled access but carries risks of alopecia, visible scar formation, and injury to the frontal branch of the facial nerve.¹ An existing laceration may also be used but may not always be available. The upper eyelid blepharoplasty incision provides direct access to the frontal bone and a well-hidden scar.⁷,⁸ This approach is used for anterior skull base surgery⁹,¹²; however, there is a paucity of literature evaluating this approach for management of frontal sinus fractures. The goal of this study is to quantify the degree of frontal bone exposure that can be achieved with an upper eyelid blepharoplasty incision.

Methods

Fourteen fresh cadaveric heads were obtained from the UC Davis Body Donation Program. No approval was required under University of California Davis Institutional Review Board guidelines. Thin-cut axial computed tomography

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(CT) scans were obtained for each specimen. Each CT data set was uploaded into Brainlab iPlan software (Brainlab AG, Munich, Germany). Within the iPlan software, a midorbital fiducial point was chosen on each superior orbital rim. These fiducial points were used as a starting point for physical measurements of the surgical exposure that can be achieved through an upper blepharoplasty incision. A simulated Stryker TPS drill model (Kalamazoo, Michigan) was fabricated with an Ultimaker 3 extended 3-dimensional printer (Geldermalsen, Netherlands). A Brainlab navigation reference array was attached to the model (Figure 1A). To ensure a consistent angle at which the drill would be used when it was passed through the upper eyelid incision, an external scaffold was added to the drill model at an angle of 45° (Figure 1A).

A skull reference array was applied to each specimen (Figure 1B). It was registered to the corresponding CT data set with the Brainlab Kick navigation system (Brainlab AG). The simulated drill was registered to the navigation system with the attached navigation reference array. Bilateral upper eyelid blepharoplasty incisions were performed on 26 of 28 orbits. Two orbits, 1 left and 1 right on separate skulls, had previous upper eyelid surgery and could not be used. A total of 13 left-sided and 13 right-sided approaches were performed. An upper blepharoplasty incision was placed approximately 6 to 8 mm above the lid margin and extended from a parasagittal plane 5 mm lateral to the medial canthus, to the level of the lateral canthus. The incision was carried through the orbicularis oculi muscle, extending superiorly in a preseptal plane. The superior orbital rim was exposed and the periorbitaic incised. The supraorbital and supratrochlear neurovascular bundles were identified and preserved. A subperiosteal dissection was carried medially, superiorly, and laterally to expose the frontal bone.

A protractor was then centered over the midorbital fiducial point, as defined by the Brainlab navigation system. Cutaneous marks were applied at the following angles: 60°, 30°, 0°, –30°, and –60° (Figure 2). These marks were used to align the drill/scaffold on the frontal bone. At each angle, the drill was advanced as far as the soft tissue would allow, and a measurement was taken with the navigation system between the midorbital fiducial point and the tip of the drill. The measurements were recorded and analyzed in Microsoft Excel. One-way analysis of variance was performed to assess differences in the means, as well as a Tukey post hoc analysis to identify which differences were significant.

**Results**

**Right Side**

The mean exposures achieved at 60°, 30°, 0°, –30°, and –60° were 20.5 mm (95% CI, 17.6-23.4 mm), 19.5 (16.4-22.7), 18.5 (16.7-20.3), 16.7 (15.1-18.2), and 15.1 (13.5-16.7), respectively (Figure 3). Significant differences were detected between the exposure achievable at 60° and –60° (P < .05).

**Left Side**

The mean exposures achieved at 60°, 30°, 0°, –30°, and –60° were 17.1 mm (95% CI, 15.1-19.1 mm), 19.0 (16.8-21.2), 18.2 (15.8-20.5), 19.2 (16.5-21.8), and 21.4 (18.6-24.2), respectively (Figure 3).

**Combined Data**

Combining the medial and lateral points on each orbit revealed an overall mean exposure distance for each angle (Figure 4). Because the right and left protractor coordinates were mirror images, labels were given to the 5 positions: far medial (–60° right/60° left), midmedial (–30° right/30° left), vertical midline (0° right/0° left), midlateral (30° right/–30° left), and far lateral (60° right/–60° left). The mean exposure achieved at each position was as follows: 16.1 mm (95% CI, 14.8-17.3 mm), 17.8 (16.5-19.2), 18.3 (16.9-19.7), 19.3 (17.4-21.3), and 20.9 (19.0-22.8), respectively. Significant differences were detected between exposures at 60° laterally and 60° medially, as well as between exposures 60° laterally and 30° medially (P < .05).
Frontal sinus fractures are an important subset of traumatic facial injuries, especially in high-velocity facial trauma. These injuries can result in aesthetic deformities, sinusitis, mucocele, CSF leak, and meningitis. Multiple surgical approaches to the frontal sinus have been described, direct, rhytid, endoscopic brow, endoscopic transnasal, gullwing/eyebrow, coronal, and upper eyelid.1

The upper eyelid blepharoplasty approach is versatile and has been described for use in multiple anterior skull base pathologies, including tumor resection, optic nerve decompression, CSF leak repair, and fracture repair.9-11,13 Owusu et al reported a series of 7 patients with anterior cranial base or sellar lesions that were treated through an upper blepharoplasty incision. The authors described excellent access to the anterior skull base and sella with minimal perioperative morbidity and no complications.14 Lim and colleagues used the upper eyelid incision to treat 9 patients with complications of sinusitis (ie, epidural abscess, orbital abscess), reporting no surgical complications or disease recurrences.9 The upper blepharoplasty approach has also been used to treat anterior table frontal sinus fractures. Hakimi et al reported excellent aesthetic results after treatment of 3 patients via an upper eyelid incision.7 Lee et al treated 13 isolated anterior table fractures via the similar infra brow approach. They reported good aesthetic contour restoration, no complications, and acceptable scars.8

While the upper eyelid blepharoplasty incision has been used for treatment of frontal sinus fractures, there are no reports evaluating the access limitations. This study quantifies frontal bone exposure that can be achieved via the upper eyelid blepharoplasty incision. We chose to use a drill as a measuring tool because it is the largest instrument that would typically be inserted through the incision. An angulation of 45° was selected to optimize the reach of the drill while maintaining an angle that would allow a screw to reliably seat into the bone.

We found that extensive blind subperiosteal dissection could be achieved through the upper eyelid incision. Simulated drill insertion distances ranged from 15.1 mm medially to 21.4 mm laterally (Figure 3). When the data were combined, far medial access was significantly less than far lateral access (Figure 4). The most likely explanation for this difference is tethering of the soft tissues medially at the neurovascular foramina. Release of the neurovascular bundle from the bony canal has the potential to increase medial access. This may, however, also increase the risk of postoperative paresthesias.15

The results suggest that an isolated upper blepharoplasty approach could be used for management of fractures extending <15 to 20 mm above the superior orbital rim. This approach could also be used for fractures extending beyond this region by incorporating percutaneous screw placement. Furthermore, simple fracture reduction may be possible...
even if the distal end of the fracture extends beyond the
direct surgical exposure.

There are several limitations of the study. First, the elastic
characteristics of the cadaver tissues used in the study may not
accurately reflect living tissues. Second, maintaining an ac-
curate dissection plane superficial to the orbital septum was
more difficult than in a live patient and could have affected
the results. Third, the study was unable to evaluate cosmesis
or functional deficits that might have occurred due to muscle
or soft tissue injury. Finally, our study did not address the
effect that a bilateral dissection may have on medial frontal
bone access. Our exposures did not reach the midline; how-
ever, “blind” bilateral subperiosteal dissection could connect
the 2 cavities, modifying the area of accessibility.

Conclusion
The upper eyelid blepharoplasty incision provides direct
surgical access to the inferior frontal bone. Access was
greatest with far lateral extension (mean, 20.9 mm) and
most limited with far medial extension close to the supraor-
bital neurovascular pedicle (mean, 16.1 mm). Treatment of
injuries above this level could be achieved with additional
percutaneous incisions for screw placement.

Author Contributions
Michael Kinzinger, study design, data collection, article drafting
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