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Novel use of an image-guided supraorbital craniotomy via an eyebrow approach for the repair of a delayed traumatic orbital encephalocele: illustrative cases

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BACKGROUND Traumatic orbital encephaloceles are rare but severe complications of orbital fractures. These encephaloceles can present months to years after the initial injury.

OBSERVATIONS The authors present two cases of traumatic orbital encephalocele in young males struck by motor vehicles.

LESSONS The exact traumatic mechanism of these encephaloceles is unknown, and diagnosis can be confounded by concomitant injuries. The use of a minimally invasive supraorbital keyhole craniotomy has the potential to change how this disease process is managed and has not been previously documented in this setting.

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KEYWORDS traumatic encephalocele; supraorbital craniotomy; case report

An orbital encephalocele is a severe, rare, and sight-threatening complication related to orbital fractures and can be difficult to diagnose in trauma patients.[1] This condition can easily be missed, because patients are typically obtunded after injury with facial swelling and ecchymosis.[1] With appropriate treatment, most patients recover completely without significant visual deficit.[2] The pathology is relatively uncommon, with fewer than 30 reported cases in the literature. Early surgical intervention is encouraged to avoid complications such as vision loss, meningitis, and brain abscess formation.[3] Typically, a bifrontal craniotomy is used for encephalocele reduction and skull base reconstruction.[3] Herein, we present two cases of orbital roof fracture with an associated posttraumatic encephalocele repaired through an image-guided, minimally invasive supraorbital keyhole craniotomy via an eyelid incision to highlight a possible strategy for reducing operative morbidity in the complicated polytrauma patient.

Illustrative Cases

Case 1

A 39-year-old male with no significant past medical history presented to our level 1 trauma center by helicopter after being struck by a motor vehicle while riding his bike. The patient was intubated in the field because of his depressed mental status.

On arrival at the hospital, he was unresponsive with a Glasgow Coma Scale (GCS) score of 3T. Pupillary examination was significant for a fixed 5-mm left pupil. His mental status rapidly improved, and on examination, he withdrew symmetrically in the bilateral upper extremities to central stimulus without opening his eyes. Computed tomography (CT) of the head revealed substantial left frontal and temporal contusions, right parietooccipital contrecoup injury, and significant bilateral facial fractures to the left frontal bone extending into the orbital roof, lamina papyracea, left temporal bone, and zygomatic arch. He was also found to have an upper-extremity fracture that would require orthopedic surgical fixation.

A right frontal fiber optic intracranial pressure monitor was placed and remained in situ for 2 days with normal intracranial pressures and improvement in his mental status to a GCS score of 12. On trauma day 9, routine CT imaging of the head demonstrated herniation of the left frontal lobe through the orbital roof defect. Magnetic resonance imaging (MRI) of the orbits demonstrated the

ABBREVIATIONS ADL = activities of daily living; CT = computed tomography; GCS = Glasgow Coma Scale; MRI = magnetic resonance imaging.

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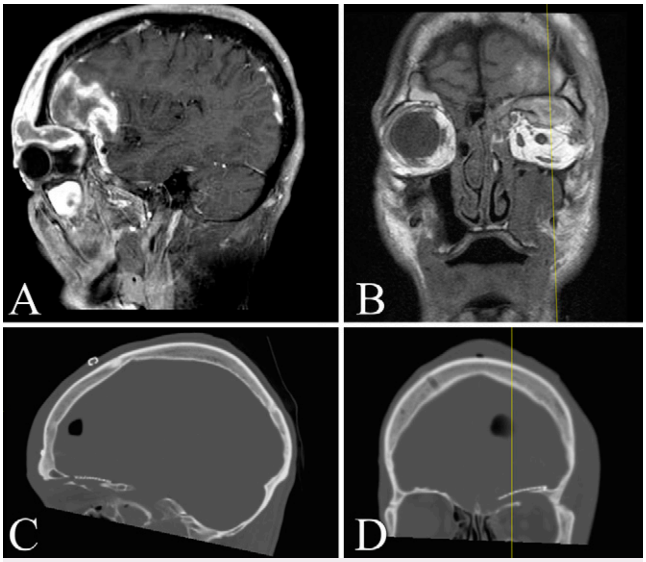

FIG. 1. Case 1. Preoperative sagittal (**A**) and coronal (**B**) T1-weighted MRI demonstrating a left supraorbital encephalocele. Postoperative sagittal (**C**) and coronal (**D**) CT demonstrating the left reconstructed orbit.

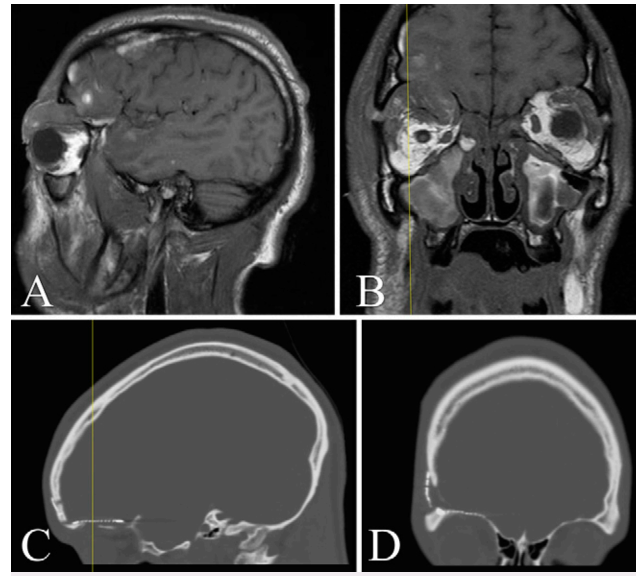

FIG. 2. Case 2. Preoperative sagittal (**A**) and coronal (**B**) T1-weighted MRI demonstrating a right supraorbital encephalocele. Postoperative sagittal (**C**) and coronal (**D**) CT demonstrating the right reconstructed orbit.

herniated left frontal lobe having mass effect on the superior rectus muscle and stretching of the left optic nerve (Fig. 1).

The patient underwent an image-guided, minimally invasive supraorbital keyhole craniotomy via a left eyelid incision to repair his subfrontal encephalocele with titanium mesh orbital roof reconstruction and pericranial onlay grafting. A lumbar drain was placed intraoperatively for cerebrospinal fluid (CSF) diversion to minimize frontal lobe retraction while resecting the nonviable brain matter in the encephalocele and to effectively identify the margins of the dural laceration(s). No overt CSF leaks were noted. The remainder of his hospital course was uncomplicated. On his postoperative visit 16 weeks later, the patient had returned to independent completion of all activities of daily living (ADL) with grossly normal extraocular movements and intact visual fields. Pupillary reactivity had not yet returned.

Case 2

A 26-year-old male without a significant past medical history presented to our trauma center via ambulance after being struck by a car. The patient had one witnessed seizure before presentation and was intubated and given 10 mg of midazolam in the field.

On examination at the hospital, the patient was intubated, localized on the right side, and withdrew on the left side with a GCS score of 7T. The right pupil was reactive and 2 mm, and the left pupil was ovoid and unreactive. A CT of the head revealed small bilateral subdural hematomas, a right frontal contusion, and bifrontal skull fractures with a right orbital roof blowout fracture with herniation of the superior rectus muscle and brain through the orbital defect. A concomitant right lower-extremity fracture that would ultimately require surgical fixation was also present.

A left frontal fiber optic intracranial pressure monitor was placed uneventfully on his presentation. The patient's condition briefly worsened to a GCS score of 3 but within a day returned to a GCS score of 7T. Intracranial pressure remained normal, and the monitor was removed on trauma day 5. After allowing for a decrease in edema from his frontal contusions, he was taken on trauma day 14 for a right eyelid approach supraorbital craniotomy to resect his orbital encephalocele and reconstruct the orbital roof with titanium mesh and a pericranial flap onlay (Fig. 2). A lumbar drain was again placed at the time of surgery for the previously mentioned indication and was removed at the end of the case. There was no CSF leak noted. The patient's postoperative course was uncomplicated, and he was discharged to rehabilitation. At the 2-month postoperative visit, the patient was living independently at home and completing ADL. Light perception was present in the right eye with the ability to count fingers, and normal extraocular motility examined though diplopia from right eye weakness was reported by the patient.

Technique

The patient is placed supine on the operating table with the head in a Mayfield skull clamp in a neutral position with slight extension. An incision is planned in the ipsilateral affected eyebrow to facilitate harvesting a large pericranial flap (Fig. 3). A Medtronic StealthStation optical tracking frame is attached to the Mayfield clamp on the contralateral side of the incision. This placement ensures the StealthStation stays clear of the operative field while enabling intraoperative navigation.

A temporary tarsorrhaphy stitch is placed in the eyelid lateral to the cornea. A no. 10 blade is used to incise the skin through the galea, taking care to leave the pericranium intact. The incision is undermined in the subgaleal plane, and a large pericranial flap is elevated and tunneled through the supraorbital incision preserving its vascular pedicle. Of note, we do not transect the lateral and inferior margin of the pericranial flap lower than the anticipated course of the frontalis branch as it courses through the superficial temporal fascia over the keyhole region en route to the frontalis muscle.

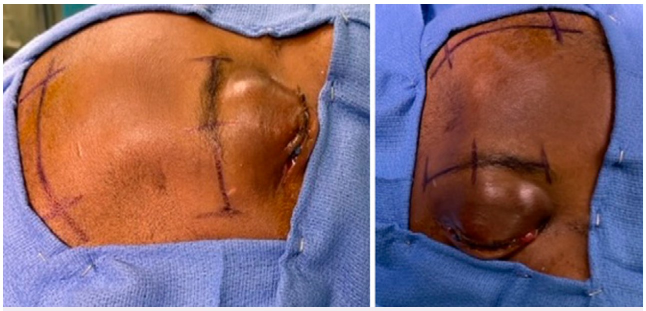

FIG. 3. Incision planning for supraorbital craniotomy to allow for a sufficient pericranial flap. Of note, the picture shows an accessory incision outlined posterior to the hairline. This was an alternative strategy in the event of being unable to harvest a sufficient pericranial graft solely from the eyelid incision itself and was not used in either case.

A supraorbital craniotomy is performed with care taken to drill the remaining bone flush with the orbital roof. Neuronavigation is utilized to avoid the frontal sinuses. The dura is then dissected around the bony margins of the orbital roof defect with resection of the nonviable brain matter present in the encephalocele to the circumferential margins of the concomitant dural defect(s). Titanium mesh is fitted over the orbital roof defect and held in place with one 4-mm screw placed in the lateral anterior skull base (Fig. 4). Dissection is then carried over the orbital rim and into the orbit, where compressive bone fragments can be removed or reduced to flatten the orbital roof plate. The pericranial onlay is then rotated over the orbital roof plate posterior to the posterior margin of the dural defect. Given the small cranial exposure through a supraorbital craniotomy, no overt CSF leakage, and a robust pericranial flap, the incision is closed without further use of dural sealant or synthetic grafts.

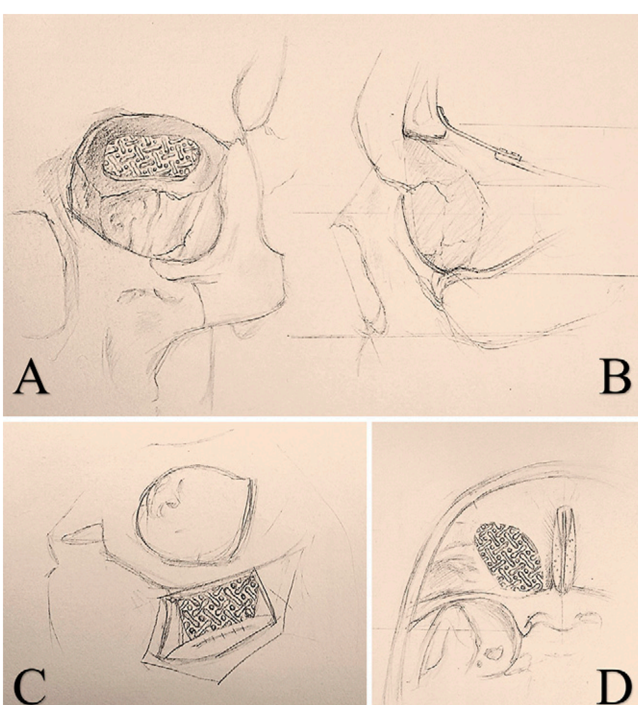

FIG. 4. Artist's rendition of a left-sided encephalocele reconstruction with titanium mesh in the coronal plane (**A**), sagittal plane (**B**), operative view (**C**), and transverse plane (**D**).

Patient Informed Consent

The necessary patient informed consent was obtained in this study.

Discussion

The vast majority of orbital encephaloceles are developmental anomalies.[4] Fewer than 30 cases in the literature are classified as secondary to trauma.[4] These reported traumatic orbital encephaloceles were discovered acutely or over weeks, months, or years.[2] The mechanism of delayed encephaloceles is not well understood.

There are many proposed mechanisms for the pathophysiology of posttraumatic encephalocele formation. These mechanisms include a gradual herniation of the arachnoid into an orbital fracture, physiological growth of the cranium and the brain in children, continuous pulsation of CSF on a fracture site, and absence of bony counter compression.[4] Gradual herniation of the arachnoid is thought to be caused by a pressure differential between the cranium and the orbit.[5] In most instances, this pressure differential only allows CSF to enter the orbit. This can present as an orbitocele, blepharocele, pulsating exophthalmos, ecchymosis, proptosis, visual acuity changes, diplopia, ocular immobility, ptosis, or a local bruit.[1,2,4]

Observations

The most common orbital encephalocele presentation is diplopia, exophthalmos, and ecchymosis.[2] As these symptoms are reasonably common, traumatic encephalocele diagnosis can be confounded by concomitant injuries such as frontal contusions, intracranial bleeding, pneumocephalus, and additional facial fractures.[2] Furthermore, encephaloceles can easily be missed, because trauma patients are typically obtunded after injury.[1] It is possible that the first patient's encephalocele mechanism was due to gradual arachnoid herniation, because it was not present on presentation and no secondary trauma was noted before routine follow-up head CT.

Orbital roof fractures are often assessed with head CT. However, MRI is needed to characterize the herniated brain tissue and to determine other possible intraorbital injuries such as vascular malformations or tumors.[6] Once imaging is complete, encephalocele treatment requires the return of meningeal and brain tissue back into the cranial vault followed by a watertight closure of the dura mater and reconstructive cranioplasty.[7]

Orbital roof reconstruction approaches are divided into transorbital and bicoronal.[4] The transorbital approach is generally performed through a superior blepharoplasty incision followed by an orbital rim osteotomy to facilitate a transorbital trajectory to the intracranial area of pathology.[8] This approach may not be familiar to most neurosurgeons and limits the ability to harvest an effective pericranial flap. A transcranial approach via a bicoronal incision is familiar to most neurosurgeons and is often used to address any concomitant intracranial injuries at the expense of a much larger incision and exposure.[2] The main advantage of the described supraorbital craniotomy over a previously described bicoronal and transorbital approach is its significantly reduced size and ability to achieve the same surgical goals.[8] This reduction in craniotomy size minimizes the amount of brain retraction, neurovascular manipulation, and amount of tissue healing in this critical patient population.[4] As used in our patient population, lumbar drains can be used for CSF diversion to minimize frontal lobe retraction while resecting the nonviable brain matter in the encephalocele and to effectively identify the margins of the dural laceration(s). In addition, the supraorbital craniotomy via an eyebrow incision is becoming increasingly used and more familiar to neurosurgeons making it an easy-to-adopt technique. Of note, we would consider the presence of grossly enlarged frontal sinuses (such that the planned craniotomy would have to involve the frontal sinuses for adequate surgical exposure) a contraindication to the herein described minimally invasive technique. In that setting, a more traditional bicoronal approach would be encouraged along with a concomitant cranialization of the involved frontal sinuses to treat the index pathology.

After orbital roof exposure and debridement, reconstruction material is applied to the encephalocele fracture site. The most popular chosen materials are bone grafts, titanium plates, silastic implants, and porous polypropylene.[9] A titanium plate was chosen for these patients because of its superior long-term stability, intraoperative malleability, and radiopacity.[9] Pericranium is used to fill and repair the skull base defect. An approximately 8- to 9-cm–long pericranial flap can be harvested from an eyelid incision using a protected Bovie tip, reaching just behind the hairline, while protecting the frontalis branch of the facial nerve. Postoperatively, the majority of traumatic encephalocele patients, including the two patients presented, recover nearly completely and show minimal visual deficits.[2,4–6,8]

Lessons

This report demonstrates a traumatic orbital roof encephalocele in two young trauma patients after traumatic brain injury and the use of an image-guided, minimally invasive supraorbital craniotomy via an eyelid incision for reconstruction of the orbit. This is the first such documented use of this approach for a posttraumatic encephalocele and potentially highlights a new approach for the trauma patient.

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Disclosures

Dr. Mossop reported one-time personal fees for proctoring a spinal instrumentation laboratory from Precision Spine outside the submitted work.

Author Contributions

Conception and design: Mossop, Ifrach. Acquisition of data: Mossop, Ifrach. Analysis and interpretation of data: Mossop. Drafting the article: Mossop, Ifrach, Neavling. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Mossop. Statistical analysis: Mossop. Administrative/technical/material support: Mossop, Ifrach, Zhang. Study supervision: Mossop.

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