K.H.K. is a 29-year-old car mechanic who sustained a contaminated 3 cm × 4 cm open wound over the left medial canthus and nose when a car suspension spring sprang out and hit his face. There were no neurological deficits or visual disturbances and no cerebrospinal fluid (CSF) leak on nasoendoscopy.

A computed tomography (CT) scan with 3-dimensional reconstruction of the face revealed (1) displaced comminuted fractures of the anterior and posterior left frontal sinus walls extending to the floor of the left anterior cranial fossa and cribriform plate, with pneumocranium; (2) fractures of bilateral orbital roofs; and (3) nasal bone fractures involving the bony canals of bilateral nasolacrimal ducts (Fig. 1).

Serial CT scans of the brain did not show any acute intracranial hemorrhage or midline shift. He was started on intravenous ceftriaxone 2 g once a day and dexamethasone 6 mg q8H.

**SURGICAL MANAGEMENT**

K.H.K. underwent open reduction and internal fixation (ORIF) of his facial fractures and left frontal sinusotomy under general anesthesia within 24 hours of admission. A bicoronal, combined with endoscopic, approach was used to access the facial fractures and the left frontal sinus.

Intraoperative findings confirmed CT findings. Of significance, a 1-cm dural tear with CSF leak was noted at the left posterior table fracture site, which resolved with multilayer repair of the dural defect. A 1.5 cm × 1.5 cm sheet of DuraGen was used as an underlay graft. A 2 cm × 2 cm pedicled (right supraorbital artery) pericranial flap was used as an onlay graft. Repair was reinforced with Tisseel glue (Fig. 2).

Left uncinectomy, medial maxillary antrostomy, anterior ethmoidectomy, and a standard Draf 2A...
frontal sinusotomy were performed to adequately expose the frontal recess boundaries. (Frontal recess boundaries are lamina papyracea laterally, middle turbinate medially, anterior wall of bulla ethmoidalis posteriorly, and posterior wall of the agger nasi cell anteriorly.)

The frontal sinus bone fragments were repositioned and fixed with plates. The bilateral supraorbital rims and frontal buttress were plated with orbital mesh plate and 4mm × 4mm screws. Pericranial flap was placed in left orbital roof defect to support dural repair. Drains were placed in subgaleal plane before the galea and skin were closed.

A 0.5-mm Silastic stent was inserted into the left frontal recess endoscopically. Merocel packs were then inserted into each nostril.

**POSTOPERATIVE MANAGEMENT**

Postoperatively he was monitored in a high dependency unit, placed on hourly conscious level charting, intravenous antibiotics, and steroids, and nursed in a 30° head-up position. Laxatives were added to prevent straining at the stools. X-ray of face confirmed correct placement of implants (Fig. 3). The Merocel packs were removed on POD1. No CSF leak was seen. He started oral feeds on POD2, and subgaleal drains were removed. He was subsequently transferred to general ward. Nasoendoscopy revealed no middle meatal adhesions or obvious CSF leak. The left frontal recess stent remained patent. Ambulatory physiotherapy commenced on POD6. He was started on sinus irrigation and discharged well after completing 1 week of intravenous acetazolamide and antibiotics. The antibiotics were oralized for another week.

He was reviewed at 3 weeks postoperatively and then monthly after. At 3 weeks, some hemoserous mucus in the left middle meatus was seen. In subsequent appointments, the left frontal-ethmoidal recess remained patent (stent was removed after 1 month) and dry with no CSF leak (Fig. 4).

**DISCUSSION**

Frontal sinus fractures form a significant portion (5–12%) of all craniofacial fractures. Due to their anatomical position and the high kinetic energy required to cause the fractures, they are associated with other possible complications (Table 1).
The management of frontal sinus fractures is complex and can be controversial at times. Treatment options range from just observation to ORIF of fractures and obliteration or cranialization of the frontal sinus.\(^2\)

Preservation of the frontal sinus anatomy is not a new concept. Anterior table fractures\(^3\) involving the frontal outflow tract have been successfully repaired with preservation of the frontal sinus and its outflow tract. In the series by Smith et al\(^4\) of 7 anterior table fractures repairs, 5 had patent outflow tracts post-operatively. Two had outflow obstruction requiring subsequent sinusotomy procedures.

The management of posterior table fractures is more controversial. Current guidelines recommend cranialization or obliteration of displaced posterior table fractures with CSF leaks\(^5\)\(^-\)\(^7\) to avoid complications of brain infections. However, there are complications of cranialization and obliteration, including postoperative CSF leak, frontocutaneous fistula,\(^8\) and mucocele (mucoceles are encapsulated collections of mucus that cause bony erosion and remodeling as they enlarge, causing orbital or intracranial erosions) formation.\(^9\)

Sinus preservation is possible in a select group of frontal sinus fractures. Chen et al\(^10\) advocate that, in the absence of fracture comminution or displacement, CSF leaks can be managed conservatively. Shi et al\(^11\) described transnasal endoscopic repair in 15 patients with traumatic frontal sinus CSF leaks, preserving frontal sinus anatomy and outflow tract. However, it was not reported whether the fractures were displaced or comminuted enough that cranialization or obliteration of the frontal sinus would have otherwise been required.

Restoring frontal sinus anatomy and outflow patency is ideal in frontal sinus fracture management. If the frontal sinus outlet tract is subsequently ste-
nosed, a later frontal sinus rescue procedure\(^\text{12}\) can be performed. If this also fails, cranialization or obliteration can still be performed.

In our case report, the severity of K.H.K.’s frontal sinus trauma would normally have necessitated cranialization or obliteration. He underwent successful ORIF of the frontal sinus fractures and dural defect closure with preservation of the frontal sinus anatomy and its outflow tract, which remained patent with no CSF leak 6 months postoperatively.

Our team proposes that frontal sinus and its outflow tract preservation are viable options in select patients with posterior table fractures and dural defects. This approach should only be performed if:

1. CSF leak can be stopped. A review\(^\text{13}\) of 875 frontal sinus fractures suggests that patients with comminuted and displaced posterior table fractures with CSF leaks could possibly be managed nonoperatively. Three of 7 such patients were managed nonoperatively, with no intracranial complications of CSF leaks. The decisions behind the conservative management and long-term complications were not documented.

2. Other causes of raised intracranial pressure such as empty sella syndrome/benign intracranial hypertension/intracerebral hemorrhage in trauma are excluded.

**REFERENCES**

1. Stammberger H. Endoscopic endonasal surgery—concepts in treatment of recurring rhinosinusitis. Part II. Surgical technique. *Otolaryngol Head Neck Surg*. 1986;94:147–156.

2. AO Foundation. CMF section of AO Surgery reference. Skull Base. Frontal sinus fracture management. Available at: https://www2.aofoundation.org/wps/portal/surgery?bone=CMF&segment=Cranium&classification=93-Frontal%20sinus,%20Posterior%20table%20fractures&showPage=indication Accessed March 1, 2014.

3. Gerbino G, Roccia F, Benech A, et al. Analysis of 158 frontal sinus fractures: current surgical management and complications. *J Craniomaxillofac Surg*. 2000;28:133–139.

4. Smith TL, Han JK, Loehr TA, et al. Endoscopic management of the frontal recess in frontal sinus fractures: a shift in paradigm? *Laryngoscope*. 2002;112:784–790.

5. AO Foundation. Available at: https://www2.aofoundation.org/wps/portal/surgery?bone=CMF&segment=Cranium&classification=93-Frontal%20sinus,%20Posterior%20table%20fractures&showPage=indication Accessed March 1, 2014.

6. Metzinger SE, Guerra AB, Garcia RE. Frontal sinus fractures: management guidelines. *Facial Plast Surg*. 2005;21:199–206.

7. Carter KB Jr, Poetker DM, Rhee JS. Sinus preservation management for frontal sinus fractures in the endoscopic sinus surgery era: a systematic review. *Craniomaxillofac Trauma Reconstr*. 2010;3:141–149.

8. Gossman DG, Archer SM, Arosarena O. Management of frontal sinus fractures: a review of 96 cases. *Laryngoscope*. 2006;116:1357–1362.

9. Bell RB, Dierks EJ, Brar P, et al. A protocol for the management of frontal sinus fractures emphasizing sinus preservation. *J Oral Maxillofac Surg*. 2007;65:825–839.

10. Chen KT, Chen CT, Mardini S, et al. Frontal sinus fractures: a treatment algorithm and assessment of outcomes based on 78 clinical cases. *Plast Reconstr Surg*. 2006;118:457–468.

11. Shi JB, Chen FH, Fu QL, et al. Frontal sinus cerebrospinal fluid leaks: repair in 15 patients using an endoscopic surgical approach. *ORL J Otorhinolaryngol Relat Spec*. 2010;72:56–62.

12. Kuhn FA, Javer AR, Nagpal K, et al. The frontal sinus rescue procedure: early experience and three-year follow-up. *Am J Rhinol*. 2000;14:211–216.

13. Choi M, Li Y, Shapiro SA, et al. A 10-year review of frontal sinus fractures: clinical outcomes of conservative management of posterior table fractures. *Plast Reconstr Surg*. 2012;130:399–406.

14. Metzinger SE, Metzinger RC. Complications of frontal sinus fractures. *Craniomaxillofac Trauma Reconstr*. 2009;2:27–34.