

Endoscopic Techniques for Treatment of Anterior Table Frontal Sinus Fracture: A Review of Literature

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Abstract: Frontal sinus fractures represent about 5% of all facial fractures, and one-third of those isolated to the anterior table. Frontal sinus fractures are typically associated with a significant force and usually involve other intracranial or facial injuries. Bicoronal, open-sky, or gull-wing approaches allow for proper reduction and reconstruction under direct visualization. Fractures that are complex or require detailed reduction and fixation techniques to gain stability should be repaired with open techniques. However, when faced with an isolated anterior table fracture that is minimally displaced and lacks comminution, the endoscopic approach may provide an alternative surgical option. The endoscopic approach avoids large incisions that may cause alopecia, paresthesia, scarring, or nerve injury. This technique provides visualization of the sinus wall fracture, and can be used to evaluate the integrity of the nasofrontal duct and posterior wall of the sinus.

Keywords: Endoscopy; Minimally Invasive; Images of inaccessible region ; Anterior table of frontal sinus

I. Introduction

There has been much advancement in endoscopic surgery since Takagi first used the technique in 1918.³⁴ The endoscope has been described as an “extra set of eyes,” and is the basis for innovation across multiple surgical disciplines and the fabrication of a new class of instruments and surgical techniques. As a teaching tool, endoscopically assisted surgery allows trainee surgeons to follow the surgery, and for the teaching surgeons to describe the procedure in real time. Although there is a learning curve, teaching of the technique is improving, and various other techniques continue to be introduced with this surgical adjunct.^{35,36,37} Some surgical procedures may also be completed with less morbidity and, perhaps, with a greater margin of safety with the use of an endoscope.^{38,39} Increasingly, more endoscopic procedures are being described in the craniomaxillofacial region. This article reviews the present use of endoscopic techniques for the treatment of Anterior table frontal sinus fracture.

Mechanisms Of Injury

Of maxillofacial fractures 2 - 15% is frontal sinus fractures, the majority caused by traffic accidents.⁵ Single outer table fractures include 18 - 43% of frontal sinus fractures.² Fractures involving the frontal sinus are sustained primarily from forces that are applied directly to the anterior aspect of the skull in the glabellar region. Most fractures are the result of blunt trauma directed to this region.³ These are associated with high-velocity blunt trauma to the head resulting in various fracture Penetrating injuries from gunshot wounds and industrial accidents are associated with greater concentration of force to a smaller area. These injuries are therefore associated with a greater risk of damage to both tables of the frontal sinus, dural tears, cribriform plate and fovea ethmoidalis fractures, as well as frontal lobe injury.^{3,4}

Classification:

The preferred classification scheme is that described by Raveh⁴⁰ in 1992. In it, the frontal, maxillary, and ethmoidal sinuses; the orbital cavity; and the nasal buttress are regarded as shock absorbers, trauma to which results in two broad injury categories: type I, which consists of fronto-naso-ethmoidal and medial orbital frame fractures without skull-base involvement; and type II, which consists of combined skull-base, fronto-naso-ethmoidal, and medial orbital frame fractures with frequent optic nerve compression. Another classification system takes into account the principles widely accepted as determinants of surgery.

Type 1: anterior wall fracture with minimal comminution, no associated NOE or orbital rim fractures.

Type 2: anterior wall comminuted fractures with possible extension to NOE and/or orbital rim¹⁴

Type 3: anterior and posterior wall fractures, posterior wall fractures without significant displacement or dural injury.

Type 4: anterior and posterior wall fractures with dural injury and cerebrospinal fluid leak

Type 5: anterior and posterior wall fractures with dural injury, cerebrospinal fluid leak, and soft tissue or bone loss and/or severe disruption of the anterior cranial fossa.

Surgical Management:

There are probably 5 categories that should be used to guide the management of frontal sinus fractures.

1. Isolated anterior table fractures with or without displacement
2. Combined anterior-posterior table fractures with or without displacement
3. Isolated posterior fractures with displacement
4. Any fracture that disrupts the NFOT (nasofrontal outflow tract)
5. Any fracture that results in dural disruption with or without underlying brain injury.

The bicoronal approach has been associated with instances of alopecia, scarring, and facial paresthesia, and, thus in recent years, there has been several small series that have described minimally invasive approaches to anterior table fractures in an attempt to obviate these morbidities.^{22,23,24,25}

Review Of Literature Of Endoscopic Management:

The endoscopically assisted method was first described by Graham and Spring in a 1996 study in which these investigators performed fracture reduction without internal fixation. Endoscopic approaches to frontal sinus fractures have been suggested for acute fracture repair usually within 1 to 10 days of injury with or without fixation, 6 delayed fracture repair.⁷

Smith TL Han JK in 2002 conducted a study in which a select group of patients with anterior table frontal fractures involving the NFOT (nasofrontal outflow tract) was treated with open reduction of the fracture without obliteration of the frontal sinus. Patients with persistent frontal sinus obstruction after medical treatment underwent an extended endoscopic frontal sinusotomy or a modified endoscopic Lothrop procedure. This study involved a small cohort of patients, and management was patient dependent in terms of compliance and reliability.

Strong EB, Buchalter in 2003 reported frontal sinus fractures were generated in 11 cadavers describing the feasibility of performing endoscopic reduction and fixation. Standard endoscopic brow-lifting techniques were used to visualize the fracture from above. A 1-cm Lynch incision was used to apply instrumentation from below.^{5,9} The investigators found that the fractures could be visualized, but they encountered difficulty with complete reduction and were unable to perform rigid fixation in a noninvasive manner. As an alternative, the investigators recommended repair of the anterior wall depression via a modified brow approach by endoscopically applying hydroxyapatite bone cement for correcting the cosmetic deformities.

Chen et al in 2003 also reported endoscopic assisted reduction using internal fixation with microplates.^{10,11} Two slit incisions were placed in the hair-bearing area, through which a 4-mm 30 degree endoscope was inserted. The depressed fracture segments of the anterior table of the frontal sinus were reduced and fixed with microplates to restore the contour of the forehead. Seven consecutive patients received endoscopic correction of frontal sinus depressed fractures. They concluded that endoscopy also helps in the diagnosis of unsuspected cerebrospinal fluid leaks. Thus, for anterior table fractures with an intact nasofrontal duct, endoscopically assisted surgery provides an alternative option of treatment.

E. Bradley Strong, Robert M. Kellman, in 2006 advocated the camouflage technique.¹² The endoscopic repair significantly reduces patient morbidity because it requires only 2 vertical small incisions behind the frontal hairline. In a case report of a single case he used two 0.85 mm thick Medpor implants were sutured together to fill dead space and to camouflage the anterior table frontal sinus fracture.

Kevin A. Shumrick in 2006,¹⁴ used 30 degree scope with an endoscopic sheath view of frontal sinus anterior wall fracture. Direct percutaneous approach with threaded Steinman pin and nerve hook was used to elevate bone fragments. Vicryl mesh placement for camouflage of residual irregularities was used.

Kim and colleagues in 2007 evaluated the endoscopic repair of isolated anterior table frontal sinus fractures with a Medpor implant in 10 cadaveric heads.¹⁵ Five cadavers received prefabricated implants generated from the post injury CT data. Five Cadavers received a standard Medpor implant (0.85 mm sheet) (Porex Surgical Inc, Newnan, GA, USA) contoured intraoperatively. Medpor sheeting fixated to stable bone with a 1.7 mm self-drilling bone screw. All 10 defects were successfully repaired within 1 to 2 mm.

Steiger and colleagues 2006 in their series stated that after 2 years of follow-up, all patients clinically showed good cosmetic results and were free of sinus complaints and radiographically had patent sinuses and reduced fractures.¹⁸ Steiger performed a frontal sinusotomy to access the fractured anterior wall and attempted transnasal endoscopic reduction using a frontal sinus curette and a Foley catheter balloon.¹⁶

Yoo and colleagues in 2008 reported another case report of transnasal endoscopic approach with 25 & 75 degree scopes were used to splint the fracture segments in a 14-year-old man with good cosmetic outcome.¹⁷ To obtain sufficient access to the frontal recess partial middle conchotomy and a wide frontal sinusotomy were performed after an anterior ethmoidectomy. To support the reduced bony fragments a custom made latex glove balloon with injection line was inserted. The balloon was inflated with normal saline 17 cc and kept in position for 3 weeks. In addition, this technique was recommended to be performed only in a subset of patients as described below.

1. Posteriorly displaced anterior table fractures.¹⁶
2. Wide anterior-posterior diameter of the frontal sinus and recess.¹⁶
3. Intact posterior frontal sinus table.¹⁶
4. Recent history of trauma (loosely fixed).¹⁶
5. Fractures at or above the supraorbital rim.¹⁷

G Mensik and colleagues in 2008 suggested that the use of endoscope made minimally invasive reduction of outer table fractures of the frontal sinus possible under local anaesthesia.^{19,20} This was performed in two out of 6 patients. A 2 mm incision was made in the natural skin creases or just above the hairline. After careful dissection of the subperiosteal layer with an optical dissector (Storz, tuttlingen Germany) a 4mm 30 degree endoscope was introduced. When needed repositioning or fixation was made in the eyebrow.

Kim and colleagues 2010 described a transcutaneous transfrontal approach through a small eyebrow incision in 17 patients with closed anterior table fractures.^{21,33} All their patients reportedly achieved satisfactory aesthetic results and minimal complications. However, this method has inherent disadvantages such as the inability to perform concomitant rigid internal fixation and potential associated morbidities of facial paresthesia, bleeding, posterior table damage, and infection.

II. Discussion

The endoscopic procedure of re-positioning frontal sinus fractures is a challenging procedure.^{2,5,9} The reported benefits of these minimally invasive approaches compared with bicoronal approaches are better cosmesis, with subsequently reduced risks of infections, and mucocele formation. Other advantages of endoscopic surgery include limited incisions, accurate visualization; even around the corners reduced soft tissue dissection, reduced risk of alopecia, minimal risk of postoperative paresthesia, reduced hospital stay, and improved patient selection. A great advantage of endoscopic technique is the possibility of surgery under local anaesthesia.¹⁹ Ideal candidates for endoscopic transnasal approach are those with isolated anterior table fractures limited to the vertical and medial portion of the frontal bone, with intact nasofrontal duct.

Disadvantages include a narrow field of view, lack of depth perception, and inability of the surgeon to operate bimanually without an assistant. Disadvantages of endoscopic reduction is sometimes difficult and time consuming, especially in cases of involvement of the supra - orbital rim ^{2,3} and in younger individuals because of the greensticking that typically occurs in this region.¹ Not all frontal sinus are suitable for endoscopic reduction. It is in appropriate for injuries with severe comminution, displaced posterior table fractures with evidence of dural tear, associated orbital roof blow- in fractures, or extensive skull bone fractures. In such situations a conventional approach is more suitable. Pre- operative evaluation including a high resolution CT scan is important for selecting the treatment method.

III. Conclusion

The use of endoscopes makes minimally invasive reduction of outer table fractures of the frontal sinus possible. Used in selected cases, it results in a good clinical outcome, with advantages on costs and logistics. Reduction and fixation can be relatively difficult however in comparison with the bicoronal approach, time reduction and fewer squeal results.

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