Complications and Treatment of Delayed or Inadequately Treated Nasoorbitoethmoid Fractures

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Abstract

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Delayed or improper repair of nasoorbitoethmoid (NOE) fractures can lead to debilitating outcomes including diplopia, epiphora, nasal obstruction, facial asymmetry, and poor cosmesis. As such, NOE fractures should be repaired promptly and properly to prevent these unwanted sequelae. Treating patients with delayed, untreated, or inadequately reduced NOE fractures is challenging due to scarring and contracture. Saddle nose deformity, telecanthus, enophthalmos, nasolacrimal duct obstruction, and soft-tissue scarring are often encountered in the secondary management of NOE fractures and should be addressed in the overall context of reestablishing facial symmetry and function.

Within the overall context of facial trauma, nasoorbitoethmoid (NOE) fractures make up a small percentage—5 and 15% of adults and pediatric patients, respectively¹—of facial fractures. However, given their associations within the facial skeleton, unreduced NOE fractures can lead to debilitating sequelae including diplopia, epiphora, facial asymmetry, poor cosmesis, and nasal obstruction. The goal of surgical reduction of NOE fractures is to return the patient to his or her premorbid appearance which, in turn, lends itself to the resolution or prevention of those unwanted sequelae.

Nasoorbitoethmoid fractures are associated with high force trauma in which the nasal bones are unable to contain the incoming pressure and force is dispersed into the ethmoid sinuses and the orbit. The ethmoid sinuses serve as a “crumple zone,” allowing the diffusion of force to route, as much as possible, away from critical structures.² Even still, intracranial, skull base, globe, and other skeletal injuries may concurrently be present,¹ the nature and management of which can delay the ability to take the patient to the operating room. Prompt surgical reduction should, therefore, be the reconstructive surgeon's primary aim. Delayed surgical intervention allows the resultant scarring, contracture, and instability of the skeletal buttresses and surrounding soft tissue to progress, leading to deformities that are difficult to address. Even still, expeditious surgery may be unable to be offered and the reconstructive surgeon should anticipate the

surgical problems that will need to be addressed. A comprehensive, detailed history should be derived from patients who have an unsatisfactory primary surgery displaying sequelae of incomplete reduction.

As part of the initial work-up, apart from a detailed clinical examination, computed tomography (CT) imaging of the maxillofacial area with 1 to 2 mm cuts should be acquired to adequately evaluate the distorted skeletal anatomy and possible surgical approaches. Three-dimensional (3D) reconstruction and surgical navigation may offer some benefit, especially in complex secondary cases. Special attention should be placed to the medial canthal tendon and the degree of bony comminution in the medial orbital rim bone and medial orbital wall as this will suggest the necessity of transnasal wiring, extent of exposure needed, and bone grafting.³ In patients who have had an unsatisfactory primary reduction, plating and wiring systems should be noted with their position and effect on orbit volume.

Disruption in the medial canthal tendon and its bony attachment to the medial orbital rim will lead to telecanthus. In revision cases, incomplete treatment and fixation of the medial canthus—whether it be with intranasal wiring, rigid fixation, or new bone grafting—may present with telecanthus as well. The overall posterior retrusion of the nasal complex found in NOE fractures, in addition to disruption of the nasal septum and its various attachments, provides a

framework for saddle nose deformities as well as loss of nasal projection.^{2,4} Bony comminution of the orbital medial walls and floor can lead to an increase in orbital volume, leading to enophthalmos. Disjointed bony fragments can obstruct the nasolacrimal duct, leading to epiphora. Displaced fracture lines can cause overlying soft tissues to scar in unnatural ways leading to facial asymmetry and poor cosmesis.

The current paradigm of primary treatment includes meticulous open reduction and internal fixation with titanium plates and screws and the use of transnasal wiring when appropriate given the degree of comminution that the medial orbital rim displays in relation to the attachment of the medial canthal tendon. Principles of secondary reconstruction follow closely with those of primary treatment; however, posttraumatic scarring and contracture with poorly defined tissue planes reemphasize the need for careful dissection. Special consideration of intercanthal distance and nasal projection should be given.⁴ Wide exposure for adequate visualization should be achieved to ensure accurate diagnosis of fracture patterns and injury. In the following sections, common complications of delayed or inadequately treated NOE fractures, as well as their treatment, are discussed.

Saddle Nose Deformity

The saddle nose deformity following NOE fractures presents a unique challenge to the reconstructive surgeon. Characteristically, the saddle nose deformity is caused by a loss of nasal support resulting in a loss of nasal projection, nasal shortening, tip overprojection, and middle vault flattening.⁵ Not only do these injuries have potentially devastating aesthetic repercussions, but they also have functional implications as well. Therefore, any repair must attempt to restore nasal projection and alleviate symptoms of nasal obstruction.

Ultimately, the reconstructive technique depends on the severity of the deformity. Currently, there is no universally agreed upon classification of saddle nose deformities. Chua and Park divide saddle nose deformities into two categories, mild or severe, based on whether the nose has good or poor septal support.⁶ Milder defects with good septal support only require dorsal augmentation, best achieved with a septal cartilage onlay graft⁷ or via the Turkish Delight technique, in which finely diced cartilage is wrapped in Surgicel⁸ or fascia, our preferred modification.⁸ Conversely, costochondral or bone strut grafts can be necessary to restore nasal projection in those more severe defects with loss of septal support (► **Figs. 1, 2**).⁶

Telecanthus

In NOE injuries, the medial canthal tendon can either become detached or displaced due to a fracture in the medial orbital wall, resulting in increased intercanthal distance. Normal intercanthal distance varies greatly within the population, but averages between 29 to 34 mm in adult females and 29 to 36 mm in adult males.⁹ During fracture reduction, the canthal-bearing bone fragments must be precisely reduced to restore the preinjury intercanthal distance. In less comminuted fractures with large bony fragments, the use of a two- or three-point plate fixation usually suffices; any nasal

Fig. 1 Cantilevered bone strut for nasal projection. (Used with permission from Dr. Alan S. Herford, DDS, MD.)

Fig. 2 Postoperative CT showing cantilevered bone strut. (Used with permission from Dr. Alan S. Herford, DDS, MD.)

bone fractures should also be reduced to maintain the patient's preinjury nasal projection. However, for NOE type III and occasionally for NOE type II fractures, the additional use of transnasal canthopexy is required to secure the avulsed medial canthal tendon to its insertion point.

Unrepaired or inadequately repaired NOE fractures can result in persistent telecanthus, requiring secondary repair. This often necessitates the use of osteotomies and bone grafting with resulting less predictable outcomes. Furthermore, both

repaired and unrepaired NOE injuries can result in pseudoelecanthus, the illusion of telecanthus despite a normal intercanthal distance, which occurs due to soft-tissue defects adjacent to the medial canthi¹⁰ or inadequate projection of the nasal dorsum.¹¹ Soft-tissue defects include canthal webbing or scarring and can be managed primarily while nasal projection can be addressed with bone grafting as noted above.

Enophthalmos and Diplopia

Posttraumatic enophthalmos is the posterior displacement of the orbital contents caused by disruption of the orbital architecture and resultant increase in orbital volume which becomes more pronounced after resolution of posttraumatic edema and with tissue remodeling. It is characterized by a sunken eye, pseudoptosis, and an exaggerated supratarsal fold.¹² Enophthalmos is easiest to appreciate from an inferior view and only 2 mm of displacement is necessary for the difference to be noticeable.¹²

Functionally, severe cases can also result in diplopia due to a malpositioned globe. This is a surgically challenging problem to treat; 83% of patients were found to have residual diplopia after delayed repair of enophthalmos.¹³ NOE injuries disrupt the bony architecture of orbital rim and can result in enophthalmos from imprecise bony reductions and improperly contoured grafts and implants, all of which affect the orbital volume. Secondary repair should be focused on reestablishing the premorbid orbital volume which requires osteotomizing misaligned fragments and realigning them with plate fixation. Bone and cartilage grafts or alloplastic implants may be needed to further repair orbital walls when bone loss is evident. Newer products, such as 3D designed custom implants and surgical navigation may assist the reconstructive surgeon in complex cases. He et al compared enophthalmos correction in delayed orbitozygomatic fractures with navigation-guided surgery with nonnavigation, traditional surgery and reported good globe projection correction in 91% of cases using navigation as compared to 74% of cases in the nonnavigation cohort.¹⁴

Nasolacrimal Duct Obstruction

Nasoorbitoethmoid fractures are the leading cause of traumatic nasolacrimal duct obstruction.¹⁵ The nasolacrimal sac is hidden within the lateral nasal wall, enclosed between the frontal process of the maxillary bone and the lacrimal bone. Between 5 and 21% of NOE fractures may involve the bony lacrimal canals leading to posttraumatic dacryostenosis.¹⁶ Radiologic features significantly associated with development of epiphora or dacryocystitis were lacrimal crest avulsion, displaced bone fragments within the lacrimal fossa or duct, more than 50% compression of the duct, and shift of the nasomaxillary buttress.¹⁷ Posttraumatic patients with epiphora that are found to have identifiable canaliculal puncta should undergo dacryocystography to identify the specific area of obstruction as well as the overarching size of the lacrimal sac and integrity of the canaliculal system.¹⁸

Early and meticulous open reduction of NOE fractures decreases the risk of posttraumatic nasolacrimal obstruction and epiphora; waiting 2 weeks or more after initial trauma

may lead to further bone loss and scarring of the lacrimal area resulting in worsening obstruction.¹⁶

Surgical treatment of epiphora should be delayed at least 3 months after primary repair to allow for posttraumatic and postsurgical swelling to resolve prior to exploration.¹⁸ Becelli et al found that 27 of their 58 patient cohort (46.5%) with NOE fractures developed postsurgical epiphora after open reduction of the NOE fractures. Of those 27, 10 were found to have normal patency of the lacrimal system and there was spontaneous resolution of the epiphora in all patients within 5 months posttrauma; the other 17 patients underwent external dacryocystorhinostomy (DCR) with a success rate of 94%.¹⁶

There have been excellent results reported using external DCR for the treatment of posttraumatic nasolacrimal obstruction with 92.8% success in Ali et al's cohort with external DCR and mitomycin C and silicone intubation,¹² 96% success in Mukherjee and Dhobekar's cohort with external DCR with and without silicone intubation,¹⁹ and Becelli et al's cohort as noted above.¹⁶

The advent of endoscopic DCR has allowed surgeons to treat nasolacrimal duct obstruction without an external scar, with faster postoperative recovery time, and avoidance of injury to the lacrimal pump.²⁰ In a meta-analysis of 2,101 acquired DCR cases comparing endoscopic mechanical DCR (using drill or Kerrison punches), laser-assisted endoscopic DCR, and external DCR cases, success rates with endoscopic mechanical DCR were been found to be comparable to external DCR, both at 87%.²⁰ Endoscopic DCR has been advocated as the preferred modality of revision DCR due to its access advantage to the ostomy site as well as avoidance of a more complex scar.²¹

While endoscopic DCR use in posttraumatic nasolacrimal duct obstruction has been reported, and given the rapid advances and successes of endoscopic DCR, further investigative studies need to be done to evaluate the utility and efficacy of endoscopic DCR in this cohort. In our practice, we have gone almost exclusively to endoscopic repair and stenting, unless bone fragment securing or tendon repair already demands external access.

Soft-Tissue Scarring

Overlying soft-tissue injury is often present in conjunction with NOE fractures and subsequent scarring is difficult to treat. Delayed treatment of fractures allows time for fibrosis and scarring of traumatically repositioned tissues, leading to aesthetically poor outcomes (►Fig. 3). Moreover, the contracted overlying soft tissue increases the risk of underlying bone resorption, accentuating contour deformities.²² Similarly, failure of adequate external compression in the medial canthal area after bicoronal approaches during the primary repair of NOE fractures can allow blood and fluid to build up underneath the degloved tissue with resultant poor contouring of lateral nasal and infraorbital areas.²³

Posttraumatic fibrosis and subsequent convexity in the tear trough or nasofacial angle region can be surgically thinned to recreate a premorbid, natural concavity. Resuspension of soft tissue can help prevent subsequent soft-tissue ptosis.⁴ Tear trough or malar concavities can be addressed with hyaluronic acid filler which, in the tear trough, can last between 6 months

Fig. 3 Posttraumatic scarring of the left medial canthal region with resulting contour deformity and contracture. (Used with permission from Dr. Alan S. Herford, DDS, MD.)

and 2 years.²⁴ More permanent results in the tear trough and malar areas may be achieved with fat grafting. Contour deformities in the nose can be addressed with fillers as well; Restylane (Galderma) is a preferred filler for use in the nose and has a low hydrophilicity and a high concentration of hyaluronic acid, an optimal combination in the thin skinned nose which leads to longevity of augmentation and decreased risk of fluid retention and edema in the injected area.²⁵

To prevent further scarring after debulking and all fracture stabilization, a Xeroform or felt bolster should be fashioned and secured with a transnasal suture and left for at least 1 week.²³ In severe fracture cases where bolstering is not possible, we have found external aquaplast nasal splint formation with stabilization using septal or transnasal K-wires (0.7–0.9 mm) and protective K-wire balls can be very helpful to reduce swelling and postoperative fluid collection.

Conclusion

Delayed or inadequate reduction of nasoorbitoethmoid fractures can lead to deficits in facial function and aesthetics. Secondary reduction is challenging due to the scarring and contracture of soft tissue and bony fragments. A problem-based approach with special attention to the intercanthal distance and nasal projection should be used in the management of secondary NOE fracture reduction.

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Conflicts of Interest
None declared.

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