BACKGROUND:

Nasal orbital ethmoid fractures (NOE) are widely considered the most difficult facial fracture to manage. Surgical repair is notoriously difficult and fraught with potential complications. As a result, published literature on the topic is quite limited. Treatment principles can be found in textbooks, but published studies in journals are rare. The literature is largely limited to a few case series reported by oral-maxillofacial surgeons. It is likely that the literature is limited because no surgeon wants to be known as an NOE expert.

DEFINITION:

In its most basic terms, an NOE fracture is a fracture of the facial skeleton in the area of the confluence of the orbits, nasal bones, maxilla, frontal bone, and anterior skull base. The key to defining whether or not a fracture qualifies as an NOE is what happens to the area where the medial canthal tendon attaches to the medial orbital wall (area surrounding the lacrimal fossa). If this area is fractured, the injury is labeled an NOE fracture.

NORMAL ANATOMY OF NOE REGION:

The normal bony anatomy in the NOE region is comprised by multiple bones. The frontal bone forms the roof of the orbit. The paired nasal bones inter-digitate with the frontal bone superiorly and to each other in the midline. The maxilla forms a large portion of the inferior orbital rim and much of the orbital floor. The nasal process of the maxilla fuses with the nasal bones laterally and the frontal bone superiorly. The lacrimal bone contributes to the medial orbital wall and corresponds to the key area in NOE fracture classification.
LACRIMAL FOSSA:

The lacrimal fossa is demarcated by the anterior and posterior lacrimal crests. The lacrimal sac sits in the lacrimal fossa and collections tears in the medial canthal region. In the cadaver specimen, the opening of the lacrimal duct can be seen as it passes inferiorly toward the nasal cavity.

ORBITAL ANATOMY- IMPORTANT DISTANCES TO KNOW:

When performing orbital surgery, it is necessary to keep important surgical landmarks in mind. The distance between the anterior lacrimal crest and the anterior ethmoid artery is 24mm. If dissection is carried 12 mm posterior to this landmark, the posterior ethmoid artery is encountered. The optic nerve can be identified 6mm posterior to the posterior ethmoid artery. A commonly use pneumonic for these distances: a case (24 pack), a 12 pack, and a 6 pack.

MEDIAL CANTHAL TENDON:

The majority of this structure is made up of the tendinous portions of the orbicularis muscle. The tendons of the orbicularis coalesce and insert medially onto the medial orbital wall. Most of the attachment is anteriorly onto the anterior lacrimal crest/frontal process of the maxilla. A small portion of the tendon inserts on the posterior lacrimal crest. The tendon straddles the lacrimal sac and acts as a pump to send excess tears through the lacrimal duct inferiorly.

CORONAL ANATOMY OF THE FACIAL SKELETON:

Managing NOE fractures requires a working knowledge of the relationship of the ethmoid sinuses, the skull base, and the lamina papyracea. Skull base anatomy is variable. In some individuals, the cribiform plate hangs low, which can have surgical implications (discussed below).

BUTTRESS SYSTEM:

The mid-face has areas of strength and weakness. The areas of strength are called buttresses. They represent loadpaths for force during chewing and trauma. They resist traumatic impact. Between the buttresses are weaker areas that tend to crumple during blunt trauma. There are two vertical buttresses on either side of the face. NOE fractures involve the medial vertical nasal buttress (nasomaxillary buttress). The lateral vertical buttress is the termed the zygomaticomaxillary buttress. Horizontal buttresses connect the vertical buttresses and are equally important in facial architecture.

NOMENCLATURE OF NOE FRACTURES:

Multiple acronyms exist to describe fractures of the nasal orbital ethmoid region. Nomenclature over the past ten years is more consistent in referring to these injuries as NOE fractures. Older names include the following: NEC (naso-ethmoid complex fracture), nasoethmoid orbital, naso-orbito ethmoid. Many textbooks group NOE fractures with frontal sinus fractures as concomitant injuries are common.
MECHANISM OF INJURY:

In the mid twentieth century, the most common cause of an NOE fracture was an MVC in which the patient’s face struck the dashboard/steering wheel. While airbags have significantly decreased the incidence of this injury, MVC accidents remain the most common cause. Any high velocity blunt force trauma to the face can cause an NOE fracture.

DEMOGRAPHICS:

NOE fractures represent only 5% adult fractures and 16% of pediatric facial fractures. These fractures don’t usually occur in isolation. Patients frequently have severe injuries to the facial skeleton, brain, and rest of the body in a polytrauma setting. There is a high rate of concomitant le fort fracture and frontal sinus fracture. 60% of NOE fractures are associated with an orbital or ZMC fracture.

Soft tissue injuries are also common. Traumatic brain injury and CSF leaks are also possible comorbidities.

PATHOPHYSIOLOGY OF THE FRACTURE:

By definition an NOE fracture involves disruption of: the inferior orbital rim, lateral nasal bones, medial orbital wall, and the frontal process of the maxilla. A high velocity force is necessary to produce these fractures. The bones in the nasion/glabellar region are very strong. Once a force strong enough to break them proceeds posteriorly, the resistance is much less. A telescoping injury can occur as the underlying lacrimal/ethmoid bones are much more fragile. The fractured segments of bone (comprised of the nasal bones and the nasal process of the frontal bone) can be driven posteriorly. The thin-walled ethmoid sinus walls are fractured and the nasal bones can get lodged superiorly under the frontal bone. The lacrimal bone gets fractured and displaced laterally. The medial canthal tendon can be disrupted, resulting in telecanthus. The medial canthal tendon and globe get displaced laterally because of the traction of the orbicularis muscle.

NOE FRACTURE CLASSIFICATION:

Multiple classification systems exist for NOE fractures, but only the Markowitz Classification is routinely cited in the literature. This system is favored because it separates fractures based on surgical repair. Sorting fractures into categories based on the central bony fragment attached to the medial canthal tendon (MCT), the Markowitz Classification has 3 types. Type I fractures involve a single, non-comminuted bony fragment with the MCT still attached. In Type II fractures, there is comminution of the central bony fragment, but the MCT is still attached. Type III fractures involve severe central fragment comminution with disruption of the MCT attachment.

WHAT MAKES NOE FRACTURES SO DIFFICULT TO MANAGE?:

A high degree of suspicion is required to diagnose NOE fractures. The exam is difficult in the acute setting because of the severity of the facial injury and other associated injuries. Management of
NOE fractures is somewhat controversial as no universally accepted method of repair or surgical approach is described. Furthermore, the NOE region is a delicate area of the face. Both bone and soft tissue structures are injured that require reconstruction for good and aesthetic and functional outcomes. For the bony portion, the fractured segments are technically difficult to reduce and plate. The soft tissue deformity is also challenging to restore to the proper, natural contour. NOE fractures are sustained in the setting of major trauma with high velocity forces. Making a diagnosis is based on physical exam alone is challenging due to the facial edema. The examiner must rely on a combination of exam and imaging.

**PHYSICAL EXAM:**

NOE fractures display a number of characteristic physical exam findings. Notably, these patients have telecanthus. Disruption of medial canthal tendon results in this traumatic telecanthus. Normal inter-canthal distance is roughly half the inter-pupillary distance. One should suspect an NOE fracture if the inter-canthal distance is 35mm. An inter-canthal distance greater than 40mm is diagnostic of an NOE fracture. The bowstring sign is a described physical exam maneuver to diagnose medial canthal disruption. The examiner places an instrument in the nose and palpates the medial canthal region. Lateral traction is placed on the lateral canthus. Normally there is palpable resistance. In NOE fractures, the examiner’s finger might sink into the orbit.

A flat nasal bridge (loss of nasal dorsal height) may also be found in NOE fractures. Injury to the nasal bones and nasal septum results in a loss of nasal support. This gives rise to the characteristic pig-snout deformity seen in some NOE fractures. By definition NOE fractures result in a disruption of the orbital wall. It is necessary to examine the eye for visual acuity and entrapment. Ophthalmology consultation is required to rule out corneal laceration, injury to the globe, dislocated lens, and detached retina.

**IMAGING:**

CT scans provide the best detail of bony anatomy in the setting of suspected NOE fracture. In the axial view it is often possible to identify the status of the central bony fragment. A normal lacrimal fossa can be seen as an indentation in the anterior aspect of the medial orbital wall. Alternatively, one can trace the lacrimal duct after it is identified inferiorly up to the lacrimal fossa to more easily identify the area. This may not be possible in type III injuries as the entire area may be blown out.

**MANAGEMENT-ACUTE STABILIZATION:**

Epistaxis is very common in all forms of nasal trauma. Severity may range from minor or extreme. Nasal packing is frequently required. The planum sphenoidale refers to an area of the floor of the anterior cranial fossa which lies between the sella turcica and the cribiform plate. It is comprised largely of the lesser wing of the sphenoid (which forms the roofs of the optic foramina). In very severe facial trauma, the optic nerves can be damaged by a fracture of this area. The fracture may extend through the superior orbital fissure and damage structures that run through the fissure: (CN III/IV/V1/VI, ophthalmic vein, sympathetic fibers).
MANAGEMENT-LACRIMAL SYSTEM:

50% of NOE fractures will present with epiphora at the time of injury. Obstruction of the lacrimal system can be secondary to injury to the duct, obstruction of duct by bone fragments, and swelling. Only 5-10% will have persistent swelling.

TIMING OF OPERATION:

Optimally, surgery takes place immediately after the swelling has subsided. This is generally 10-14 days after the injury. With Type III fractures, locating the medial canthal ligament is difficult in the delayed setting. Timing of the operation is also influenced by the patient’s overall general condition. Frequently, the operation is delayed by management of intra-cranial injury.

PICKING A SURGICAL APPROACH:

Multiple options exist for surgical approaches to repair NOE fractures. Three approaches predominate the literature (open sky, midface degloving, and coronal approach). Each surgeon must pick the approach he is most comfortable performing safely that affords the exposure needed. NOE fractures rarely occur in isolation and the surgeon may need to address multiple fractures by performing multiple approaches.

OPEN SKY/EXISTING LACERATION:

The open sky approach is essentially bilateral lynch incisions connected with a transverse incision just below the glabella. This provides excellent exposure of the NOE region. Downsides include significant scarring. This approach is generally avoided unless a pre-existing laceration provides direct access.

MID-FACE DE-GLOVING:

The main benefit of a mid-face de-gloving is avoiding skin incisions. In addition, addressing other associated mid-face fractures (e.g.: Le Forte, ZMC) can be accomplished easily. Drawbacks include difficulty exposing the medial canthal region.

BI-CORONAL FLAP/APPROACH:

The coronal flap is the most popular approach described in the literature. This approach provides access to frontal sinus area as well as the medial canthal regions. Harvesting parietal bone for grafting is also possible in the coronal approach. Additional approaches to repair the orbital floor and frontal process of the maxilla are required (eg. trans-conjunctival or sub-ciliary). In addition, it is difficult to gain access to associated mid-face fractures.
BI-CORONAL TECHNIQUE:

A skin incision is traditionally made from helix to helix across the scalp. Dissection is carried down to the periostium and the flap is elevated between the frontalis muscle/galea and the periostium of the frontal bone. The periostium can be incised and lifted with the flap, or it can be incised over the forehead region when dissection transitions to sub-periostial.. The supra-orbital neuro-vascular bundles are identified in the area of the medial superior orbital rim. In some cases, ligation is necessary to gain exposure. Dissection on the medial orbital wall must proceed with caution to avoid inadvertently avulsing the medial canthal tendon insertion. This results in turning a type I fracture into a type III fracture. Ligation of the anterior ethmoid artery may be necessary for exposure as well when retracting the globe.

SURGICAL REPAIR- GENERAL CONSIDERATIONS:

Repair of NOE fractures is very difficult and the type of repair is dictated by fracture classification. Almost all NOE fractures require surgical repair. Select type I injuries with non-mobile medial canthal regions are candidates for observation. Goals of surgery include restoring the face to pre injury function/appearance, reconstructing the medial orbital wall (if necessary), resetting the nasal dorsum (if necessary), and re-attaching the medial canthal tendons (if necessary). Over-correction of telecanthus is preferred as the canthi will tend to drift apart in the post-operative period. The patient may have multiple facial fractures that require repair. It is preferable to fix other fractures first and then repair the NOE fracture. This maximizes facial landmarks used for reconstruction.

TYPE I SURGICAL REPAIR:

Type I fractures involve a large central bony fragment in the NOE region with the MCT attached. After adequate exposure, microplates are used to secure the frontal process of maxilla to central bone fragment. The frontal bone is also plated to the central bone fragment.

TYPE II SURGICAL REPAIR:

Type II fractures require more extensive techniques. Because the central bony fragment is comminuted, these fractures require microplating and transnasal wiring (trans-nasal canthopexy). More extensive exposure is required, including retraction of the orbit. It is preferable to perform trans-nasal wiring first and then plate the fracture second.

Trans-nasal wiring involves passing a 26 gauge wire from lateral to medial through the central fragment. Holes are drilled in the bony fragment posterior to the to the lacrimal fossa before passing the wire. The wire is passed through the ethmoids/septum and secured to the contralateral orbital wall. The wire may be secured either to a plate/screw on the contralateral side or to the trans-nasal wire from the contralateral side if the fracture is bilateral. When drilling holes in the medial orbital wall it is necessary to drill posterior to the lacrimal fossa. This avoids an unfavorable vector which would result in telecanthus. One must avoid the pitfall of drilling above the fronto-ethmoid suture line on the medial orbital wall to avoid hitting the cribiform plate.
TYPE III FRACTURE REPAIR:

Type III NOE fractures are the most challenging and are also the least common (1-5% of all NOE fractures). Repair is similar to type II fractures in that the exposure required is extensive. Type III fractures also require trans-nasal wiring and plating. In addition, severe comminution may require reconstruction of the medial orbital wall in the area of the lacrimal fossa. This can be achieved with bone grafting or placing a titanium mesh plate. Reconstruction of the medial orbital wall is needed if 2 drill holes 4mm apart vertically cannot be placed with sufficient surrounding bone for microplating.

If the avulsed medial canthal tendon can be identified, it can be re-attached to the bone graft/titanium plate used in orbital wall reconstruction. A modified kessler stitch may be used to secure the tendon to bone fragment. Reconstructing the nasal dorsum can be accomplished, if needed, with calvarial bone grafts. A cantilevered bone graft can be plated or screwed to the radix.

DERMAL CONTOURING- TYPE II/III FRACTURES

Type II/III injuries require wide exposure around the medial canthal tendon region. The subperiostial dissection often results in hematoma/chronic edema which may lead to scarring. Scaring in the NOE region can cause excessive tension on the medial canthal tendon resulting a loss of adherence of the soft tissue to the underlying bone. This phenomenon, known as pseudo-telecanthus, gives the appearance of a widened nasal bridge despite proper reduction of the bony skeleton. Pseudo-telecanthus can be mitigated by placing soft tissue bolsters. Several authors describe using 2mm thick lead plates lined with ortho felt. These bolsters are secured with 28 gauge wire passed through the nasal bones to help in soft tissue compression for the first week after surgery.

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