Management of Nasoorbitoethmoidal Fracture: An Institutional Experience

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Received: 30 May 2018 / Accepted: 17 August 2018 / Published online: 4 September 2018
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Abstract The nasoorbitoethmoidal fractures remain the most complex of all facial fractures to diagnose and treat mainly because of the intricate anatomy and difficulty in fracture fixation. The number of such fractures are increasing with the more incidence of high-speed, high-force accidents. The nasoorbitoethmoidal fractures rarely occur as an isolated event. Associated injuries often include central nervous system injuries, cribriform plate fracture, cerebrospinal fluid rhinorrhea, and fractures of the frontal bone, orbital floor, and middle third of the face as well as injury to the lacrimal system. The appropriate management of these injuries require an understanding of the anatomic features of the region, the degree of severity of damage. The purpose of this article is to provide a general overview of the topic, with a more specific focus on the pearls of managing these fractures. Twenty-four patients who suffered The nasoorbitoethmoidal fractures with/without associated multiple midfacial injuries were included in the

study. Postoperatively, results show stable symmetrical fixation of the canthus in three dimensions with good apposition of the eyelids against the ocular globe along with acceptable nasofrontal angle and nasal prominence. Prompt and proper management of these injuries can achieve both adequate functional and aesthetic outcomes.

Keywords Nasoorbitoethmoid fractures · Medial canthal tendon · Coronal flap · Rigid fixation

Introduction

The nasoorbitoethmoidal (NOE) complex is the conglomeration of frontal sinus, ethmoid sinuses, anterior cranial fossa, orbits, frontal bone and nasal bone. The medial canthal tendon (MCT) splits before inserting into the frontal process of the maxilla and surrounds the lacrimal fossa. This critical central component to the NOE is surrounded posteriorly by the lacrimal bone, anteriorly by the nasal bones and pyriform aperture, cranially by the frontal bone, inferiorly by the maxilla, medially by the ethmoid air cells, and laterally by the orbit and its contents. This complex anatomy renders NOE injuries as one of the most challenging field of facial reconstruction. Inadequately treated NOE injuries produce secondary defects which are extremely difficult to correct. Long term sequelae of NOE fracture include blindness, telecanthus, enophthalmus, mid-face retrusion, cerebrospinal fluid (CSF) fistula, anosmia, epiphora, sinusitis and nasal deformities [1]. Definitive diagnosis and prompt surgical treatment of NOE fracture are critical to avoid any complication and to obtain a good result.

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Materials and Methods

Twenty-four patients were randomly selected regardless of age and sex who reported to our centre from April 2015 to May 2017. They required reduction and rigid fixation of NOE injuries with or without associated fractures of facial skeleton thus were considered for inclusion in this study.

Inclusion Criteria

- A clinical diagnosis of NOE fracture.
- CT and radiographic imaging showing NOE fractures isolated or associated midfacial fractures were included in the study.

Exclusion Criteria

Patient suffering from uncontrolled diabetes, metabolic diseases, immunocompromised status, poor GCS scale, acute/chronic conjunctival diseases, previous history of facial trauma or history of retinal detachment surgery, preoperative facial nerve weakness, preoperative neurosensory deficit and previously operated by the coronal incision were not included in this study.

History was recorded and nature and severity of the injury assessed.

Clinical Diagnosis

The criteria for making this diagnosis are as follows

Physical Examination

1. Visual inspection
 - a. Ecchymosis and edema.
 - b. Periorbital, subconjunctival hemorrhage and septal hematoma.
 - c. Laceration overlying the MCT.
 - d. 'Pig snout' appearance.
 - e. Frontal depression/widened interorbital space.
 - f. Traumatic telecanthus: Increased intercanthal distance > 35 mm.
 - g. CSF rhinorrhea.
 - h. Palpebral fissure: Narrow almond-shaped.
 - i. Eyelids become lax and prominent epicanthal folds.
 - j. Pneumocephalus.
 - k. Epiphora.

2. Palpation

Direct palpation of the medial orbital rim and nasal bridge.

3. Bimanual examination

Movement of the central fragment indicates instability of the fracture.

Ophthalmologic Evaluation

- Assessment of visual acuity.
- Speed and symmetry of pupillary reaction.
- Visual fields.
- Intraocular pressure.
- Enophthal.
- Diplopia.

Radiological Evaluation (Table 1)

Preoperative Workup

- A. A high index of suspicion for the possibility of NOE fracture is necessary; most of these patients have multiple injuries.
 1. Documentation of the intercanthal distance and relate it with interpupillary distance (intercanthal distance = 1/2 interpupillary distance) and to the distance of the midpoint of the nose.
 2. Determining the laxity of the lids by Bowstring test.
 3. Check for the characteristic clinical appearance.
 4. Check for CSF leak (paper test and beta2-transferrin estimation).
 5. The status of the main sensory and motor nerves of the face and forehead was documented prior to surgery.
- B. Preoperative ophthalmologic consultation is done
 1. Corneal laceration.
 2. Open globe.
 3. Hyphema.
 4. Detached retina.
 5. Visual acuity and visual fields.
 6. Indirect ophthalmoscopy.
 7. Forced duction test.
 8. The Jones tests of lacrimal integrity.

Table 1 Various radiographs utilized for diagnosis

Type of radiograph	Remarks
Plain films	
Occipito-frontal at 25° angulation	It shows interorbital space and the frontal processes of the maxillary bone and thus clearly delineates lateral displacement of these bones.
Occipito-mental projection	This projection shows the facial skeleton and maxillary antra and avoids superimposition of the dense bones of the base of the skull.
Lateral view of the skull and facial bones	This view provides an overview of the entire skull rather than attempting to highlight any one region.
Occlusal films	Shows ethmoid disruption
Computed Tomography (1.5 mm thin cut slices)	
Axial slices	Easy for the patient and landmarks are easy to identify on the initial scanogram view which are frontal sinus, lamina papyracea, ethmoid complex, nasal septum and nasal bone
Coronal slices	Helpful in- i) orbital examination ii) visualizing the horizontal struts, or plates of bone which lie parallel to the slice plane and are poorly visualized

Fig. 1 3D CT showing frontal ZMC and NOE fracture

- C. Thorough delineation of the extent of all facial injuries.
- D. CT demonstration of the all facial fractures and the extent of comminution of the complex, in addition to delineating the integrity of the cribriform plate and anterior cranial fossa (Fig. 1).
- E. Obtaining preoperative photographs.

All cases were treated under general anaesthesia with nasotracheal intubation. The patient/guardian was intimated the risks and possible complications of the procedure.

Sequencing Surgical Treatment

Attaining the ‘ABC’ of emergency management and looking into the consideration of other periorbital injuries the following sequence is followed.

1. Proper access to fracture site.
2. Reconstruction of the cranial base, outer orbital frame; management of the frontal sinus if necessary.
3. Reconstruction of frontonasal buttress and orbital rim.
4. The nasal dorsum reconstructed and nasal projection restored.
5. Reconstruction of medial orbits.
6. Medial canthal ligament.
7. Lacrimal system.
8. Closure and drain.
9. Consideration for secondary external support of the medial canthal ligament.
10. Nasal plaster.
11. Dressings, antibiotics and eye drops.

Surgical Treatment

Surgical Approach

The surgical approach can be achieved in several ways:

1. Through an existing laceration.
2. “W” incisions.
3. Coronal approach (Fig. 2).
4. ‘Open sky’ technique.
5. Lynch incision.
6. Bilateral ‘Z’ approach.
7. Midline vertical approach.

Fig. 2 Bicoronal Flap Raised

Techniques of Repair

1. The bony skeleton:

- a. Extensive comminution and fragmentation were examined and each fragment was identified and preserved.
- b. Midfacial and frontal fractures was reduced and fixated with microplates.
- c. The frontal process of the maxilla and the nasal bones were aligned with the frontal bone and directly fixed.
 - Asch forceps aided reduction.
 - Skin hook was inserted behind impacted bones to provide additional traction.
 The bone fragments are aligned and wired to each other with stainless-steel wire (Fig. 3).

2. The medial canthal tendon (MCT).

With adequate exposure of the inner canthus identification of the tendon was not difficult. After the complete exposure is was decided whether or not the bone fragment containing the MCT is large enough to support direct plating. In our two cases of class III fracture transnasal canthopexy were performed by wiring the bone fragment transnasally to the opposite anterior lacrimal crest. 0.3 or 0.4 mm stainless steel wire was passed through the tendon and bone twice; the ends were then passed transnasally through pre-drilled holes in the opposite anterior lacrimal crest with a curved awl. The ends were then twisted over a toggle wire. Therefore, the

Fig. 3 Fixation of Hardware

tendon is always suspended posterior and superior to its original. Esthetically, an overcorrected result is far superior to an undercorrected telecanthus.

Now one is ready to secure the transnasal sutures. It is critical in the healing phase that pressure be applied externally on the soft tissue in the medial canthal region. To do this, we took a very large suture on a cutting needle and passed it from one medial canthal region through or below the nasal bones under direct vision and out the skin of the other medial canthal region. The MCT was then secured and the wound was irrigated and closed. Suture was tied over this quite firmly to provide the external pressure that is so critical in obtaining an excellent result.

3. Bone grafting.

In 2 cases nasal dorsal support was found to be inadequate, a cranial bone graft was harvested and plated into the region. The distal aspect of this graft was tucked under the lower lateral cartilages to prevent palpability.

4. Lacrimal repairs.

In our cases Jones I and II tests were negative, so we did not have to go for lacrimal repairs. Injury to the lacrimal system was avoided by intraoperative stenting of the lacrimal puncta and duct.

Postoperative Considerations (Fig. 4)

- A. Prophylactic antibiotics (perioperative period and continued for 5–7 days).
- B. Nasal splints removed in 2 weeks.
- C. Close postoperative follow-up by the ophthalmologist to ensure early detection and correction of diplopia.

Fig. 4 Post-operative Radiograph

- D. The suction drain removed 24 h and pressure dressing removed after 72 h.
- E. The bolsters and scalp suture removed after 10 days.
- F. The patient was examined for any CSF leak.
- G. Standard nasal hygiene advised (nasal saline irrigation and no nose blowing).
- H. Routine follow-up was performed at 2 weeks. 1st month, 3rd month, 6th month and 8th month.

Results and Observation

Twenty-four patients were involved in the study with a mean age of 34 years (18–50 years). Etiological factors in these cases were mainly road traffic accident (78%), others

Fig. 5 Average time taken for incision making

Fig. 6 Incisions employed in number of cases

(22%) (self-fall/occupational injuries). There were 14 males and 10 females and operation were performed at 5–24 days (post injury). Out of the 24 cases, 3 cases were explored through existing laceration and in a few cases transconjunctival and infraorbital incisions were used as adjunctive incision. In one case, transconjunctival approach was supplemented with lateral canthotomy to get adequate exposure of the frontozygomatic suture (Figs. 5, 6).

In no case persistent telecanthus was evident and 6 cases showed epiphora immediately postoperatively which resolved spontaneously with resolution of the soft tissue swelling. Two cases of temporal branch of facial nerve weakness was noticed which persisted at 3 weeks postoperatively. There was complete recovery of function in these cases at the end of 2 months. No cases of postoperative hemorrhage, haematoma, infection or temporal fossa hollowing were noted. Postoperative follow-up period has been for 8 months (Fig. 7).

Discussion

Markowitz and Manson classification is the most common system used for grading injuries to this region, which grades the extent of damage based on the status of the central fragment and MCT [2].

Markowitz classified the NOE fractures as follows [3]:

Fig. 7 Postoperative findings after 8 months

Type I fracture In which the medial canthal tendon is intact and connected to a single large fracture fragment.

Type II fracture The fracture is comminuted, and the medial canthal tendon is attached to a single bone fragment.

Type III fracture comminution extends to the medial canthal tendon insertion site on the anterior medial orbital wall at the level of the lacrimal fossa, with resultant avulsion of the tendon.

The possibility of canthal spread should be considered. The timing of examination is also important because gross oedema or emphysema initially may mask the most obvious local findings. In general NOE fractures with panfacial injuries are associated with a diffuse facial oedema, whereas isolated NOE fractures are associated with localized ecchymosis and oedema in the nasal and periorbital region [4]. The bimanual examination confirms the diagnosis and also determines the need for surgical repair. The most important factor in determining the treatment plan for a NOE injury is stability of the bone to which the MCT attaches.

The most relevant radiograph for the diagnosis of NOE fracture is the occipito-frontal view at 25° angulation [5]. Plain radiographs are now supplemented by computerized tomography (CT). Usually a slice thickness of 2–4 mm is adequate in assessing facial trauma. However, if reformatting is required very thin (e.g. 1.5 mm) slices are best. Now the recent introduction of 3-D SLA (stereolithographic) model has been a significant contribution in the treatment.

If the patient is to be brought to the operating room for other fractures, one may better assess the need for operative fixation by taking a blunt elevator and placing it

intranasally on the medial aspect of the lacrimal fossa [6, 7]. With digital manipulation externally and pressure on the blunt elevator, one can assess the mobility of the area. Nonmobile class I injuries can be managed nonoperatively.

Delayed repair is especially complicated for type III injuries involving the canthal ligaments. Therefore, treatment should be initiated as early as possible (not exceeding 10–14 days) after the oedema from injury subsides and the patient is stable enough to undergo the procedure.

Before 1960, the treatment of NOE fractures generally involved closed reduction with external plates and splint fixation techniques [1, 8–10]. The drawbacks of closed reduction:

1. Wires, plates and splints lie anterior to the critical point.
2. Local skin necrosis.
3. Gross separation between the nasal and frontal bones.
4. Post-traumatic telecanthus.

Mustarde [11] and Dingman [12] demonstrated superior results with open reduction and internal fixation using interfragmental wiring [3, 13]. Later, in 1970, Stranc [2] highlighted the incidence of the MCT avulsion and advocated exploration through existing lacerations or local incisions and treatment with anterior transnasal wires. Mathog and Bauer [14] advised direct wiring to the posterior lacrimal crest, if intact [2]. Stoll et al. [15] showed very rigid anterior stability by the application of two contoured miniplates screwed centrally to the frontal bone above and below on each side to the frontal process of maxillary bone. Shore et al. [7] described the use of cantilevered, mini-plate fixation of the canthus, for unilateral detachment.

Surgical Access

We have experienced excellent exposure to the upper midfacial skeleton, supraorbital margin, frontonasal suture, nasoethmoid suture, lateral orbital margin by the coronal surgical incision which is similar to experience reported by Marshall et al. [16], Abubaker et al. [17], [18]. In our series of cases no evidence of hematoma was recorded. Suction drain for 24 h and pressure dressing removed after 72 h in all our cases. Abubaker et al. [19] reported 2 cases out of 28 patients with haematoma [20]. In a study conducted on 100 patients by Frodal et al. [21], no flap infection and 4 cases of stitch abscess were noted. We experienced no such flap infection or stitch abscess in our series. In our study two patients had facial nerve weakness which persisted for 3 weeks, completely recovered at the end of 2 months. Incorporation of a W-plasty into the design of the local incision improves scar camouflage which was utilized in few cases of our series. This view is supported by Leon A. Assael [22]. We have also employed Infraorbital approach in 2 cases of persistent periorbital oedema which can be worsened by surgical manipulation and lead to technical difficulty or failure of reinsertion of canthus at the end of the operation. Bahr et al. reported more conspicuous scar in infraorbital incision but in our small number of cases we have acceptable scar formation. Closure of soft tissues should be done in layers for better aesthetics [2, 23]. The access can also have done with infraorbital, subciliary, lateral orbitotomy approach, and maxillary vestibular incision (intraoral) [24]. Other approaches include Lynch incision and Open sky approach, although they may appear more direct, actually has more limited access and result in scarring.

Bone Grafting

Immediate bone grafting is indicated in type II and III fractures. If the bone grafting is delayed the soft tissues may contract, making later secondary grafting difficult. Often, type III fractures also require construction of medial orbital wall with a bone graft. With the coronal flap elevated, a split thickness graft from the adjacent parietal calvarium can easily be harvested through coronal incision.

Addressing the Nasolacrimal Injury

Lacrimal dysfunction is not a significant problem with NOE fractures unless treatment is delayed. Nasolacrimal tract obstruction after open reduction is rare (5–10%) [2]. Some patients (50%) can present with epiphora immediate postoperatively which resolves spontaneously.

Conclusion

Management of NOE fractures require a thorough understanding of the local anatomy, a detailed clinical examination and proper treatment planning. To achieve good results, one must emphasize early treatment, wide exposure through esthetic incisions and reconstruction using rigid fixation and bone grafting where appropriate. Overcorrection of the bony position and compression of the soft tissue overlying the MCT are critical.

Compliance with Ethical Standards

Conflict of interest The authors do not have any financial or personal relationship with any other person or organisation that could inappropriately influence (bias) this work.

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