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Maxillofacial Fractures: From Diagnosis to Treatment

Mohammad Esmaeelinejad

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Abstract

Oral and maxillofacial fractures are common injuries among multiple trauma patients. Mid-face fractures are considered serious medical problems rather than all other maxillofacial injuries due to their complexity of management. An appropriate treatment plan is essential to reconstruct the mid-face aperture esthetically and functionally. Favorable results are provided by interdisciplinary approaches and appropriate surgical treatments. The authors believe in that a complete and universal book about trauma surgery should contain a chapter about this issue which includes all aspects of mid-face fractures. So we aim to provide a comprehensive chapter about diagnosis and treatment of mid-face fractures which may be a complete and useful guideline for trauma surgeons.

Keywords: Le Fort fractures, orbital wall fracture, NOE complex

1. Introduction

Mid-face fractures are common in different populations [1, 2]. Facial fractures are detected in almost 5–10% of trauma patients [3]. Motor vehicle accidents seem to be the first cause of mid-face fractures all around the word [4]. The other causes of facial fractures including mid-face trauma indicated in the literature are assaults, falls, sport injuries, and anima attacks [5, 6].

The importance of mid-face is clear in function and esthetics. The mid-face skeleton is important in providing a functional unit for respiratory, olfactory, vision, and digestive systems. The mid-face consists of vertical, horizontal, and sagittal pillars. Understanding the principles of mid-facial repair is the key to optimize the outcome.

Diagnosing mid-face fractures is sometimes very difficult in emergency cases. Diagnosis of the types of mid-face fractures is the first and basic step in management of mid-face trauma.

The treatment of mid-face fractures is complex due to the physiology and anatomy of mid-facial subunits. Quality of life of the patients is influenced following unsuccessful management of mid-face fractures which lead to permanent functional problems. Esthetic disfiguring trauma changes the whole mid-facial compartments.

This chapter aims to present a comprehensive review of mid-face fractures types' diagnosis and management.

2. Examination of trauma patients

Advanced trauma life support (ATLS) is the first step that should be applied in emergency cases. Airway obstruction should be evaluated as soon as possible since the mid-face is the beginning of the respiratory pathway. Hemorrhage and secretions may obstruct the oropharynx and nasopharynx. Removal of fractured teeth, clots, and loose dental crowns or dentures is important to open the oral airway. Packing should be used to control acute bleeding. Intubation to secure the airway in instable mid-face fractures is the next step that should be considered in emergency patients [7, 8]. It is important to keep the airway open in mid-face fractures because there is always the potential of airway obstruction due to displacement of bones or severe bleeding in such cases.

Cervical spine injuries are common in facial fractures. The incidence rate of cervical spine trauma in pediatric facial fracture cases is almost 3.5% [9] whilst this number is much higher in adult trauma patients [10]. According to the possibility of spinal injuries in facial trauma patients stabilizing the cervical spine by a rigid collar is necessary until the spinal injury is ruled out.

After providing a secure airway, ATLS protocol can continued. When the patient is stable, facial examination to detect the mid-face fractures is executed as follow.

3. Maxillofacial fractures

3.1. Le Fort fractures

3.1.1. Classification

Le Fort fractures are classified as three types. Le Fort I injury is defined as separation of maxilla from the mid-face (**Figure 1**A). Nasal septum, lateral nasal walls, lateral maxillary sinus wall, and pterygoid plates are involved in these kinds of fractures (**Figure 2**). Le Fort II fracture is also called the pyramidal fracture pattern which is identified by the separation of nasomaxillary complex (**Figure 1**B). Nasal and lacrimal bones, nasofrontal suture, infraorbital rims, and pterygoid plates are involved in this fracture pattern. Le Fort III also known as craniofacial dissociation is detected by the separation of the whole mid-face from the skull (**Figure 1**C). This fracture occurs in nasofrontal and zygomaticomaxillary sutures, zygomatic arch, and pterygoid plates.
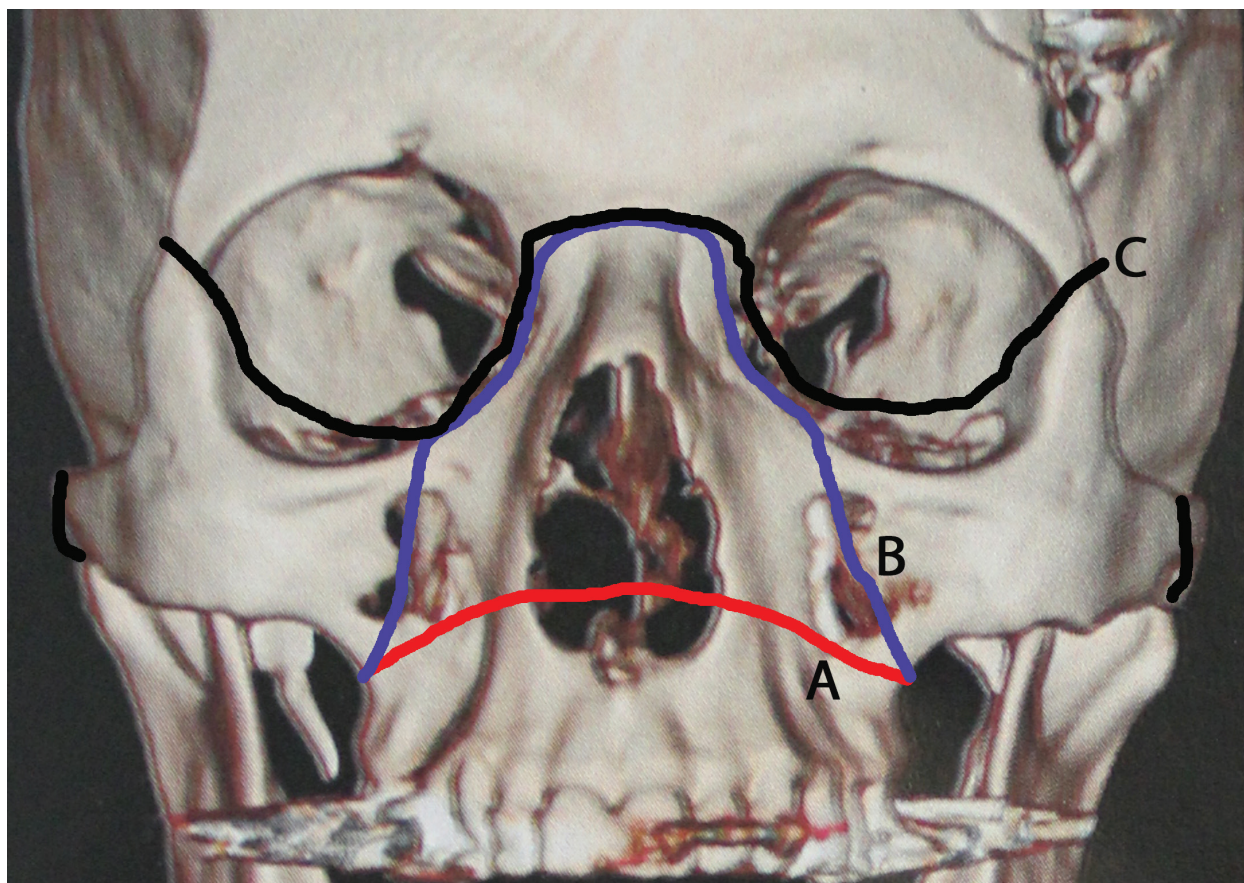
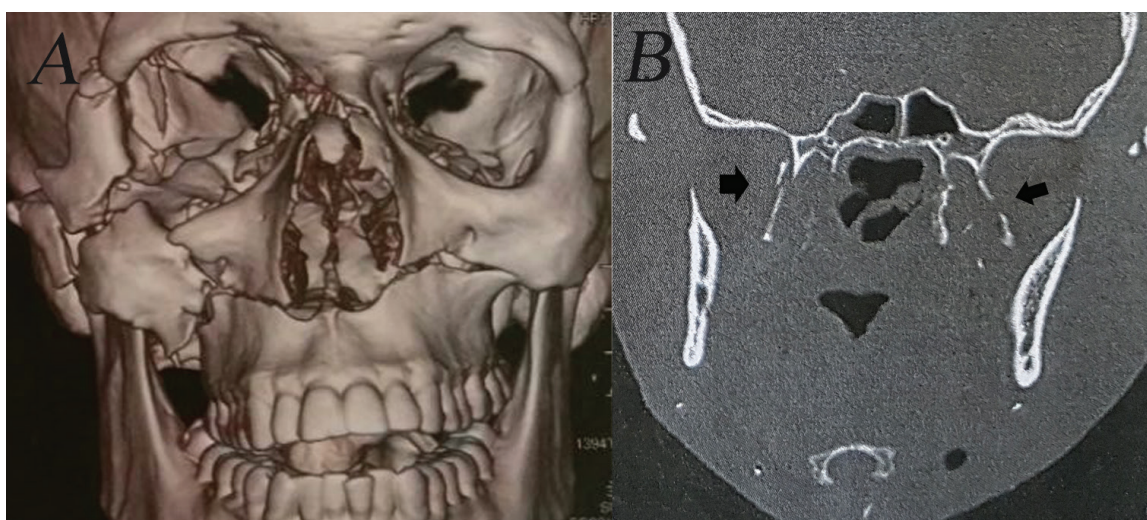**Figure 1.** Le Fort I (A), II (B), III (C) fracture patterns on a three-dimensional model.

Figure 2. A, a three-dimensional view of Le Fort I fracture and B, pterygoid plate involvement in Le Fort I fracture (arrow head).

3.1.2. Signs and symptoms

As an initial examination mobility of maxilla is evaluated. The maxillary arch is grasped by thumb and pointing fingers of one hand and the mobility is checked by the other hand on pyriform

Figure 3. A classic raccoon eye is a sign of Le Fort II fracture.

aperture, nasofrontal suture, and zygomaticofrontal suture. In Le Fort fractures, lateral and medial pterygoid muscles pull the fracture segment posteriorly and inferiorly lead to an anterior open bite deformity. So malocclusion is an important sign in diagnosing the Le Fort fractures. Epistaxis is a common sign in all three patterns of Le Fort fractures. Hypoesthesia of the infraorbital nerve is seen in types I and II of Le Fort fractures. Bilateral periorbital ecchymosis which is called raccoon eyes is a classic sign of Le Fort II and III fractures (**Figure 3**). The clinician should be aware of the possibility of cerebrospinal fluid (CSF) leak in Le Fort II and III fractures.

3.1.3. Management

The decision to choose whether the open or closed technique in Le Fort fractures is dependent on the mobility of the maxilla and severity of maxillary displacement results in malocclusion. Minor maxillary displacement and malocclusion and low mobility of fractured segment are the indications of closed treatment. Closed technique could be performed by either maxillomandibular fixation (MMF) or skeletal suspension (**Figure 4**). The method of choice in the treatment of mobile maxilla with severe malocclusion is open reduction and internal fixation (ORIF). In the Le Fort I pattern lateral nasal walls and zygomatic buttresses are used to provide stability by four plates. Displaced Le Fort II fracture is treated by ORIF of bilateral infraorbital rims and zygomatic buttresses simultaneously using a miniplate to fix the nasofrontal suture. Mobile mid-face and esthetic problems following Le Fort III fracture (dish-face deformity) are the main indications of ORIF treatment. The number of fixations is dependent on

Figure 4. Suspension and closed treatment of comminuted Le Fort fractures.

the extent of comminution and dislocation. Bilateral zygomatic arches and zygomaticofrontal sutures and nasofrontal sutures should be fixed in severely displaced cases.

3.2. Palatal fractures

3.2.1. Classification

Hendrickson et al. [11] classified the palatal fracture into six patterns anatomically (**Figure 5**). Computed tomographies (CTs) in coronal and axial views are helpful in detecting the palatal fractures. Alveolar fracture is classified as type I palatal fracture in which it is categorized
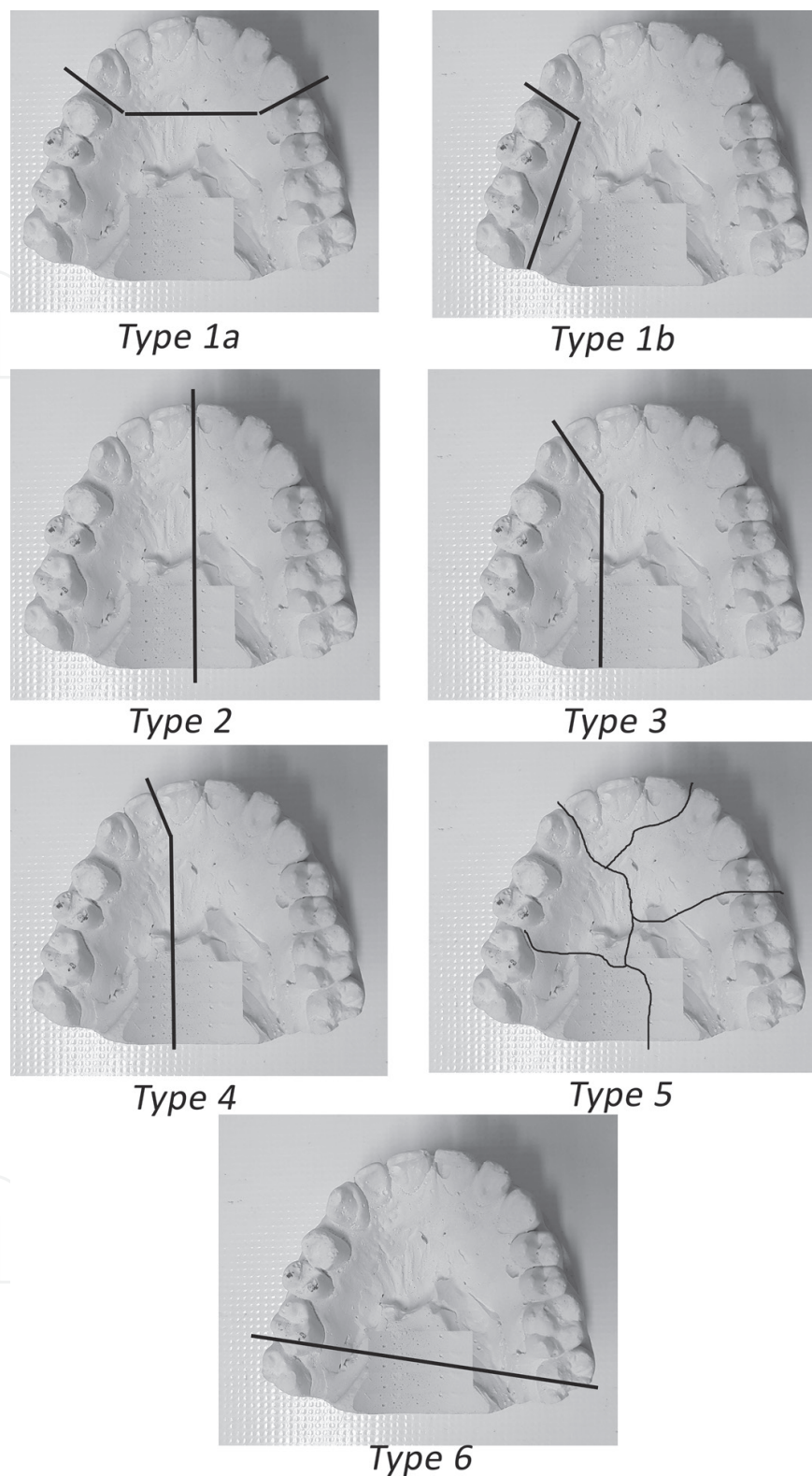
Figure 5. Classification of palatal fractures.

into two subcategories of anterior and posterolateral fractures. Anterior type I palatal fracture involves the incisor teeth and involving the posterior teeth it is defined as type 1b palatal fracture. Type II palatal fracture is defined as sagittal fracture which is less common in adults. Type III and IV fractures are the most common palatal fractures in adults [11]. Type III is also

called para-sagittal fracture which occurs in the thin part of the palate lateral to the attachment of vomer bone to the maxilla. The anterior limit of the fracture is between canine teeth which extend to the pyriform aperture. Type III fracture pattern extends posteriorly to the tuberosity or track approximate to the midline. Type IV fracture also known as para-alveolar fracture is a variant of the type III pattern. The fracture line in this pattern tracks medial to the alveolar bone of maxilla. The type V pattern is a complex fracture with comminution fragments. The transverse palatal fracture is classified as the type VI pattern which is the least common palatal fracture type.

3.2.2. Signs and symptoms

Mobility of alveolar segments should be checked for the entire maxillary arch. Displacement of fractured segments results in malocclusion which is an important sign to the clinician in diagnosing the palatal fracture. Ecchymosis of the palate may also indicate the line of fracture.

3.2.3. Management

When the occlusion is good enough and the fractured segment is either minimally displaced or not displaced at all the surgeon may decide to follow the patient and choose no intervention. MMF is the treatment of choice in minimally displaced palatal fractures unless there is a contraindication for MMF. Gunning and palatal splints are other amenable methods for closed treatment of palatal fracture (**Figure 6**). ORIF of palatal fracture is indicated in severely mobile and displaced patterns to prevent splaying of the fragments.

3.3. Orbital fractures

3.3.1. Classification

According to the involved orbital walls there are five fracture patterns. The most common fracture of the orbit is the orbital floor fracture mostly detected as a blow-out fracture [6] (**Figure 7**).
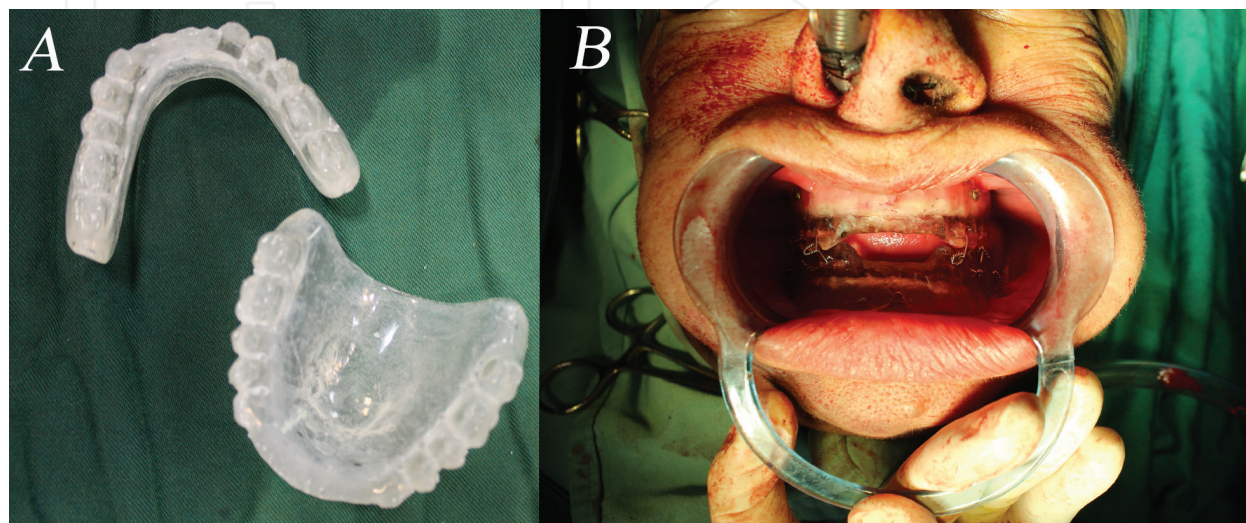

Figure 6. (A) Gunning for closed treatment of simultaneous mandibular and palatal fractures in an edentulous patient and (B) Maxillomandibular fixation for closed treatment of the patient.
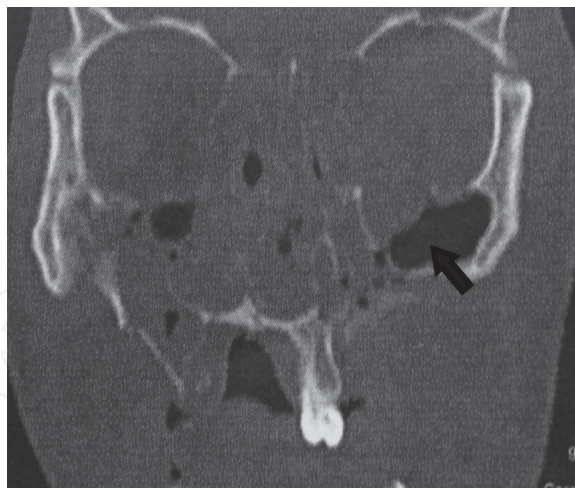
Figure 7. Coronal CT view indicating orbital floor (blow out) fracture.

Orbital roof fracture is the most common fracture in pediatric population [12]. Other less common orbital fractures involve medial or lateral wall. Combined orbital fracture especially involving all four orbital walls are the least common orbital fracture [6] patterns whilst the leading functional and esthetic problems of this pattern are much more serious than former fracture types.

3.3.2. Signs and symptoms

Entrapment of extraocular muscles should be assessed when there is suspected orbital wall fracture (**Figure 8**). Forced duction test is helpful in distancing between muscle entrapment and neurologic disturbance although this test is sometimes falsely negative due to post-injury edema. Diplopia is a common sign of orbital fracture, especially medial fracture pattern due to rectus muscle entrapment [13]. Infraorbital nerve hypoesthesia is a symptom of orbital fracture especially when the infraorbital rim is involved [14]. Subconjunctival hemorrhage and periorbital ecchymosis are useful signs of an underlying orbital fracture [15] (**Figure 9**). Enophthalmus is an important sign of orbital fracture and also a significant indication of orbital reconstruction [16]. Enophthalmus usually occurs as a result of increased orbital volume or loss of orbital content especially orbital fat.

3.3.3. Management

Orbital fracture cases are non- or minimally displaced should just observe. No intervention is needed when Orbital fractures do not result in any ocular problems including diplopia or enophthalmus. Orbital fracture treatment is a controversial issue among maxillofacial and oculoplastic surgeons. Fracture size, timing of the reconstruction, and biomaterials for reconstructions are all important issues which should be considered in orbital fracture repair. The debate still is present in deciding on whether to treat an orbital fracture or not. The investigations are insufficient with high heterogeneity in this field. As a general rule it is almost acceptable that defects more than 50% of the orbital wall or 2 cm length should be treated [17]. Enophthalmus and positive-forced duction tests are two indications for management of orbital wall fractures.

Figure 8. The patient is not able to look upward concurrently by both eyes due to left orbital floor fracture lead to inferior rectus muscle entrapment.

Figure 9. Periorbital ecchymosis and subconjuctival hemorrhage following orbital fracture.

Timing of orbital reconstruction is categorized into three groups of immediate categories: within 24 h, early (between first and day 14), and delayed (after 2 weeks) [18]. When the reason of diplopia is muscle entrapment immediate reconstruction of the orbit is advocated by the investigators. Blow-out fracture in young patients is the other indication for immediate repair. Early orbital reconstruction is advocated by some surgeons in cases of early enophthalmus and symptomatic diplopia with positive forced duction test. Early reconstruction should also be considered in cases with large orbital wall defects (more than 50% defects). Symptomatic diplopia with negative force duction test and late-onset enophthalmus are indications for delayed orbital reconstructions [18].

Decision-making on the ideal material for orbital reconstruction is based on the surgeon's experience, cost, defect size, and medical history (**Figure 10**) [19]. The available material and their pros and cons are categorized in **Table 1**.

3.4. Naso-orbital-ethmoid (NOE) fractures

3.4.1. Classification

According to Markowitz's classification naso-orbital-ethmoid (NOE) fracture is defined as three patterns [20] (**Figure 11**). Type I NOE fracture is defined as single-segment central fragment. This pattern could be in a uni- or bilateral form. The medial tendon is attached to the fractures segment in this pattern. Type II NOE fracture consists of comminuted central fragments external to the medial canthal tendon insertion. In type III fracture the fracture line
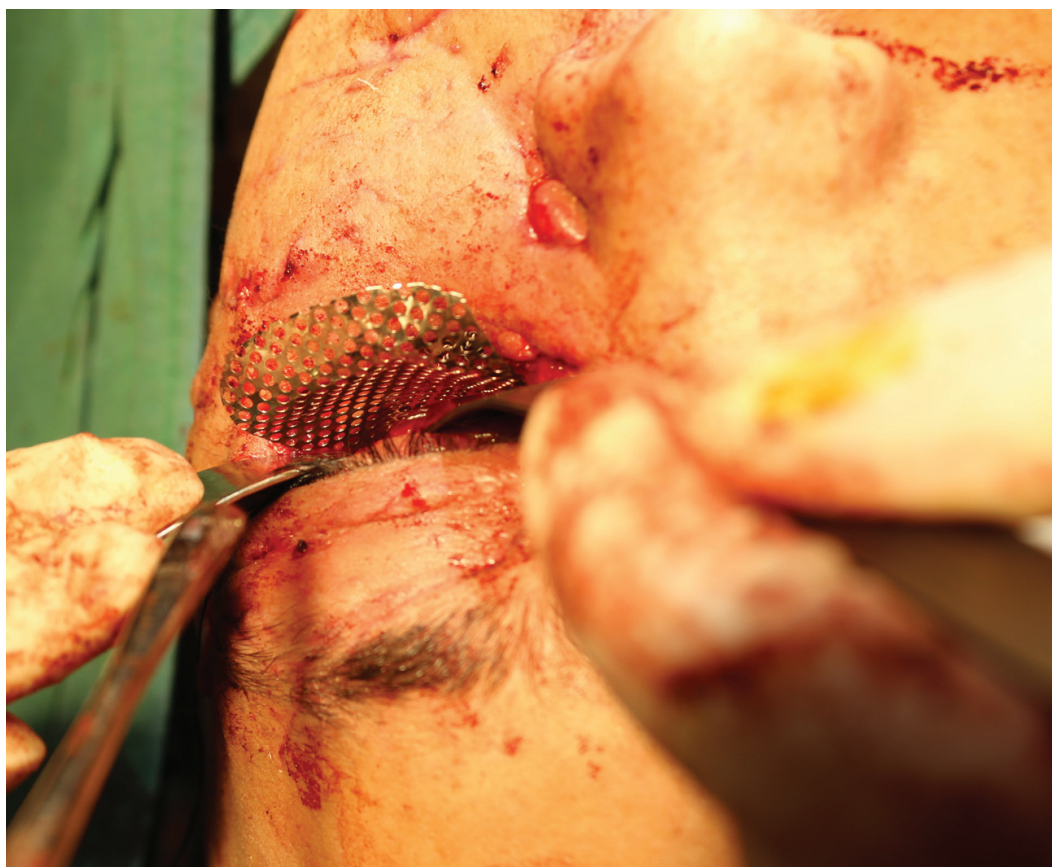

Figure 10. Titanium meshwork plate is used to reconstruct the orbital floor defect.

Materials	Examples	Advantages	Disadvantages	Indications
Autogenous bone grafts	Iliac bone graft, caldaria grafts	Biocompatibility, cost effective, variability in thickness, radio opacity	Donor site morbidity, difficult to shape, high resorption rate	Large defects, immature orbits, secondary defect reconstruction
Resorbable materials	poly-l-lactic acid (PLLA),	Replacement with bone formation	High cost, radiolucency, low stability	Small defects
Non-resorbable materials	Titanium mesh, Porous polyethylene sheets	High stability, easy fixation, availability, no donor site defect	High cost, increased infection rate	Medium size defects with medium complexity

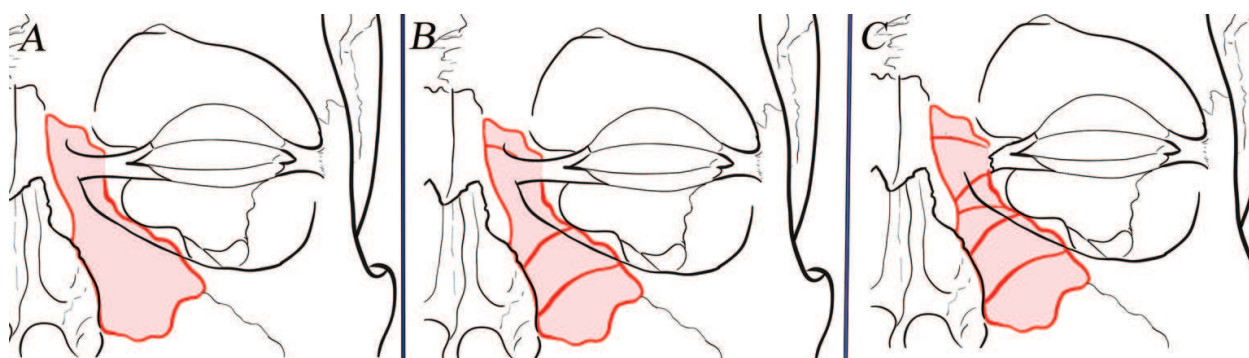**Table 1.** Materials available for orbital reconstruction.

Figure 11. Naso-orbital-ethmoid fracture types. A, type I Naso-orbital-ethmoid fracture. B, type II naso-orbital-ethmoid fracture. C, type III naso-orbital-ethmoid fracture.

Figure 12. Signs in a patient with naso-orbital-ethmoid fracture. Rounding of the left medial canthus (arrow) and traumatic telecanthus is obvious in this patient.
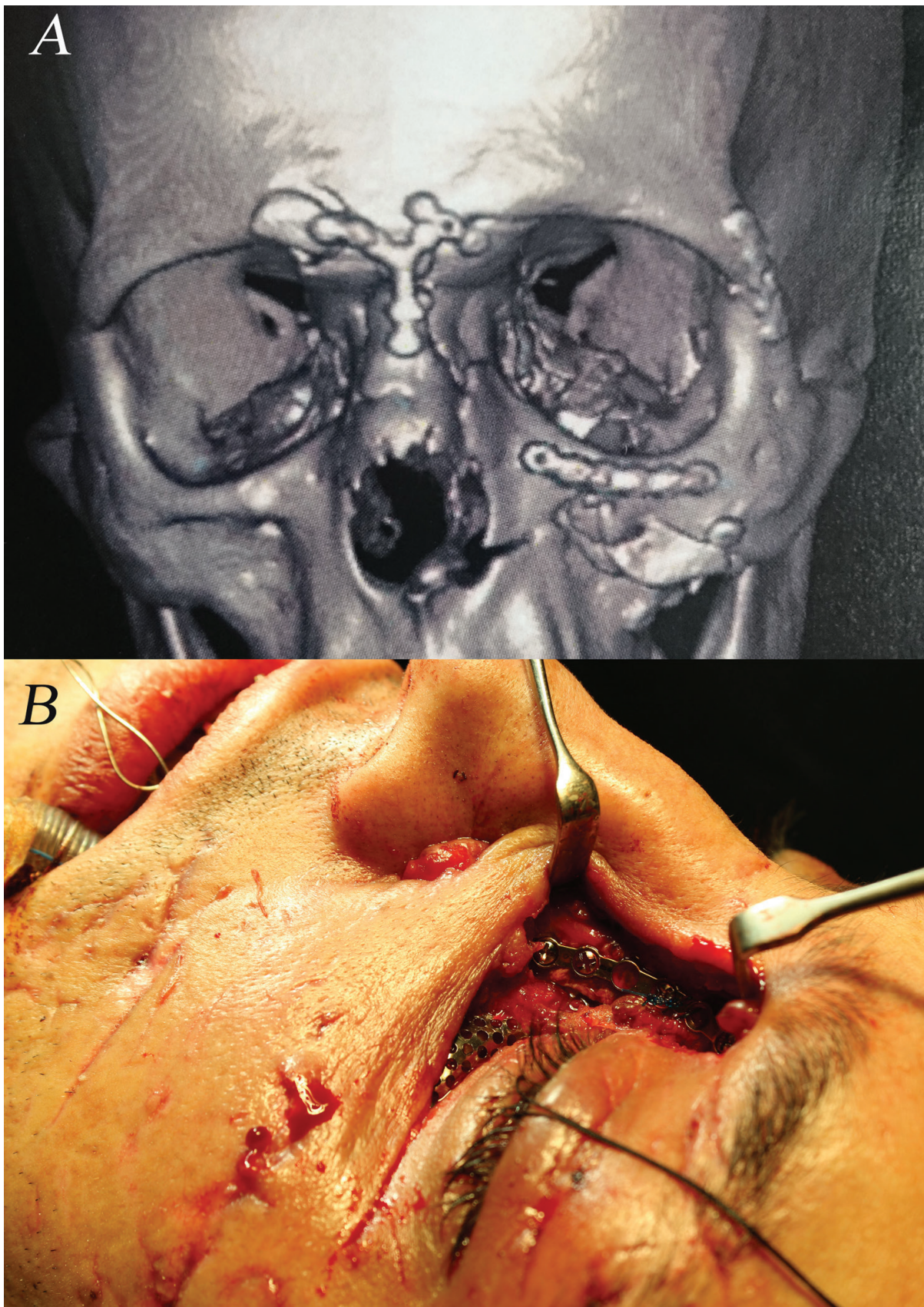
Figure 13. A, fixation of the type I naso-orbital-ethmoid fracture. B, reconstruction of left type II naso-orbital-ethmoid fracture.

extends into the medial canthal insertion segment. The medial canthal tendon either remains attached to the central segment or does not.

3.4.2. Signs and symptoms

Epistaxis is a common sign of NOE fracture. Involving the NOE complex in trauma patients results in splayed nasal complex and widened the nasal bridge. In the case of medial canthal tendon detachment or disruption of traumatic telecanthus and medial canthus rounding occurs (**Figure 12**). The intercanthal distance is usually half of the interpupillary distance (average of 28–35 mm in white adults). So when this measure is more than 40 mm or half of the interpupillary distance, the traumatic telecanthus is defined [21]. Bimanual test is a useful method in detecting the instability of NOE fracture [22].

3.4.3. Management

Stabilization of the fractures segment is the only intervention advocated in NOE type I fracture (**Figure 13**A). Stabilizing the central fragment in which the medial canthal tendon is inserted is the treatment of choice in type II fracture (**Figure 13**B). Transnasal wiring simultaneously with orbital medial wall reconstruction is considered in type III pattern.

4. Surgical approaches in treatment of mid-face fractures

4.1. Intraoral approaches

Intraoral approach and vestibular incision is the most common technique used in treatment of Le Fort fractures (**Figure 14**). Circum-vestibular incision mesial to the second premolar is used to reach the nasal lateral walls and zygomatic buttresses. As mentioned earlier these buttresses are stable enough to maintain the maxilla at the right position following rigid fixation. Cinch suture and V-Y plasty is necessary when the incision involves the nasalis muscles.

4.2. Extraoral approaches

After decision-making of rigid fixation of the Le Fort III fracture, extraoral approaches to the zygomaticofrontal and nasofrontal sutures are applied (**Figure 15**). Bicoronal flap is the common approach to achieve all three sutures by one sing incision. Also this is a good approach in repairing the NOE fracture. The incision is made several centimeters behind the hair line between the upper origins of the temporal muscles from one superior temporal line to the other. Dissection of the flap is performed in the subgaleal plane up to 2 cm above the superior orbital rims. The periosteum is incised at this level and subperiosteal dissection is continued to expose the zygomaticofrontal and nasofrontal sutures. Using a suction drain is optional during closure.

When there is no displacement of nasofrontal suture, fixation of zygomaticofrontal sutures is applicable by lateral brow approach. The incision is made almost 2 cm parallel to the hair follicles
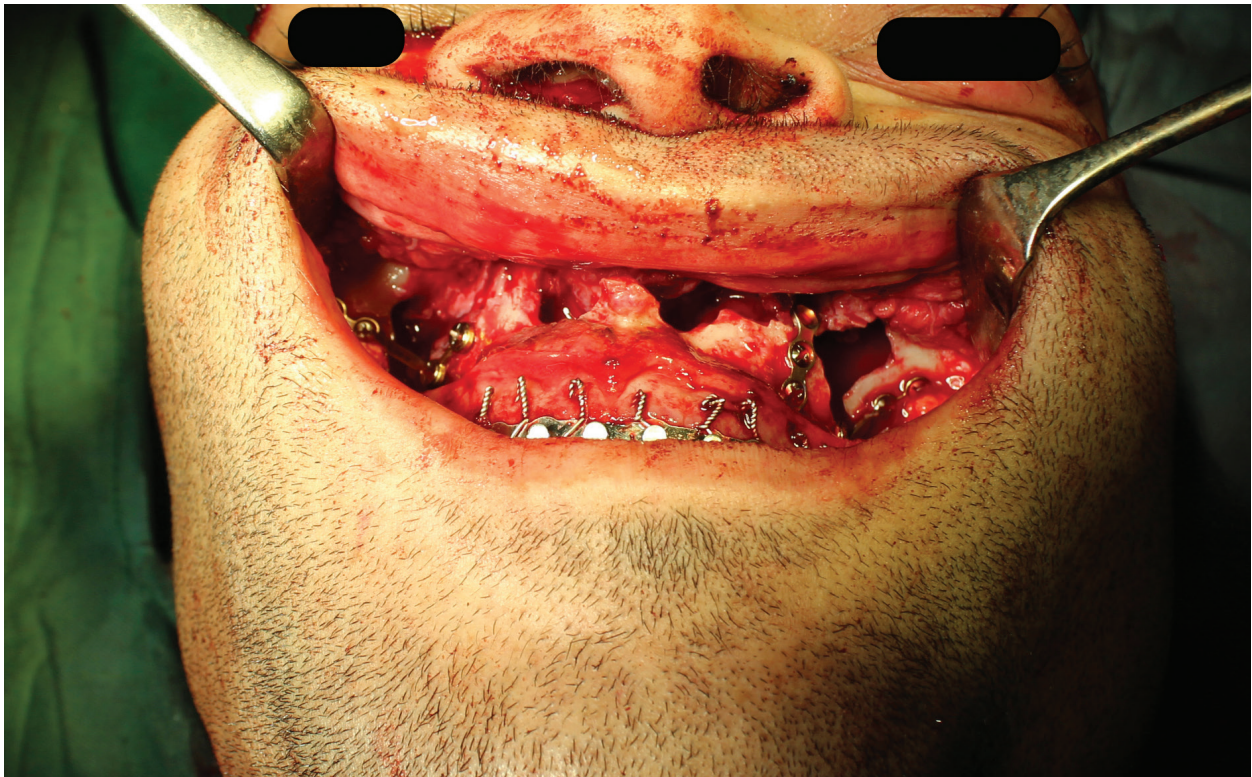
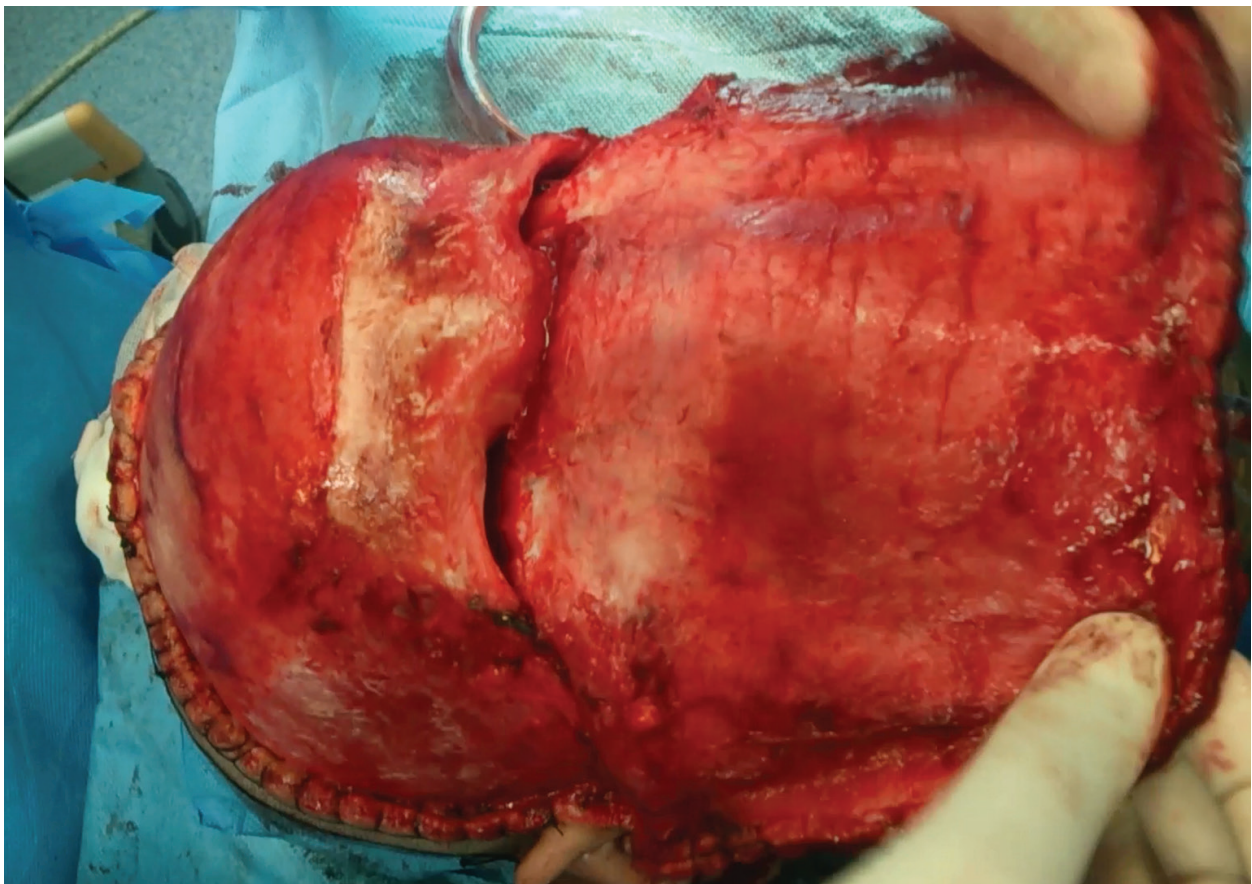**Figure 14.** Intraoral approach to expose the Le Fort I fracture line.

Figure 15. Coronal approach for management of Le Fort III fracture (courtesy of Dr. Fereydoun Pourdanesh).

of the lateral eyebrow (**Figure 16**). The advantages of this technique are least noticeable scar and no adjacent anatomical structure.

Glabellar and ethmoidal (known as Lynch approach) approaches are used in solitary NOE fracture. The latter technique is not recommended by AOCMF due to visible scar band (web) [23]. Glabellar incision is made in old patients in the glabellar furrows through the skin, subcutaneous layer, and the periosteum.

4.3. Periorbital approaches

Four kinds of periorbital approaches are represented in the literature for reconstruction of orbital fractures and Le Fort II fracture. The incisions on the lower lid are classified into three types based on the distance from the gray line (**Figure 17**). The periorbital approach is called subciliary incision when this distance is about 2–3 mm. When this distance is almost 3–4 mm to the gray line the incision is known as mid-lower lid or subtarsal approach. The dissection of these two techniques is in three fashions. The best dissection technique is to start a few millimeters subcutaneously followed by orbicularis oculi muscle dissection. Skin only or pre-orbicularis oculi muscle incision is not advocated by authors due to high possibility of ectropion rate. The third incision is called skin-muscle flap which involves both skin and orbicularis oculi muscle.

Another popular periorbital approach because of its invisible scar is the transconjunctival technique (**Figure 18**). The incision is made parallel to the gray line through the conjunctive. This approach is divided into preseptal and retroseptal techniques based on the dissection plane. Lateral canthotomy and inferior cantholysis are used in some cases when the surgeon needs more access to the orbit.

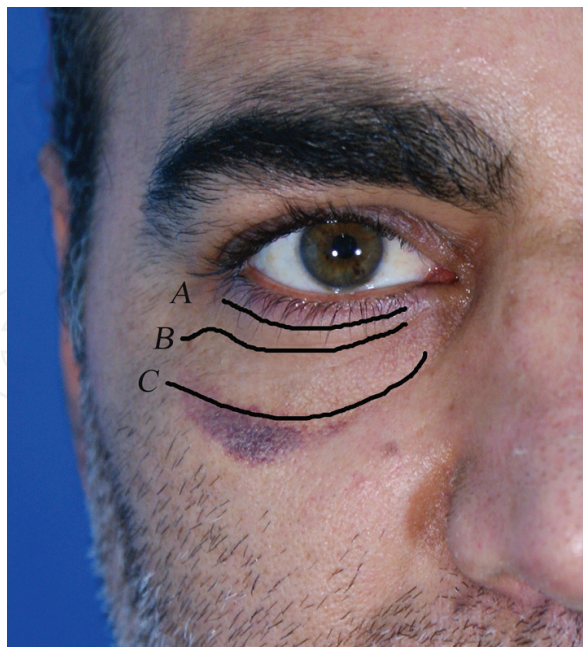**Figure 16.** Lateral brow approach.

Figure 17. Periorbital incisions. Subciliary (A), subtarsal (B), and infraorbital (C) approaches are shown in this picture.

Figure 18. Transconjunctival approach is used to expose the orbital floor fracture.

5. Conclusions

The mid-face is esthetically and functionally very important which makes repairing the deformities of this facial part very difficult. Diagnosing the exact injuries on the facial bones is the

key step of deciding the treatment plan. The surgeon should have enough knowledge of facial anatomy and physiology to be able to reconstruct the fractured segments. Deformity following facial trauma is hard to repair on the second surgery. So the importance of managing almost all problems of mid-face fractures in the first surgery is pretty clear to all traumatologists.

Conflict of interest

The authors declare that they have no conflict of interest. The photos not referenced in the text belong to the author.

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