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Chapter 15

Management of Midfacial Fractures

Sertac Aktop, Onur Gonul, Tulin Satilmis, Hasan Garip and Kamil Goker

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/54644

1. Introduction

The management of midfacial fractures includes the treatment of facial fractures, dentoalveolar trauma, and soft-tissue injuries, as well as associated injuries, mainly of the head and neck [1]. The management of fractures of the maxillofacial complex remains a challenge for the oral maxillofacial surgeon, demanding both skill and expertise [2]. The success of treatment and implementation of preventive measures are more specifically dependent on epidemiologic assessments [3].

Midfacial fractures can occur in isolation or in combination with other serious injuries, including mandibular, ophthalmologic, cranial, spinal, thoracic, and abdominal trauma, as well as upper and lower orthopedic injuries [4]. The epidemiology of facial fractures varies in type, severity, and cause depending on the population studied. Differences among populations in the causes of maxillofacial fractures may be the result of differences in risk and cultural factors among countries, but are more likely to be influenced by the severity of injury [1,5]. The causes of maxillofacial fractures have changed over the past three decades, and they continue to do so. The main causes worldwide are traffic accidents, assaults, falls, sport-related injuries, and warfare [6-8]. Many articles pertaining to the incidence and causes of maxillofacial injuries have been published [1,4,7-10]. In 2003, Motamedi [7] reported the distribution of facial fractures as 72.9% mandibular, 13.9% maxillary, 13.5% zygomatic, 24.0% zygomatico-orbital, 2.1% cranial, 2.1% nasal, and 1.6% frontal injuries [Figure 1].

Causes of these maxillofacial injuries were automobile (30.8%) and motorcycle (23.2%) accidents, altercations (9.7%), sport (6.3%), and warfare (9.7%) [Figure 2].

The distribution of maxillary fractures was 54.6% Le Fort II, 24.2% Le Fort I, 12.1% Le Fort III, and 9.1% alveolar [7] [Figure 3].

According to Cook and Rowe [4], midfacial injuries occur most frequently in individuals aged 21–30 years (43%). The 11–20-year and 31–40-year age groups each account for 20% of these
fractures. Most (83.1%) midfacial fractures occur in males, with the remainder (16.9%) occurring in females [4] [Figure 4].

Thoren [9] noted that injuries are associated with 25.2% of midfacial fractures. These injuries most commonly affect a limb (13.5%), followed by the brain (11.0%), chest (5.5%), spine (2.7%), and abdomen (0.8%) [9].

2. Surgical anatomy

The anatomy of the head is complex; the physical properties of the skin, bone, and brain differ markedly and the facial skeletal components articulate and interdigitate in a complex fashion, with the consequence that a given facial bone is rarely fractured without disrupting its
The severity and pattern of a fracture depend on the magnitude of the causative force, impact duration, the acceleration imparted by impact to the affected part of the body, and the rate of acceleration change. The surface area of the impact site is also relevant [11,12].

The middle third of the facial skeleton is defined as an area bounded superiorly by a line drawn across the skull from the zygomaticofrontal suture, across the frontonasal and frontomaxillary sutures, to the zygomaticofrontal suture on the opposite side; and inferiorly by the occlusal plane of the maxillary teeth, or, in an edentulous patient, by the maxillary alveolar ridge. It extends posteriorly to the frontal bone in the superior region and the body of the sphenoid in the inferior region, and the pterygoid plates of the sphenoid are usually involved in any severe fracture [13].

The middle third of the facial skeleton comprises the following bones [14] [Figure 5]:

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Figure 3. Distribution of maxillary fractures in Motamedi’s assessment of maxillofacial trauma patients

Figure 4. Age distribution of midfacial fracture patients according to Cook and Rowe.
• Two maxillae
• Two zygomatic bones
• Two zygomatic processes of the temporal bones
• Two palatine bones
• Two nasal bones
• Two lacrimal bones
• The vomer
• The ethmoid and attached conchae
• Two inferior conchae
• The pterygoid plates of the sphenoid

![Bones of the middle third of the facial skeleton](image)

**Figure 5.** Bones of the middle third of the facial skeleton

The frontal bone and the sphenoid body and greater and lesser wings are not usually fractured. In fact, they are protected to a considerable extent by the cushioning effect achieved as the fracturing force crushes the comparatively weak bones comprising the middle third of the facial skeleton [13].

3. Initial management of the midfacial trauma patient

The initial assessment and management of a patient’s injuries must be completed in an accurate and systematic manner to quickly establish the extent of any damage to vital life-support
systems. Patients are assessed and treatment priorities are established based on patients’ injuries and the stability of their vital signs. Injuries can be divided into three general categories: severe, urgent, and non-urgent. Severe injuries are immediately life threatening and interfere with vital physiologic functions; examples are compromised airway, inadequate breathing, hemorrhage, and circulatory system damage or shock. These injuries constitute approximately 5% of patient injuries but represent more than 50% of injuries associated with all trauma deaths. Urgent injuries make up approximately 10–15% of all injuries and present no immediate threat to life. Patients with this type of injury may present with damage to the abdomen, orofacial structures, chest, or extremities that requires surgical intervention or repair, but their vital signs are stable. Non-urgent injuries account for approximately 80% of all injuries and are not immediately life threatening. Patients with this type of trauma eventually require surgical or medical management, although the exact nature of the injury may not become apparent until significant evaluation and observation are performed. The goal of initial emergency care is to provide life-saving and support measures until definitive care can be initiated. Any trauma victim with altered consciousness must be considered to have a brain injury. The level of consciousness is assessed by serial Glasgow Coma Scale evaluations [15] (Table 1).

<table>
<thead>
<tr>
<th>Action</th>
<th>Score</th>
</tr>
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<tbody>
<tr>
<td>Eye Opening</td>
<td>4</td>
</tr>
<tr>
<td>Spontaneous</td>
<td>3</td>
</tr>
<tr>
<td>To speech</td>
<td>2</td>
</tr>
<tr>
<td>To pain</td>
<td>1</td>
</tr>
<tr>
<td>None</td>
<td>6</td>
</tr>
<tr>
<td>Motor Response</td>
<td>5</td>
</tr>
<tr>
<td>Obeys</td>
<td>4</td>
</tr>
<tr>
<td>Localises pain</td>
<td>3</td>
</tr>
<tr>
<td>Withdraws from pain</td>
<td>2</td>
</tr>
<tr>
<td>Flexion to pain</td>
<td>1</td>
</tr>
<tr>
<td>Extension to pain</td>
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<td>None</td>
<td>4</td>
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<tr>
<td>Verbal Response</td>
<td>3</td>
</tr>
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<td>Incomprehensible</td>
<td></td>
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Adapted from Teasdale and Jennett [15]. A patient’s score determines the category of neurologic impairment: 15 = normal, 13 or 14 = mild injury, 9–12 = moderate injury, and 3–8 = severe injury.

Table 1. Glasgow Coma Scale.
Other signs of brain damage include restlessness, convulsions, and cranial nerve dysfunction (e.g., a nonreactive pupil). The classic Cushing triad (hypertension, bradycardia, and respiratory disturbances) is a late and unreliable sign that usually closely precedes brain herniation. Hypotension is rarely due to head injury alone. Patients suspected of sustaining head trauma should not receive any premedication that will alter their mental status (e.g., sedatives or analgesics) or neurologic examination (e.g., anticholinergic-induced pupillary dilation).

### 3.1. Primary Survey: ABCs

During the primary survey, life-threatening conditions are identified and reversed quickly. This period calls for quick and efficient evaluation of the patient’s injuries and almost simultaneous life-saving intervention. The primary survey progresses in a logical manner based on the ABC pneumonic: airway maintenance with cervical spine control, breathing and adequate ventilation, and circulation with control of hemorrhage. The letters D and E have also been added: a brief neurologic examination to establish the degree of consciousness, and exposure of the patient via complete undressing to avoid overlooking injuries camouflaged by clothing.

Maxillofacial injuries may result in airway compromise caused by any of several factors: blood and secretions, a mandibular fracture that allows the tongue to fall against the posterior wall of the pharynx, a midfacial injury that causes the maxilla to fall posteroinferiorly into the nasopharynx, and foreign debris such as avulsed teeth or dentures. A large tonsillar suction tip should be used to clear the oral cavity and pharynx. The establishment of an oral airway assists with tongue position; however, care must always be taken to avoid manipulation of the neck and to provide access to the oral cavity and dentition for the reduction and fixation of any fractures requiring a period of intermaxillary fixation. Neither midfacial fractures nor cerebrospinal rhinorrhea are contraindications to nasal intubation. Care should be taken to pass the tube along the nasal floor into the pharynx, and the tube should be visualised before tracheal intubation. Hypertension or tachycardia during intubation can be attenuated with the intravenous administration of lidocaine or fentanyl. Intubation while the patient is awake causes a precipitous rise in intracranial pressure. Nasal passage of an endotracheal or nasogastric tube in a patient with a basal skull fracture risks cribriform plate perforation and cerebrospinal fluid infection. Slight elevation of the head will improve venous drainage and decrease intracranial pressure.

### 3.2. Physical examination

The physical examination should begin with an evaluation of soft-tissue injuries. Lacerations should be debrided and examined for disruption of vital structures, such as the facial nerve or parotid duct. The eyelids should be elevated to allow evaluation of the eyes for neurologic and ocular damage. The face should be symmetric, without discolouration or swelling suggestive of bony or soft-tissue injury. The bony landmarks should be palpated, beginning with the supraorbital and lateral orbital rims and followed by the infraorbital rims, malar eminences, zygomatic arches, and nasal bones. Any steps or irregularities along the bony margin are suggestive of a fracture. Numbness over the area of distribution of the trigeminal nerve is usually noted with fractures of the facial skeleton. The oral cavity should be inspected and...
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Classification of Nasoorbitoethmoidal fractures

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Increased intercanthal distance, termed telecanthus, is a key deformity resulting from naso-orbito-ethmoidal injury. Normal intercanthal distances are 29–36 mm in males and 29–34 mm in females; a distance exceeding 40 mm is classified as telecanthus and may indicate that surgical treatment is required. The medial canthal tendon is a very important anatomic factor in naso-orbito-ethmoidal injuries resulting in telecanthus. The pretarsal portions of the orbicularis oculi muscle in the upper and lower lids unite at the canthus to form the medial canthal tendon. The superficial portion of this tendon provides support to the eyelids and maintains the integrity of the palpebral fissure. Restoration of this component after canthal detachment is critical for maintaining proper eyelid appearance. The deeper portion, also called Horner's muscle, attaches to the posterior lacrimal crest and assists in the movement of fluid through the lacrimal system. Disruption of the medial canthal tendon causes contraction of the orbicularis oculi muscle, increasing the intercanthal distance and laterally displacing the rounded contour of the medial palpebral fissure. The 'bowstring test' is a useful method of assessing the status of the medial canthal tendon's attachment to the bone. This test involves lateral pulling of the lid while palpating the tendon area to detect movement of fracture segments [27] [Figure 21].
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Periorbital ecchymosis, subconjunctival hemorrhage, and pain are the most common signs and symptoms of naso-orbito-ethmoidal fractures. Other signs and symptoms include skin and mucosal lacerations, epistaxis, nasal obstruction, edema, telecanthus, and increased canthal angles. Depression of the bony segment causes internal and external nasal cosmetic deformities. Edema may obscure such depression for up to 5 days, and most surgeons recommend the postponement of surgery until the edema has resolved. The impaction of bony segments to the orbit may cause exophthalmos, proptosis, or ptosis. Fractures of cribriform plate and posterior wall of the frontal sinus may cause cerebrospinal fluid leakage. Nasal bone mobility, traumatic telecanthus, crepitus, and depressibility of the area are the clinical digital-examination findings for naso-orbito-ethmoidal fractures.

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Two- and three-dimensional CT using axial and coronal views are the most valuable imaging methods for the diagnosis of naso-orbito-ethmoidal fractures. The use of conventional imaging techniques is not recommended because these modalities do not provide adequate information.

8.2. Treatment

The goals of naso-orbito-ethmoidal fracture treatment are the resolution of the three major issues described above: Establishment of proper nasal projection, narrowing of the intercanthal distance, and establishment of the nasofrontal and lacrimal fluid route. The surgeon should seek to achieve satisfactory results in a single surgery because corrective secondary surgery may cause scarring and fibrosis. For this reason, most authors have advocated the postponement of surgery for 3–7 days to allow for the recession of edema. For naso-orbito-ethmoidal fractures involving a single fragment (type I), treatment can be attempted with closed reduction and the provision of intranasal packing support. If the fragment cannot be reduced satisfactorily by closed reduction, the operation should be converted immediately to an open reduction to avoid the need for secondary surgery. In most cases, a transoral approach is sufficient to reach the injured area without an additional incision.

Proper restoration of types II and III naso-orbito-ethmoidal fractures usually require wide access, which can be provided only by a coronal flap. Wide exposure of the nasal bones and medial orbital walls can be achieved readily. When necessary, a transoral approach can be used to access the paranasal areas and a transconjunctival approach can be used to expose the inferior orbital rim or inferomedial wall. Existing lacerations can also be used to access the injured area. Transcutaneous approaches are not considered to be acceptable because they cause facial scarring.

In severe naso-orbito-ethmoidal injuries, nasal dorsal strut grafting is often required to reestablish support for the entire nose. This graft is cantilevered from the stable frontal bone and placed in the subcutaneous plane, extending inferiorly to the nasal tip.

When the medial canthal tendon is detached completely or attached to an unusable bone fragment, its proper position must be secured immediately using medial canthopexy. The
medial canthal tendon should be reduced into a position slightly posterosuperior to the posterior lacrimal crest. The tendon is then sutured with a wire passing transnasally to a cantilevered miniplate on the opposing (undamaged) side. The canthopexy should be positioned sufficiently deep in the orbit to achieve the proper shape of the palpebral fissure and lower lid, as the superficial portion of the medial canthal tendon secures the position of the lower lid and contour of the palpebral fissure. Proper positioning of the medial canthal tendon will achieve correct lacrimal fluid drainage, which is aided by the deep portion of the tendon. When nasofrontal obstruction is a concern, endoscopic frontal sinus surgery can be indicated to re-establish nasofrontal drainage. The medial canthal tendon should be slightly over-reduced in canthopexy procedures to compensate for remodelling of related tissues.

8.3. Complications

Cosmetic deformities are foreseeable after nasal and naso-orbito-ethmoidal injuries. Postoperative septal hematoma, septal abscess, and/or destructive fracture of the septal cartilage/bone are the postoperative causes of nasal deformity. Massive comminution of the naso-orbito-ethmoidal complex is classically associated with saddle nose deformity. Bone grafting is required in most patients to establish proper nasal projection, symmetry, and contour. However, even bone grafts can be associated with potential resorption problems in the long term. Depending on the fracture level, cartilage or bone grafts and nasal implants can be used to improve the appearance of these deformities.

Septal deviation due to inadequate closed reduction often results in external nasal asymmetry. Direct septal visualisation via the open rhinoplasty approach is preferred for the correction of this defect.

After naso-orbito-ethmoidal injury, scar contracture results in cosmetic and functional deformities. Thus, secondary surgery should be avoided because it may result in scarring.

Open reduction and internal fixation procedures often damage the medial canthal tendon or nasolacrimal apparatus. As a result, epiphora related to nasolacrimal duct obstruction can be an issue. Intubation or stenting of the lacrimal duct may be necessary in such cases.

9. Midfacial fractures in children

Midfacial fractures are not common in children; they account for only 1–8% of pediatric fractures [28-31] and usually affect the mandible. This low incidence is related to the protection provided by the mandible and cranium, which absorb most of the traumatic impact, and to the elastic nature of midfacial bones and flexibility of osseous suture lines [32]. Children form a distinct patient group in maxillofacial surgery due to significant differences between the facial skeletons of children and adults. Depending on the patient’s age, these differences include small bone size, small paranasal sinus volume, growth potential, the presence of tooth germs in alveoli during primary and mixed dentition stages, a more rapid healing process compared with adults, and difficulty with cooperation resulting in the need for general
anaesthesia in more cases than in adults [33]. The proportion of children in whom midfacial fractures are identified has increased over time, probably due to the increased use of adequate imaging modalities [34]. CT has largely supplanted standard radiography as the preferred imaging method for pediatric facial trauma.

The presence of tooth germs in alveoli potentially creates zones of weakness in the jaws and limits the placement of certain plate and screw types, given the need to avoid damage to the developing dentition. The treatment of pediatric patients with midfacial fractures using intermaxillary fixation is also quite difficult, and erupting or exfoliating teeth can be an issue. On the other hand, the on-going processes of tooth eruption and exfoliation may compensate for minor inaccuracies in reduction and fixation. Recognition of the differences between children and their adult counterparts is important in facial rehabilitation.

Several aspects of dentoalveolar trauma management in children differ from that in adults. Developing roots have open apices, and the preservation of pulp vitality is important. In complicated crown and crown–root fractures, pulpotomy can be performed 1–2 mm below the exposed pulp tissue and Ca(OH)$_2$ or mineral trioxide aggregate can be applied. The second step in such cases is composite restoration or bonding of the crown fragment to the tooth. If the pulp is necrotic, apexification with intracanal application of Ca(OH)$_2$ must be used instead of pulpotomy. In pediatric cases of intrusion, spontaneous re-eruption may occur. Orthodontic repositioning can be a second treatment plan unless movement is observed within about 3 weeks. In the pediatric dentition, osseous replacement in ankylosis occurs much faster than in adults; dentoalveolar ankylosis usually interferes with alveolar process growth, and the tooth might be malpositioned.

Fractures in the maxillary region tend to be less comminuted in children than in adults because children’s paranasal sinuses are not fully developed. Open reduction and internal fixation are the preferred treatment methods, but intermaxillary fixation may be necessary in some cases. Avoiding damage to permanent tooth germs is a mandatory indication for closed reduction. Intermaxillary fixation with arch bars presents some difficulties in patients with mixed dentition, but the fixation period can be shorter than in adults. Teeth may be avulsed by the force of arch bars, and the fixation of arch bars to the teeth may not provide adequate retention because of weak and undeveloped roots. For this reason, the fabrication and use of Gunning splints to provide retention from the zygomatic arches, piriform apertures, and mandible via circumferential wires is recommended when intermaxillary fixation is necessary. As in adults, restoration of the normal anatomic position of the midfacial skeleton in children generally requires open reduction and stable fixation with miniplates and screws. In pediatric Le Fort II and III fractures, open reduction and internal fixation are necessary to re-establish proper anatomic and functional relationships. Pediatric fractures in the maxillary region are often of the greenstick type, which increases the complexity of fragment reduction. Because a greenstick fracture line limits fragment movement, proper reduction may require osteotomy.

Paediatric orbital fractures resulting in herniation and extraocular muscle entrapment require immediate intervention and even orbital exploration. Fractures of the orbital floor or wall in children heal rapidly, increasing the risks of scar cicatrisation and related ischemic necrosis of entrapped tissues.
Because the development of the nasal septum is a very important factor in facial growth, post-traumatic septal hematoma, which may cause septal necrosis and resorption, should not be ignored because it may result in saddle nose deformity.

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