

Biomechanics of Maxillofacial Trauma and Fractures

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Abstract

Tolerability of the maxillofacial bone to trauma depends upon bone thickness (facial buttresses system) and the velocity, directions, and force of trauma besides the paranasal sinuses pneumatizations. Muscle action on the fractured bones determines the degree and severity of displacement of fractured facial bones. The current article tried to increase the understanding of the biomechanics of maxillofacial trauma and fractures in the way for optimum management of such fractures.

Keywords: Maxillofacial trauma; Fracture; Open reduction; Internal fixation; Biomechanics

Background

Maxillofacial trauma that is better called craniomaxillofacial trauma because it involves the anterior wall and floor of anterior the cranial fossa is common nowadays. It is sometimes named as facial orthopedics as it involves management of the facial skeleton.

Accurate maxillofacial bone repositioning after trauma has major implications on 1-bone healing, 2-facial aesthetics, 3-soft tissue redraping and 4-critical functions as vision and mastication.

The maxillofacial skeleton is usually divided into 3 parts. Upper third consists of the frontal bone and sinuses. The lower third is the mandible. While the middle third consists of bones that are situated between upper and lower thirds including nasoethmoidal and Zygomaticomaxillary Complex (ZMC).

Biomechanics

The most common cause of trauma leading to maxillofacial fractures is motor vehicle accident. But other forms of trauma such as falls and blows can also cause maxillofacial fractures.

The maxillofacial trauma could have low, intermediate or high velocity. Tolerability (resistance) of the facial bone to trauma depends upon bone thickness (facial buttresses system) and the force, velocity, and directions of the trauma besides the paranasal sinuses pneumatizations.

The facial skeleton has areas of strength (maxillofacial facial buttresses or pillars) and areas of weakness (in-between walls) such as lamina papyræa, ethmoid bones, and orbital floor.

Facial buttresses are areas of increased bone thickness that increase the stability of face and have direct or indirect communication with the cranium and/or skull base.

Components of the buttress system consist of vertical and horizontal buttresses. The well-developed vertical buttresses include mainly; the nasomaxillary buttress, zygomaticomaxillary buttress, and pterygomaxillary buttress. The horizontal buttresses that interconnect

and provide support for the vertical buttresses include mainly; the frontal bar, infraorbital rim, hard palate, maxillary alveolus and the superior and inferior transverse mandibular buttresses.

Because maxillofacial buttresses represent the bars that support the maxillofacial skeleton building, they serve as the prime locations for plate fixation during repair [1-3].

Muscle action (particularly the masticatory muscles) on the fractured bones determines the degree and severity of displacement of fractured facial bones [1]. Muscles attached to inner surface of the mandible (genioglossus and geniohyoid) can cause inward displacement of fractured bony segment particularly the central mandibular segment. This can lead to retro placement of the tongue base with potential airway compromise. While for fracture of the lateral part of the mandible, if the fracture line lies in a line parallel to the masseter muscle fibers, muscles action will lead to more displacement of the fracture so the fracture is referred to as unfavorable fracture mandible. On the other hand, if the fracture line passes in a line perpendicular to the masseter muscle fibers, muscles action will resist displacement (reduce) the fractured segments so such fracture is named favorable fracture mandible.

The masseter muscles can also affect the ZMC fracture. Thus, by masseter muscles, action on the fractured segment displaces the fractured zygoma mainly downward inward with medial rotation [1-3].

Types of bone healing are either direct or indirect healing. Direct (primary) healing occurs without callus formation when there is no motion across the fracture line. Indirect (secondary) healing happens when there is motion across the fracture line. The more motion across fracture lines, the greater amount of callus needed to stabilize the fractured fragments [4]. If the callus is unable to stabilize the fracture, the bone will never form and the fracture remains bridged by fibrous tissue resulting in the fibrous union (nonunion, fibrous nonunion, pseudoarthrosis).

Direct bone healing needs anatomical reduction and rigid stable conditions that is commonly achieved by open reduction and internal fixation [4].

Bone healing occurs via bridging of the fracture by new bone. If the fractured segments are fully stabilized, proper healing is achieved.

Once fracture bridged by bone, the newly formed bone form can then remodeled to match its function according to Wolff's law (bone remodels according to forces acting on it resulting in a recreation of proper form to match function). This process tends to be very effective for long bone healing. However, for craniomaxillofacial fracture [5], Wolff's law fails to account for two key needs of facial skeleton: aesthetics and dental function. So, leaving facial bones to heal on their own tends results in significant cosmetic deformities and compromised masticatory functions.

Although tooth-containing bones will indeed remodel in response to forces act on them, they will not remodel to recreate proper and functional occlusal relationship between maxillary and mandibular dentition. Therefore, it is critical to guide the healing process. The basic principle of fracture treatment is a reduction, fixation, immobilization, prevention of infection, and rehabilitation [6,7].

So recently, open reduction and internal fixation has become the standard management of displaced maxillofacial fractures because it affords stable three-dimensional rebuilding, promotes primary bone healing, and reduces treatment time [6-8].

Today, most maxillofacial repairs are performed using titanium plates and screws. In maxillofacial trauma involving tooth-bearing segments, proper occlusal relationship reestablishment is essential for restoration of normal masticatory function and this represents the primary goal of repair. While realignment of bone fragments always takes second place to restore the pre-trauma patient occlusion.

So, understanding of the biomechanics of maxillofacial trauma and fractures is one of the keys for optimum management of such fractures.

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