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PEDIATRIC TRAUMA: SURGICAL ANATOMY- A NARRATIVE REVIEW

Maxillofacial Surgery

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ABSTRACT

Pediatric trauma is associated with severe injury and disability of face involving bones. The most common facial fracture is mandible, nasal and maxilla. Motor vehicle, collision, violence and falls are the common cause of facial injuries seen in pediatric patients. Cranial and central facial injuries are common in toddlers and mandibular injuries are common in adolescent. Craniofacial trauma requires hospitalization and mortality rate is high. An overview of cause and surgical anatomy of pediatric trauma is discussed in this article.

KEYWORDS

Maxillofacial Trauma, Children, Fracture, Surgical Anatomy

INTRODUCTION

Trauma is defined as a physical force that result in injury. Facial trauma has presented an increasing occurrence in the last four decades especially due to the growth of the accidents with automobile and urban violence (Montovani and Jeetal., 2006).

Trauma is the leading cause of morbidity and mortality in the pediatric population worldwide. Out of these injuries, cranio-facial trauma is significant cause of morbidity in pediatric population. However, fracture of facial skeleton is less common in children when compared with adult population. (Montovani and Jeetal., 2006), incidence of pediatric fracture ranges between 1% and 14.7% for victim under the age of 16 years and 0.87% to 1% for those younger than 5 years of the age.

Another unique feature is facial fracture are minimally displaced in children as thick layer of adipose tissue covers the more elastic bone and presence of flexible suture line. Also, children present with unique feature that make them particularly prone to sustain fracture is high head to body mass ratio. At birth ration between cranial volume and facial volume is approximately 8:1, which became close to 2.5:1 in adults.

The treatment of undisplaced green stick fracture is by close observation, liquid soft diet and avoidance of physical activities. In case of minimally displaced green stick fracture, using of occlusal splints, circumferential wiring, arch bar and gunning splints for closed reduction.

These closed reduction techniques provide good reduction of fracture segments, continuity of periosteal sleeves and maintenance of soft tissue, all then create a favorable environment and preventing healing complication like fibrous union and non-union in children. However, displaced fracture of the mandibular angle requires an open reduction as the proximal fragment cannot be controlled. Microplate and miniplate system were the first step toward osteosynthesis of mandible in children. When planning treatment in children's fracture, all of the following points should be taken into account:

1) The age of the patient.
2) The anatomic site and complexity of the fracture.
3) The time elapsed since injury and concomitant injuries.

Internal fixation implies an open approach with subsequent subperiosteal dissection, which interrupt the osteogenic potential of the periosteum and create scarring, which may further restrict growth. Therefore, conservative treatment management of the growing bone is preferred whenever possible (Kaban L and Troulis M., 2004).

Surgical Anatomy Of Pediatric Skeleton

Pediatric maxillofacial fracture patterns are distinctly different than those seen in adults. Craniofacial proportion and growth patterns in children are a factor in this difference. In the early year of age, the ratio between cranial volume and facial volume is approximately 8:1 and by the completion of growth, this ratio become 2.5:1 and hence the pattern of trauma differs. As with increasing age, the face grows in a downward and forward direction and the midface and mandible become more prominent and increase in incidence of facial fracture and decrease in cranial injuries with age.

The craniofacial skeleton originates primarily from cell of neural crest origin. Cranial growth is driven by underlying brain and the suture allow expansion of the cranium. By the age of 5, the cranium has reached greater than 85% of the final adult size, although the most rapid growth occurs from birth to 2 years.

The growth of the orbit is similarly directed by its content with 90% of the size of the orbit completed by age 5. Cranio-orbital injuries after age 5 should have minimal long-term effects on growth. At birth, children cranium to facial ratio is 8:1, at age 5, 4:1 and by adolescence, 2:1. Facial growth occurs in two general concept – Displacement & Remodelling

Displacement is the movement of bone in relation to rest of facial skeleton.

Remodelling is the change in shape of bone by deposition of bone at one end with resorption of the other (Wheeler J and Phillips., 2011).

Midface

1) Orbit
2) Nose
3) Maxilla
4) Mandible

1) Orbit

Seven bones make up the orbit: frontal, maxilla, zygoma, lacrimal, greater and lesser wings of sphenoid, and palatine. The outer rim of the orbit is comprised of the first three robust bony elements, protecting the more delicate internal bones of the orbital cavity. The orbital cavity is itself bound by the orbital roof and floor, lateral and medial walls. The structural integrity is changed by the boundaries closely related to sinus-pneumatization. In utero, the sinuses and nasal cavity are a single structure. The ethmoid, frontal and maxillary sinuses then subdivided from the nasal cavity in second trimester.

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The ethmoid sinuses are fluid filled with structure in a new born child. The cell grows gradually to adult size by 12. The medial orbital wall becomes progressively thin during ethmoid sinus development. As a consequence, the medial wall of the orbit become increasingly susceptible to fracture in adulthood.

Based on data, at age 7, orbital floor fractures become more common than orbital roof fracture. The orbital floor becomes more susceptible to fracture in later childhood (Koltai et al., 1995).

The lateral orbital wall is the only non-sinus boundary of the orbital cavity. Fracture of the lateral orbital wall are rare in children-owing to the strong zygomatic and frontal bones which meet at the zygomaticofrontal suture. Fracture of the ZMC complex do occur and the lateral orbital wall is disrupted at the articulation of the zygoma and greater wings of the sphenoid.

The content of the orbital cavity includes globe, extraocular muscle, lacrimal gland, periorbital fat and neuromuscular bundles. The ligamentous support of the globe includes the medial and lateral check ligaments. The elasticity and resilience of these structures in the pediatric orbit provide additional stability. Enophthalmos is less commonly observed in children. The medial canthal tendon may be disrupted in lacrimal bone fracture (Wright RJ., 2011).

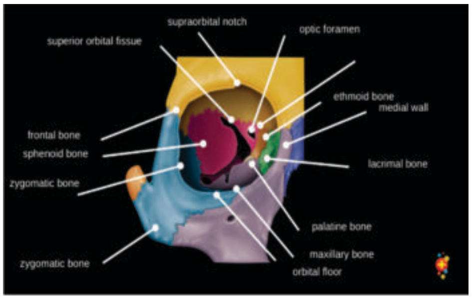

Figure 1: Bones that form the orbit

2) Nose

Growth at the nasomaxillary complex occur in an inferior and anterior direction, mainly involves the lower midface. Any damage to the septum in young age lead to hypoplasia, for this reason, injury affecting integrity of septum in pediatric patient should not be ignored, need proper intervention.

In children, the nasal framework is more cartilaginous than bony and has less frontal projection. In younger children the nasal bones are separated in middle by an open suture line, laterally the nasal bones overlap the frontal process of the maxilla. In infants, the nose has less frontal projection, short dorsum, shorter columella, large nasolabial angle, round nares. Main supporting structure is the dorsoseptal cartilage with increasing age, new cartilage and subsequent ossification from the perpendicular plate of the ethmoid.

This, coupled with growth of the vomer in a dorsal/superior direction, form the adult bony nasal septum. Verwoerd-verhoef described two growth centers of nasal septum, one that extends from the sphenoid to the nasal dorsum and is termed the *sphenodorsal zone*, and a second that extends from the sphenoid to the anterior nasal spine and is termed the *sphenospinal zone.* Vertical growth in the sphenodorsal zone results in increased length and height of the nasal dorsum, and sagittal growth in the sphenospinal zone contribute to anterior projection of the nose and maxilla. Injury to any of these growth centers may lead to loss of vertical height and sagittal projection of the nose and subsequently the midface, as the developmental organization provided by the nasal septum suffers.

Another proposed model of nasomaxillary growth is based on septopremaxillary ligament. In this model, growth of the nasal septum is an important starter mechanism during fetal development for the initiation of downward and forward growth of the maxilla. The septopremaxillary ligament is described as bundle of fibers arising from the anterior-inferior border of the nasal septum and coursing posteroinferiorly to insert on the nasal spine of the premaxillary bone. As the septum grows, it transmits a forward pull to the maxilla via this ligament. Interestingly, this model focuses on fetal development and its relation to congenital abnormalities.

Naso-orbital-ethmoid fractures are rare in children and occur mainly due to high velocity trauma. The NOE complex consists of medial orbital walls, the nasal bones and nasal projections of frontal bone. The sign of an NOE injury includes a flattened nasal root, telecanthus, rounding of the medial canthus, periorbital edema and ecchymosis and CSF leak. In patient older than 5 years, an intercanthal distance longer than 35 mm is suggestive of NOE fracture and a distance longer than 40 mm is diagnostic (Munante-Cardenas., 2011).

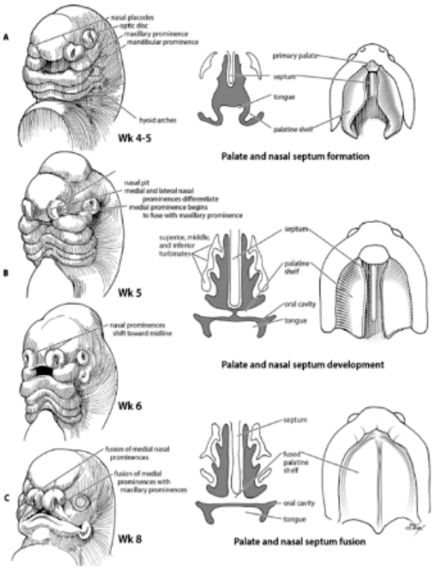

Figure 2: Embryology of the nose and midface

3) Maxilla

The sinuses are also important to the discussion of pediatric facial fractures. It is believed that the sinuses help to provide a cushioning effect for traumatic forces delivered to the facial skeleton. In addition, specific facial fracture patterns and their management are based on how well-developed certain sinuses are. We will mainly discuss on maxillary, ethmoid, and frontal sinuses.

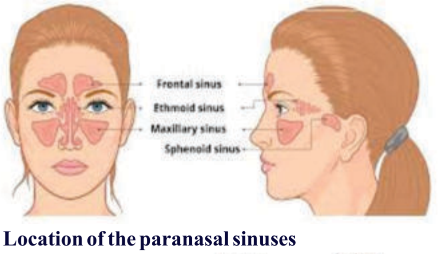

Figure 3: Location of the paranasal sinuses

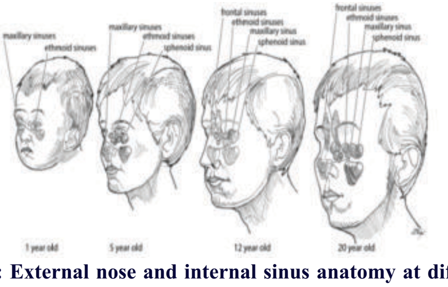

Figure 4: External nose and internal sinus anatomy at different ages in comparison of the craniofacial shape

At birth, the maxillary and ethmoid sinuses are present. However, they are typically not visible. The maxillary sinus undergoes significant growth around 3 years of age, at which time it become visible on imaging studies. The floor of the maxillary sinus undergoes significant development around 7-8 years of age when permanent teeth begin erupting. The maxillary sinus completes its growth around 16. The ethmoid sinuses undergo significant growth around 3-7 years of age, and complete their growth by 12-14 years of age. The frontal sinuses, unlike the ethmoid and maxillary sinuses, are not present at birth. They begin development around 3 years of age, becoming visible around 6 years of age. The completion of growth is related to puberty, and as such is completed sooner in females around 12-14 years of age. In males, the frontal sinuses do not complete growth until 16-18 years of age (Padmini C., 2015).

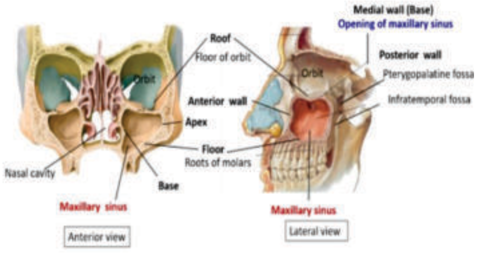

Figure 5: Boundaries of maxillary sinus

4) Mandible

The mandible develops from neural crest cells of the first pharyngeal arch of Meckel's cartilage by intramembranous ossification. The condylar region is cartilaginous and thought to be a significant growth center directing the elongation of the posterior border of the ramus and causing the gonial angle to become more acute. The muscular action of the pterygomasseteric complex when chewing is also thought to contribute to the development of the mandible.

Transverse width and anteroposterior growth are achieved by resorption of bone along the lingual border and deposition of new bone along the labial and buccal surfaces of the bone. Transverse width is highly developed with bigonial distances over 80% complete by age 1 year. Height of the mandible is increased by deposition of new bone along the inferior border of the mandible and is only two-thirds complete by age 1.

The mandible undergoes periods of fastest growth, and if the growth centers are injured at this time, more significant growth disturbances may occur. Mandibular growth is complete in females at age 14 to 16 years and males at age 18 to 20.

Growth of the mandible occur in a lateral and anterior direction, widening and elongating the face. The condylar growth center is the main coordinator of mandibular growth. Any injury here may result in delayed growth, facial asymmetry, mandibular deviation and malocclusion. Of all the facial bones, the mandible is the last to complete its growth.

The general pattern of the normal facial growth occurs in a downward and forward motion along with concurrent lateral expansion, depending on the amount and location of apposition and resorption of the bone are responsible for characterizing the typical growth pattern of the face, any disturbance can cause skeleton malocclusion. The mandible follows downward and forward growth pattern of the face with addition of upward and backward growth of the condyles to maintain contact with glenoid fossa. Vertical height is gained at the condylar region through endochondral replacement, and height is added via remodelling of the ramus.

The following are some relevant points related to the development of the condylar region.

Age group 0 to 2

- The condylar neck is short and thick and engages a shallow glenoid fossa.
- Extensive vascular channels are found in the condylar head that make it vulnerable to a crush-type injury.
- Unlike older age groups, the short stocky nature of the condylar neck makes it relatively resistance to fracture, whereas the regenerative capacity is significant.

Age group 3 to 12

- A more adult like configuration of the condylar process and glenoid fossa begins to develop.
- Although unlike adults, there still remains an enormous potential for regeneration and remodelling in this age group.

Age group 13 to 18

- Although the capacity for extensive new bone formation is equivalent to that of children, teenagers lack the corresponding capacity for condylar remodelling that is found in younger groups.

Figure 6: Age changes of mandible

The pediatric bony skeleton is also worth mentioning in this discussion as it differs greatly from adults in many areas. Pediatric bones contain more cartilage, and the bone is less mineralized. This leads to greater elasticity of the bones. There is also a higher proportion of cancellous to cortical bone. In addition, the medullocortical junction is usually indistinct. All of these properties result in more greenstick and irregular fracture patterns (Padmini C., 2015).

CONCLUSION

Facial fractures in children exhibit important characteristics as concerned with incidence, diagnosis and treatment, and attract special attention in relation to the psychological and physiological condition inherent to age. The incidence of these fractures is low. Intense trauma often does not provoke fracture, although they cause edema in the tissues.

The main cause of mid facial fractures, as reported worldwide are interpersonal violence, traffic accidents, falls and sports injuries. Facial bones most frequently involved are mandible, nasal and zygoma. Simple or low complex fractures correlates with physical aggression where as highly complex fractures are correlated with motor vehicles accidents.

At present the association between alcohol and drug use, driving and urban violence leads to increasingly complex facial trauma. It is no coincidence that most of these injuries occurs during weekends when parties, bars, and other similar activities favour drug and alcohol abuse for leisure and fun.

Children have greater osteogenic potential and faster healing rate than adults. Therefore, anatomic reduction in children must be accomplished as early as possible and immobilisation should be shorter. Conservative approaches to the pediatric facial trauma are recommended. Non-union and fibrous reunion rarely occurs in children and excellent modelling occurs under masticatory forces even there is imperfect apposition of fracture segment.

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