

TITLE: Pediatric Facial Fractures

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INTRODUCTION

Trauma accounts for significant morbidity and mortality amongst the pediatric population. It is estimated that trauma is responsible for nearly 1/2 of all deaths amongst children, which is about 15,000 deaths per year. Although uncommon, pediatric facial fractures have the potential to result in significant morbidity. For this reason, all physicians involved in the care of the pediatric trauma patient should have knowledge of pediatric facial fractures.

EPIDEMIOLOGY

Pediatric facial fractures represent roughly 5% of all facial fractures (pediatric and adult). They are very rare amongst children less than 5 years of age, with roughly 10% of these fractures occurring in that age group. Males suffer more of these injuries than females, with a reported ratio of about 1.5:1 (male:female). The reason for this difference is mainly due to the fact that males are more often involved in interpersonal violence and sports related injuries.

ETIOLOGY

The etiology of pediatric facial fractures varies with age. Children less than five tend to suffer fewer injuries, and have fewer reasons for such injuries. This is because this age group tends to be under more supervision, with less independence. As children become older than 5 years, the incidence as well as the reasons for injury increases. This is due to the fact that this age group is given more independence and is involved in many more activities.

Amongst children less than 3 years of age, falls are the most common cause of facial fractures. From 3-5 years of age, motor vehicle accidents and falls are nearly equal. Once children are older than 5, motor vehicle accidents become the most common reason for suffering a facial fracture. Other etiologies that increase significantly as age increases are interpersonal

violence and injuries related to recreational activities. In all age groups, the physician must be aware of child abuse.

GENERAL GROWTH AND DEVELOPMENT

In order to fully understand pediatric facial trauma, and the patterns of fractures seen, one must first understand pediatric facial growth and development. At birth, a child's cranium to facial ratio is 8:1. Around 5 years of age, it is 4:1. By adolescence, the ratio is 2:1; the adult ratio. Facial growth occurs through two general concepts, displacement and remodeling. Displacement is the movement of bone in relation to the rest of the facial skeleton. Remodeling is the change of shape of the bone by deposition of bone at one end with resorption of bone at the other.

Growth at the nasomaxillary complex occurs in an inferior and anterior direction, and mainly involves the lower midface. Overall, the septum is the coordinating center of midfacial growth. A study was performed on primates where the septum of the young primate was removed early in life. This removal resulted in midface hypoplasia. For this reason, any injury affecting the integrity of the septum in a pediatric patient should be taken seriously, and intervention undertaken early.

Growth of the mandible occurs 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 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. For the purpose of this discussion, we will focus mainly on the maxillary, ethmoid, and frontal sinuses.

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 becomes visible on imaging studies. The inferior floor of the maxillary sinus undergoes significant development around 7-8 years of age when the 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 typically 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.

Tooth development begins with the eruption of deciduous teeth around 6 months of age. A full set of deciduous teeth are typically present by 2 years of age. These teeth remain stable until around 6 years of age when their roots begin to resorb. Around the same time, the permanent teeth begin to erupt. The first permanent teeth are the 1st molars and central incisors. The 2nd permanent molars erupt around 12 years of age.

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 that is present 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.

PRESENTATION AND INITIAL MANAGEMENT

All trauma victims should be approached in a similar manner, and this begins with the ABCs – airway, breathing, and circulation. Details about this can be found in many trauma references, and is beyond the scope of this discussion, but there are some areas worth noting.

Airway

The pediatric airway is much smaller than the adult airway. For this reason, even modest edema may lead to significant airway compromise. Children also have larger tongues that may more easily obstruct the airway. To help prevent this, a traction suture may be needed in certain instances to help bring the tongue anteriorly, opening the airway.

One should always assume a c-spine injury when dealing with a trauma patient, and thus proper precautions should be taken to avoid further injury. The proper positioning of a child is also very important as it may be the only maneuver needed to maintain a proper airway. The child should be placed in the supine position with his head in a neutral position. A jaw thrust may be applied to further improve the patency of the airway. The oral cavity should also be suctioned of all debris and blood so that this material does not lead to obstruction.

If intubation is deemed appropriate for airway control, there are a few things that can be done to help with better visualization of the airway. If the child is less than 2 years of age, a small towel may be placed under the shoulders. If the patient is older than 2 years of age, the towel should be placed under the head. The equation $(\text{age} + 16)/4$ is utilized when selecting the appropriate size endotracheal tube, while the proper depth of the tube is roughly 3 times the endotracheal tube size. Always consider fiberoptic intubation in cases where the child cannot be intubated orally (severe trismus).

If all other airway methods have failed, and a surgical airway is required, age must be considered when determining which method to utilize. If the patient is less than 12, the physician should avoid a cricothyrotomy as landmarks are very difficult to assess, and there is a higher incidence of late airway stenosis in this age group following this procedure. Therefore, a tracheotomy is the preferred surgical airway method in this age group. If the child is older than 12, a cricothyrotomy is appropriate. Another option for all age groups is the needle cricothyrotomy. It will allow the physician more time (10-30 minutes) to perform other methods to obtain a definitive airway under a more controlled environment.

Circulation

It is worth mentioning that the face and scalp have an abundant blood supply. As such, a child with a wound in this area could lose a significant amount of blood if proper measures are not taken to control the bleeding. Use direct pressure and suture ligation, if needed, to help

control the bleeding. Close all facial and scalp wounds as soon as possible to help decrease blood loss.

Secondary Assessment

The secondary survey is where the physician examines all aspects of the patient's body looking for other injuries. This portion of the exam is typically more difficult in children since they are less cooperative than adults. When assessing the face, the physician should examine and palpate all aspects of the head and neck region. Signs of underlying fracture includes step-offs, asymmetry, crepitance, tenderness, ecchymosis, and hematomas. Loss of sensation may also be a sign of a fracture as the injury to sensory nerves is commonly seen with facial fractures, especially mandible fractures. For this reason, sensory testing should be conducted over the distribution of the infraorbital, supraorbital, and inferior alveolar nerves.

A very important examination to perform is the nasal examination as children are at a higher risk of septal injuries, and thus septal hematomas. Oral examination should make note of missing teeth (may be able to replace), open mandibular fractures, midface stability, and occlusion. Occlusion is more difficult to assess in children as the number and type of teeth present are variable from patient to patient. In addition to this, wear facets are less apparent. Another important part of the examination is the ophthalmologic examination. Visual acuity and extraocular muscle function should be assessed. Entrapment noted here could be the sign of a serious orbital fracture. Any patient with an underlying orbital injury should undergo formal ophthalmologic assessment.

Imaging

Computed Tomography (CT) scans have replaced plain films in the evaluation of almost all facial fractures except isolated mandible fractures. The reason for this is that CT scans are readily available and allow for much better visualization of fractures and surrounding structures. Both axial and coronal scans should be obtained. When a patient is suspected of having an isolated mandible fracture, most physicians would recommend obtaining a Panorex as this simple, and easily obtained film provides the best view of the mandible when compared to other plain films. However, condyle injuries can be difficult to detect on Panorex films, thus a second view such as a Town's view (occipitofrontal) may be needed to assess the mandibular condyles.

GENERAL OVERVIEW OF FACIAL FRACTURES

Nasal fractures are the most common pediatric facial fractures, representing 45% of all facial fractures in this age group. The 2nd most common fractures are the mandible fractures accounting for 32% of all pediatric facial fractures. Twelve percent of these occur in children less than 6 years of age. Orbital fractures are the 3rd most common pediatric facial fracture accounting for roughly 15% of these fractures.

There are some general considerations the treating physician must take into account when managing pediatric facial fractures. First, pediatric facial bones tend to heal much faster than adults, thus intervention, if required, must be performed sooner. Most pediatric facial fractures can be managed through observation or closed techniques alone with pretty good results. If open reduction and internal fixation are deemed necessary, the surgeon should obtain proper

alignment of all suture lines and avoid extensive periosteal elevation as this may lead to growth disturbances.

Plating Systems

The use of alloplastic materials in the treatment of pediatric facial fractures is controversial. Most controversy surrounds the use of metallic materials, especially metallic plating systems. The use of these materials in the pediatric population could potentially lead to metal hypersensitivity, bone atrophy, allergy to the specific metal used, growth restrictions, and migration of plates into the cranium. One study performed examining outcomes when metal plates were used to treat facial fractures in pediatric patients found that only 8% of patients actually suffered from one of the complications previously stated. However, the current recommendation is to consider other methods for fixation prior to the use of metallic materials. If they are deemed necessary, the surgeon should use the smallest plates possible, and should not cross more than one suture line with the plate. Some surgeons have actually recommended removal of these plates in all pediatric patients 4-6 weeks after placement when the bone has likely healed. However, this may lead to further deleterious effects on growth.

The trend in the repair of pediatric facial fractures is moving toward the use of resorbable plating systems. These systems are made of high molecular weight poly-alpha-hydroxy acids, which are broken down into by-products through hydrolysis and phagocytosis. The degradation products are then excreted by respiration and/or urine. Multiple studies involving humans and animals have been performed in an attempt to compare resorbable plating systems to metallic plating systems. The findings are that resorbable systems have similar functional outcomes as well as similar fixation stability and strength when compared to the metallic systems. The resorbable plates and screws retain full strength for 4-6 weeks, and are completely resorbed by 12-36 months. They also do not interfere with radiographic studies. Similar complications are noted amongst the two plating systems, but the most common complications associated with resorbable systems are edema of the tissue around the plate and visibility of the plate since they are bulkier. However, both of these resolve with time.

Maxillomandibular Fixation

A very common form of treatment utilized in facial fracture repair is maxillomandibular fixation or MMF. When it comes to the pediatric population, how it is performed is determined by that patient's age. If the patient is less than 2 years of age, it is likely that the patient has very few, if any teeth to work with. For this reason, the patient is approached as an edentulous patient. One method used for MMF in this age group is the use of acrylic splints. These can be made by a dentist and given to the treating surgeon for use in placing the patient in MMF. It is important that these splints be thinned along their posterior edge so as to prevent premature posterior closure once in place. If left unaltered, the patient may have an open bite. The splints can be secured in place with circummandibular wires, and the jaw immobilized with both circummandibular wires and wires through the pyriform aperture. When a patient is 2-5 years of age, a full complement of deciduous teeth are usually present. For this reason, arch bars or cap splints can be utilized. If further support is needed, circummandibular wires and wires through the pyriform aperture are good options. From 6-12 years of age, the pediatric patient's teeth are variable, and thus options for MMF vary. If the patient is 6-7 years of age, the deciduous molars

may be used for fixation as they tend to be stable. From 8-10 years of age, the permanent first molars and central incisors are usually present, thus they can be utilized in this age group for fixation. When the child reaches the age of 10, there are typically enough permanent teeth available for proper fixation with arch bars. Another option for fixation involves the use of orthodontic devices already in place.

NASAL FRACTURES

The pediatric nasal bone is very compliant, and thus bends more readily when force is applied. These forces tend to dissipate into the surrounding maxillary tissue and lateral buttresses resulting in a significant amount of edema. This makes it very difficult to assess underlying fractures.

As stated previously, the pediatric septum is more prone to injury than the nasal bones. The reason for this is that the septum is more rigid, held very tightly in place by the perichondrium and surrounding bone. There are three common patterns of pediatric septal injuries seen. The first is where the perichondrium is torn from the underlying cartilage leaving a potential space for blood to accumulate. This leads to a septal hematoma. The second type is where the caudal septum becomes dislocated, leading to acute nasal obstruction. If left untreated, this injury will likely result in a twisting deformity of the nasal septum. The third type of septal injury involves the separation of the bony and cartilaginous septum. This too leads to acute airway obstruction, but if left untreated in a developing patient, could lead to midfacial growth abnormalities.

The management of pediatric nasal fractures depends on whether a septal hematoma is present or not. The septal hematoma will present as a purple, compressible bulge on the nasal septum, and does not shrink with Afrin. If this is present, it must be drained acutely to avoid late complications that result from necrosis of the nasal septum. When draining a septal hematoma, the child should first be placed under general anesthesia. Next, a hemitransfixion incision is made to allow for drainage of the hematoma. A quilting stitch is then used to close the space between the perichondrium and septal cartilage to prevent reaccumulation of blood. The surgeon should avoid the use of splints, if possible, as these will be extremely difficult to remove in later. While the child is under general anesthesia, other nasal fractures should be addressed with closed techniques.

If no septal hematoma is present, the recommendation is to wait 5 days to allow for the swelling to improve and then re-examine the patient focusing on any cosmetic or functional (obstruction) defects. If present, closed reduction under general anesthesia should be attempted, and is usually all that is required for treatment. This is performed through internal and external manipulation of the nasal bones. If the septum is fractured or dislocated, it may reduce with the nasal bone manipulation. If not, one may consider using Asch forceps in an attempt to reduce a closed septal fracture. However, many times further intervention will be required. This may involve a septoplasty or even a septorhinoplasty. Open approaches should be considered in cases where closed reduction has failed, fractures are 2-3 weeks old, or further septal work needs to be performed. The open approach is also good for greenstick fractures causing morbidity as these are very difficult to address without a completion osteotomy.

MANDIBLE FRACTURES

The mandibular condyle is the most commonly fractured site in the pediatric mandible with the subcondyle being the most common subsite involved. The condyle fracture represents 55-72% of all pediatric mandible fractures. The symphyseal/parasymphyseal area is the second most commonly fractured site, accounting for 27% of pediatric mandible fractures. Less common are the body and angle regions, accounting for 9% and 8% of fractures respectively. However, the incidence of fractures involving the body and angle increases with age, as does the incidence of multiple mandible fractures.

General Treatment Considerations

The primary goal in the treatment of mandible fractures is to restore occlusion, function, and facial balance. When it comes to the repair of fractures in the pediatric population, it must be noted that callus formation may be present as early as 5-7 days. This callus will need to be removed in order to obtain proper reduction if an open approach is needed for fixation.

Condyle Fractures

Pediatric mandibular condyle fractures are typically considered “self correcting,” thus the treatment of these fractures is nearly always conservative. The extent of therapy, however, varies with the extent of injury. If there is a unilateral condyle fracture and the patient has normal occlusion and function, then observation with pain control, soft diet, and range of motion exercises is all that is required for the treatment. If, however, a unilateral condyle fracture has occurred and the patient has mild deviation from the midline with no open bite, or the patient has suffered bilateral condyle fractures with normal occlusion and function, then the treatment must include the use of elastic guiding bands for 6-8 weeks along with the range of motion exercises. Any condyle fracture where the patient has an open bite deformity, severe functional impairment, or severe deviation from the midline must be immobilized (MMF) for 2-3 weeks followed by the use of guiding elastics for 6-8 weeks. Open repair of condyle fractures is reserved for cases where the condyle has been displaced into the middle cranial fossa or is prohibiting the movement of the mandible. Some authors recommend open treatment whenever the condyle growth center is involved as these fractures may lead to growth disturbance.

Arch Fractures

The majority of mandibular arch fractures are non-displaced or greenstick fractures. Patients suffering these types of fractures should be placed on a soft diet and followed very closely. If any change occurs where the patient begins to have worsening pain or new functional impairments (open bite, malocclusion), new films should be obtained with the suspicion that the fracture has now become displaced and requires further intervention. For fractures of the arch (parasympheseal), body, and angle that are displaced, closed reduction should first be attempted. If proper reduction can be obtained through this method, the patient should be placed in MMF for 2-3 weeks followed by 6-8 weeks of guiding elastics. If reduction is unsuccessful through a closed approach, then an open approach must be utilized. In these cases, the patient is initially placed in MMF and then open reduction and internal fixation (ORIF) is performed. If plates are

being utilized for fixation, monocortical screws must be used in children less than 12 years of age in order to avoid injuring developing teeth.

For dentoalveolar fractures, the teeth are the primary concern. Tooth avulsion is very common with these fractures, thus the treating physician should have a good understanding of how to manage this scenario. If the tooth that has been avulsed is a deciduous tooth, it does not need to be replaced. However, if a permanent tooth is involved, it should be replaced within 1 hour of avulsion. In some cases the fractured bony segment may make it difficult to return the avulsed tooth. For this reason, it should be reduced by manipulation followed by replacement of the tooth. The fractured segment should then be plated, if needed, while the tooth is secured into place with wires as the patient is placed in MMF for 2-3 weeks. All patients with avulsed teeth should see a dentist as further dental work will be required.

ORBITAL FRACTURES

Orbital floor and roof fractures are the most common orbital fractures that occur in children. In children less than 7 years of age, the roof is the most common site. In children older than 7 years, the floor is the most common site. The medial orbital wall is fractured in anywhere from 5-19% of cases, while mixed fractures are seen in nearly 35% of cases.

Orbital Roof Fractures

The classic presentation of a pediatric patient suffering an orbital roof fracture is one who has sustained a blow to the upper face with a late developing periorbital hematoma. These fractures are commonly associated with neurocranial injuries, thus neurosurgery should be involved in every case. Orbital roof fractures can be classified into three types. Type I is a comminuted fracture of the orbital roof without displacement of the fragments. A type II fracture is considered a “blow-out” fracture as the comminuted pieces of bone are displaced superiorly. The type III orbital roof fracture involves the displacement of the comminuted fragments into the orbit, and thus is considered a “blow-in” fracture. Initial observation is usually at that is required for these patients. If functional or aesthetic deformities remain after 7-10, intervention is required. Intervention may also be needed in cases in which a traumatic encephalocele has formed or there is a persistent CSF leak. The surgical approach to this region may vary greatly depending on the extent of injury. Common approaches include the coronal and transpalpebral (upper eyelid incision) approaches. The fractured segment should be reduced or reconstructed depending on the extent of injury. The use of material for this is controversial. Some authors recommend only using calvarial bone or costal cartilage in the orbit, whereas others have utilized alloplastic materials with success.

Orbital Floor Fractures

A pediatric patient with an orbital floor fracture may present with multiple signs and symptoms that include periorbital ecchymosis and edema, entrapment, enophthalmus, diplopia, severe nausea and emesis, bradycardia, and infraorbital anesthesia. The incidence of these fractures increases with age and the developing maxillary sinus. Initial management of these fractures typically begins with a period of observation for 7-10 days. If after this time the patient is suffering from enophthalmus, diplopia, or severe pain, then surgical intervention will be

required. If at any time entrapment has occurred or the patient is suffering from bradycardia or severe emesis, acute surgical intervention is required.

A special consideration must be made for the pediatric trapdoor fracture, or “white-eyed” fracture. The floor of the orbit in the pediatric patient is very weak over the infraorbital canal. When a force is applied, the elastic bone may fracture in this area leading to displacement of the fractured segments inferiorly into the canal. Orbital soft tissue may then prolapse through the fracture site and become trapped when the fractured bony segments snap back superiorly. This causes the patient to suffer from entrapment that manifests as decreased supraduction of the involved orbit. The patient may also experience bradycardia as well as severe nausea and emesis with any attempted movement of the involved eye. A CT scan may show a subtle floor fracture or nothing at all. If entrapment is present, surgical intervention is required, and should be performed within 2-3 days of injury, preferably sooner than later. The reason for this intervention is to prevent orbital soft tissue necrosis and fibrosis that will result in a permanent functional disability.

The approach to the repair of orbital floor fractures in the pediatric population is very similar to adults, and involves the transconjunctival, subciliary, subtarsal, or endoscopic approaches. If an endoscopic approach is being considered, the patient must be evaluated for an adequately sized maxillary sinus. As with orbital roof fracture repair, the use of materials in the orbit for repair is controversial. However, if the orbit has been entered to repair an orbital floor fracture, the fracture should be properly covered to prevent future morbidity.

ZYGOMATICOMAXILLARY COMPLEX FRACTURES

Zygomaticomaxillary complex (ZMC) fractures are very rare in children, especially those younger than 5 years of age. However, the incidence of these fractures increases with the development of the maxillary sinuses. Some common signs and symptoms of ZMC fractures include a depressed zygomatic arch, pain, periorbital hematoma, epistaxis, subconjunctival hemorrhage, and ecchymosis of the overlying skin.

ZMC fractures are managed according to the fracture pattern present. Since most of the fractures seen are non-displaced or greenstick fractures, management is typically conservative with observation and comfort measures. When displacement is present, the most common fracture pattern is a displaced fracture of the zygomaticomaxillary buttress with greenstick fractures of the zygomatic arch and frontozygomatic suture. The treatment of this fracture pattern is reduction of the zygomaticomaxillary fracture with single point fixation at the fracture site. The greenstick fractures do not require exposure, manipulation, or fixation. If an isolated zygomatic arch fracture is present resulting in a cosmetic deformity, a Gillies approach may be utilized for reduction. For other types of displaced fracture patterns involving the ZMC, 2 or even 3 point fixation should be utilized, and involves the frontozygomatic suture, infraorbital rim, and/or the zygomaticomaxillary suture. Multiple approaches can be utilized for proper exposure of each fracture site. These include the gingivobuccal sulcus, extended blepharoplasty, transconjunctival, subciliary, and coronal/hemicoronal approaches.

MIDFACE FRACTURES

Midface fractures are another set of fracture patterns that are rarely seen in children. This is mainly due to the fact that children have underdeveloped sinuses and unerupted maxillary teeth. They also have more soft tissue overlying their midface that helps to provide a cushioning effect for traumatic forces. The majority of midface fractures in children are the result of a tremendous amount of force, and as such these children nearly always have associated injuries.

Midface fractures can be further divided into zygomatic, dentoalveolar, nasal, and LeFort fractures. The first three fracture types have already been discussed above, and thus LeFort fractures will be covered in this section. There are three types of LeFort fractures. A LeFort I fracture involves the separation of the palate and alveolus from the rest of the maxilla. The structures involved include the anterolateral and medial maxillary walls, septum at the floor of the nose, nasal floor, and pterygoid plate. A LeFort II fracture is a pyramidal fracture that involves the nasofrontal suture, medial and inferior orbital walls, anterior maxillary wall, frontal process of the maxilla, high septum, and pterygoid plate. A LeFort III fracture involves the complete separation of the facial skeleton from the skull base. The structures involved in this fracture pattern include the nasofrontal suture, medial and lateral orbital walls, orbital floor, frontozygomatic suture, zygomatic arch, nasal septum, and pterygoid plate.

The primary goals in the management of LeFort fractures are to obtain proper occlusion and normal facial proportions and symmetry. As with ZMC fractures, the forces involved with LeFort fractures are extreme and result in significant facial edema. For this reason, it is best to wait a few days prior to performing an operation to allow time for some of the swelling to decrease. However, these fractures should be repaired within one week of injury.

When repairing a LeFort I fracture, a common approach is to create a gingivobuccal sulcus incision with proper exposure of the fracture line. The fracture is then reduced, and the patient is placed in MMF. Four plates are ideal for proper fixation. This includes placing a plate on each side of the pyriform aperture, as well as plating both zygomaticomaxillary sutures. Once complete, the patient is taken out of MMF.

LeFort II fractures are a bit more complex, and require multiple approaches. The patient should be initially placed in MMF to provide a stable base to work from. The nasal root is then reduced, and plates are placed on both sides. The zygomaticomaxillary buttress is then reduced and plated. The orbit is addressed as previously discussed. Once complete, the patient is taken out of MMF.

A LeFort III fracture is very complex and will require extensive planning prior to surgical correction. Multiple approaches will be required. The patient should initially be placed in MMF to provide a stable base. The fractures should then be approached from a lateral to medial direction, beginning with the zygoma and zygomaticomaxillary buttress.

NASO-ORBITO-ETHMOID FRACTURES

As with other midface fractures, naso-orbito-ethmoid (NOE) fractures are very rare in children for the same reasons as the midface fractures. The NOE complex is made up of the nasal, lacrimal, ethmoid, maxillary (frontal process), and frontal bones. The medial canthal

tendon (MCT), an extension of the obicularis oculi muscle, is involved in this complex with its attachment to the lacrimal crest. In addition to acting as a pump for the lacrimal sac, the MCT also helps to maintain the proper intercanthal distance. The proper intercanthal distance in pediatric patients varies with age. In infants, it is slightly less than 22mm. By 4 years of age, the distance is around 25mm. At 12 years of age, the distance is nearly 28mm, and above 12 years of age, the distance is that of adults (~30mm). An intercanthal distance variation of 5mm from normal is considered abnormal, and thus an injury to the MCT should be suspected. A distance of 10mm or more from normal is diagnostic of an MCT injury.

The signs of an NOE injury include a flattened nasal root, telecanthus, rounding of the medial canthus, periorbital edema and ecchymosis, epistaxis, and CSF leak. During the physical examination, a bowstring sign may be present. This occurs when the examiner grasps the medial eyebrow near the lash line and pulls lateral. If the lid does not snap back medially, the sign is considered positive, and an MCT injury is suspected. Another option for assessing MCT stability is to palpate the medial orbital wall through the nasal cavity. This maneuver assesses the stability of the central bony segment that holds the attachment of the MCT. When the child is under general anesthesia, a hemostat is placed in the ipsilateral nasal cavity and directed toward the medial orbital wall. The tip of the instrument is used to apply pressure to the central bony segment in this area. If there is movement, the segment is likely displaced and will need to be repaired.

MCT injury can be classified into three types. A type I injury involves a single, non-comminuted fracture of the central bony segment with the MCT remaining attached. The fracture can either be displaced or non-displaced. A type II injury involves a comminuted fracture of the central bony segment, but the MCT remains attached. This injury is considered unstable, and will require repair. A type III injury involves a severely comminuted fracture with detachment of the MCT.

NOE fractures are typically complex and are associated with other injuries. As such, multiple approaches and treatment guidelines will be required, and typically involve multiple surgical sub-specialties. For the purpose of this discussion, focus will be directed toward the management of MCT injuries, as correcting these injuries should take precedence over other NOE injuries.

As stated earlier, type I MCT injuries may involve displaced or non-displaced fractures of the central bony segment. The non-displaced fractures do not require any intervention. However, the displaced fractures require reduction and fixation. Fixation comes in the form of two plates. The first plate is placed from the frontal bone to the central bony segment, and the other plate is placed from the maxilla to the central bony segment. Type II MCT injuries require the use of 28 gauge wires connecting the comminuted central bony segment to the opposite medial orbital wall. If bilateral type II injuries exist, the segments can be wired to each other in the midline. In a type III fracture, the MCT must be reattached to the central segment. If the fracture is so comminuted that a proper piece does not exist for attachment, the wall must be reconstructed with calvarial bone. The MCT is then attached to the bone and the bony segment is wired to the opposite medial orbital wall. If bilateral type III fractures exist, the segments are wired to each other in the midline.

CONCLUSION

Facial fractures are a rare type of injury suffered by pediatric trauma patients, but can result in significant morbidity if not properly managed. The majority of these fractures can be managed conservatively. If surgery is required, care must be taken to avoid further morbidity in the form of growth disturbances that may result from extensive periosteal elevation or improper fracture reduction. The use of alloplastic material in treatment of pediatric facial fractures remains controversial due to fact that there are very few long term studies involving their use in this age group. However, some reports have shown good results with minimal complications when alloplastic materials are properly utilized. Metallic materials remain an option for pediatric fracture repair, but other options should be considered prior to their use.

DISCUSSANT'S REMARKS BY DR. SHRADDHA MUKERJI

The majority of facial fractures in children can be managed conservatively and this should be tried before doing any open reduction. The anatomy and the pliancy of the facial bones in children make them more amenable to conservative treatment. If open reduction and internal fixation is attempted for nasal fractures, the septum should be managed conservatively and with care since it the pivotal area for midfacial growth and any damage or excessive removal of this structure can lead to hypoplasia. For the same reason, septal hematomas should be drained as soon as possible.

Whenever considering plating for mandibular fractures or facial fractures, resorbable plates should be used if possible, because there are no long term studies for metallic plates or metallic implants. For dental, maxillary or mandibular fractures, OMFS should be involved if there is any doubt about treatment.

DISCUSSANT'S REMARKS BY DR. HAROLD PINE:

I second Dr. Mukerjee's important point about getting Oromaxillofacial Surgery involved. In fact, I will go as far as to say if my two little boys came in with a mandible fracture, I don't care if OMFS is not on call for facial trauma, we'll consult OMFS. And that's how strongly I feel about it.

Secondarily, this is just a small point that didn't come up but there's an entity known as septal deviation in the newborn in these traumatic deliveries where the Newborn ICU folks will call us and say, "Golly, the kid's septum is way over in the nose" and it doesn't happen often but it is something I've seen a couple of times which you can fix right in the nursery just with some forceps with tape on them. You can basically just stick the instrument in there and move the septum right over. I don't tend to make a big deal over it or try to localize or anything- I just sort of hold the kid and do it. And I think you can save yourself some grief if you correct it early on versus letting it sit and stabilize in that area.

Dr. Quinn raised the possibility of using a Barton bandage for temporary, even indefinite stabilization of mandibular fractures with minimal displacement and where deciduous occlusion remains acceptable.

Dr. Pine: Does anybody know how to put on a Barton bandage anymore? That's Old School, professor!

(Laughter)

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