ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 3, Issue – 5, October - 2020, Page No. : 346 - 359

Pediatric Facial Fractures: Are Kids Implicitly A Miniature Version of Adults: A Review

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Citation of this Article: Dr. Josie Kurian Paul, Dr. Nainik Mehta, Dr. Dhruvika Garg, Dr. Charan Teja Vemagiri, Dr. Gauri Pande, Dr. Ritika Kataria, "Pediatric Facial Fractures: Are Kids Implicitly A Miniature Version of Adults: A Review", IJDSIR- October - 2020, Vol. – 3, Issue - 5, P. No. 346 – 359.

Type of Publication: Review Article

Conflicts of Interest: Nil

Abstract

During the past decades, there have been enormous advances in the management of pediatric facial fractures. Trauma regarded as the sole reason for the cause of morbidity and mortality in children. Variations in pediatric anatomical skeleton compared with the adults, makes it a different call for the surgeons, to treat them differently than the adults. Diagnosis is more difficult in children than the adults and fractures are easily overlooked. CT imaging is the gold standard for the diagnostic purposes. Operative management must be done while keeping in mind the child's skeletal and dental age.

Keywords: Pediatric Facial Trauma, Resorbable Plating System

Introduction

Trauma has been considered as the leading cause of morbidity and mortality in children. Unlike adults the facial skeletal fractures in children are less likely to occur and are minimally displaced.[1] This is due to the relative smaller size of the facial skeleton, the nature of elasticity of bones,[2] shortness of condyles and non-prominent chin region.[3] Facial fractures in young adults comprise less than 15% of all the facial fractures. They are seen rarely below the age of 5 years, having a male dominating predilection, seen as a constant incidence over the years.

Various etiological factors associated are Road Traffic Accidents, Falls, Motor vehicle accidents, Sports related injuries, Child Abuse,[1] Bicycle related injuries (not wearing protective helmets).[1,4,5,6,7] Even though the incidence of injuries is low in comparison with the adult population, the impact of pediatric facial fractures can be more serious as the facial structures are undergoing significant developmental changes and growth.[8] Preventive measures are to be undertaken in reducing accidents and severity of injuries by using seat restraints and helmets.[5,9,10,11,12,13,14,15] Certain abdominal and thoracic injuries could be sustained with the conventional seat belts in pediatric patients due to the greater body mass above the waist, as the center of gravity stays higher in children compared to the adults (as the anterior superior iliac spine is underdeveloped).[5]

Site, Pattern and Incidence

The site and pattern of fracture depends on the inter relationship between the etiology, force and magnitude of the impact of injury with child's stage of development.[1] From the review of studies done till date, certain points and special considerations give us a clear understanding of the patterns of pediatric maxillofacial trauma (Ponick, 1992).[8] Infants below the age of 2 years are more likely to sustain injuries of frontal region,[1,6,16] while the older ones are more prone to injuries of lip/chin area. Incidence of mandibular fractures is more common in children (73.9%), midfacial fractures(15.2%), dentoalveolar fractures (7.6%), upper third facial skeletal fracture(3.2%).[1] In 1995, Anderson studied the fractures of facial skeleton in Scotland. The preponderance of males with facial bones fractures of all types (male: female ratio was 3:1) similar to most of the earlier studies of facial fractures was noted.[2]

One of the most fractured site is the condylar fracture,[16,17,18,19,20,21,22,23,24,25,26] it is affected bilaterally in 20% of the cases.[24,27,28,29] Condylar fractures are more frequently intra-capsular than the extra-capsular below the 6 years of age. Passing this age group most condylar fracture occurs in the neck region.[29] Furthermore, the symphysis and parasymphysis fracture occurs more often than the body fracture in children as compared with the adults.[30]

Midface fractures are rare, which may result from high-velocity forces.[22,23,24,31,32,33,34,35] The incidence of midface fracture increases above the age of 5 years as the maxillary sinus expands and the teeth erupts, with the highest incidence between 13-15 years.[24,36,37] Followed by maxillary alveolar fracture and nasal injuries, zygomatic complex fracture are the most frequent.[31,36,38] Le Fort fractures are rarely seen below 2 years of age.[36] McGraw and Cole[39,40] stated that the incidence of lower facial fracture increases with age, midfacial injuries are common in young children which mandibular fracture in older children.

The most frequent site of involvement is the frontal bone, below the age of 6 years (due to its prominence).[33,37] The reason that the frontal sinus is not involved is due to its small size, measuring less than a cherry size and it has not reached the orbital floor.[41] Pneumatization of frontal sinus during pubertal development, increases its involvement.[42]

Adding up with the nasal fracture, which make up approximately 50% of all the facial fractures in children,[22,43] nasal bones being least resistant of the facial skeleton in conjunction with the prominence of the nose (increasing with growth) makes it likely, a target to sustain injury in older children [22,43,44,45,46]

Orbital injuries comprises of 20% of the pediatric facial fractures, [20,22,33,37,46] resulting from spread of forces directly from a blow to the bony orbital ring towards the thin orbital walls, either from the indirect forces from a

hydraulic pressure effect of displaced orbital soft tissues.[48,49] Fracture of the orbital floor is more likely to occur than the orbital roof fracture in older patients (maxillary sinus has expanded beyond the equator of the globe), while the orbital roof fractures can be seen in whom the frontal sinus is still underdeveloped.[50]

Etiology, Gender

The major causes of facial fracture in children incorporates falls, sports injury and RTA.[18,22,23,24,25,31,37,43,45,51,52] The rate of occurrence solely depends upon the age factor of the child and the types of fractures included (young children may sustain injury from low-velocity forces like falls, while the older once require higher velocity forces such as RTA, sports-related injury). Furthermore, the low incidence of recorded facial injuries in infants is due to the high mortality rate because of the concomitant neuro-cranial injuries.[5] Most of the sports injuries are seen in children between 10-14 years of age.[36,53,54,,56,57,58] Facial fractures are seen in 2.3% in the cases of child abuse,[59] with newborns, infants and preschool children being most prone, specifically boys.[59,60,61,62] The preponderance of boys over girls can be explained because of frequent involvement in sports related activities, dangerous behavior and activities.[63]

Distinct Features of The Pediatric Patient

At birth the cranial volume and facial volume ratio is approximately 8:1, which after the growth completion becomes 2.5:1.[64] As a matter of fact, the prominent frontal bone (with the protecting skull) and the retruded facial skeleton is likely to be the cause of higher incidence of cranial injuries in children less than 5 years of age.[33,65] With the progression of growth of facial skeleton, the incidence of midface and mandibular injuries increases due to their prominence (downward and forward growth), decreasing the neural injuries.[33]

Facial fractures in children are less likely to occur than adults with minimal displacement, due to the fact that the elastic bones of a child is covered with a thicker layer of adipose tissue with flexible suture lines. The presence of tooth buds and lack of pneumatization increases the stability of the fractured bone.[37,66,67]

Furthermore, the growth potential of the condyle may come in handy to compensate post condylar fracture, while a spontaneous occlusal readjustment during the mixed dentition stage can be accomplished.[5]

Concomitant Injuries

Facial trauma and multiple fractures often demonstrated simultaneously.[68] Associated trauma can be diagnosed in 25-75% of the cases.[20,47,33,37,65] mandibular[22,69] or midface[20,47,36,37] fractures are associated with chest, abdominal, extremity, cervical spine injuries, caused due to the high-velocity forces/accidents.[37]

Diagnosis of Facial Fracture in Children

Diagnosing a fracture may put a clinician into a dilemma, as the fractures are uncommon in a pediatric patient. The suture lines and the elastic bony skeleton may mimic fracture gaps on palpation, creating a doubt of sustained injuries. CT Scan being the gold standard in diagnostic aid is helpful in pediatric patients, especially in midfacial fracture, comprising of underdeveloped sinuses and tooth buds obscuring the skeletal bones. Plain radiographs may not prove to be useful as in the case of adults.[37,66,70,71]

Management

Changing social conditions, better housing conditions, nutrition, immunization has helped in reducing the threat of infectious diseases, while over the years introduction of automobile, motor vehicles have increased the risk of injury.[1] Young children having a higher cranio maxillofacial mass to body ratio, oxygen demand, metabolic rate and cardiac output in comparison with the adults, demonstrating the capacity of risking hypothermia,

hypotension and hypoxia post blood loss. Considering the fact that any mechanical airway obstruction can obscure the airway, making it even more critical to maintain the breathing, control hemorrhage and early resuscitation.[5] Goth et al. (2012)[72] stated that the management requires a treatment varying from soft diet to open reduction and internal fixation. Establishment of the pre-injury skeletal framework and the occlusion is performed by manual reduction of the fractured fragments in relation with the dental occlusion.[73,74] Besides, children have higher osteogenic potential and healing rate than the adults, making it an early call for the treatment and lesser immobilization period suggestive of approximately 2 weeks, which is 4-6 weeks in adults.

Undisplaced fractures can be preferably treated by observation, in conjunction with soft and liquid diet plus analgesics as needed. Displaced fractures need to be operated with closed or open reduction with fixation.[33,37] Fracture fixation can be achieved via maxillomandibular fixation (MMF) or internal skeletal fixation, relying specifically on the patients stage of development and the type of fracture in question.[75] Additionally, long term sequelae can influence the treatment type to prevent complications such as facial asymmetry and malocclusion.[76]

Rigid Internal Fixation as an Option In Children

Closed reduction and internal fixation was considered and performed in all the pediatric facial fracture cases till the mid of 1970s,[35,77,78] which thereafter was replaced by a more stable three- dimensional and standard care for reconstruction purposes via open reduction and internal fixation (ORIF). It comes with a package of advantages over the closed reduction technique, such as it promotes primary healing, lesser treatment period, early removal of MMF enhancing postoperative oral hygiene, nutritional intake and respiratory care,[37] However, there are controversies concerning the use of rigid internal fixation in growing children, comprising of the high cost, potential artifacts on CT/MRI, visibility of plates through the child's thin skin, pain, early/late infection, trauma to the tooth buds and erupting teeth, risk of dural penetration of plates and screws (potential risk of secondary headacks/ seizure focus),[79] cerebrospinal fluid leak, meningitis, brain injury, disturbed growth pattern.[72,80,81,82,83] Mini plates and screws are known to possess the capacity to migrate in bone and other tissues such as cartilage.[83,84] Device loosening, skin irritation and device exposure are the causes of potential need for secondary removal surgery.[79]

It is suggested to remove the plate and screws as early as possible (within 2-3 months). Furthermore, the plates and screws must not traverse suture lines or the midline of the mandible.[21,81] With the introduction of absorbable plates and screws these complications will be further minimized.[83]

Hausman in 1886, described the use of plates and screws in rigid internal fixation for immobilization of mandibular fracture.[85] Since then the use of rigid internal fixation has expanded as a treatment option for congenital anomalies, deformities of mandible, cranial, maxillofacial region.[86,87,88,89,90]

Resorbable Plating System

With the introduction of resorbable material the need for additional surgery for the removal of hardware is eliminated.[63,91,92,93] Adding to its advantages such as lesser hospital spending, the use of large mesh panels helps to contain the cost with resorbable systems (by placing several small pieces in cost-effective fashion) from a single large panel.[94] Improving patients quality of life. Various authors in their respective studies demonstrated that the larger resorbable plate fixation in the tooth bearing regions can be troublesome in a way that

the developing tooth buds and the roots of erupting teeth may be damaged, making them a selective choice of treatment in mixed dentition phase. They are also presumed to have lower biomechanical strength.[63,95] Ballon et al. (2011),[96] Landes and Ballon (2006)[97,98] documented in their report that the resorbable plates and screws demonstrated sufficient rigidity and immobilization for routine osteosynthesis within the upper and middle facial skeleton.

As a matter of fact, internal fixation in craniomaxillofacial surgery encounters a wide range of masticatory forces. The degree of segmentation and the elastic recoil from the overlying soft tissue makes it a prerequisite to assess each case discretely, while selecting the type of fixation. Yet in case of mandibular fracture, resorbable systems fail to provide adequate stability making it unadvisable in patients more than 3 years of age.[72]

The development and use of bioresorbable material such as polylactic (PLA), polyglycolic (PGA) and polydioxanone acid plates has transformed the way and view point of pediatric fracture treatment, as they are biocompatible in nature with complete degradation within 12-14 months after the completion of bone healing through hydrolysis.[99,100]

Mandibular Fractures

The management of mandibular fractures in young children offers numerous remarkable challenges for the oral surgeon. The fractures are likely along the line of unerupted teeth, frequently irregular, long and oblique fracture line.[101] Mandibular fracture in growing children are unlikely to occur (i.e. <10% of all the mandibular fractures)[102-104] perhaps when they occur its approximately 50% condylar or ramus-condyle unit fracture.[102,103,105-107] Children below the age of 6 years encounters intra-capsular condylar fracture (58%), whereas in older children condylar neck is the involved site (extracapsular) or ramus (78%).[108]

In order to compliment the limited physical examination and history, a clinician may have a need to rely on the radiographs to establish a diagnosis.[79] CT Scan being the gold standard for assessment of condylar fracture is determined by Chacon and colleagues to have an accuracy of 90%, whereas that of panoramic radiograph is 73%.[109] In scenarios where only plain films are onboard, panoramic radiograph, Towne's view, bilateral lateral oblique views,[79] occlusal view[5] are helpful. Treatment of mandibular fracture depends on the fracture site and the stage of skeletal and mental development.[66,110] Mostly condylar fractures are treated with supportive care (observation, soft diet, physiotherapy, long span of postoperative follow up). A short period of MMF (<2 weeks) with guiding elastics (<8 weeks) after MMF release is suggested in case of malocclusion. Postoperative physiotherapy (passive jaw exercise) is advised for an extended period of time.[5,79] Furthermore, open reduction avoids MMF, improving the functional outcome.[111] Various absolute indications may convince the surgeon to carry out open reduction and internal fixation for example, condylar displacement into middle cranial fossa, interference of displaced condylar fragment in jaw opening, presence of a readily access from a pre-existing laceration, loss of ramal height, persistent malocclusion. Other relative indications comprises of seizure disorders, developmental disturbances, inability to tolerate MMF, airway obstruction, facilitating oral hygiene.[79] Fearing the risk of unpredictable but documented ankyloses, long term follow up is required till the growth ceases. Given a recommended monitoring protocol stating clinical examination at 1st and 4th weeks followed by 2nd, 6th, 12th months of clinical and radiographic evaluation.[112]

Fractures associated with alveolar process may be treated by open or closed reduction followed by immobilization for 2-3 weeks (via splints and arch bar), rarely indicated for 2 months preventing malocclusion.[113] Displaced mandibular fractures can be alternatively immobilized using splint fixed to teeth, to the mandible with circum-mandibular wiring (Gunning splint), or a splint with MMF.[5]

Displaced symphysis fracture can be treated with ORIF in children more than 6 years of age (after the eruption of permanent incisors). However, for parasymphysis fracture ORIF is recommended after the age 9 (after the tooth buds of canine have moved up from the inferior border of mandible). Likewise for body fracture, when the buds of premolars and molars have moved upwards.[110]

Several postoperative complications have an uncertainty to occur such as infection, malocclusion, malunion/ nonunion (rare), damage to permanent teeth (50%), TMJ dysfunction (noise, pain, deviation, ankyloses), growth disturbances.[79,114]

Midface Fractures

Relative to the calvaria, midface is the most protected area of the child due to its retruded position in the facial skeleton. Rowe reported in his case series that the fracture of the middle third of the child consists 0.5% of all the pediatric as well as the adults.[115,116] Kaban et al. demonstrated that there were no midfacial fracture in their study consisting of 109 pediatric patients during a 10 year duration.[117] Furthermore, during the next 10 years in 184 other patients trial, only 5 midfacial injuries were encountered (only Le Fort 3).[118]

The diagnosis of midfacial fracture entirely relays on the history, physical examination and imaging techniques. Various physical findings can be encountered such as pain on palpation, facial asymmetry (particularly when examined from below or from behind), periorbital swelling, monocular or binocular ecchymosis, chemosis, enophthalamos, decreased and painful ocular mobility, diplopia, blurred vision, sensory abnormalities in the distribution of infraorbital nerve.[5] CT Scan being the gold standard in midfacial fractures of pediatric cases.[119] Plain radiographs are not advised as they are easily overlooked[66] and obscured by lack of pneumatization of sinuses with the presence of tooth buds in the mailla.[66,70,71]

Midface injuries in children compose of nasal, orbital, zygomatic complex, Le Fort type, nasoethmoidal fractures.[120] Access to the midfacial skeleton can be achieved via coronal incision and craniofacial dissection, with internal fixation done using miniplatees or microplates. Bone grafting has been proved to be successful with severely comminuted fractures and avulsed segments of bone.[121,122] Additionally, subcilliary and intaoral incisions can also be used in conjunction with esthetic coronal incision.[120]

Zygomatic Complex Fractures

The zygomatic complex fracture has the occurrence incidence of 7%-41% in pediatric patients.[123] Undisplaced fracture without any functional deficits (diplopia, sensory defects) and greenstick fracture may be treated by observation.[37] For displaced fracture, comminuted fracture, in cases of esthetic and functional impairment open reduction and internal fixation is indicated.[5] Various complications encountered are enophthalmos, facial asymmetry, paresthesia (in the distribution of the infraorbital nerve), orbital floor defects with entrapment of orbital soft tissues with or without limitation of eye movement.[5] Fracture lines in children can be accessed via the lateral upper eyelid incision (for frontozygomatic suture), lower eyelid, infra-ciliary or trans-conjunctival incision (for infraorbital rim, orbital floor), trans-oral buccal sulcus approach (for zygomatic

buttress). Intraoral and Giles temporal approach are effective for the displaced zygomatic arch fracture. Zygomatic arch fractures are commonly stable without fixation. It is approached via coronal approach in Le Fort 3 fractures. Concerns regarding growth disturbances subsequent to zygomatic fracture are fewer in literature. One point fixation at the frontozygomatic suture is sufficient, due to the shorter lever arm forces from the frontozygomatic suture to the infraorbital rim.[5,124]

Orbital Fractures, Frontal Bone Fractures And Fronto-Naso-Ethmoidal Fractures

Fronto-orbital injuries have a varying degree of incidence (2.9% -35%). Isolated orbital injury has an incidence of about 10-13%, with the involvement of floor fracture (25-58%), roof fracture (18-35%), medial wall (5-28%). Although, the site of injury is age specific. Orbital roof fracture occurs below age 7 (due to the underdeveloped sinuses), whereas the involvement of roof, floor, medial and lateral walls can be seen above age 7 in conjunction with frontal sinus fracture. Undisplaced or minimally displaced orbital roof fracture, without impairment of extraocular movement are observed (for neurosurgical consultation). ORIF is indicated in case of displaced fracture with hindrance of extraocular movements/ intracranial injury, indicating bitemporal flap.[124]

After the completion of growth basically after the age 7, open approach is suggestive in orbital reconstruction, without fearing about the growth disturbances. A transconjunctival incision with lateral canthotomy extension may be required to gain access to the floor and the lateral wall of the orbit. However, a superior blepharoplasty incision gives the access to approach the medial wall and the roof. At this age the growth pattern is not hindered by the use of titanium screws and plates. Dispite, the alloplasts (for the orbital reconstruction) have been disapproved by few authors, yet their use is contraindicated in case of allergies or intolerance only. Although, resorbable mesh, film or sheets attributes to fit in the cases of raised concerns withstanding growth still going on. These injuries must be handled in 5-7 days.[123,124]

Ample exposure can be achieved via a coronal approach (including orbital rims, zygomatic arches, nasal root). In severely disrupted sinus, the mucosa must be ablated with drainage to be pursued via ostium and nasofrontal duct (using tracheal spiral catheter).[5] Target is to restore the orbital volume, releasing the incarcerated soft tissues.[37] In frontonasoethmoidal fractures, the repositioning of the medial canthal ligament is necessary, which may be attached to the bony fragment, with or without the use of the miniplates and screws or trans-nasal wires in order to prevent telecanthus. Additionally, the calvarial bone grafts with primary stenting of nasolacrimal duct may be mandatory in severely comminuted fractures.[5]

Naso-Orbital-Ethmoidal Fractures

They are rare in children (1-8%). Although considered difficult to treat in children, it is possibly most deforming in the growing patient.[123,124] Resorbable fixation is acceptable in a case of naso-orbital-ethmoidal fracture to avoid second surgical procedure, preventing its migration and growth restriction.[124] Migration of the hardware has been reported in the growing patients. In case of traumatic telecanthus, anatomic repositioning and careful handling of soft tissue is important because canthopexy may cause abnormal child appearance.[123] The canthal ligament should be reattached in a more posterior and superior position. The treatment is acceptable to begin in 4 days.[123,124]

LE Fort Fractures

Open reduction and internal fixation is a choice for the treatment of displaced midface fractures, using plates and screws (when the damage to the tooth buds and erupting

teeth can be prevented).[37] Various incisions can be incorporated for the needful, comprising of coronal, infra-ciliary, trans-conjunctival, intraoral incisions. It is recommended to stabilize the fractured fragment via inter-maxillary fixation and suspension from zygomatic arches or from piriform aperture for 2-3 weeks.[31,69]

Nasal Fractures

Young children encounters nasal fractures (1%-45%). Nasal fractures are diagnosed over the two factors such as physical examination and the history. It can be difficult to diagnose a nasal fracture in children due to difficulty in physical examination (intranasal diagnosis with a speculum), edema may mask deviation of the nasal dorsum.[5] Refracture or osteotomy of the malunion and definitive treatment with intranasal packing and external splinting should be done if the fracture could not be identified initially due to edema. Careful anatomic reduction of nasal bones, lateral nasal cartilages, osseous and cartilaginous septum are to be attended strictly. Premature ossification of the septovomerine suture, caused due to nasal injuries and inadequately treated injuries extended till nasoethmoidal sutures are the reasons for growth disturbances.[123] Reduction of the displaced fracture segment to its anatomical form must be done in 7 days.[31] Furthermore, in contrast to the adults, surgical reconstruction is prohibited in still growing children.[5] Usually, the anatomical reduction, hemostasis and fixation are accomplished by closed reduction under general anesthesia.[37] It is recommended to give bilateral intranasal packing or splinting for 10-12 days. Bilateral intranasal packing is contraindicated in newborns, as they are primarily nasal breathers. The external splint should be changed for stabilization purpose as the facial swelling decreases. Open reduction is rarely required.[5] Pediatric nose is endangered to have soft tissue injuries due to cartilaginous detachment and septal hematoma.[123]

Complications

Complications in pediatric patients is a rare entity, due to greater osteogenic potential, faster healing rates, avoiding the necessity of open approaches for reduction and fixation for severely comminuted fractures. However, commonly the fractures are minimally or non-displaced.[5,47] Malocclusion as a complication is seen rarely. Though, it can occur for short duration of time in alveolar fracture, or due to growth abnormalities after condylar fracture. It gets corrected itself with the shedding of deciduous dentition and eruption of permanent dentition.[33,47113] TMJ ankyloses can be prevented by short period of immobilization with consecutive active mobilization thereafter.[27,28]

Conclusion

It is anticipated that the pediatric growth is a complex, integrated process consisting of multiple morphologic forces, with simultaneous interaction of displacement and remodeling displaying bone as a liquid medium. This medium permits the placement of rigid fixation with minimal consequences. Though, placement of fixed, non-resorbable plating system in the immature and growing craniomaxillofacial skeleton of children has sparkled much of a debate. Use of resorbable polymer system has revolutionized pediatric craniofacial surgery with reducing the risk of growth restriction, transcranial migration of the plates and screws. Despite its limitations of use in mandibular fracture cases, it has favorable outcomes when open reduction and internal fixation is the treatment of choice.

Declaration Of Patient Concent

The authors certify that they have obtained all the appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their/images and other clinical information to be reported in the journal. The patient(s) understand that their

name and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be granted.

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