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6 Fractures in the growing skeleton

1 Introduction

In treatment of pediatric facial fractures surgeons must not only understand how facial fractures can affect growth, but they must also be aware of the differences in treatment strategies between adults and children and among children of different age.

At birth the craniofacial ratio is 8:1 and the face is located in a recessed position relative to the large skull. The cranium and forehead effectively shield the smaller lower and middle thirds of the face from injury. By 1.5 years old, the cranium has grown to 80% of its mature size (**Fig 6-1**). Facial growth is also rapid during this period, but it is only after the second year that facial growth outpaces cranial growth. Brain and ocular growth are near completion by the age of 6 (**Fig 6-2**). Facial growth continues into the second decade of life, with a final craniofacial ratio of 2:1 (**Fig 6-3**). As a result, the cranium absorbs most of the impacting force, especially the prominent forehead overhanging the face. This disparity in facial structure explains to some degree, why young children experience more skull fractures and fewer facial fractures (including serious midfacial fractures) than adults. In children, the force necessary to cause major craniofacial disruption often results in brain injury and death.

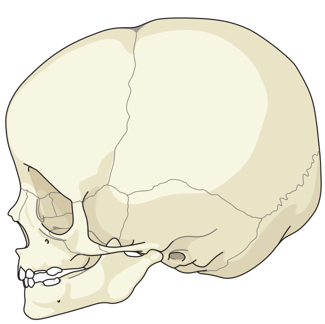

Fig 6-1 Lateral view of a 1.5-year-old child's skull. Craniofacial ratio is 6:1.

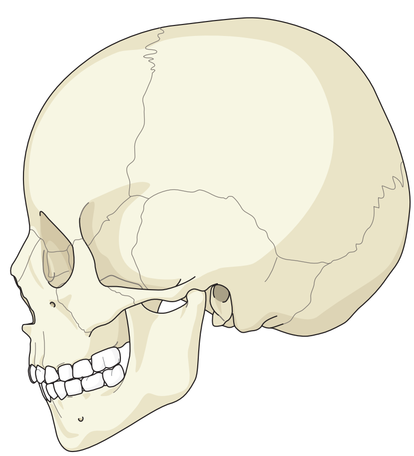

Fig 6-2 Lateral view of a 6-year-old child's skull. Brain and ocular growth are nearly completed.

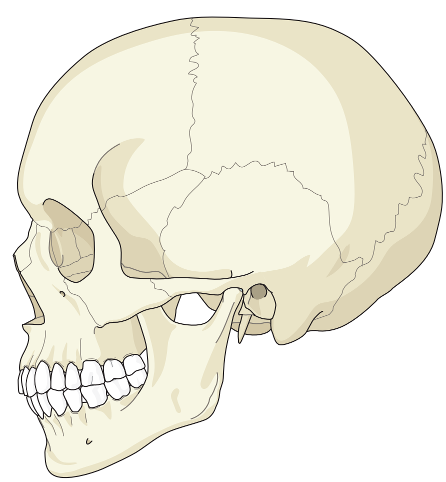

Fig 6-3 Lateral view of an adult skull. Craniofacial ratio is 2:1.

2 Facial growth and trauma

Craniofacial bone growth is a complex process that is not understood completely. The nose, nasoorbitoethmoidal (NOE) complex, and maxilla are more prone to growth abnormalities caused by trauma. This is most likely because of the minor restorative functional movement that these bones are subject to, the physiologic derangements that result from the fractures, the importance of the septum as a regional growth site, and the vulnerability of the multiple-suture sites to scar formation. These factors suggest that some basic tenets should be followed when pediatric fractures are repaired:

- Careful restoration of injured soft tissue, particularly the periosteum
- Close attention to septal injuries with an emphasis on realignment rather than resection
- Reduction of fractures into their stable anatomical locations
- Correct realignment of suture lines
- Minimal periosteal elevation
- 3-D stable fixation of complex fractures
- Use of rigidly fixed bone grafts as a substrate for growth in areas of bone loss

3 Rigid fixation

Use of rigid fixation in the developing face is a controversial topic. Fixation should be performed with caution and reserved for fractures when the original features are difficult to restore by other means (**Fig 6-4**). Although excellent for fixation, there are several drawbacks to leaving a metallic foreign material in a growing child. Resorbable osteosynthesis material is comparable in efficiency to metallic fixation material in nonload-bearing bone. At present, resorbable plates are not recommended for all types of pediatric facial fractures. The use of resorbable plates in the mandible and load-bearing bone in children is still being studied and long-term results are limited.

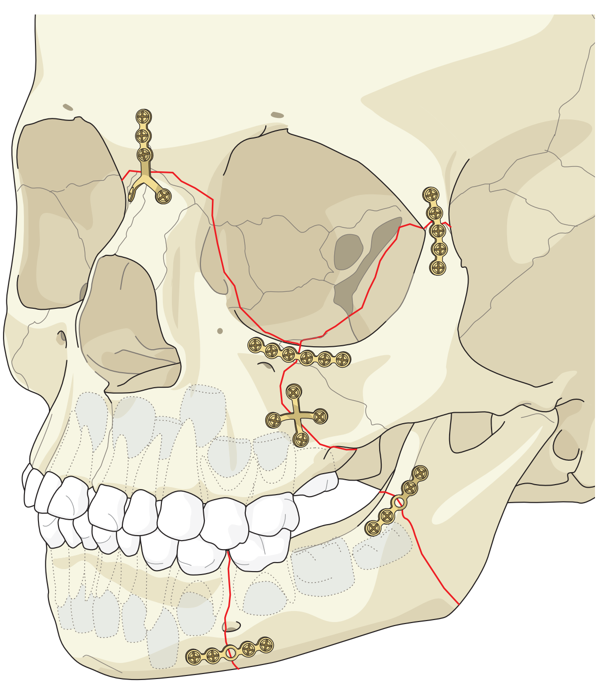

Fig 6-4 Fixation of mandibular and midfacial fractures with titanium miniplates in a 5-year-old child.

4 Mandibulomaxillary fixation (MMF)

To obtain mandibulomaxillary fixation (MMF), one must consider the age and development of the teeth. Arch bars and interdental wiring are often impractical especially in young children, who lack teeth or have poor retentive shape of the deciduous teeth. In those cases, alternative methods need to be considered. Fortunately, 2–3 weeks of mandibular immobilization in children younger than 12 years is adequate for nonoperative management.

One alternative approach for treating mandibular fractures involves using an overlay acrylic mandibular splint that is held in place by circummandibular wires.

In children between 2 and 5 years the deciduous incisors have firm roots, and if the deciduous molars have formed, they can be used for cap splints or arch bars. After age 10, the presence of permanent teeth generally provides safe anchors. However, children develop at different rates and the strength of the teeth should be carefully examined before placing any type of tooth-anchored MMF. An alternative to arch bars is the use of orthodontic brackets that are glued to the teeth.

MMF today is generally performed with elastics rather than with steel wires.

5 Surgical approaches

The entire facial skeleton can be accessed and reconstructed using a combination of six incisions. The coronal approach exposes the upper third of the face including the zygomatic arches, the lateral, medial, and superior orbital rims, and the NOE region. Orbital roof and NOE exposure can be obtained by mobilizing the supraorbital neurovascular bundle. Detaching the temporalis fascia from the lateral orbital rim and zygomatic arch reveals the bones of the entire upper face, completely from the zygomatic root on one side around to the other side. The exposure provides a means to realign and rigidly fix the frontozygomatic suture, the entire zygomatic arch, and the nasal skeleton.

The inferior orbital rims and floor can be exposed by either a subciliary, high crest lid or transconjunctival incision. The medial orbit and apex can be exposed by a transcaruncular approach. The gingivolabial sulcus approach provides access to the entire maxilla, laterally to the lower part of the zygoma, anteriorly to the infraorbital nerve, and medially up to the lacrimal fossa. The exposure provides for the reestablishment of both the lateral zygomaticomaxillary buttress and the medial nasomaxillary buttress. The lower NOE area can be exposed by a midfacial degloving incision.

The sequencing of severe midfacial fractures, especially when the mandible is fractured, is important. Reestablishing occlusion by MMF and repairing the mandible establishes a solid base for upper face reconstruction. The approach to pediatric injuries is based on the knowledge that the face is composed of component units connected by their associated buttresses and that the most prominent and most challenging esthetic unit is the NOE area. First, occlusion is established and, if necessary, the mandible is repaired. The central core is then reconstructed, followed by positioning of the orbits and the outer facial frame to the central core. In cases with severely comminuted mandibles, midface fixation can be done first, in order to use the midface as a reference for the mandible.

In children, fractures in the area of the mandibular body are mostly exposed by transoral incisions in the same fashion as in adults (see chapters 2 and 5).

6 Surgical reconstruction

6.1 Dentoalveolar fractures

When an alveolar fracture is associated with a tooth fracture or luxation, the treatment is more problematic. It can be very difficult to properly reposition the alveolar fragments, although reduction should be attempted. Prolonged periods of MMF are often required to maintain these fragments. It is sometimes helpful to stabilize the fracture with miniplates, if the bone is large enough to accept screw fixation and there is enough space to avoid injury to the healthy surrounding roots.

6.2 Fractures of the mandible

6.2.1 Condylar fractures

Most children with unilateral and some with bilateral condylar fractures will present with normal occlusion and almost normal mobility. Treatment in these patients usually consists of a soft diet and movement exercises. Children with condylar fractures who present with an open bite, mandibular retrusion, or limited movement are best treated with 2 to 3 weeks of MMF. Early and persistent movement with an elastic jaw exerciser generally prevents ankylosis and helps restore function.

The indications for an open surgical approach of pediatric condylar fractures are limited and reserved for the displacement of the condyle into the middle cranial fossa or severely displaced fractures. These are best approached with either a preauricular or a retromandibular approach, depending on the location of the fracture. Endoscopically assisted fixation via a transoral incision is another option.

6.2.2 Body fractures

MMF with elastic traction is usually adequate for nondisplaced or mildly displaced body fractures. However, if misalignment of fragments cannot be controlled in a nonsurgical manner, open reduction with internal fixation and the placement of miniplates fixed monocortically is necessary.

6.2.3 Symphyseal and parasymphyseal fractures

Fractures with minimal to moderate displacement can often be realigned with careful manual manipulation under anesthesia and immobilized with the methods described for pediatric MMF.

The decision to treat with soft diet, MMF, or open reduction and internal fixation (ORIF) should be based on the degree of disruption in the fracture, the extent of occlusion change, and associated pain. To better reduce serious displacement, ORIF of the fragments is required. Fixation is usually performed with titanium or biodegradable miniplates and screws. During screw insertion, exercise great care when placing the drill holes, to prevent injury to the developing tooth buds. Once preinjury occlusion is established, a minor degree of osseous gap at the fracture site is of less consequence in bony healing of pediatric mandibular fractures.

6.3 Midfacial fractures

Central midfacial fractures in children rarely follow the typical Le Fort patterns of injury. Significantly displaced fractures should be reduced within 10 days because of the high osteogenic potential of the periosteum. Rapid interfragmentary healing makes late reduction difficult. Acute reduction should be considered when fractures are accessible through open wounds.

6.3.1 Central midface fractures (Le Fort type)

Central midface fractures of the Le Fort type are rare, especially in small children, but they do exist (chapter 3.2 Upper midface (Le Fort II and III), **Fig 3.2-2a–b**). Similar to Le Fort-type fractures in adults, they rarely follow the pure Le Fort classification.

Le Fort-type fractures with no occlusion derangement and no severe displacement can be managed nonsurgically with a soft diet, especially in small children. Central midface fractures with severe displacement and/or disturbances of the occlusion require active treatment with open reduction and internal fixation. In these cases, the occlusion is typically secured by mandibulomaxillary fixation, frequently with arch bars or other tooth-anchored devices, for instance orthodontic brackets.

Exposure to the lower midface is done from an upper sulcus transoral incision, and exposure to the orbits and the craniofacial junction is achieved either through a craniofacial coronal approach, transfacial approaches, or combinations. After fragment reduction, internal fixation can be performed with titanium miniplates or biodegradable osteosynthesis material, according to the size of the skull and the fragments. Hardware placement is, along the facial buttresses, similar to the techniques described for adult midfacial fractures. In cases of orbital wall involvement, the orbital walls are treated as described below.

6.3.2 Zygomaticomaxillary complex fractures and zygomatic arch fractures

Zygomaticomaxillary complex fractures correspond to the maxillary sinus pneumatization and are uncommon before 5 years of age. The frontozygomatic suture tends to be weak in children and is easily displaced.

Nondisplaced or minimally displaced fractures are not treated. An elevation from a Gillie's approach, with a transcutaneous bone hook or a Carroll-Girard–type device (chapter 3.3 Zygomaticomaxillary complex fractures, zygomatic arch fractures) can reduce greenstick-type injuries, which frequently will not require internal fixation for stability. When simple reduction techniques result in unstable or nonanatomical reduction, ORIF is indicated.

Surgical correction involves adequate control of the frontozygomatic suture, the infraorbital rim, and the lateral buttresses. In simple fractures, control of the infraorbital rim and frontozygomatic suture can be accomplished with external palpation. Open visualization is only necessary for the zygomaticomaxillary buttress via an transoral gingivolabial sulcus incision.

For more complex fractures, for instance with segmentation, open visualization can be accomplished through a brow, subciliary, or transconjuctival with lateral canthotomy incision and an upper buccal sulcus incision. When reconstruction of the zygomatic arch is required, a coronal or hemicoronal approach is necessary. Once exposure is achieved, most injuries can be reconstructed by 1-point fixation of the zygomaticomaxillary buttress or by 2-point fixation with miniplates at the frontozygomatic suture, infraorbital rim, or zygomaticomaxillary suture. Severe fractures will require at least 3-point fixation (see chapter 3.3 Zygomaticomaxillary complex fractures, zygomatic arch fractures, **Fig 3.3-14**, page 217). Zygomatic arch deformities can usually be repositioned by elevating through a step, Gillie's-type, or transoral incision. When indicated, orbital floor exploration and reconstruction should be performed (chapter 3.4 Orbital fractures).

6.4 Orbital fractures

Suspected orbital trauma warrants an ophthalmologic evaluation. The extraocular musculature is tested for voluntary range of motion and, if necessary, with forced duction under anesthesia.

Orbital wall fractures in children are treated similar to orbital fractures in adults. Orbital wall reconstruction is done with titanium meshes, mesh plate, porous polyethylene, or bone grafts.

Orbital roof fractures rarely require repair. However, if ocular mobility has not improved within 7–10 days of injury, repair should be performed. Permanent exophthalmos, vertical dystopia, and encephaloceles can result from unattended fractures.

6.4.1 Orbital apex

Orbital apex injuries in children are exceedingly rare, probably because the force required is often lethal. Fractures of the apex are usually due to posterior extensions of complex craniofacial injuries. Blindness is the greatest concern, which occurs as a result of optic nerve injury and vascular injury to the ophthalmic artery. Loss of visual acuity and afferent pupil defect are the hallmark findings for an optic neuropathy. Initial treatment consists of high-dose steroids. If visual acuity is absent or does not improve, optic nerve decompression may be considered using a transphenoidal, intracranial, or endoscopic approach.

6.4.2 Orbital wall

Indications for surgical intervention after an internal orbital fracture include significant (>2 mm) enophthalmos, extraocular muscle restriction with positive forced ductions (>30º), symptomatic diplopia, and/or computed tomographic findings of large orbital wall defect. It is crucial that pseudoentrapment conditions, such as orbital soft-tissue swelling, extraocular muscle contusion, and cranial nerve injuries are distinguished from true muscular entrapment, because patients with the former condition can be observed.

Patients with a tight restriction of extraocular muscles or a true muscle incarceration are more likely to recover their ocular motility with early intervention, which is preferably administered as early as possible, ideally not later than within 48 hours, but the sooner the better.

Up to 86% of orbital roof fractures are associated with intracranial injury. The orbit and globe rarely sustain long-term damage, thus, surgery is rarely necessary. Fracture fragments that are displaced into the orbit require combined intracranial and extracranial exploration with cranial bone graft or titanium mesh reconstruction of the deficit to correct dystopia and exophthalmos, and to prevent encephaloceles.

6.5 Nasal fractures

Immediate intranasal examination is essential to evaluate for septal injury, particularly septal hematoma. When present, these injuries should be treated immediately with evacuation. In most cases, this will require general anesthesia. The use of a Killian septal incision allows for both drainage of the hematoma as well as investigation and suture reduction of any displaced septal fragments. Following exploration, the mucoperichondrial leaflet is sewn back to the cartilage with a through-and-through suture. Septal splints and packing should be used for 2–3 days, to prevent the reformation of the hematoma.

If a bony or septal fracture is present resulting in a cosmetic deformity or a fixed nasal obstruction, definitive surgical management is undertaken. Closed reduction of the bony fracture can be performed with intranasal instrumentation and bimanual external manipulation. Ideally, this is performed within a maximum of 10 days after the injury.

Greenstick fractures may not always reduce into the desired position, and they sometimes require small osteotomies for proper alignment of the fragments. If significant dislocations are present or if the injury is more than 2 weeks old, then open reduction may be necessary. The timing of open reduction is of some debate, and often waiting is the best approach.

6.5.1 Newborn nose

Infants are occasionally born with a symmetric tip deformity. They typically have a flattened nasal tip off to one side, with the septum tilted in the same direction. The bony dorsum is invariably straight. Some surgeons advocate immediate surgical reduction of these deformities by straightening and relocating the septum. However, in the authors' experience, these deformities generally straighten over time without intervention or late sequelae. It is possible that such a displacement can cause airway obstruction, and if this occurs, relocation of the septum is indicated.

6.5.2 Frontal sinus fractures

The frontal sinus is the last of the paranasal sinuses to develop in children and is, therefore, not prone to injury until adolescence. However, when such injury occurs, 70% involve the posterior table. The rate of cerebrospinal fluid (CSF) leaks is with 18% nearly twice as high as in the adult population. Management of frontal sinus fractures in children is similar to that of adults. When forehead deformity is present in an anterior table fracture, it must be reduced. The nasofrontal drainage should be investigated using both direct visualization of the sinus floor and endoscopy. Posterior table fractures require open reconstruction, and severe comminution warrants neurosurgical consultation. Most posterior fractures are associated with anterior fractures and can be repaired concurrently. The need for sinus obliteration is based on the same criteria as for adults. Long-term sequelae include cerebrospinal fluid leak, intracranial abscess, and mucopyocele formation.

Fractures of the supraorbital rim can be approached either through the extension of overlying lacerations or by coronal incision. Occasionally, a brow incision may be used, especially if a patient does not agree to coronal incision.

6.5.3 Nasoorbitoethmoidal (NOE) fractures

NOE fractures are anatomically defined as fractures of the nasofrontal suture, nasal bones, medial orbital rim, infraorbital rim, medial orbital wall, and orbital floor. This makes up "the central fragment" core of the midface. Comminution of this core determines the severity of the fracture and complexity for providing optimal cosmetic and functional results. Evaluation of the medial canthal ligaments is mandatory and best performed by inserting a hemostat in the nose up toward the medial orbital rim with the patient under anesthesia. Traumatic hypertelorism is evaluated by the intercanthal distance. The average intercanthal distance is about 25 mm at age 3, 28 mm at age 12, and 30 mm by adulthood, with great variation among individuals and ethnicities. An additional 5 mm of soft-tissue widening above the age-adjusted average is indicative of displaced fractures of the NOE complex, with 10 mm being diagnostic.

Most NOE fractures are best treated with ORIF. Although technically difficult, overcorrection of the NOE fracture is esthetically superior to undercorrection. Exposure of the nasal dorsum is best obtained using preexisting lacerations or through coronal incisions. The major fragments and the medial canthal ligaments are identified. Care is taken to preserve the attachment of the ligament to the bony insertion. Resetting the intercanthal distance is the most important step for esthetically optimal results. Interorbital growth is nearly complete by the age of 8 years. It is crucial in children to set the intercanthal distance narrower than anticipated. In medial canthal reconstruction, a drill hole is made in the anterior lacrimal crest just above the insertion of the anterior limb of the tendon. A second drill hole is made in the posterior lacrimal crest just behind the insertion point of the posterior limbs. Contralateral drill holes are made, and a 28-gauge stainless steel wire is passed transnasally between the two fragments and tightened in an effort to overcorrect the deformity. An alternative technique is to use a small screw as the anchor for the transnasal wires (chapter 3.5 Nasoorbitoethmoidal (NOE) fractures). Interfragmentary wiring is completed and, if unstable, can be further supported by plate fixation of the medial orbital rim.

The final step is reconstruction of the nasal dorsum, which often loses its support. A cantilever calvarial bone graft can be used to correct this deformity, which should be rigidly fixed to limit reabsorption. The tip of the graft should be deep to the upper border of the lower lateral cartilages.

Direct injury to the lacrimal drainage system is uncommon in NOE fractures. Nevertheless, the lacrimal sac, duct, and canaliculi should be examined, and if injured, definitive repair with stents should be performed to prevent epiphora.

7 Conclusions

Children can sustain severe craniomaxillofacial injuries that require appropriate repair. The primary factors that distinguish the treatment of pediatric and adult fractures are facial growth, a faster healing process, and a higher potential for remodeling (eg, condyle). Inadequate treatment of upper and midfacial injuries may result in serious alterations of facial growth. CT scanning, craniofacial exposure, bone grafting, and the advent of rigid fixation facilitate our ability to reconstruct the most complex 3-D disfigurements. These techniques have solid theoretic and practical applications in severe facial trauma.

8 References and suggested reading

Aizenbud D, Morrill LR, Schendel SA (2010) Midfacial trauma and facial growth: a longitudinal case study of monozygotic twins. *Am J Orthod Dentofacial Orthop;* 138(5):641–648.

Amaratunga NAS (1987) The relation of age to the immobilization period required for healing of mandibular fractures. *I Oromaxillofac Surg;* 45:111–113.

Banks P (1998) A pragmatic approach to the management of condylar fractures. *Int J Oral Maxillofac Surg;* 27(4):244–246.

Bartlett SP, DeLozier JB III (1992) Controversies in the management of pediatric facial fractures. *Clin Plast Surg;* 19(1):245– 258.

Blez P, Champy M, Klink M, et al (1992) [Fractures of the middle third of the face in children: anatomo-clinical, diagnostic and therapeutic characteristics]. *Rev Stomatol Chir Maxillofac;* 93(3):148–150. French.

Bos RR (2005) Treatment of pediatric facial fractures: the case for metallic fixation. *J Oral Maxillofac Surg;* 63(3):382–384.

Bowman MK, Mantle B, Accortt N, et al (2011) Appropriate hearing screening in the pediatric patient with head trauma. *Int J Pediatr Otorhinolaryngol;* 75(4):468–471.

Bansagi ZC, Meyer DR (2000) Internal orbital fractures in the pediatric age group: characterization and management. *Ophthalmology;* 107(5):829–836.

Champy M, Lodde JP, Muster D, et al (1977) [Osteosynthesis using miniaturized screws on plates in facial and cranial surgery. Indications and results in 400 cases]. *Ann Chir Plast;* 22(4):261–264. French.

Chao MT, Losee JE (2009) Complications in pediatric facial fractures. *Craniomaxillofac Trauma Reconstr;* 2(2):103–112.

Crockett DM, Funk GF (1991) Management of complicated fractures involving the orbits and nasoethmoid complex in young children. *Otolaryngol Clin North Am;* 24(1):119.

Demianczuk AN, Verchere C, Phillips JH (1999) The effect on facial growth of pediatric mandibular fractures. The effect on facial growth of pediatric mandibular fractures. *J Craniofac Surg;* 10(4):323–328.

Ellis E (1993) Sequencing treatment for naso-orbito-ethmoid fractures. *J Oral Maxillofac Surg;* 51:543–558.

Enlow DH (1990). *Facial Growth.* 3rd ed. Philadelphia: WB Saunders Co; 1–24.

Eppley BL (2005) Use of resorbable plates and screws in pediatric facial fractures. *J Oral Maxillofac Surg, 63(3):385–391.*

Glarner H, Meuli M, Hof E, et al (1994) Management of petrous bone fractures in children: analysis of 127 cases. *J Trauma;* 36(2):198–201.

Gassner R, Tuli T, Hächl O, et al (2004) Craniomaxillofacial trauma in children: a review of 3,385 cases with 6,060 injuries in 10 years. *J Oral Maxillofac Surg;* 62(4):399–407. Review.

Goth S, Sawatari Y, Peleg M (2012) Management of pediatric mandible fractures. *J Craniofac Surg;* 23(1):47–56.

Grunwaldt L, Smith DM, Zuckerbraun NS, et al (2011) Pediatric facial fractures: demographics, injury patterns, and associated injuries in 772 consecutive patients. *Plast Reconstr Surg;* 128(6):1263–1271.

Graham S, Thomas R, Carter K, et al (2002) The transcaruncular approach to the medorbital wall. *Laryngoscope;* 112:986–989.

Gussack GS, Lutterman A, Rodgers K, et al (1987) Pediatric maxillofacial trauma: unique features in diagnosis and treatment. *Laryngoscope;* 97:925–930.

Hardt , Gottsauner A (1993) The treatment of mandibular fractures in children. *J Craniomaxillofac Surg;* 21(5):214–219.

Haug RH, Cunningham LL, Brandt MT (2003) Plates, screws, and children: their relationship in craniomaxillofacial trauma. *J Long Term Eff Med Implants;*13(4):271–287.

Holan G (1998) Traumatic injuries to the chin: a survey in a paediatric dental practice. *Int J Paediatr Dent:8(2):143–148.*

Hurt TL, Fisher B, Peterson BM, et al (1988) Mandibular fractures in association with chin trauma in pediatric patients. *Pediatr Emerg Care;* 4(2):121–123.

Iizuka T, Thorén H, Annino DJ Jr, et al (1995) Midfacial fractures in pediatric patients. Frequency, characteristics, and causes. *Arch Otolaryngol Head Neck Surg;* 121(12):1366–1371.

Imola MJ, Hamlar DD, Shao W, et al (2001) Resorbable plate fixation I pediatric craniofacial surgery: long-term outcome. *Arch Facial Plast Surg;* 3(2):79–90.

James D (1985) Maxillofacial injuries in children. *Rowe NL, Williams JL (eds), Maxillofacial Injuries.* Edinburgh: Churchill Livingstone.

Kaban LB (1993) Diagnosis and treatment of fractures of the facial bones in children 1943-1993. *J Oral Maxillofac;* 51(7):722–729. Review.

Koltai PJ, Amjad I, Meyer D, et al (1995) Orbital fractures in children. *Arch Otolaryngol Head Neck Surg;* 121(12):1375–1379.

Koltai PJ, Rabkin D (1996) Management of facial trauma in children. *Pediatr Clin North Am;* 43(6):1253–75. Review.

Koltai PJ, Rabkin D, Hoehn J (1995) Rigid fixation of facial fractures in children. *J Cranio Maxillo Trauma;* 1(2):32–42.

Kumar AV, Staffenberg DA, Petronio JA, et al (1997) Bioabsorbable plates and screws in pediatric craniofacial surgery: a review of 22 cases. *J Craniofac Surg;* 8(2):97–99.

Lee CY, McCullon C III, Blaustein DI, et al (1993) Sequelae of unrecognized, untreated mandibular condylar fractures in the pediatric patient. *Ann Dent;* 52(1):5–8.

Liau JY, Woodlief J, van Aalst JA (2011) Pediatric nasoorbitoethmoid fractures. *J Craniofac Surg;*22(5):1834–1838. Review.

Lund K (1974) Mandibular growth and remodeling processes after condylar fracture: a longitudinal roentgen cephalometric study. *Acta Odontol Scand;* 32(suppl 64):3–117.

Mast G, Ehrenfeld M, Cornelius CP (2012) [Maxillofacial fractures: midface and internal orbit; Part 2: therapeutic options]. *Unfallchirurg;* 115(2):145–164. German.

Messinger A, Radkowski MA, Greenwald MJ, et al (1989) Orbital roof fractures in the pediatric population. *Plast Reconstr Surg;* 84(2):213–216; discussion 217–218.

Messinger A, Radkowski MA, Greenwald MJ, et al (1989) Orbital roof fractures in the pediatric population. *Plast Reconstr Surg;* 84(2):213–216.

Morlin JD, Hill JC, Anderson JE, et al (1963) A study of growth of growth in the interorbital region. *Am J Ophtalmol;* 56:895–901.

Nowinski D, Di Rocco F, Roujeau T, et al (2010) Complex pediatric orbital fractures combined with traumatic brain injury: treatment and follow-up. *J Craniofac Surg;* 21(4):1054–1059.

Parker MG, Lehman JA (1989) Management of facial fractures in children. *Perspect Plast Sur;*g 3:1.

Paskert JP, Manson PN, Iliff NT (1988) Nasoethmoidal and orbital fractures. *Clin Plast Surg;* 15:209–223.

Perheentupa U, Kinnunen I, Grénman R, et al (2010) Management and outcome of pediatric skull base fractures. *Int J Pediatr Otorhinolaryngol;* 74(11):1245–1250.

Polayes IM (1989). Facial fractures in the pediatric patient. *Habal M, Aryan S (eds), Facial Fractures.* Philadelphia: BC Decker, 257–288.

Posnick JC, Wells M, Pron GE (1993) Pediatric facial fractures: evolving patterns of treatment. *J Oral Maxillofac Surg;* 51(8):836–844; discussion 844–845.

Reedy BK, Bartlett SP (1997) Pediatric facial fractures. *Bentz MI (ed), Pediatric Plastic Surgery.* Stamford, Conn: Appleton-Lange, 463–486.

Regev E, Zeltser R, Shteyer A (2002) [The overlooked chin trauma in children]. *Refuat Hapeh Vehashinayim:* 9(2):56–61, 79. Hebrew.

Schaller B, Hosokawa S, Büttner J, et al (2011) Occurrence, types and severity of associated injuries of paediatric patients with fractures of the frontal skull base. *J Craniomaxillofac Surg.* Nov. 9. [Epub ahead of print].

Schweinfurth J, Koltai PJ (1998) Pediatric mandibular fractures. *Facial Plast Surg;* 14(1):31–44.

Shumrick KA, Kersten RC, Kulwin DR, et al (1992) Extended access/internal approaches for the management of facial trauma. *Arch Otolaryngol Head Neck Surg;* 118:1105–1112.

Siy RW, Brown RH, Koshy JC, et al (2011) General management considerations in pediatric facial fractures. *J Craniofac Surg;* 22(4):1190–1195. Review.

Stolsted P, Schonsted-Madsen V (1979) Traumatology of the newborn's nose. *Rhinolaryngology;* 17:77.

Thorén H, Schaller B, Suominen AL, et al (2012) Occurrence and severity of concomitant injuries in other areas than the face in children with mandibular and midfacial fractures. *J Oral Maxillofac Surg;* 70(1):92–96.

Thorén H, Seto I, Büttner M, et al (2011) Patterns of frontobasal and frontosinal fractures in children and teenagers relative to developmental stage of the facial skeleton. *Arch Otolaryngol Head Neck Surg;* 137(6):549–556.

Wheeler J, Phillips J (2011) Pediatric facial fractures and potential long-term growth disturbances. *Craniomaxillofac Trauma Reconstr;* 4(1):43–52.

Williams WT, Ghorayeb BY, Yeakley JW (1992) Pediatric temporal bone fractures. *Laryngoscope;* 102(6):600–603.

Wright DL, Hoffman HT, Hoyt DB (1992) Frontal sinus fractures in the pediatric population. *Laryngoscope;* 102:1216–1219.

Wright RJ, Murakami CS, Ambro BT (2011) Pediatric nasal injuries and management. *Facial Plast Surg;* 27(5):483–490.

Yaremchuk MJ, Fiala TG, Barker F, et al (1994) The effects of rigid fixation on craniofacial growth of rhesus monkeys. *Plast Reconstr Surg;* 93:1–10.

Zimmermann CE, Troulis MJ, Kaban LB (2006) Pediatric facial fractures: recent advances in prevention, diagnosis and management. *Int J Oral Maxillofac Surg;* 35(1):2–13. Review.

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