Pediatric Craniofacial Trauma: Challenging Pediatric Cases—Craniofacial Trauma

Craig R. Dufresne, M.D., F.A.C.S., F.I.C.S.,¹ and Paul N. Manson, M.D., F.A.C.S.²

ABSTRACT

The pediatric population, as well as the adult population, is subject to similar injuries and traumatic events involving the craniofacial skeleton. Although less frequent than adult injuries, the craniofacial injuries sustained by children are considered separately in textbooks and the literature because of the special unique problems associated with their treatment and the effects they might have on growth and development that can arise as a result of their management. Some of the more challenging cases that I have seen involve the very young with cranial bone fractures and cranial base fractures and those that involve the nasal and/or orbital-ethmoidal areas in young children and their secondary reconstruction. Some of these types of cases are not always clearly and thoroughly addressed in textbooks or articles because of their infrequent occurrence. Often, surgeons differ in approaches to treatment because of certain anatomic or physiological factors specifically related to childhood, facial growth, and the timing of treatment. Some of the cranial and facial developmental malformations seen in older children or adults can be attributed to trauma sustained in early childhood. This is because trauma may have a deleterious effect on the growth and development of facial structures in the postnatal life similar to that seen resulting from a genetic mutation.

KEYWORDS: Pediatric, craniofacial, trauma

Prenatal and birth injuries to the cranium are rare, but do occur. They can be due to intrauterine compression, prolonged difficult delivery as the infant passes through the birth canal, or obstetric forceps or suction-assisted delivery techniques. All have been implicated as the cause of some postnatal deformities, but usually the injuries are minimal and recovery takes place without residual deformity. When the injuries are more extensive or do not resolve, the patients who have residual contour deformities are sent to the craniofacial surgeon for evaluation. Many of these contour deformities are the result of subgaleal or subperiosteal hematomas that are not resorbed and ossify. On computed

tomography (CT), there can appear to be a duplicated cranial vault. They often take years to remodel and some have to be recontoured if they persist as aesthetic deformity (Figs. 1A–1C).

When the delivery is a particularly traumatic one, cranial fractures can occur. As a potential consequence, an unusual phenomenon called “pseudo-growth” of the skull fracture may occur in some children. This skull fracture radiologically and clinically seems to enlarge slowly over a period of 1 to 6 months after the fracture has occurred. A palpable bone defect with protrusion of the meninges develops as the dura separates. In some patients, the defect is large enough

¹Georgetown University and Medical Center, Chevy Chase, Maryland;
²Division of Plastic Surgery, The Johns Hopkins University, Baltimore, Maryland.

Address for correspondence and reprint requests: Craig R. Dufresne, M.D., F.A.C.S., F.I.C.S., 5530 Wisconsin Avenue, Suite #1235, Chevy Chase, MD 20815 (e-mail: drdufresne@cdufresnemd.com).

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Figure 1 (A–C) This infant sustained a difficult delivery with forceps resulting in a subgaleal hematoma that has resulted in a duplication of the diploe and thickening of the skull.

to require bone grafting. In other patients, the pseudo-growth of the skull can be seen on radiological studies (Fig. 2A, 2B). In other cases, the defect is small or very limited and may not always be identifiable clinically but can be noted by palpation. Radiographic appearances, however, are not always a guide to treatment. It is the clinical examination of the integrity of the skull that dictates the need for calvarial reconstruction. Some deformity is due to a dural laceration with expansion of the remainder of the meninges and brain through the dural defect with pressure causing bone resorption. Surgical repair requires at least dural repair and possibly bone reconstruction depending upon the age of the patient.^{1,2} Once the patient is over a year old, the efficiency of periosteal reformation of the bone is less predictable. In these cases, bone grafting is required. The use of absorbable plates and screws allows less negative influence on the healing of the reconstructed site and less potential deformity.^{3,4} Some authors recommend routine radiological follow-up 1 year after any skull fracture to document the appearance of the pseudogrowth defect.^{1,2}

Havlik et al reviewed their experience and found an incidence of 0.6 to 2% of skull fractures.¹ The contributing factors were a craniofacial bone defect, a dural tear, and expanding extracranial process, which could be either growth or a condition, such as hydrocephalus. All of the children seen in their

series with this problem were 2 years of age or younger.^{1,2,5}

SUPRAORBITAL FRACTURES

Supraorbital fractures are those that involve the superior portion of the orbital rim and orbital roof. These range from small fragments that are localized to the orbital rim to more extensive fractures that can simultaneously involve the lateral frontal bone and temporal bone. The diagnosis of supraorbital fracture is made by identifying a depression, step-off, or discrepancy in the contour of the supraorbital rim. The depression of the roof pushes the orbital globe both inferiorly and anteriorly, creating an exophthalmos and inferior globe displacement. If there is paralysis of the levator muscle, a partial or complete ptosis may be created (Fig. 3). If the patient is unable to rotate the eye upward, it may be due to direct muscle contusion or involvement of the motor nerves in the superior orbital fissure.^{6,7} A severe fracture that extends into the superior orbital fissure may produce superior orbital fissure syndrome. The syndrome produces paralysis of all the extraocular muscles, complete ptosis, and anesthesia in the ophthalmic division of the trigeminal nerve. If the fractures extend to the optic foramen, then orbital apex syndrome results in the superior orbital fissure syndrome and blindness.⁵⁻⁸

Figure 2 Fractures resulting in pseudogrowth are often seen long after the injury and result in the need for surgical correction with repair of the fracture, repair of the dural tears, and grafting of the bone (A, B). The defect is prevented from healing by the dural tears with herniation of the meninges (C).

A craniofacial CT scan is used to evaluate the brain and orbital region for the exact determination of the frontal and orbital fracture pattern and the displacements. Treatment is performed through an open reduction and fixation, often through a coronal incision, but if the fracture pattern is limited, then it might be done through an existing laceration. A more open exposure is more often needed to evacuate for epidural hematomas, repair fracture segments, brain injury, or dural lacerations.

A thorough visual screening examination should be performed whenever an orbital fracture or globe

injury is suspected. The basis screening consists of evaluation of the visual acuity, confrontation fields, extraocular motion, pupil size and reactivity, evaluation of diplopia, and examination of the anterior and posterior chambers.^{5,6}

NASO-ORBITAL-ETHMOIDAL FRACTURES

Another area where significant challenging problems occur is at the frontal cranial region involving the naso-orbital-ethmoidal (NOE) areas of the skull. The

portions of the face change markedly during the period of postnatal growth. The skull at birth represents relatively large cranial portion and a small facial component compared with that of an adult skull. The cranial to facial proportions are 8:1 at birth, but they fall to 4:1 by 5 years of age and 2:1 in the adult. These changes are due to two factors: the natural actual growth of the face and a modification of proportions, which brings forth charac-

teristics distinguishing the adult faces of men and women from the younger persons to establish adult individual features.^{9,10}

The children's craniofacial skeleton is distinguished from adults in that the nose and sinuses are essentially a single structure with the sinuses being small or absent. The ethmoid and maxillary sinuses begin to invaginate from the nasal cavity during the

Figure 3 An 18-month-old child who fell from a second story landing, striking his frontal orbital area and sustaining a frontal orbital fracture with proptosis and inferior displacement of the globe (A). Computed tomography scans (B, C) reveal the clinical findings as demonstrated by the artist diagram (D).

Figure 3 (Continued) Correction required a bicoronal incision, repair of dural lacerations, and reduction and fixation of orbital and frontal fractures (E, F). Final postoperative picture, 1 year later (G).

Figure 4 (A–C) This 20-month-old child was noted to have flattening of the nasal pyramid and severe telecanthus.

second trimester. They first present as separate recesses, with the ethmoid sinuses later growing into a honeycomb cluster of cells. The growth of the maxillary sinus parallels that of the face. The maxillary sinuses are narrow in the newborn and not sufficiently developed in the area beneath the orbit. The sinuses grow slowly and increase in size and become large after the age of 5 years.^{1,5}

Following an injury to the upper facial area, clinical examination of the child is often difficult. Pediatric patients are frequently unable or unwilling to provide a history and the parents may or may not be present to provide additional detailed information. The children are often uncooperative and become easily frightened and apprehensive. In some cases, there may not be a history of trauma to the child, but one can see telltale signs of a significant

previous injury on physical examination and CT scans (Figs. 4, 5).

The clinical examination consists of an orderly inspection of all facial areas, including observation, palpation, and a functional examination. Areas in which lacerations or bruises are present are identified. The specific areas are inspected. Frequently, an underlying fracture is present. An orderly palpation of all bone surfaces should be performed by beginning in the skull and forehead areas; the rims of the orbits and nose are palpated to identify any evidence of tenderness, irregularity, "step" or "level" discrepancies in the surface bone structure. Crepitus may be present particularly over nasal or orbital rim fractures. The examination is continued over the zygomatic arches, the cheeks, and the surface of the mandible. An intraoral examination is performed to demonstrate

Figure 5 (A–D) Computed tomography scans of the child in Fig. 4 reveal untreated naso-orbital-ethmoidal fractures with displacement of the nasal pyramid and telescoping of the ethmoid sinus and fractures involving the orbital roofs.

Figure 6 A 14-year-old boy struck the dashboard of a car in a motor vehicle accident. He sustained a severe naso-orbital-ethmoidal (NOE) fracture with collapse of the nasal structures (A–C). After open reduction and internal fixation of the NOE fracture, primary bone grafting to the nasal bridge was performed in a “cantilever” fashion (D–H). (Reprinted with permission from Dufresne CR, Manson PN. Pediatric facial injuries. In: Mathes J, ed. Plastic Surgery. Philadelphia: W.B. Saunders; 2005:435.⁵⁾

Figure 6 (Continued)

loose teeth and to identify intraoral lacerations or hematomas. Lateral pressure on the mandible and maxillary dental arches is necessary to determine the instability or pain in fractures involving the midline of the mandible and/or maxilla.

The clarity of imaging on computerized CT has improved the radiological diagnosis of mid- and upper-facial fractures and has replaced the use of plain films. Fractures of the frontal area, orbit, and maxilla are precisely demonstrated, although the examination may require sedation in young children. In addition, concomitant brain injury can be evaluated by combining facial and cranial CT scans in a single examination. However, “greenstick” and nondisplaced fractures are not as easily identified in CT scans.

NOE fractures often result from a severe direct blow to the frontal, glabellar, or upper-nasal region or accompany frontal bone or high Le Fort II or III fractures. The nasal components of NOE fracture are pushed backward posteriorly into the interorbital space along the medial orbital rims and walls. NOE fractures are characterized by retrusion and flattening of the nasal pyramid and increased columella-lip angle with loss of distal septal nasal support. Telecanthus also exists because the fractures also involve the medial portion of the

orbital rims and extend into the ethmoid sinuses, orbital floors, and medial portions of the infraorbital rims on one or both sides (Fig. 6A to 6D).^{11–13}

The most important principles in the treatment of NOE fractures are to restore proper projection, width, and height of the affected structures both in the acute setting as well as in the secondary reconstructions. The key initial step is to restore the proper intercanthal distance by a transnasal reduction of the medial orbital rims. The transnasal wires are placed through bone behind the canthal ligament on the posterior edge of the medial orbital rim fragments above and behind the lacrimal fossa and led to the other side so that the distance between the medial orbital rims is limited by the tightening of the two wires. Bone grafts are often used to reconstitute the nasal height, improve the aesthetic appearance, and support the distal septal structures. These are fixed to the frontal bone in a cantilever fashion.^{5,11–13}

In secondary procedures, the same principles apply; however, they are often more challenging. Often, soft tissue contraction, loss of bony support, and failure to obtain adequate correction will result in an unsatisfactory result. Additional bone grafting around the orbital and nasal region is required to obtain the necessary support and contour correction to restore facial harmony (Fig. 7).

Figure 7 (A) Preinjury photo of a 17-year-old girl. At 18 years of age, she sustained a naso-orbital-ethmoidal injury and was primarily reconstructed (B–E).

Figure 7 (Continued) However, the corrections did not achieve the desired result when compared with her preinjury appearance. Correction required releasing the soft tissue scars and bone grafting the orbital and nasal structures, thereby correcting the enophthalmos and loss of nasal projection (F–H).

CONCLUSION

As we develop a better understanding of the treatment of these unique injuries, we can develop management protocols that permit the best outcome and at the same time prevent or avoid the potential for further deformity or secondary growth disturbances.

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