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Pediatric Midface Fractures: Outcomes and Complications of 218 Patients

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Objective: To analyze management, outcomes, and complications of pediatric midface fractures.

Methods: Retrospective cohort study at an urban, single-institution, multispecialty surgical teams, at two level 1 pediatric trauma centers. Query included subjects aged 0–17 diagnosed with midface fractures between 2012 and 2016.

Results: A total of 218 pediatric patients presented with 410 total midface fractures. The most common etiologies included motor vehicle collisions (MVC) (n = 56, 25.7%), sport-related (n = 35, 16.1%), and assault/battery (n = 32, 14.7%). Fracture site distribution included: 125 maxillary (34 with exclusively the nasal/frontal process), 109 nasal, 47 ethmoid, 40 sphenoid, 33 zygoma, 29 frontal sinus, 21 lacrimal, and 6 palatal. Among these, there were 105 orbital, 17 naso-orbito-ethmoid, and 12 Le Fort fractures. One-quarter of patients received at least one midface-related operation during the initial encounter. Operative intervention rates for specific midface fracture subsites were not significantly different (X^2 = 6.827, P = .234). One hundred thirty-five patients (63.4%) attended follow-up, thus known complication rate was 14.6% (n = 31). Complication rates between midface fracture subsites were not significantly different (X^2 = 5.629, P = .229). Complications included facial deformity (n = 18), nasal airway obstruction (n = 8), diplopia (n = 4), hardware-related pain (n = 3), and paresthesias (n = 3).

Conclusions: The most common sites of pediatric midface fractures involved the maxilla, and nasal bones. Three quarters of pediatric midface fractures were treated conservatively, with low rates of complications. Facial deformity was the most common complication; as such, proper management and follow-up are important to ensure normal growth and development of the pediatric facial skeleton.

Key Words: Pediatric, trauma, midface, complications.
Level of Evidence: 4

INTRODUCTION

Pediatric facial fractures can cause lifelong irreversible impairment in function and cosmesis.[1] Fortunately, pediatric facial fractures occur much less frequently than in adults and comprise only 15% of all facial fractures in the United States.[2] This is in part due to the pediatric skeleton's higher resilience to traumatic forces, attributable to its higher elasticity, higher cancellous to cortical bone proportion, and thicker overlying soft tissue and fat.[3]

Pediatric midface fractures tend to require a more interdisciplinary approach, not infrequently involving evaluation and treatment from our neurosurgical and ophthalmology colleagues in the setting of skull base or orbital involvement. Severe midface fractures have been shown to produce very high incidences of subsequent deformities.[4] Furthermore, pediatric patients presenting with midface fractures are statistically associated with increased rates of intubation compared to other polytrauma fracture patterns,[5] thereby incurring a greater expense in the health care system. Despite the potential severity of pediatric midface fractures, there exists a paucity of literature specifically investigating this subset of trauma patients.

To our knowledge, this study represents the largest single institution cohort study in the United States for pediatric midface fractures in the literature. The goal of this study was to retrospectively analyze management, outcomes, and complications of pediatric midface fractures at our institution. We hypothesize that conservative management is favored for most pediatric midface fractures. However, the risk of facial deformity is substantial with midface fractures and may ultimately require revision surgeries to improve function and/or cosmesis. Therefore, these patients require regular and long-term surveillance to address any potential sequela of the injury or surgery received.

METHODS

This was an institutional review board (IRB) approved, single-institution retrospective cohort study at two level 1 trauma centers. Inclusion criteria were 1) the *International*

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Classification of Diseases, Ninth Revision (ICD-9) codes 802.0–802.7, or the *International Classification of Diseases, Tenth Revision* (ICD-10) code S02.2, S02.3, S02.4, 2) ages 0–17 at time of presentation, and 3) occurring between 2012 and 2016. At our institution, multiple surgical specialty teams treat pediatric midface fractures, including otolaryngology, plastic surgery, oculoplastic surgery, and oral maxillofacial surgery.

Data extracted from the electronic medical record included basic demographics, mechanisms, operations, complications, and follow-up. All imaging was reviewed. Fractures were categorized according to AO CMF Midface Fracture Classifications[6] in addition to categorization of sinus fractures when applicable. Each subject could be classified as having each fracture type only once. Le Fort fracture classification was considered for each unilateral face, as so-called "hemi-Lefort" fractures. To demonstrate, bilateral Le Fort II fractures were classified as two fractures. Septal fractures were unreliably diagnosed by imaging and examination and thus were not included within the data collection. Statistical analysis was performed using chi-squared tests using Microsoft Excel (Microsoft Corporation, Redmond, WA).

RESULTS

A total of 218 pediatric subjects with midface fractures were evaluated at our institution between 2012 and 2016. There was a male predominance at 65% (see Table I). The average age was 11.5 years (SD = 5.2), with 56.0% of the subjects being teenagers (n = 122). The most common mechanisms of injury overall included MVC (25.7%, n = 56), sport-related (16.1%, n = 35), assault/battery (14.7%, n = 32), and falls (10.1%, n = 22, see Table II). The most common mechanisms of injury by age were falls for patients 0–6.99 years (28.6%, n = 14), MVC for patients 7–12.99 years (31.9%, n = 15), and assault/battery for patients 13–17.99 years (23.8%, n = 29, see Fig. 1).

The vast majority of patients (n = 212, 97% of total) received computed tomography (CT) Maxillofacial scans. Five of these received both CT and X-ray of the face. Six patients received X-ray only, and all of these had isolated nasal bone fractures only.

TABLE I.
Subject Demographics.

Demographic	Number of Subjects	Percentage of Total
Sex		
Male	142	65.1
Female	76	34.9
Age		
0–6.99	49	22.48
7–12.99	47	21.56
13–17.99	122	55.96
Race		
Caucasian	147	67.4
African-American	54	24.8
Hispanic	12	5.5
Other/unknown	5	2.3

TABLE II.
Midface Fracture Mechanisms.

Mechanism	Number of Subjects	Percentage of Subjects
Motor vehicle collision	56	25.7
Sport-related	35	16.1
Assault/battery	32	14.7
Fall	22	10.1
Motorcycle/moped/ All-terrain vehicle	20	9.2
Pedestrian struck	18	8.3
Other blunt	14	6.4
Bicycle	11	5.0
Animal-related	7	3.2
Gunshot wound	3	1.4

There was a total of 410 midface fracture sites in our pediatric population (see Table III), with 45.4% (n = 99) of subjects having two or more different types of midface fractures and 20.2% (n = 44) with three or more different types. Fractures of the maxilla and nasal bone were most common and similarly distributed, represented by 30.5% and 26.6% of subjects, respectively. Ethmoid, sphenoid, zygoma, frontal sinus, and lacrimal fractures were less common, ranging 5.1–11.5% each. Palatoalveolar fractures were the least common (1.5%). Separate from the 410 total midface fractures were the following named combination fractures: 105 orbit, 17 naso-orbito-ethmoid (NOE), 2 Le Fort I, 9 Le Fort II, and 1 Le Fort III fractures.

Five subjects were pronounced deceased during hospitalization, and each of these subjects had at least four different types of midface fractures. The only patient with a Le Fort III fracture died from their injuries.

Overall, 25.2% of subjects (n = 55) initially received at least one type of midface-related operative intervention. The other 74.8% of subjects (n = 163) were treated nonoperatively. Rates of operative intervention for nasal bone, maxilla, zygoma, ethmoid, sphenoid, and frontal fracture subsites were not significantly different (X^2 [5, n = 383] = 6.827, P = .234). However, patients with two or more different fractures were significantly more likely to receive an operative intervention compared to patients with only one fracture subsite (35.4% vs. 16.8%, X^2 [1, n = 218] = 9.854, P = .002).

Of operative cases (n = 55), 49.1% (n = 27) had hardware placement via open reduction and internal fixation (ORIF) and/or orbital reconstruction with an implant. Closed reduction alone accounted for 30.9% (n = 17) of cases, 15 of which were for fractures of the nasal bone and/or nasal/frontal process of the maxilla. Figure 2 illustrates management by age. Although not statistically significant, patients age 0–6.99 and 7–12.99 years had higher rates of ORIF and/or orbital reconstruction compared to patients age 13–17.99 (16.3%, 17.0%, and 9.0%, respectively).

Of the 27 patients who received implanted hardware, three received resorbable hardware and six had the

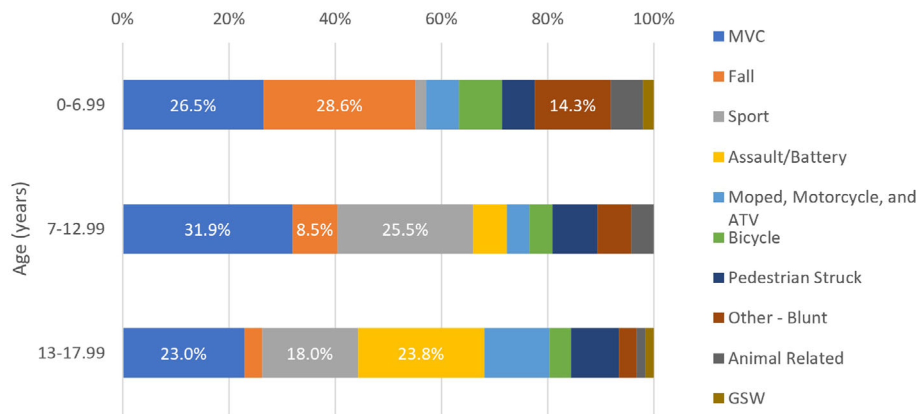

Fig. 1. Mechanisms of injury by age.

TABLE III.
Total Fractures by Site Involvement.

Fracture Site	Number of Fractures	Percentage of Fractures
Maxilla*	125	30.5
Nasal	109	26.6
Ethmoid	47	11.5
Sphenoid	40	9.8
Zygoma	33	8.0
Frontal sinus	29	7.1
Lacrimal	21	5.1
Palatoalveolar	6	1.5
Additional classifications		
Orbit	105	N/A^
Naso-orbital-ethmoid	17	N/A^
Le Fort I	2	N/A^
Le Fort II	9	N/A^
Le Fort III	1	N/A^

*34 of the maxilla fractures were of the nasal/frontal process of the maxilla alone without sinus involvement.

^These additional classifications are not considered a subset of exclusively midface fractures.

hardware later removed. Operations for hardware removal were an average of 289 days (SD = 250 days) after original. Two subjects had planned removal of hardware at 63 and 78 days postoperatively. The other four subjects required removal after experiencing hardware-related pain, a non-healing wound, or concern for bone hypoplasia.

Excluding the five deceased patients, 63.4% (n = 135) of all patients followed-up in clinic. The average follow-up length for these patients was 841.5 days (SD = 668 days), and the known complication rate was 14.6% (n = 31) for the total subject population. Complication rates did not differ significantly between the three age groups (X^2 [2, n = 218] = 0.851, P = .653). Patients with three or more fractures were significantly more likely to experience complications compared to patients with one fracture (33.3% vs. 8.4%, X^2 [1, n = 158] = 14.677, P = .0001) or two fractures (33.3% vs. 14.5%, X^2 [1, n = 94] = 4.643, P = .031). Reported complications (see Table IV) were most often found with fractures of the nasal bone, zygoma, maxilla, frontal sinus, and palate. However, rates of complications between these midface fracture subsites were not significantly different (X^2 [4, n = 287] = 5.629, P = .229). Facial deformity was the most frequently reported complication (n = 18). These included nasal deformity (n = 9), maxillary hypoplasia with facial asymmetry (n = 3), upper lip contour irregularity (n = 1), upper lip scar (n = 1), lower eyelid retraction (n = 1), tattooing of skin secondary to embedded tissue (n = 1), contour irregularity caused by hardware itself (n = 1), and facial nerve paralysis (n = 1).

Of patients with initial operations, 36.4% (n = 20) experienced complications and 20.0% (n = 11) required additional or revisional surgeries. Of patients initially

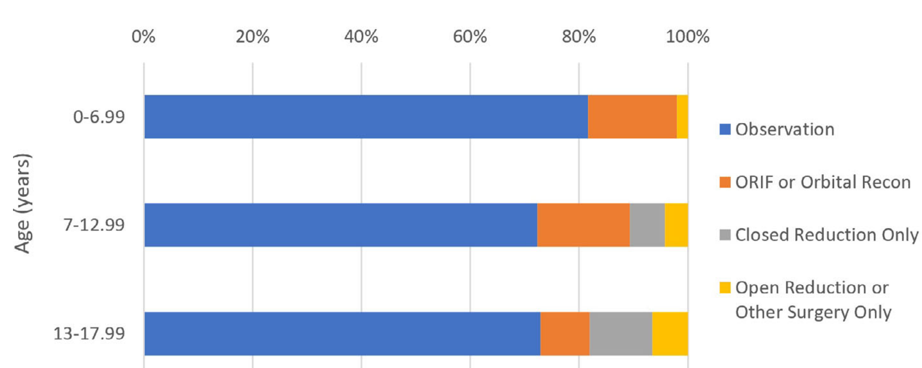

Fig. 2. Management by age.

TABLE IV.
Reported Complications.

Complication	Frequency	Associated Fracture(s)
Facial deformity	18	Nasal bone, maxilla, palate, zygoma, frontal sinus (orbit, naso-orbito-ethmoid, Le Fort I, Le Fort II)
Nasal airway obstruction	8	Nasal, maxilla
Diplopia/gaze deficits	4	Maxilla, zygoma (orbit, Le Fort II)
Hardware-related pain	3	Frontal sinus, orbit
Paresthesias	3	Zygoma, maxilla, nasal (orbit, Le Fort II)
Sinusitis	2	Maxilla
Pain not related to hardware	2	Nasal, zygoma, maxilla (orbit)
Residual foreign body	2	Frontal sinus (orbit)
Optic neuropathy	2	Maxilla (orbit)
Facial nerve paralysis	1	Zygoma (Le Fort II)
Supratrochlear neuroma	1	Frontal sinus
Intermittent epistaxis	1	Nasal
Intermittent swelling near frontal sinus	1	Frontal sinus
Retinopathy	1	Frontal sinus (orbit)
Retinal detachment	1	Maxilla (orbit)
Cataract	1	Maxilla (orbit)
Orbital cellulitis	1	Maxilla (orbit)
Persistent drainage from eye	1	Maxilla (orbit)
Decreased tear duct function	1	Maxilla (orbit)

treated conservatively, 7.0% (n = 11) experienced complications and 2.5% (n = 4) eventually required surgery. Indications for this included nasal obstruction, diplopia, and cataract development—all of which were performed in teenaged patients.

DISCUSSION

The incidence of pediatric midface fractures among maxillofacial trauma as a whole remains low.[7] First, the midface is shielded from the more prominent surrounding structures—the mandible and cranial skeleton.[8] Second, central to any discussion regarding midface trauma is the significance of paranasal sinus development. It is thought that the incomplete pneumatization of the maxillary sinuses and unerupted dentition provide additional strength to the maxilla. As such, maxillary fractures largely occur only after the age of 5 as the maxillary sinuses expand and permanent teeth erupt.[9]

Excluding the fractures of the nasal bone and nasal process of the maxilla, maxillary fractures were the most commonly occurring fracture in our study (n = 91). In comparison, there were significantly fewer zygoma fractures (n = 33). This is in contrast to previous studies, which reported higher rates of zygoma than maxillary fractures.[10–14] The reasons for this discrepancy are likely multifactorial. The most significant difference is in nomenclature. In previous studies, there was consolidation of maxillary fractures into orbital floor fractures,[13] zygomaticomaxillary complex fractures,[14] or Lefort fractures[11] instead of as their own separate entity. Additionally, 97% of subjects received CT maxillofacial studies in their evaluation, which may indicate higher sensitivity of fracture diagnosis within the midface than previously possible in older studies.

In any study on pediatric facial trauma, it is important to consider the complex developmental and sociocultural differences across age groups and countries. For instance, young children are most prone to falls, whereas older children are more susceptible to assault as they develop more adult behaviors.[10] Additionally, etiology of pediatric facial trauma varies regionally and internationally, and is significantly influenced by cultural, religious, educational, and socioeconomic factors.[12] Our study found that MVC, sport, assault, and falls or play were the most common mechanisms, which were consistent with previous studies of pediatric midface fractures.[12,13]

The complication rate of pediatric midface fractures was low at 14.6%; however, the most common complications were facial deformity and nasal airway obstruction. The clinical significance of this centers around the potential growth disturbances caused by midface fractures. Animal studies have produced mixed results in investigating the impact of trauma to the cartilaginous septum, oft-theorized to play an integral role in midfacial growth.[15] Yet, maxillary hypoplasia secondary to midface trauma is a well-documented phenomenon.[4,15–17] Therefore, we recommend educating the patient and family on the risk of potential growth disturbances due to midface fractures during the initial evaluation. Regular follow-up is also incredibly important in the care and satisfaction of these patients.

Interestingly, a majority of these patients attended some form of follow-up (63%), though the length of follow-up varied greatly. This was an unexpected finding, as this represents a higher rate than observed in the adult trauma population (31%) at a level 1 trauma tertiary care center.[18] The explanation for this is likely multifaceted. We postulate that the interdisciplinary approach to treatment may impose more frequent follow-up visits, and generally increases communication and contact with the health care system. Additionally, patients may find it more convenient to conduct all of their follow-up at the same institution, rather than split care between multiple institutions and locations. The accessibility of the tertiary care center with its multiple surgical subspecialties, therefore, may outweigh its inconveniences (eg, urban commute, distance from home, associated increased costs) in the treatment of pediatric midface fractures.

When surgical intervention is indicated, we prefer using closed reduction techniques when possible. This reduces the damage to the underlying vasculature and periosteum supplying the osteogenic potential of the bone. Moreover, the pediatric facial skeleton's inherent remodeling capability allows for adequate results even with some distraction of fracture segments. Closed reduction, in contrast to internal fixation, does not physically restrict natural growth of the fragments distal to the fracture. When internal fixation with plating is indicated, consideration of removing the plating depends on the complexity of the fracture, age and facial maturation of the patient, adequate bony healing, as well as presence of facial deformity. When performing rigid fixation, or adjunctive maxillomandibular fixation in some cases, avoiding injury to tooth roots is especially critical in those subjects with unerupted dentition.

CONCLUSION

Maxilla and nasal bone fractures were the most common types of pediatric midface fractures found in our study. This is in contrast to prior studies that have described a higher rate of zygoma fractures within the midface. It is thought that the use of dedicated Maxillofacial CT scans, which predominates in our study, has increased the sensitivity of detecting midface fractures than seen in previous studies.

Conservative management was favored for most pediatric midface fractures. In operative cases, closed reduction was favored when possible, as in most nasal bone fractures. This approach seeks to decrease the degree of midface growth restriction by limiting periosteal dissection, physical strain on the developing bone, and injury to the bone itself. However, open reduction with plating was used in half of operative cases, reserved for more displaced and complex fractures. Facial deformity was the most common complication in this patient subset and should be a strong point of educational emphasis in the consultation period with the patient and family.

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