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Analysis of pediatric maxillofacial trauma in North China: Epidemiology, pattern, and management ☆,☆☆

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ABSTRACT

Purpose: To analyze epidemiology, pattern, and management of pediatric maxillofacial trauma in North China.

Patients and Methods: Clinical records of patients aged 0–18 years with maxillofacial trauma, from January 2008 to December 2016 were reviewed. 390 patients with an average age of 9.8 ±5.8 years (range: 8 months–18 years) and a male:female ratio of approximately 2:1 were included in the study. Epidemiological features (age, sex, etiology), characteristics of injuries (locations, types, associated injuries), treatments, and complications were analyzed.

Results: Among 55 patients with soft tissue injuries, palate was the most common site (32.7%). Among 335 fracture cases, the most common age group was 16–18 years (25.1%); falls was the main cause (38.2%). Overall, there were 450 fractures (1.78 per capita), primarily mandible (69.3%), followed by zygoma (12.9%), maxilla (7.7%) and other sites. Multiple fractures occurred in 61.5% of patients. The most common site of mandibular fractures was condyle. The proportion of mid-face fractures to mandibular fractures increased with age ($p < 0.01$) and stabilized gradually after 12 (approximately 1.14:1). 77.5% of fractures were treated surgically. There was an independent association of surgical intervention with age older than 6 years old ($p < 0.05$). Absorbable plates were mainly applied to mandibular fractures in patients aged 0–7 and only 1 was removed because of insufficient fixation strength.

Conclusions: The primary cause of pediatric maxillofacial fractures in North China was falls; traffic accidents led more multiple fractures and associated injuries. Palate and mandible were the most common sites of pediatric maxillofacial soft tissue injuries and fractures, respectively. The proportion of mandibular fractures to mid-face fractures decreased with the increase of age until 12.

Maxillofacial trauma is infrequent in pediatric population [1,2]. Studies have shown that maxillofacial fractures in children under 16 years old account for 1%–14% of all fractures, while those in children under 5 years old account for only 0.87%–1% [3,4]. This reduced incidence may be explained by the flexibility of pediatric skeleton, the large quantities of facial soft tissues, the presence of unerupted teeth, the lack of paranasal sinus pneumatization, as well as being protected by parents and schools [5–10].

Management of maxillofacial trauma must be planned by taking into account the fact that unlike adults, children are in the growth and development stage. If not appropriately managed, complications such as growth disturbances and temporomandibular joint (TMJ) ankylosis may occur [8,11,12]. Therefore, understanding the characteristics of pediatric maxillofacial trauma can help clinicians in performing accurate diagnosis and selecting appropriate treatment methods [6].

Owing to the influence of social, environmental, and economic factors, the characteristics of pediatric maxillofacial trauma are associated with time and region, with a certain degree of variation [7,13–15]. Only a few studies have been conducted on pediatric maxillofacial trauma in China in the past decade. The purpose of this article was to analyze the epidemiology, pattern, and management of pediatric maxillofacial trauma treated at our institution in the past 9 years. Our study was approved by the medical ethics committee in our hospital.

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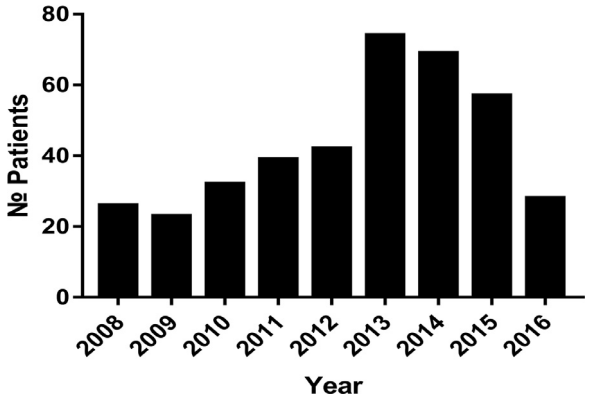

Fig. 1. Annual distribution of patients.

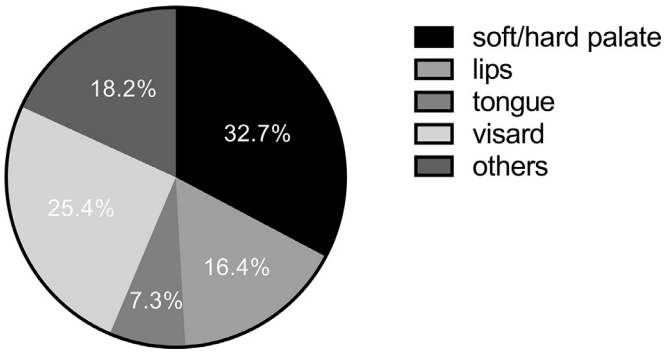

Fig. 2. Location of soft injury by percentage.

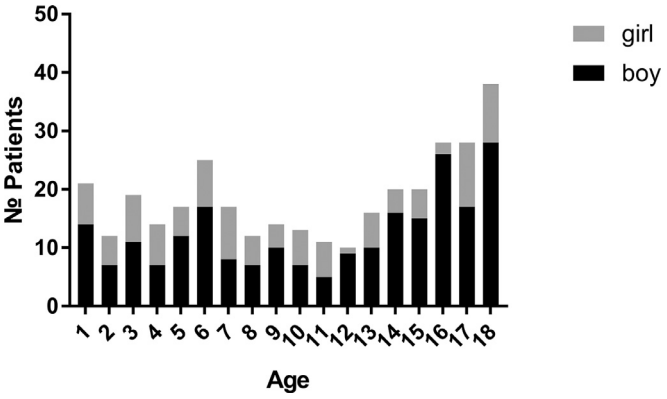

Fig. 3. Distribution of patients in different age groups by sex.

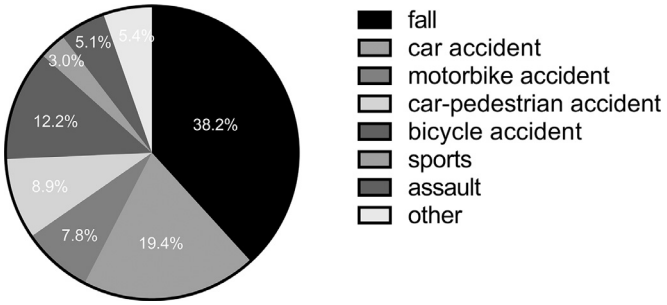

Fig. 4. Mechanisms of injury by percentage.

Patients and methods

Study sample

390 consecutive patients aged 0–18 years with maxillofacial trauma, from January 2008 to December 2016 were eligible for this study. The mean age was 9.8 ± 5.8 years and ranged from 8 months to 18 years. 262 were males and 128 were females, with a male-to-female ratio of approximately 2:1. The medical records of them were retrospectively retrieved and analyzed for prevalence, etiology, pattern, management, and complications of maxillofacial trauma.

Variables

Patients were divided into 6 age groups: 0–3, 4–6, 7–9, 10–12, 13–15, and 16–18 years. The mechanism of trauma included falls, motor vehicle accidents (MVA), bicycle accidents, sports, violence, and others. MVA included car accidents, motorcycle accidents, and car-pedestrian accidents.

Trauma was divided into two types: soft tissue injuries and fractures. Soft tissue injuries were classified as injuries in palate, lips, tongue, cheek, and other sites. Fractures were categorized as mandible, maxilla, zygoma, orbit and naso-orbital-ethmoid (NOE). Sites of mandibular fractures included symphysis, parasymphysis, body, angle, ramus, coronoid, condyle, and alveolar process. As a special type of maxillary fracture, Le Fort fracture was separately analyzed.

Statistical analysis

Following data were subjected to statistically analysis: age, sex, etiology, location and type of injuries, associated injuries, and treatment methods. Chin-square test was performed using SPSS version 20.0 (SPSS, Chicago, IL), with a 2-sided significance level set at $p < 0.05$.

Results

There were 55 cases of soft tissue injuries and 335 cases of fractures. Figure 1 shows patient distribution during the entire study period.

Maxillofacial soft tissue injury

Most of the 55 patients with soft tissue injuries were children aged <5 years (38/55). The most common site was palate, followed by cheek, lips, tongue, and other sites (Fig. 2). Two patients were not treated owing to their general conditions, and the remaining received debridement and sutures. In addition, 7 patients sustained facial nerve injury, and 6 of them underwent facial nerve anastomosis. Two patients experienced parotid duct injury, one of whom received parotid duct anastomosis while the other received parotid duct ligation.

Maxillofacial fracture

Fracture was diagnosed in 335 patients. The incidence was highest in the 16–18 years age group (25.1%) and lowest in the 10–12 years age group (9.3%). Two peaks were found at the ages of 6 and 16–18, respectively (Fig. 3). The male-to-female ratio aged ≤12 years was 1.6:1, while it increased to 2.9:1 in patients aged >12 years.

Mechanism of injury

The primary mechanism of fractures was falls (38.2%), followed by MVA (19.4%) (Fig. 4). Mechanism of fractures was associated with patient age. Falls was the most common etiology in children aged ≤6 years (56.5%), while in those aged >6 years, the leading

Table 1
Concomitant Injuries

Injured Organ System	Type of Injury	n	% of total
Head and neck			
	Cerebral injury	28	12.8
	Dental injury	103	47.2
	Cervical spine injury	2	0.9
	Eye injury	8	3.7
	Ear injury	2	0.9
	Facial nerve palsy	4	1.8
	Parotid duct damage	1	0.5
Thorax			
	Rib fracture	3	1.4
	Pneumothorax/hemothorax	7	3.2
	Lung contusion	7	3.2
Abdomen			
	Liver	3	1.4
	Spleen	1	0.5
	Bladder	1	0.5
	Gastrointestinal hemorrhage	1	0.5
Upper limbs			
	Upper limb fracture	23	10.6
Lower limbs			
	Lower limb fracture	24	11.0

etiology was MVA (35.7%) ($p < 0.001$). Isolated fractures were primarily caused by falls, while multiple fractures were mostly caused by MVA ($p < 0.001$).

Associated injury

In total, 159 (57.9%) patients sustained associated injuries. The most common associated injury was dental injury (47.2%), which was categorized as avulsion (51.6%), tooth fracture (34.9%), extrusion (10.3%) and intrusion (3.2%). Other high prevalence of associated injuries included cerebral injury (12.8%), lower limb fracture (11.0%), and upper limb fracture (10.6%) (Table 1). Among patients with associated injuries, MVA was the most common cause (45.9%).

Location and type of fracture

A total of 597 fractures were registered in the 335 study patients (average: 1.78). Of these, 129 patients (38.5%) sustained isolated fractures and 206 patients (61.5%) sustained multiple fractures. The mandible was the most common fracture site (69.3%), followed by zygoma (12.9%), maxilla (7.7%), NOE (4.2%), Le Fort type (3.9%), and orbit (2.0%) (Table 1).

The mean age of patients with mandibular fractures was 9.6±5.8 years. The most common site of mandibular fractures was condyle (38.2%), followed by symphysis (34.5%) (Table 3). In addition, 58.3% of mandibular fractures were multiple fractures, of which, the most common type was symphysis-condylar fracture (57.4%). Mandibular fractures were more common in children younger than 10 years, and the occurrence decreased with increasing age group ($p < 0.001$) (Fig. 5). Among patients aged 4–10 years with symphysis or parasymphysis fractures, 53.1% were the same type—the fracture line crossed the canine bud (Fig. 6).

The mean age of patients with mid-face fractures was 13.1±4.4 years, and the proportion of mid-face fractures increased with age ($p < 0.01$) (Fig. 5). After 12 years of age, the ratio of mid-face fractures to mandibular fractures tended to stabilize at approximately 1.14:1 (Fig. 5). Le Fort fractures were primarily seen in patients older than 12 years (19/23). Le Fort type I fracture was the most prevalent type (20/23). Only 3 patients sustained Le Fort type II or III fractures. Orbital fractures occurred mostly in the orbital floor, with only one case occurring in the medial orbital wall. All patients with NOE fractures were aged >6 years, and most of them also suffered fractures at other sites of the mid-face (17/25).

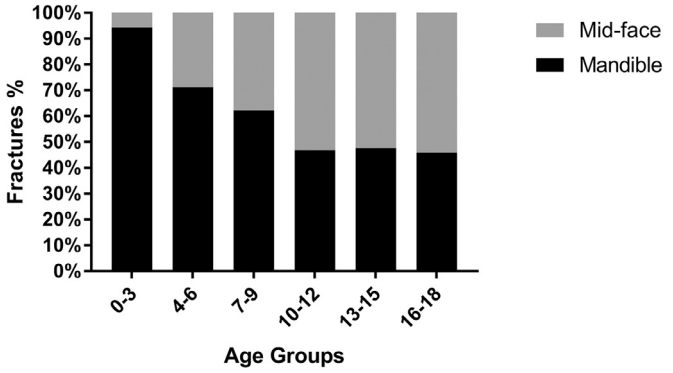

Fig. 5. Distribution of different fractures in each age group.

Fig. 6. Mandibular symphysis fracture in a 4-year-old boy (fracture line crossing the canine bud).

Treatment and outcome

Among the 335 patients, 77.5% of fractures were treated surgically whereas 22.5% of fractures were treated conservatively. Surgical treatment included closed reduction and open reduction (Fig. 7). Conservative treatment consisted of observation, diet management, maxillomandibular fixation (MMF), and splints. Treatments by fracture sites were summarized in Table 2. A significant correlation was noted between treatment method and fracture location ($p < 0.001$) (Table 4). The proportion of surgical treatment in patients aged ≤6 years was significantly lower compared with those aged >6 years ($p < 0.05$) (Table 5). For condylar fractures, conservative treatment was preferred in patients ≤12 years old while surgical treatment was performed mainly in patients >12 years old ($p < 0.001$) (Table 6).

Of all 410 fractures treated by open reduction and internal fixation (ORIF), 102 (24.9%) cases were fixed with absorbable plates, most of which were mandibular body fractures (90.2%) and had primarily occurred in children aged 0–7 years (82.3%). A common indication was mandibular symphysis fracture combined with bilateral condylar fractures. For this type of fracture, an absorbable plate was fixed on the inferior border of the mandible, and bilateral condylar fractures were treated conservatively (Fig. 8). As a supplement, steel wires were commonly used to ligate 4-6 teeth on both sides of the fracture line.

The average follow-up time was 6 months. Complications encountered were summarized in Table 7. Two patients experienced facial asymmetry. A 9-year-old girl with fracture of maxilla and zygoma caused by MVA developed maxillary hypoplasia after surgery. The other case was a 5-year-old boy with mandibular symphysis fracture caused by fall who developed mandibular deviation after surgery. Both of them received secondary orthognathic surgery. Six patients (average age: 5.3 years) developed infection after surgery; of them, 5 sustained multiple or comminuted mandibular fractures, with an average operation time

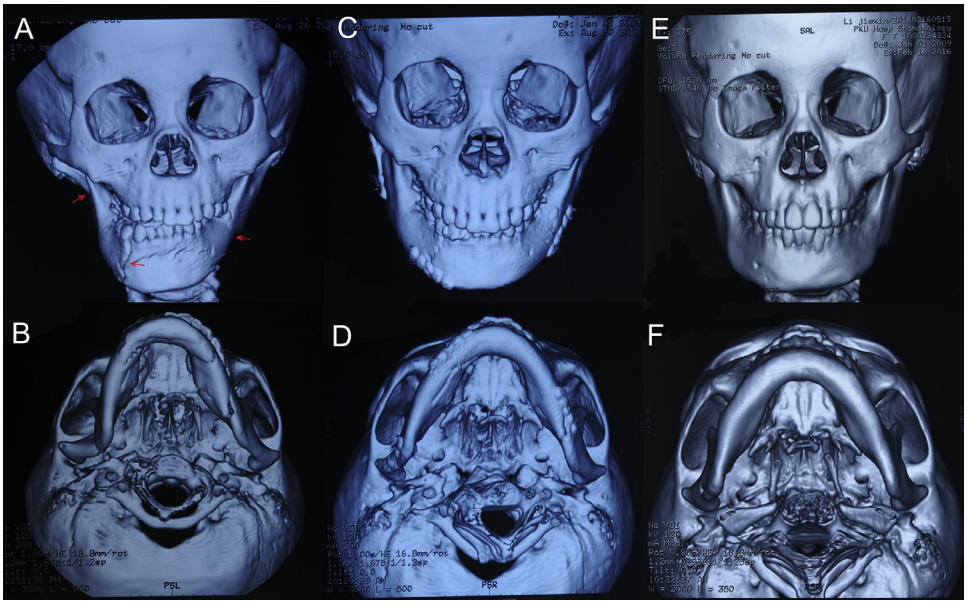

Fig. 7. A 4-year-old girl sustained mandibular multiple fractures from fall. (A, B) Preoperative 3-dimensional CT demonstrated fractures of the left angle, the right parasymphysis and the right condylar neck (red arrow). (C, D) Postoperative CT after open reduction and internal fixation. (E, F) CT scan 2.5 years after the operation showing well fracture healing and symmetric contour of the mandible.

Table 2
Locations of 597 fractures and treatments.

Fracture Location and Treatment	n	%
Mandibular	**414** (406)*	**69.3**
Conservative	112	
Closed reduction + MMF	3	
Open reduction	6	
ORIF		
Miniplate fixation	179	
Absorbable plate fixation	92	
Wire fixation	14	
Maxillary	**46 (45)***	**7.7**
Conservative	9	
Closed reduction + wire fixation	3	
Open reduction	2	
ORIF		
Miniplate fixation	29	
Absorbable plate fixation	2	
Zygomatic	**77 (75)***	**12.9**
Conservative	2	
Open reduction	2	
ORIF		
Miniplate fixation	64	
Absorbable plate fixation	7	
Le Fort	**23**	**3.9**
ORIF		
Miniplate fixation	22	
Absorbable plate fixation	1	
Naso-orbital-ethmoid	**25**	**4.2**
Conservative	4	
Open reduction + miniplate fixation	15	
Open reduction + titanium mesh	6	
Orbital	**12**	**2.0**
Conservative	5	
Open reduction + titanium mesh	3	
Open reduction + absorbable mesh	2	
Open reduction + bone graft	2	

MMF, maxillomandibular fixation; ORIF, open reduction and internal fixation
* fractures that were practically treated in our department

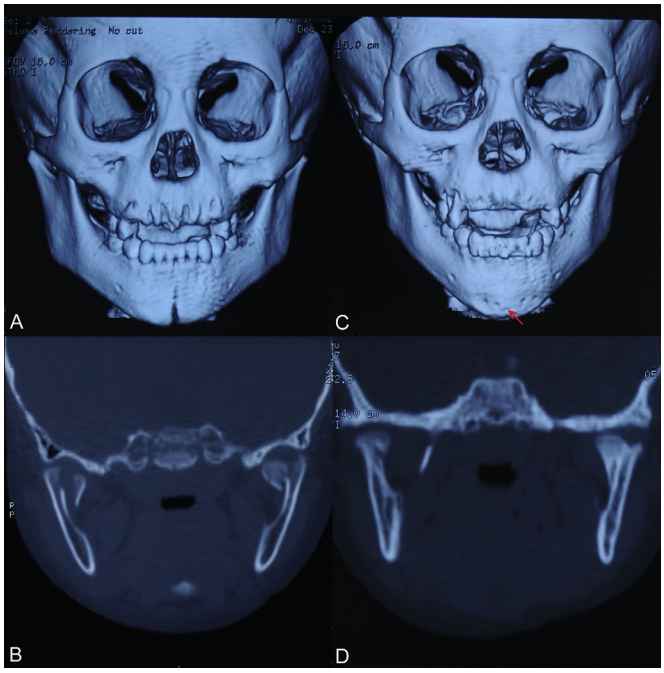

Fig. 8. A 4-year -old girl sustained symphysis and bilateral condylar fractures from a traffic accident. (A, B) Preoperative CT of the fractures. (C) The symphysis fracture was fixed with an absorbable plate on the inferior border of the mandible. A 3-dimensional CT scan 3 months after the operation revealing well fracture healing (red arrow). (D) Coronal CT 3 months after the operation showing remodeling of the bilateral condyles after conservative treatment.

of 2.5 hours. Fracture displacement occurred in 2 patients after ORIF, with titanium plate and absorbable plate accounting for one case each. Complications such as nasal deformity, eye deformity, and epiphora were primarily reported in patients with NOE fractures.

Table 3
Locations of mandibular fractures.

Sites	n	%
Symphysis	143	34.5
Parasymphysis	41	9.9
Body	20	4.8
Angle	30	7.2
Ramus	5	1.2
Condyle	158	38.2
Coronoid	8	1.9
Alveolus	9	2.2
Total	414	100.0

Table 5
Treatment of Fractures by Different Age Groups

Treatment	Age Groups (years)		χ^2 test
	0–6	7–18	
Not operated on	53	79	$\chi^2 = 8.299$
Operated on	123	331	$p < 0.05$

Table 6
Treatment of Condylar Fractures by Different Age Groups

Treatment	Age Groups (years)		χ^2 test
	0–12	13–18	
Not operated on	69	17	$\chi^2 = 55.302$
Operated on	14	55	$p < 0.001$

Table 7
Complications of facial fractures

Complications	n
Facial asymmetry	2
Unsatisfactory fracture repair	3
Infection	6
Facial scarring	8
Plate movement	2
Nasal deformity	3
Eye deformity	5
Epiphora	2
Decreased visual acuity	1

Discussion

Since children are in the growth and development phase of their life, their anatomy, physiology, and biomechanics are quite different from those of adults. Low mineralization, limited development of the cortex, and more flexible suture lines provide great elasticity to the pediatric facial skeleton; thus, children are more prone to greenstick fractures compared with adults [13]. Moreover, the osteogenic and remodeling capabilities of pediatric skeleton is higher, and hence, conservative treatment is often given priority. However, inappropriate treatment of oral and maxillofacial trauma in children can cause serious complications. Previous studies on pediatric maxillofacial trauma have often been conducted on children under the age of 12 [16] or 16 [11,13,17]. According to international standards, people under the age of 18 are defined as children; the present study adopted this as one of the inclusion criterion.

According to available literature, the mean age of occurrence of maxillofacial trauma in children ranged from 9.5 to 14.2 years [1,6,9,11,14,17,18]. In the present study, this value was 9.8 years. In addition, we noted two peaks of incidence of maxillofacial trauma, one in children aged 6 years and the other in 16–18 years. This finding is consistent with the finding from a previous study [12]. At the age of 6, mixed dentition begins to form, and the stability of jaws decreases. Besides, children start to attend school, departing from parental protection, and hence, the incidence of trauma is high. On the other hand, adolescent children (16–18 years) are more active in daily life and sports, which explains the high incidence of trauma in this age group [2].

In general, the incidence of maxillofacial trauma in children is higher in males than in females [2–4,6,13,14,16,18–20]. The male:female ratio in our study was approximately 2:1. Meanwhile, our results also showed that this ratio increased with increasing age. The male:female ratio in patients aged ≤12 years was 1.6:1, while it was 2.9:1 in patients aged >12 years. This could be attributed to the differences in physiological structure, daily behavior, and social division of labor between males and females after the emergence of secondary sexual characters.

Globally, the primary causes of pediatric maxillofacial fractures are falls and traffic accidents [2,13,16], followed by sports and violence [4,21]. A study including 1416 children with maxillofacial trauma revealed traffic accident as the most common etiology (48.7%) [7]. Studies by Massenburg et al. and Allred also showed that traffic accidents played a leading role in pediatric maxillofacial injuries [6,12]. However, in a multicenter prospective study from Europe, falls was found to be the most common cause of injury (32%) [14], which is consistent with findings from the present study (38.2%). In a study of pediatric maxillofacial trauma conducted in South China in 2013, bicycle accidents was the most common etiology [15]. Taken together, the etiologies of pediatric maxillofacial trauma are probably related to both environment and time. Studies have demonstrated that children in developing countries are more likely to be involved in traffic accidents because motor vehicle safety measures in such countries are not widely promoted or practiced [7]. In our study, falls was more common in younger children (≤6 years) (56.5%) and MVA was mainly reported in older children (>6 years) (35.7%). This result is consistent with results from previous studies [7,13,21].

In our study, palatal laceration was extremely common, accounting for about one third (32.7%) of all maxillofacial soft tissue injuries. Zhang et al. evaluated data from 470 children with maxillofacial trauma in China and observed that the proportion of palatal injuries was 5.9% [15]. Children often keep hard objects in their mouth after eating and drinking, such as chopsticks, ice-cream sticks, and straws; consequently, when they fall, the palate can get easily punctured by such objects.

According to available literature, the incidence of associated injuries in pediatric maxillofacial fractures ranges 6.3%–88% [6]. In our study, this incidence was 57.9%. Furthermore, compared with falls, fractures caused by traffic accidents were more likely to be accompanied with associated injuries. Our results showed that dental injury (47.2%) were the most common associated injuries. In a study by Gassner et al., the proportion of dental injury

Table 4
Patient Treatment by Location of Fracture

	Mandible	Maxillary	Zygomatic	Le Fort	NOE	Orbital	χ^2 test
Conservative	112	9	2	0	4	5	χ^2=40.378
Surgical	294	36	73	23	21	7	p<0.001
Total	406	45	75	23	25	12	

was 59.5%, which was similar to the proportion reported in our study [22]. Previous literatures have shown that enamal fracture accounted for the majority of dental trauma [23,24]. But in our series, the incidence of tooth avulsion was extremely high. One of the explanations was that children with maxillofacial fractures usually experienced high strength force, which is more likely to cause severe dental injuries. In the other hand, it is hard for children with maxillofacial fractures to cooperate with oral examination. Thus, the proportion of mild dental trauma such as enamal fracture and craze lines may be underestimated. However, dental injuries after trauma, especially avulsion and intrusion, may cause developing disturbances of permanent dentition [25]. Researchers have assessed the association between dental trauma and facial forms, increased overjet and malocclusion complexity, which is beneficial for preventing pediatric dental injuries [23,26,27]. Another consideration is whether the teeth in the fracture line can erupt normally after treatment, and further research is required.

Mandible is a common fracture site, accounting for 32.2%–89.3% of maxillofacial fractures in children [2,4–6]. In the present study, this proportion was 69.3%. According to our findings, the condyle was the most common site of mandibular fracture (38.2%), which is consistent with findings from a previous study [11]. Ashrafullah et al. found that 46% of mandibular fractures in children were multiple fractures [13]. In the present study, this proportion was considerably higher at 58.3%. This may be due to the fact that for certain patients with isolated mandibular fractures, conservative treatment was often adopted as an outpatient procedure.

In general, unerupted teeth can protect and stabilize the jaws [9,13]. In the present study, 53.1% of patients aged 4–10 years with symphysis or parasymphysis fractures experienced the same type of fracture—the fracture line crossed the canine bud. The high incidence of fracture at this site could be because the canine erupts later than adjacent teeth and the canine bud is larger, which weakens the continuity of the mandible and reduces the bone strength in this area. This traumatic mechanism is similar to that of the third molar promoting the occurrence of mandibular angle fractures [14]. Because developing teeth and dental follicles often interfere with the judgement of fracture lines [15], we recommend that clinical and imaging examinations should be performed to accurately determine the presence of such fractures in children aged 4–10 who are suspected to have mandibular fractures.

In our series, mid-face fractures were primarily seen in older children (average age: 13.1 years), and with the increase of age, this proportion increased. This is because as children grow up, the cranium-to-face ratio decreases, and paranasal sinuses in the midface begin to pneumatize. We found that after 12 years of age, the proportion of mid-face and mandibular fractures gradually stabilized, and typical Le Fort type fractures began to occur. This may indicate that characteristics of maxillofacial fractures in children over 12 years old are similar to those in adults.

Management of maxillofacial fractures in children depends on age, dentition, displacement of fracture, and the period after trauma [6]. Initially, pediatric maxillofacial fractures were primarily treated conservatively, but now, for displaced fractures, ORIF has become the gold standard [19]. Compared with conservative treatment, surgical treatment provides better prognosis and shorter recovery periods. In a retrospective study of 1416 children with maxillofacial fractures, 74.4% of patients needed surgical intervention [7]. This finding was corroborated by findings from our study (77.5%). Our results showed that surgical treatments were performed more often in children over 6 years old, which was consistent with results reported by Massenburg and Ferreira et al [7,12]. For condylar fractures, surgical treatments were adopted more often in patients over 12 years old than in those under 12. This is attributed to the characteristic of condylar fracture in children aged >12 years, which is similar to condylar fractures in adults—the remodeling capability is limited, and thus, surgical treatment is often needed to avoid adverse outcomes of TMJ [3].

At present, absorbable plates are increasingly used in children with maxillofacial fractures. Absorbable plates can be degraded and absorbed in vivo, and hence, no second surgery is needed [28]. In our series, of the 410 fractures treated by ORIF, 102 (24.9%) were fixed with absorbable plates. Among them, a majority of patients were 0–7 years old (82.3%) and these plates were mainly applied to mandibular body fractures (90.2%). Only in one case, the absorbable plate was removed and replaced with a titanium plate because of insufficient fixation strength and looseness. According to our previous study, patients treated with absorbable plates may develop fistula at the intraoral incision, and osteolysis may occur around the plate. However, the adverse outcomes would disappear with/without clinical intervention [28]. In our opinion, for isolated linear mandibular body fractures in young children, absorbable plates can be a feasible treatment option.

In our study, 10% of patients with maxillofacial fractures experienced complications. Allred et al. summarized 204 cases of maxillofacial fractures in children, wherein the incidence of complications was 11.2% [6], which was consistent with our conclusion. Davidson et al. classified adverse outcomes of pediatric maxillofacial fractures into three categories: I, caused by the fracture; II, caused by fracture treatment; III, caused by interaction between the fracture and its treatment and subsequent growth and development [29]. In our study, 2 patients developed jaw deformity, but owing to the short period of follow-up time and lack of clinical control studies, we could not accurately categorize them. In addition, 6 patients (1.3%) developed operative area infection after surgery, and 5 of them (83.3%) sustained multiple or comminuted mandibular fractures. Although children have strong healing abilities and are not susceptible to infection [7], for complex multiple fractures or comminuted fractures, owing to challenges of fracture reduction, long operation time, poor blood supply of fracture fragments after extensive stripping, and communication between operative area and oral cavity, children also are at a risk of developing infection after surgery.

In summary, maxillofacial trauma in children is quite different from that in adults in terms of epidemiology, fracture characteristics, diagnosis, and treatment. Conservative treatment is preferred for pediatric maxillofacial fractures, but it is not the reason for improper management. In accordance with treatment principles of maxillofacial fractures and considering the characteristics of pediatric fractures, appropriate computed tomography examination, bone transplantation, and rigid fixation can help provide optimal outcomes for pediatric maxillofacial fractures.

Declaration of Competing Interest

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in, or the review of, the manuscript entitled “Analysis of pediatric maxillofacial trauma in North China: Epidemiology, pattern and management”.

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