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The management of mandibular body fractures in young children

REVIEW ARTICLE

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Abstract – This article reviews the management of mandibular body fractures in young children. Treatment principles of this fracture type differ from that of adults due to concerns regarding mandibular growth processes and dentition development. The goal of this fracture treatment is to restore the underlying bony architecture to its preinjury position in a stable fashion as non-invasively as possible and with minimal residual esthetic and functional impairment. The management of mandibular body fractures in children depends on the fracture type and the stage of skeletal and dental development; treatment modalities range from conservative non-invasive, through closed reduction and immobilization methods to open reduction with internal fixation. Disruption of the periosteal envelope of the mandibular body may have an unpredictable effect on growth. Thus, if intervention is required closed reduction is favored.

The management of mandibular body fractures in children differs from that of adults due to concern for mandible growth and dentition development (1, 2). Whereas absolute reduction and fixation of fractures is indicated in adults, concern for minimal manipulation of the facial skeleton is mandated in children. The small size of the jaw, existing active bony growth centers and the contained, overwhelmingly crowded deciduous teeth with permanent tooth buds located in great proximity to the mandibular and mental nerves, all significantly increase the therapy-related risks of pediatric mandibular fractures and their growth related abnormalities. Intact active mandibular growth centers are important for preserving mandibular function, which have a significant influence on future facial development. Thus, restoration of the mandibular continuity after fracture is important not only for immediate function but also for future craniofacial development (3). Accordingly, the goal of treatment is to restore the underlying bony architecture to its preinjury position in a stable fashion as non-invasively as possible with minimal residual esthetic and functional impairment.

Facial fractures in the pediatric age group generally account for about 5% of all facial fractures and this percentage drops considerably in those less than the age of 5 (4–6). Their incidence rises as children begin school and also peaks during puberty and adolescence. A male dominance exists in all age groups (7, 8).

The most common fractures in children requiring hospitalization and/or surgery generally involve the mandible and in particular the condyle. Fractures in the condylar region are followed in number by symphysis, angle and body fractures, respectively (9–11). Fractures of the body and angle are initially infrequent, but increase with age (12).

The etiology of mandibular fractures in children differs from adults. Motor vehicle accidents, falls and sports are the most common causes of mandibular fractures in most countries. In contrast to younger children, with older children sport injuries usually escalate due to less parental supervision leading to an increase in the risk of serious injury (4, 8, 13, 14).

A child's face has protective anatomic features which decreases the incidence of facial fractures. In young children (less than the age of 5) the face is in a more retruded position relative to the 'protective' skull. Therefore, there is a lower incidence of midface and mandibular fractures and a higher incidence of cranial injuries. With increasing age and facial growth, in a downward and forward direction, the midface and mandible become more prominent and the incidence of facial fractures increases, while cranial injuries decrease (15).

The reasons for the low prevalence of facial bone fractures and the fact that they are more often minimally displaced in children are high elasticity of young bones, a thicker layer of the adipose tissue covering them, a high cancellous-to-cortical bone ratio and flexible suture lines. In addition, the mixed dentition and the lack of sinus pneumatization contribute to the elasticity and stability of the mandible (8, 16–18).

The clinical signs and symptoms of a fractured mandible in a child are the same as in an adult: pain, swelling, trismus, derangement of occlusion, sublingual hematoma, step deformity, deviation, loss of sensation due to nerve damage, bleeding, ecchymosis, temporomandibular joint (TMJ) problems, tenderness, movement restriction, open bite and crepitus. Thorough clinical examination, however, may be impossible in uncooperative young trauma patients. Lacerations should be evaluated to reveal injuries to underlying structures. Gentle palpation should be applied over all bony surfaces of the mandible. The mandibular range of motion must be examined as the patients actively open and close their mouths.

For radiologic examination, plain radiographs in young children are less helpful than in adults due to unerupted tooth buds obscuring fractures, the increased incidence of greenstick fractures and the fact that the cortex is underdeveloped leading to difficulty in visualizing fractures. Because of these facts CT scans greatly increase diagnostic accuracy and have become the standard of care for imaging pediatric mandibular fracture trauma victims (14, 19).

Treatment of mandibular body fractures in children depends on the fracture type and the stage of skeletal and dental development (Table 1) (4, 20).

The lack of stable fixation units in young children

Precarious dental stability is characteristic of the mixed dental development period. Attrition of deciduous teeth further compounded by resorption of roots results in quite a loose anchorage system (1, 4, 14). Partially erupted secondary teeth are not yet sufficiently stable in the pediatric soft bone (4). Intermaxillary types of fixation (IMF) including arch-bars or eyelets are splinting devices for the closed reduction of mandibular body fractures in young children (1, 4, 6, 13, 14, 17, 20–22). IMF can cause avulsion of the primary teeth which are not sufficiently stable due to the pressure exerted. Furthermore, the conical shape of the primary teeth, with their wide cervical margins and tapered occlusal surface, makes the placement of these IMF devices or eyelets technically challenging (2, 8, 23, 24). IMF was also found to restrict normal dietary intake in children resulting in significant weight and protein loss, reduced

Table 1. The advantages and disadvantages of the different management/fixation techniques available for the various types of mandibular body fractures in children

Type of fracture	Treatment possibilities	Type of management/ fixation Technique	Disadvantages	Advantages
Greenstick	Conservative	Close observation Liquid to soft diet Avoidance of physical activities (e.g. sports) Analgesics		Conservative non-invasive treatment.
Greenstick with minimal displacement	Closed reduction and immobilization	Splints Acrylic Prefabricated acrylic Gunning Wiring Circumferential Arch bar IMF Eyelets Arch bars Nickel-titanium staples Orthodontic material and devices Brackets Orthodontic Resin Rubber elastics Orthodontic prefabricated splint	A lack of stable fixation units for the immobilization. Imperfect apposition of bone surfaces. IMF restricts normal dietary intake, reduces tidal volume and increases the risk of aspiration of gastric contents should the patient vomit. The wires are uncomfortable and may cause damage to the periodontal tissues. Difficult to maintain good oral hygiene.	Ease of application and removal. Reduced operation time. Stable Continuity of the periosteal sleeve and maintenance of the soft tissue. Enables normal function during healing period. Minimal trauma for adjacent anatomic structures. Comfort for young patients. Can be utilized in the out-patient clinic. Enables the patient to be released from the hospital on the same day. Avoidance of the use of a general anesthesia associated with in-patient problems, such as bed or operating room availability and recovery time.
Mandibular body fracture with displacment	Open reduction	Miniplate and screw devices Titanium Resorbable	Potential growth restriction. Damage to primary teeth and permanent tooth germs. Creates artifacts on CT scans or MRI. Can be visible or palpated through the child's thin skin. May cause pain and early or late infection. A need for general anesthesia and hospitalization for application and removal of the hardware materials after complete healing.	Provides stable three-dimensional reconstruction. Enable precise anatomical reduction and fixation under direct vision. Promotes primary bone healing. Shortens treatment time. Eliminates the need for or permits early release of the IMF.

tidal volume and an increase in the risk of aspiration of gastric contents should the patient vomit (4). The wires themselves are uncomfortable and damage the periodontal tissues (4). However, some authors have indicated that IMF using arch bars is safe in children, especially those older than 9 or even 11 years (23, 24).

Mandibular body greenstick fractures and closed reduction techniques

A greenstick fracture is a fracture in which one cortex of the bone is broken and the other cortex is bent. Pediatric patients are more likely than adults to sustain greenstick or incomplete fractures. This is due to relatively high elasticity of the mandibular body's thin cortical bone and a thick surrounding layer of adipose tissue. Thus, the relatively larger amount of medullary bone is held by a strong periosteal support (16, 25). Furthermore, because of the presence of tooth buds and developing crypts, pediatric fractures are often long and irregular in character, with the fracture generally running inferiorly and anteriorly (25). In all cases of pediatric mandibular body fractures, it is very important to note any involvement of condylar fractures (13, 14).

A greenstick fracture will ensure stability of the undisplaced segments in children less than 5 years (16). Furthermore, the osteogenic potential of the periosteum in the developing craniofacial skeleton is very high and will lead to somewhat rapid and easier healing which occurs under the influence of masticatory stresses, even when there is imperfect apposition of bone surfaces (6, 20–22). Thus, there is a greater degree of tolerance permissible in the alignment of fragments and restoration of occlusion, which will subsequently be corrected by alveolar bone growth at the time of eruption of permanent teeth (16). Therefore, greenstick fractures without displacement and malocclusion are managed merely by close observation, a liquid-to-soft diet, avoidance of physical activities (e.g. sports) and analgesics (5, 8). There may be cases in which the fractures can be snapped back into a good reduced position and held by the periosteal sleeve, the fracture surfaces and even by the occlusion (16). For greenstick/minimally displaced fractures, conservative closed reduction is the most frequently recommended treatment. The closed reduction and immobilization approach can be achieved by means of lingual acrylic splints, circumferential wiring, arch bars, or gunning splints (12). These techniques provide a good reduced position, continuity of the periosteal sleeve and maintenance of the soft tissue, thus creating a positive environment for rapid osteogenesis and remodeling processes as well as prevention of any type of non- or fibrous union (6, 22). Furthermore, in the splinted mandible the fracture segments are tightly fixed and serve in reducing tenderness and pain reactions during a child's daily activity (6, 22).

Alternative devices for close reduction

Several studies have recommended the use of prefabricated acrylic splints as a treatment for pediatric mandibular fractures. Theses splints are more reliable than open reduction or IMF techniques with regard to cost-effectiveness, ease of application and removal, reduced operation time, maximum stability during healing period, minimal trauma for adjacent anatomic structures and comfort for young patients (5, 26, 27).

Laster et al. (12) described a new treatment modality based on nickel-titanium (NiTi) staples which are inserted in a relatively non-invasive and pain-free manner, and their eventual removal, if required, is as quick as their insertion, facilitated by the fact that the staples are not osseointegrated. Thanks to their superficial location, there is little risk for inhibiting and deforming facial bone development, harming any proximal strategic structures such as nerves and developing dentition. Furthermore, the reducing-compression rendered by the staple on the bone fragments results in primary healing with no callus produced.

Other studies have recommended the use of orthodontic components for the treatment of facial fractures: (i) modified orthodontic brackets have been used for maxillomandibular fixation (28, 29), (ii) orthodontic resin has been used for fixation of mandibular fractures in children (30), (iii) orthodontic rubber elastics were used in combination with fixed orthodontic brackets to create compressive horizontal force marginally over the mandibular fracture site from one side to the other (7) and (iv) a modified orthodontic splint appliance has been applied to fractures where two orthodontic bands are fit on the primary second molars with rounded stainless steel arch wires soldered to them on the buccal and lingual side (31).

All these different conservative approaches of treatment can be utilized in the out-patient clinic enabling completion of treatment and release of the patient from the hospital on the same day (7, 28–30). The avoidance of the use of a general anesthesia associated with in-patient problems, such as bed or operating room availability and recovery time, has a distinct advantage for both patients and attending medical staff over conventional fixation procedures previously discussed (26).

Open reduction management of mandibular body fractures in children

Closed reduction by means of IMF was used for all types of pediatric fractures till the mid seventies (6). Today, open reduction and rigid internal fixation (ORIF) has become the standard of care for management of displaced fractures (8). Mandibular fractures are often substantially displaced, and thus a low-damage, open-reduction treatment strategy would be preferable. ORIF includes micro or miniplates or biodegradable devices, which significantly increase the therapy-related risks previously mentioned. Nonetheless, this technique provides stable three-dimensional reconstruction, promotes primary bone healing, shortens treatment time and eliminates the need for early release of the IMF. Posnick et al. (14) claimed that a decreased dependence on IMF improved postoperative respiratory care, nutritional intake and oral hygiene measures.

The treatment modality for displaced mandibular body fractures in young ages is debatable, between conservative treatment methods (arch-bars, eyelets, splints) which are considered as closed reduction and ORIF. While the different open reduction techniques have been the standard of care for adults for a long time, its suitability for children remains controversial (2, 16). The effect of implanted hardware in the mandible of the growing child is not completely understood; some evidence suggests that the disruption of the functional matrix bone and mandibular growth centers may result in alteration of development. This damage to the periosteum and the surrounding soft tissue must be taken into consideration while choosing the internal fixation technique (4, 14, 17). There is also potential damage to primary teeth and permanent tooth germs which may result in disturbance to their normal development and damage to their pulp causing its obliteration (16, 32). Furthermore, the rigid internal fixation might create artifacts on CT scans or MRI, be visible or palpated through the child's thin skin and cause pain and early or late infection (8). Therefore, the decision to use ORIF in children should be taken with great caution and only if other means of reduction and fixation are not attainable.

Miniplate and screw devices have revolutionized the modern management of facial fractures by enabling precise anatomical reduction and fixation under direct vision. In all cases involving a fracture of a dentate jaw, it is mandatory for the correct prefracture occlusion to be securely maintained in IMF, while the miniplates are applied to the fracture sites.

The placement of miniplate and screw devices in mandibular fractures is probably only safe in the symphyseal and parasymphyseal regions at the lower border of the mandible after the eruption of the incisors and the canines. Similarly, in body fractures, the inferior mandibular border can be plated, when the buds of the permanent premolar and molar have migrated superiorly toward the alveolus as there is usually space that can be utilized beneath the developing tooth germs (4, 16, 33). This may be possible via an intraoral approach but the external incision may be unavoidable with the risk of facial scarring and damage to the marginal mandibular nerve (16). Thus, placing miniplates in a growing mandible can interfere with normal development and result in some growth restriction that may occur, although it is rare in fractures of the mandibular body (8). Moreover, general anesthesia and hospitalization is needed for removal of the hardware materials after complete healing (5, 7). Some patients develop allergic reactions to the metal, which can cause inflammation and the need for removal of the plate. Stress shielding, especially after rigid plate fixation, has been reported and may be a cause for weakening of the bone after removal of the implant (33). Corrosion and release of metal ions can be a reason for removing the osteofixation devices (33, 34).

Currently, ORIF with resorbable osteosynthesis plates and screws is increasingly being used for children. These biodegradable materials do not interfere with radiodiagnostic techniques due to their radiolucency and they guarantee sufficient rigidity and stability to enable initial bone healing of the mandible, followed by eventual degradation, resorption and elimination from the body (33). The avoidance of secondary implant removal operations reduces the costs and the amount of physical and psychological trauma. Although this innovative skeletal surgery handles the issue of altered skeletal growth when using ordinary titanium plates and screws with nearly no side effects on the growing facial skeleton and was found to be well tolerated and effective (35), the risk of damaging tooth buds in the pediatric jaw is still present due to drilling for direct application of the resorbable plates and screws (5, 33, 36). Eppley (35) claims that this risk is minimal since the drill hole and the tapping of the screw penetrate only the outer cortex of the bone. Even if the resorbable screw tip encroaches upon a tooth, its tip is blunt and non-penetrating. Subsequent resorption of the screw removes any potential obstruction to tooth eruption. Despite the above, the literature advocates conservative management of mandibular body fractures at young ages which also benefits in decreased immobilization time, decreased muscular atrophy and better oral hygiene (7, 31, 37).

Complications

Postoperative infection, malunion or non-union are rare in children because of the child's greater osteogenic potential, faster healing rates, and the less frequent requirement for ORIF. Furthermore, a greater number of fractures are minimally to non-displaced. Late complications such as damage to permanent teeth, which may occur in 50% of mandibular fractures, TMJ dysfunction (recurrent subluxation, noise and pain, limited condylar translation, deviation on opening, ankylosis) and growth disturbances (e.g. secondary midface deformity, mandibular hypoplasia or asymmetry) usually occur only in pediatric patients with severely comminuted fractures (4, 38–40).

Malocclusion as a complication of pediatric facial fractures is rare (39). It has been attributed to short fixation times in alveolar fractures and may be caused by growth abnormalities after condylar fracture (15, 38). Spontaneous correction of malocclusion is seen as deciduous teeth shed and permanent teeth erupt (4). Furthermore, Ellis et al. (41) did not find occlusal complications associated with the use of closed treatment and IMF.

Lois et al. (42) found no difference in the complication rate of fractures treated by mandibulomaxillary fixation versus open reduction and internal fixation (4.3% and 5.45%, respectively). They concluded that in fractures with displacement in the range of 2–4 mm, there is no difference between mandibulomaxillary fixation and open reduction/internal fixation.

A recent study on mandibular body fractures complications in children (43) noted a lower complication rate (9.1%) with closed treatment of mandibular body, angle, and parasymphyseal fracture, while open reductions using miniplate, mandibular plate and mandibular/miniplate fixation revealed a higher rate of complication (30%, 28.6%, 29.2% respectively).Rates of infection and wound dehiscence occurred less often for closed versus open treatment, possibly because less complicated fractures, which are generally more amenable to closed treatment, are selected for this treatment group.

Non-unions occurred significantly less often in closed reductions than open treatment. Non-unions of the mandible may develop due to a number of factors, including poor nutritional status, poor patient compliance with postoperative care, metabolic disturbances, and generalized disease states, which all can lead to inadequate bone healing. Other local reasons for non-union may be related to inadequate immobilization of the fracture segments, infections at the fracture site, tissue or foreign bodies between the segments, and inadequate reduction of the fracture segments (43).

However, Ellis et al. (41) found lower complication rates in patients with comminuted mandibular fractures that underwent open reduction and fixation (10.3%) than in those who were treated with closed reduction with IMF (17.1%).

In cases of using resorbable osteosynthesis plates and screws for ORIF, Yerit et al. (33) found uneventful healing and no complications, while others described the same type of complications as mentioned for non-resorbable miniplates: infection due to mucosal exposure of the plates (44), premature occlusal contact, and temporomandibular disorders (45).

Long-term follow-up on facial and teeth development

A long term follow up period is recommended post-operatively in cases of mandibular body fracture in children (5, 26, 31, 34). Facial growth pattern should be monitored and treated if required (34). Complete mandibular envelope of movements should be recorded.

Ranta and Ylipaavalniemi (32) pointed out that teeth in which root development has already begun at the time of the fracture, appear to erupt normally; however, marked deformation of the crown and roots occur in teeth located on the fracture line when the calcification process was still in progress at the time of the fracture. Nonetheless, developmental disturbances occur in the lower tooth buds at the precalcification stages involved in the fracture and internal fixation site. These include damage to their pulp causing pulp obliteration and extensive root resorption as well as impaction (32). Koenig et al. (46) pointed out, that the developing follicle is more elastic than the surrounding bone and better able to survive mechanical injury. Nevertheless, it is difficult to predict the fate of tooth buds based on an evaluation of the condition of the tooth buds and fracture and the implanted hardware fixation. Suei et al. (47) mentioned that the presence of infection in the fracture site is a crucial factor affecting odontogenic cells in the dental follicle. Surgical procedures as well as fixation and reduction are also potential causes of impaction (48). Nixon and Lowey (49) concluded that mandibular fractures which occur during mixed dentition can be associated with subsequent failed eruption of permanent teeth when the fracture line is reduced using an open surgical approach.

Conclusions

The anatomical complexity of the developing mandible and teeth, and concerns regarding the biocompatibility of implanted hardware, often mandate the use of surgical techniques that differ markedly from those used in adults in cases of mandibular fractures of the young child. Therefore, the management of this kind of fractures in children is age dependent. Disruption of the periosteal envelope of the mandibular body may have unpredictable effects on growth. Thus, if intervention is required, closed reduction is favored. The placement of internal wires or plates can be fraught with danger to the maturation of tooth buds. IMF, eyelets, different kinds of splints and conservative orthodontic fixation techniques are recommended.

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