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Paediatric condylar trauma – primary management considerations – A review

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ABSTRACT

Children are not simply "small adults'', and the application of adult-type treatment can be inappropriate in many circumstances. Their craniomaxillofacial (CMF) structure changes dramatically as children grow and develop. This anatomical change also changes the location, pattern, and nature of CMF injury. Similarly, condylar architecture and anatomy also differ in children, due to which the management of paediatric condylar fractures is strikingly different from adult condylar fractures. In addition to this physiological, and behavioural differences pose an additional challenge to a surgeon.

Paediatric condylar fracture also considers conservative/non-operative treatment as an effective treatment option. However, the decision between operative and non-operative management compromises paediatric facial growth, precise reduction, and rigid fixation. This decision is crucial and is guided by many factors. Improper treatment protocol can have a devastating effect on a child facial growth and development. It can lead to various deforming complications mainly ankylosis. Hence treatment of paediatric condylar fracture should be well planned and executed.

1. Introduction

According to the American Association of Maxillofacial Surgeons, paediatric refers to people 12 years or younger. The management of paediatric facial fractures presents the surgeon with unique challenges. Usually, children below five years of age suffer less trauma. This may be attributed to the fact that children below 5 years are well protected and supervised by their parents in all that they do. As age progresses and the child starts with his/her schooling, exposure to the outer environment increases. More often, they are enthusiastic about exploring new things. In this process, the incidences of trauma increase after five years.[1]

The fact that younger children are less susceptible to major facial injuries is also attributed to the following major anatomical characteristics.

- Ratio of face to the cranium is 1:8
- Position of the face to the skull is retruded
- Adipose tissue cover is thick
- Ratio of cancellous to the cortical bone is high
- Suture lines are not fused and flexible
- Elastic bones
- Increased stability due to tooth buds
- Lack of sinus pneumatization

The condyle also changes with age (Fig. 1). There is active growth in posterior borders of ramus and condyle with resorption in the anterior border. The lower jaw's developmental anatomy influences the type of fracture patterns and distribution of fracture of the mandibular condyle. The mandibular condyle in a child of 2 years–5 years is predisposed to intracapsular comminuted fracture patterns. However, after the age of 5, the most common fracture pattern observed is condylar neck fracture. This is because in this age, the condyle has a thin cortex with a thickened periosteum. The neck of the condyle is also very thin. Active growth centres and remodelling sites make the paediatric condylar unit highly regenerative in nature with high osteogenic potential.[1]

Open reduction and internal fixation have become a mainstay treatment of the adult mandibular condylar fracture. However, the paediatric condylar fracture can seldom be treated by ORIF. Therefore,

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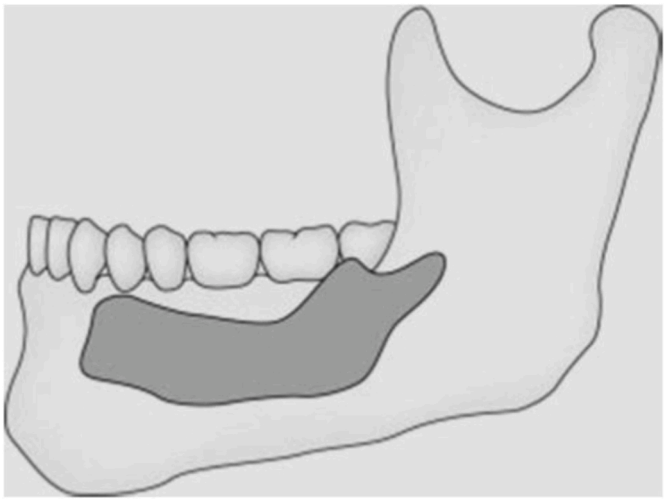

Fig. 1. The relative size and shape of neonatal and adult mandibles. The rami form an angle with the body of 160° at birth; this angle is reduced to 130° at adolescence and 120° in adulthood.[32] (Modified from Arey LB. Developmental anatomy. Philadelphia: Saunders; 1942.).

subjects in this age group are often treated non-operatively. Non operative (Conservative) management usually provides satisfactory to excellent clinical outcomes. Trauma to the paediatric or adolescent condyle can disrupt growth and have long-term adverse effects including occlusal disturbances, pain, masticatory dysfunction, restricted mandibular movements, facial asymmetry, and debilitating conditions like temporomandibular joint disorders or ankylosis.[2]

Accurate diagnosis and appropriate treatment are the key to avoid any such complications.

The objectives for treatment, therefore includes.

1. Reduction of potential risks
2. Restoration of function
3. Restoring the occlusion and symmetry
4. Maintenance of mandibular growth.[2]

2. Development of the condyle

The surgeon requires a sound perception of craniofacial growth and development to manage these injuries appropriately. The response of the paediatric mandible to trauma is largely determined by its anatomy. Human facial skeletal growth occurs in a forward and downward direction and synchronous lateral expansion. Location and rate of resorption and apposition determine the growth of the mandible. The development of the corpus of the mandible is in a forward and downward direction. To maintain condylar contact with the glenoid fossa, the condyle grows backwards and upward (Fig. 2). Endochondral replacement at the condyle contributes to its height. The vertical height of the ramus condyle unit is gained by two processes – endochondral replacement at the condyle and remodelling of the ramus. The skeletal maturity of the mandible and maxilla is different in both genders. Skeletal maturity is attained approximately by 14–16 years in girls, whereas in boys' maturity occurs at 16–18 years. Growth may, however continue into the mid-20s. The mandible is associated with more growth-related injuries because it attains its skeletal maturity later than the other facial bones. Therefore, the fracture pattern is largely influenced by the patient's age and the stage of mandibular growth (Refer to Table 1).

3. Demographics

Facial fractures represent 4–6% of all fractures.1 Mandibular

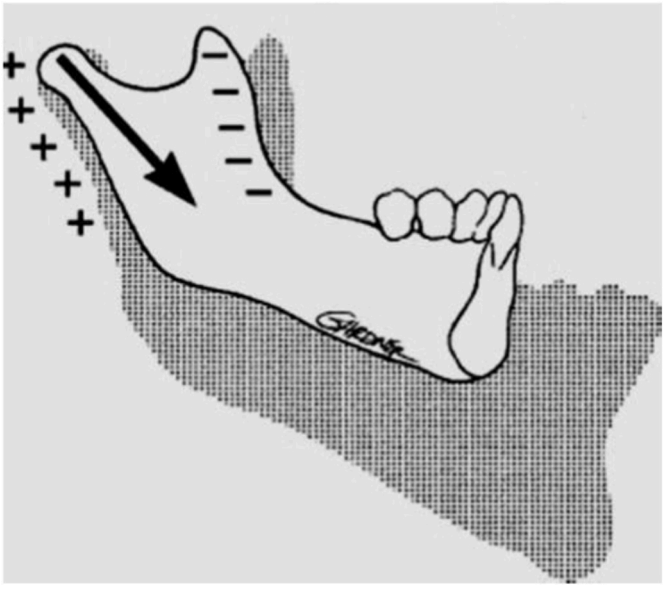

Fig. 2. Vector of mandibular growth[33] adapted from Digman SW, Hayes SL, Niel JG. Paediatric dentoalveolar surgery. Munich, Germany: Saunders; 2009. p. 165e84.

Table 1
Anatomical variation with age.

AGE OF THE CHILD IN YEARS	ANATOMICAL CHARACTERISTICS
0–2	• Short & thick condylar neck engaging a shallow glenoid fossa • Extensive vascular channels in the condylar head predisposing to crush-type injury and medial pole fracture • Short stocky nature of the condylar neck making it relatively resistant to fracture • Significant regenerative capacity
3–12	• Development of adultlike configuration of the condylar process and glenoid fossa • However, potential for regeneration and remodelling in this age group is still enormous
13–18	• Ability for a new bone formation is same as that od children however capacity for condylar remodelling reduces

fracture has the highest incidence among all facial bone fractures, next to nasal bone fracture. Condylar fracture is the most frequently occurring mandibular fracture.[3,4]

Mandibular condylar fracture constitutes about 30–40% of all mandibular fractures and 11–16% of all facial fractures. Condylar fractures are not usually due to direct trauma but from indirect force impact on the chin or the body of the mandible. Hence, mandibular condylar fracture often goes undiagnosed.[3,5]

Imahara and colleagues demonstrated that fractures of mandible account for 32.7% of total facial fractures in children. Of these, 20% have condylar fractures, 11.8% have a condylar head fracture, and 9.4% have a condylar base fracture.[6] Owusu and colleagues recently showed that the condyle is the most frequently fractured site with 14.6% cases. However, the mechanism of injury and site of injury varies with age and gender.[7] (Fig. 3).

Posnick and colleagues reviewed 137 paediatric patients with facial fractures. Most of these patients were males in the age range of 6–12 years. Motor vehicle accidents, slip and fall, sports injuries, and interpersonal violence were common aetiology. The causation of the injury will vary between different countries and population groups. Mandibular fractures comprised 55% of the overall maxillofacial injuries.

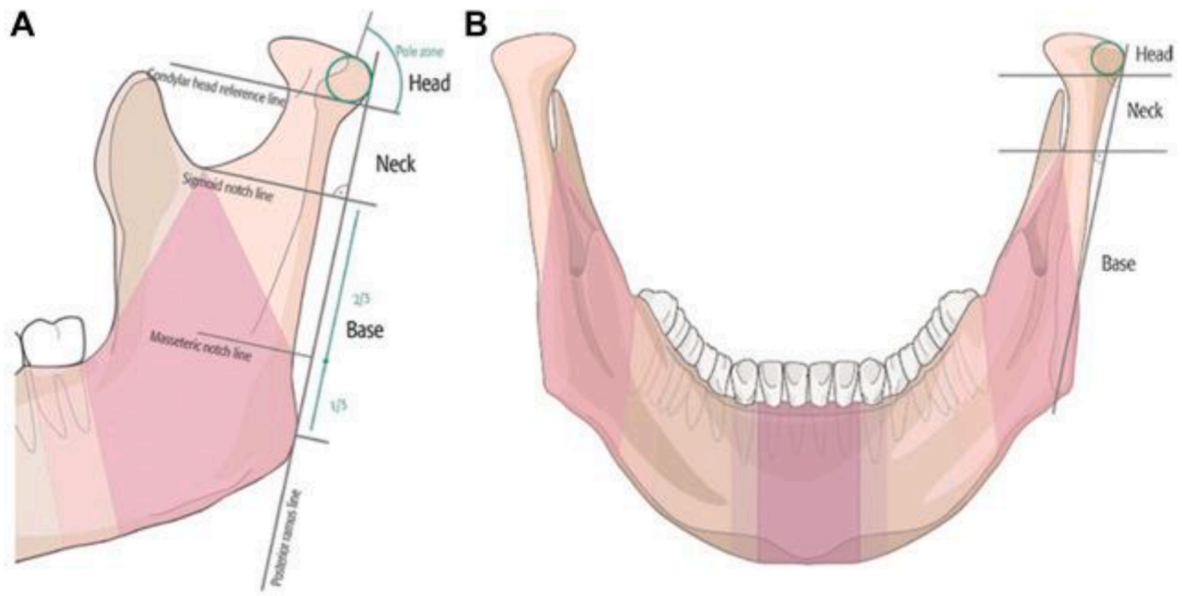

Fig. 3. Classification of mandibular condylar fracture – Loukuta Classification[34]
(Mooney Sean, Gulati Rahul D, Yusupov Steve,. Butts Sydney C. Mandibular Condylar Fracture, Facial Plastic Surgery Clinics.2020; Vol30, Issue 1, P85-98).

Condylar fractures were most prevalent amongst all mandibular fractures. This is followed by the symphyseal region, body, and, finally, the angle fracture of the mandible.[8]

4. Diagnosis

An accurate clinical and radiological evaluation is of paramount importance for diagnosing paediatric condylar fractures. The limiting factor in the diagnosis of a paediatric fracture is the patient's age. In younger patients, it becomes challenging to elicit subjective symptoms like inferior alveolar nerve dysfunction, pain, or malocclusion. Though the patient becomes more responsive and cooperative as age progress, imaging remains the best modality to support a diagnosis of a facial fracture in paediatric subjects.[2] Condylar fractures are usually associated with symphysis, parasymphysis and body fractures. Therefore, we may frequently encounter a laceration in the submental region or a sublingual ecchymosis. A classical clinical feature is the deviation of the chin to the affected side due to the shortening of Ramal height on the ipsilateral side. Flattening of the body of the mandible and open bite can be appreciated on the contralateral side in such cases. Patients with bilateral condylar fractures may present with anterior open bite with posterior gagging of occlusion. Occasionally, the mandible's occlusion, projection, and symmetry can be maintained despite a condylar fracture in cases where ramal height is maintained despite the fracture. Taking a plain radiograph requires patient cooperation, which can be challenging to achieve in a young patient who is likely to be uncooperative due to pain. In addition to this, overlapping of the condyle ramus complex can go unnoticed in a plain radiograph. Computed tomography (CT) is the preferred modality to diagnose this area appropriately, and this may require sedation to gain adequate images without movement artefact.[8]

5. Management

5.1. Stabilization

Like adults, children may present with multiple injuries and initial assessment and stabilisation follows Advanced Trauma Life Support principles of ABCDE. Critical life-threatening injuries should initially be managed, bearing in mind that facial injuries in themselves may contribute to airway compromise and may be associated with neck and neurological injuries.[9] (Refer Tables 2 and 3)

5.2. Examination

Paediatric facial fractures are usually related to severe trauma. Hence such patients should be evaluated for intracranial/cervical spine injuries, skull fractures, long bone injuries and soft tissue injuries. Neurocranial injury is frequently seen along with mandible and midface fractures. Due to the proximity of condyle to the skull base, a thorough neurosurgical evaluation is of paramount importance. Fortunately, children are less prone to cervical injury than adults but SCIWORA (Spinal Cord injury Without Radiological abnormality) should be borne in mind[9]

Mandibular Condylar Fracture, if undiagnosed in a child, may not be noticeable until the child grows.[10,11]

The following are reasons why Mandibular Condylar Fracture remain undiagnosed.

(1) physicians fail to diagnose Mandibular Condylar Fracture due to lack of training
(2) the overlying soft tissue evidence may not be enough to diagnose underlying bone disruption
(3) due to the presence of other serious associated injuries in the acute stage, attention from condylar fracture may get deviated[4]

The clinical features (Refer Table 4) may provide substantial indication to the presence of a condylar injury.[10,12] Despite a thorough clinical examination, radiological investigations are often required to support a definitive diagnosis.[10,13]

Table 2
Anatomical differnence.[9]

PARAMETERS	EFFECT
Smaller caliber of airway Relatively larger and more flaccid oral and pharyngeal soft tissues More cephalad larynx Narrower epiglottis	Difficult intubation and ventilation

Table 3
PHYSIOLOGICAL DIFFERENCES[1,9]

PARAMETERS	EFFECT
Higher surface-to-body volume ratio Higher metabolic rate Lower stroke volumes Higher oxygen demand Higher cardiac output Lower total blood	• Hypothermia • Hypotension • Hypoxia

Table 4
Clinical features.

Sl.no.	Clinical Features
1	Pain in preauricular region
2	Swelling in preauricular region
3	Painful trismus
4	Malocclusion
5	Premature contact of molars on fractured side
6	Deviation on mandibular opening
7	Anterior open bite if there is fracture displacement of both condyles
8	Posterior open bite on non-fractured side
9	Loss of translation results in deviation to fractured side

6. Imaging

It is challenging and, at times, perhaps impossible to take imaging in an awake, traumatized child. Therefore, it is always wise to wait for initial 24 h for pain and shock to recede. Orthopantamogram (OPG) is the first step, followed by CT.[14] Chacon concluded that condylar fracture could easily be unnoticed on a panoramic view and thus CT should be used when there is the slightest doubt.[4,14] CT scan is preferred to OPG as it has greater accuracy of diagnosis, sensitivity, and specificity. OPG is reported to have a high rate of false-negative and false-positive results, and therefore three plane CT scans should be preferably used routine investigation in these patients.[4]

7. Treatment options

1. NON-OPERATIVE MANAGEMENT
   a. Functional treatment
   b. Mobilization
2. OPERATIVE MANAGEMENT
   a. Closed
      i. Closed reduction with the use of functional appliances
      ii. Maxillomandibular fixation
   b. Open Reduction and internal fixation
      i. Use of conventional miniplates (Fig. 4)
      ii. Use of bioresorbable plates
      iii. Minimally invasive endoscopic assisted techniques

Banks suggested the following protocol.

- Condylar head as well as neck and base fracture in children **below 5 years** requires closed treatment or functional treatment for 2 weeks
- Condylar head fracture in children **above 5 year** also requires closed treatment or functional treatment for 2–4 weeks
- In case of condylar neck and base fracture in children above 5–8 years
  - o Open reduction is considered first
  - o If Open reduction is not possible then, 3–6 week of intermaxillary fixation, 4 week of functional treatment and then 3months of follow up.

The management of the condylar fracture is a matter of controversy amongst maxillofacial surgeons, and there is no fixed consensus on the management approach. In addition, the management of paediatric fractures differs from adult fractures due to physiological and anatomical differences. Paediatric condylar fractures usually happen transversely at the neck. Most commonly, medial condylar head dislocation is encountered due to the unopposed pull of the lateral pterygoid. This contrasts to adult fractures, where the fracture is typically oblique at the base with mandibular shortening at the posterior aspect. This is because the proximal condylar segment laterally overrides the ascending ramus at the fracture point. The proximal condylar segment is normally flexed but remains seated in the condylar fossa. In adults, the capacity to autocorrect the malunited fractures anatomically is limited. Even if the masticatory function is restored with rehabilitation and new vascular adaptation, the jaw remains mechanically disadvantaged.[15] On the contrary condylar fracture in children has immense capacity to self-correct due to high osteogenic potential. Thus, non-operative management aims to harness these characteristics of the paediatric condyle. On the other hand, open surgical treatment has resulted in a growth disturbance from the surgical manipulation of the fractured segments and rigid hardware placement across the condylar growth centre.[10] Evaluation and follow-up of paediatric fractures are essential to monitoring longer-term complications.[16] The current literature suggests that 5–10% of paediatric condylar fractures lead to a mandibular deficiency or asymmetry resulting from disordered growth after injury. In a grossly displaced fracture, disordered growth has been reported to occur in 22% following a condylar fracture.[17–19]

7.1. Non-operative management

A condylar head fracture with no gross deformity management should be a neuromuscular adaptation of the condyle. Liquid oral diet, aggressive physiotherapy exercises with ice-cream sticks and anti-inflammatory medication are the mainstay of functional management. This is followed by meticulous follow up with a regular assessment of mouth opening. The use of functional appliances re-establishes the vertical dimension and encourages remodelling of the temporomandibular joint and soft tissues surrounding it. A functional appliance is designed on the basis of specific treatment objectives to establish a functional and balanced occlusion. Zhao et al., in a retrospective study, demonstrated that a removable occlusal splint, if worn for 1–3 months, can give satisfactory clinical results. The age, dentition stage, fracture

Fig. 4. Case of bilateral condylar fracture in a paediatric patient with permanent dentition treated by open reduction internal fixation under General anesthesia.

level, and degree of dislocation determine the thickness of the splint and duration of wear.[2,20]

7.2. Operative management

7.2.1. Closed management

Maxillomandibular fixation is another form of closed management of paediatric fractures. Most commonly MMF can be achieved with Erich arch bars, Risdon cables, or Ivy Loops. Other than these orthodontic brackets, vacuum-formed splint, screw-based appliances, and anchoring tooth can be used for MMF. Traditionally MMF is done for 10–14 days.[2,21] At times it is difficult to place traditional arch bars in either the primary or mixed dentition for paediatric patients due to their short and bulbous crowns, which causes difficulty in arch bar retention. In such cases, circum-mandibular wires, piriform wires, circum-zygomatic wires, or a combination of these can be used to secure the arch bar. Alternatively, Risdon cables can better adapt to the primary or mixed dentition with better retention.[2]

The modalities can be combined to produce the desired outcomes. Temporary maxillomandibular fixation (MMF) and functional treatment of paediatric mandibular condylar fractures done simultaneously can provide good results. The MMF can be applied for a brief duration, followed by using orthodontic guiding elastics. This will guide the mandible into centric occlusion. However, few surgeons have suggested no benefit in using MMF as a treatment modality, preferring, early mobilization to improve the lymphatic and vascular circulation adjoining the fracture site and accelerate the regeneration of the fractured condyle.[22]

Other disadvantages of MMF are.

- deterioration in oral hygiene
- tooth decay,
- injury to the dentition by fixation methods
- malnutrition
- weight loss
- bony ankylosis or fibrosis and severely limited mouth opening if MMF use is prolonged.[20]

Functional appliances are preferred over traditional MMF in several ways. They allow restoration occlusal plane aligned orthogonally to the forces of occlusion. They also enable the accurate transfer of forces through the maxilla to the rest of the cranial bones, crucial for proper facial development.[22] Principally this approach aims to activate the bone remodelling process, rebalances the intra-articular functional structures, and causes reacquisition of mandibular movements at the level of the fractured condyle. This is achieved through the early restoration of a stable occlusion and the normalization of muscle functionality. This approach focuses on early joint activation, preventing functional limitations or ankylosis. Moreover, functional appliances are removable and better tolerated; however, they are limited by the patient's cooperation,[23] education and dexterity.

The following should be considered when deciding on conservative functional management:[23]

- The two fragments are separated, but dislocation is not wide, suggesting that the periosteal layer is not interrupted. This ensures the continuity of the bony pieces
- The fracture line does not involve the condylar head area. This ensures the absence of blood in the articular space. The lack of intra-articular blood reduces the risk of fibrous organization in the TMJ. In such situation, a two-week delay in starting the CTR (closed functional therapeutic regimen) may be wise.
- The vertical dimension and the occlusion are maintained.
- The patient is of young age (5yrs–10 yrs) at the time of injury.

7.2.2. Open reduction and internal fixation (ORIF)

ORIF is traditionally used for neck and base fracture of the mandibular condyle. It can be used in children with permanent dentition with unilateral/bilateral condylar fractures, especially when it is dislocated. It can also be used in fractures with persistent malocclusion after a course of MMF after two weeks. ORIF is also indicated in missile injuries and pan facial fractures of children. Fixation is usually with miniplates as used in adult fractures.[10] However, metal miniplates should be avoided for condylar neck or base fractures under 12 years of age due to ongoing growth.[25,26] This is because a second surgery to remove the metal plates and screws is required to avoid significant growth disturbance of the mandible.

Secondary surgery unnecessarily exposes children to the risk of a second surgery and increases the cost of treatment.[24,27] Alternatively, bioabsorbable osteosynthesis materials can be used. These can be considered for use in the treatment of severely dislocated fractures of the condylar neck and base. Fractures treated by osteosynthesis with two bioabsorbable miniplates (8 cortices of fixation) has been reported to show good stability of the fragments in sheep.[28] Use of bioresorbable plates has the following advantages:[29]

- It does not interfere with radio - diagnostic techniques due to their radiolucency
- There is no need for secondary surgery for plate removal as these are biodegradable
- The growth of mandible is not further retarded.

Zhang et al. stated that ORIF with bioabsorbable miniplate and screws is a superior treatment modality for use in the treatment of severely dislocated (the condyle dislocated from the glenoid fossa) fractures of the condylar neck and base with crown fracture of deciduous molar and permanent molar or dislocation of the teeth in children when non-invasive or occlusal therapies were ineffective.[24]

Minimally invasive endoscopic approaches for condylar base fractures may be a suitable alternative to avoid concerns with scarring and facial nerve injury. This modality has been well documented in adult fractures. Whilst it is easy to execute in fractures with lateral override, medial override is difficult to reduce and leads to prolonged surgical time with increasing chances of nerve injury. Endoscopy relies on interfragmentary friction and visual fracture alignment to determine the accuracy of fracture reduction. Moreover, rigid stabilisation demands adequate length of extracapsular condylar length to place the miniplate and screws. Coronal computed tomographic images of the condylar region are best for this purpose. Contraindications includes comminuted and intracapsular fractures.[15] Schiel et al. evaluated the possible benefits of open surgery and endoscopically assisted reduction and fixation using a transoral route and compared outcomes. They concluded that transoral endoscopically assisted surgical treatment of severely displaced condylar base and neck fractures in children and young teenagers offers a reliable solution to preclude the complications of closed treatment, such as altered morphology and functional disturbances, and eliminated visible scars and reduced the risk of facial nerve damage compared with open reduction using an extra oral approach.[30]

8. Complications

Paediatric condylar fracture has their own spectrum of complications.

- Pain
- Malocclusion
- masticatory dysfunction
- facial asymmetry
- restricted mandibular movements
- temporomandibular joint disorders
- ankylosis (Fig. 5)

Fig. 5. Post traumatic ankylosis of mandibular paediatric condylar fracture.

This condition is one of the most serious complications of the condylar head paediatric mandible fracture and may lead to impairment of speech, difficulty in mastication, and poor oral hygiene. It is usually associated with undiagnosed condylar fractures. This is discussed elsewhere in this edition.

- uncommon injuries such as intracranial intrusion of the condyle through the glenoid fossa into the middle cranial fossa. Blunt trauma to the chin typically results in fractures to the narrow neck of the mandibular condyle rather than transmission of the force to the glenoid fossa. Due to the thicker and broader condylar neck, this kind of fracture is more common (although rare) in children. The increased pneumatization of the temporal bone and absence of posterior dentition are additional contributory factors. The intrusion of the mandibular condyle into the cranial cavity can result in neurologic manifestations as follows
  - o hearing deficits
  - o cerebrospinal fluid otorrhea
  - o facial nerve paralysis
  - o altered consciousness from cerebral contusions or hematomas.

Treatment includes reduction of the condyle back into the temporomandibular capsule, re-establishing the preinjury occlusion, and possible reconstruction of the glenoid fossa. Neurosurgical consultation is mandatory for possible intervention for dural tears or other intracranial injuries.[31]

9. Conclusion

Paediatric condylar fracture requires thoughtful consideration in management to not only treat the fractures but also try to avoid future growth complications. The aim is to restore function and symmetry while avoiding the complications of malocclusion and temporomandibular joint dysfunction. Treatment can be non-operative or operative, closed or open and should be based on the nature of injury and age of the patient. Non-operative and closed techniques have often been preferred over open surgical management. It is important to remember that children are not simply “small adults” and that the use of “adult” treatment may be unsuitable in certain situations. At present there is no definitive age or set of guidelines that defines the treatment of condylar fractures at any age group and the final treatment plan is always a joint decision between surgeon, patient (if Gillick competent) and the parents.

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