Review Article

Orthodontic Management of Creniofacial Disorders: A Review Article

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Abstract:
A craniofacial malformation is a defect in embryonic development that causes significant impairments in the normal anatomy of the skull, jaws, and associated soft tissues. Because the problems of these patients frequently differ significantly from those of normal patients, geneticists, surgeons, paediatricians, neurosurgeons, ENTs, orthodontists, ophthalmologists, speech therapists, and many others who will care for them should all have a very specific expertise in the field. As one of several specialists on the craniofacial team, the orthodontist plays a critical role in the stabilisation and optimisation of craniofacial abnormalities from birth to skeletal growth maturation.
In this article, the most encountered craniofacial anomalies related to the field of orthodontics will be discussed in groups with more focus will be given to the role of the orthodontists in the management of these anomalies.
Keywords: Craniofacial disorders, Orthodontic management.

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INTRODUCTION

A craniofacial malformation is a defect in embryonic development that causes significant impairments in the normal anatomy of the skull, jaws, and associated soft tissues. Most birth abnormalities fall into the "craniofacial" category. Children with craniofacial deformities necessitate highly precise and one-of-a-kind medical care. Because the problems of these patients frequently differ significantly from those of normal patients, geneticists, surgeons, paediatricians, neurosurgeons, ENTs, orthodontists, ophthalmologists, speech therapists, and many others who will care for them should all have a very specific expertise in the field[1]

As one of several specialists on the craniofacial team, the orthodontist plays a critical role in the stabilisation and optimisation of craniofacial abnormalities from birth to skeletal growth maturation. To support skeletal, dental, and soft tissue components, systematic techniques of orthodontic therapy protocols must be followed, depending on the the aberration. This was proven to considerably increase the psychological state of patients who were previously suffering from due to the prevalence of facial deformities. Some of the most important craniofacial anomalies connected to orthodontics will be covered briefly in groups in this article. The involvement of orthodontists in the management of these aberrations will be emphasised further.[2]

In this article, only the four main craniofacial anomalies groups will be presented in terms of facial and occlusal features accompanied with and the role of the orthodontist in the management as a member of the craniofacial medical team. Such management principles could be effective for other defects, but the exact pathology of the affected facial skeleton is

required to pick between the appropriate and valid orthodontic treatment choices.

❖ **Recommended Nomenclature[3]**

Nomenclature (suggested definitions)

A. Malformation—a primary structural defect that results from a localized error of morphogenesis, e.g., cleft lip

B. Deformation—an alteration in shape and/or structure of a previously normally formed part, e.g., torticollis

C. Anomalad—a malformation together with its subsequently derived structural changes, e.g., Robin anomalad

D. Malformation syndrome—a recognized pattern of malformation presumably having the same etiology and currently not interpreted as the consequence of a single localized error in morphogenesis, e'g Down syndrome

E. Association—a recognized pattern of malformations which currently is not considered to constitute a syndrome or an anomalad; as knowledge advances, an association may be reclassified as a syndrome or as an anomalad. e.g., hemihypcrtrophy with Wilms tumor

A wide variety of craniofacial anomalies are reported in the literature with extensive lists of facial dysmorphology types. The most common facial malformations are cleft lip and cleft palate. Less frequent are the syndromes of the I and II branchial arches and the forms more accurately called "craniofacial", that primarily involve the midface and the skull; craniofacial synostosis

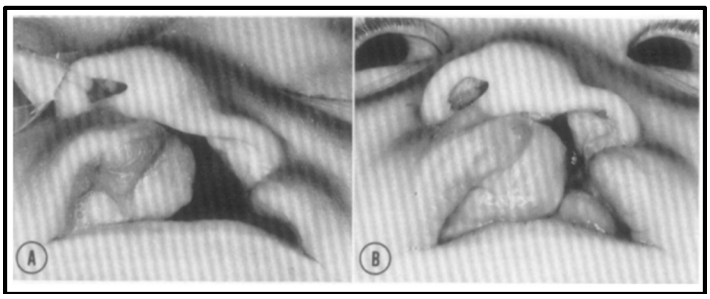
Classification of Craniofacial Anomalies[4]

1. Orofacial clefting syndromes
   a) Cleft lip and palate
   b) Pierre-Robin syndrome
2. Craniosynostosis
   a) Muenke Syndrome
   b) Crouzon Syndrome
   c) Apert Syndrome
   d) Crouzondermoskeletal syndrome
   e) Pfeiffer Syndrome
   f) Carpenter Syndrome
   g) Jackson-Weiss syndrome
   h) Saethre-Chotzen Syndrome
3. Branchial arch disorders
   a) Hemifacial microsomia
   b) Treacher Collins syndrome
   c) Goldenhar Syndrome
   d) Di George's syndrome
   e) Nager Syndrome
   f) Miller Syndrome
   g) Oro-facial-digital syndrome
4. Syndromes affecting bone/cartilage
   a) Achondroplasia
   b) Cleido-cranial dysplasia
5. Others
   a) Binder's syndromes (maxilla-nasal dysplasia)

1. Orofacial clefting syndromes

A. Cleft lip and palate

Facial clefts can manifest as a single cleft palate (CP), a single cleft lip (CL), or a combination of both (CLP). These symptoms can be unilateral, bilateral, solitary, or part of a more complex disease. Around 400 syndromes have been reported, with clefting being one of the symptoms.



(Fig no. 1 Unilateral total cleft)

Examples include; Van der Woude syndrome, Stickler syndrome, Treacher Collins syndrome and Pierre-Robin syndrome. The general orthodontic treatment of patients with CLP is divided into four phases.[1]

a) **Presurgical infant orthopaedics.**
b) **Treatment in the deciduous dentition.**
c) **Treatment in the mixed dentition.**
d) **Treatment in the permanent dentition.**

a) Presurgical infant orthopaedics

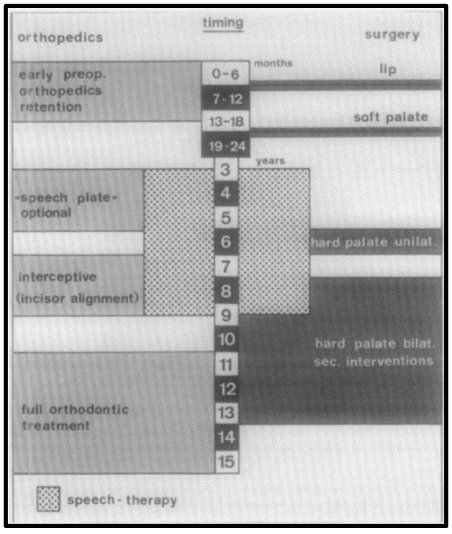
Presurgical infant orthopaedics with the NAM method is extremely beneficial for patients with bilateral CLP. However, such a protocol is not required for persons who have unilateral CLP. At this point, parents require supporting psychological therapy.5

b) Treatment in the deciduous dentition

At this stage, only cross bite cases with mandibular shift should be targeted with basic techniques such as grinding of the premature contacts that caused the shift. Otherwise, waiting till the mixed dentition period is best.6

c) Orthopaedics and Orthodontics in the mixed dentition

At this stage, the primary goal of the patients' treatment is to prepare them for alveolar bone transplantation. Palatal arch expansion, preferably using a Hyrax expander, is the most successful procedure, combined with simple orthodontic mechanics, for aligning emerging permanent teeth, not only for functional reasons, but also for cosmetic and psychological ones for both the patient and the parents.7



(Fig. 2. Timing of procedures. Active treatment is limited to definite periods as necessity demands, in order not to overstress patients. Surgery is delayed until functional requirements impose anatomic continuity. Speech therapy entails, from 3 to 5 years of age, coaching of parents and child; from 5 years of age and later, actual treatment according to the individual situation, either on an outpatient basis or in boarding school emphasizing speech therapy.)

d) Orthodontic treatment in the permanent dentition

At this stage, orthodontic therapy may be final or used to prepare for future orthognathic surgery. Orthognathic surgery may be beneficial for CLP individuals who have substantial skeletal discrepancies. Because of the diminished nasal support and insufficient thickness of the upper lip, a patient with CLP is always more in need of extra maxillary support via maxillary advancement surgery with Le Fort I osteotomy. 8 Some individuals may have substantial palatal and labial scarring, increasing the likelihood of post-orthognathic surgical recurrence. Distraction osteogenesis is required in these individuals, particularly in growing children, and has been demonstrated to greatly improve cosmetic results.

B. Pierre-Robin syndrome

The Pierre Robin sequence (PRS) is a trio of micrognathia, glossoptosis, and airway obstruction that is present at birth. PRS people with related disorders have genes that are unique to the illnesses. Micrognathia was recognised as the key feature of PRS by clinical experience and a literature analysis, and it was coupled with two other required conditions: glossoptosis and upper airway obstruction.

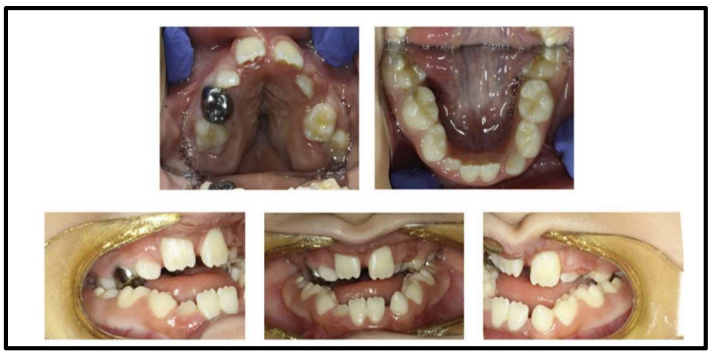
Orthodontic management

The orthodontist on the team oversees tooth development, short maxilla arch due to palate cleft, and insufficient maxillary and mandibular jaw growth. Orthodontic therapy should be carried out in coordination with the cleft and craniofacial team, with an emphasis on the airway and feeding management plan. Adult patients with PRS may

present to treat orthodontic recurrence, improve facial aesthetics, or address sleep apnea symptoms.

2. Craniosynostosis syndromes (CFS)

Craniosynostosis, defined as the early fusion of one or more cranial sutures, is one of the most frequent congenital craniofacial deformities, occurring approximately 1 in 2000 to 2500 live births. Patients with deformed head shapes have a lack of growth perpendicular to fused sutures and compensatory growth at normal ones10. The vast majority of craniosynostosis instances are isolated or nonsyndromic, while 9% to 40% of patients have a syndromic form, with over 130 symptoms connected with craniosynostosis.10, 11



(Fig.3. Intraoral findings in Craniosynostosis syndromes)

Patients with syndromic craniosynostosis may also have concomitant facial, trunk, and extremity abnormalities that vary in appearance, severity, and aetiology.Early detection and treatment of craniosynostosis is critical to ensure that brain growth is not hampered by low cranial volume and to minimise cranial deformation. In severe situations, patients may have elevated intracranial pressure (ICP) and functional issues (for example, trouble breathing, choking or vomiting during feeding), exorbitism, irritability, developmental delays, and even death.

Syndromes associated with craniosynostosis

A. Muenke Syndrome

Muenke syndrome is an autosomal dominant condition that affects one in every 30,000 live births. It is distinguished by unicoronal or bicoronal synostosis12. Muenke syndrome is characterised by macrocephaly, midface hypoplasia, and developmental delay. Anterior crossbite, class III molar and canine connection, and a concave profile are all characteristics of a class III skeletal pattern.13

B. Crouzon Syndrome

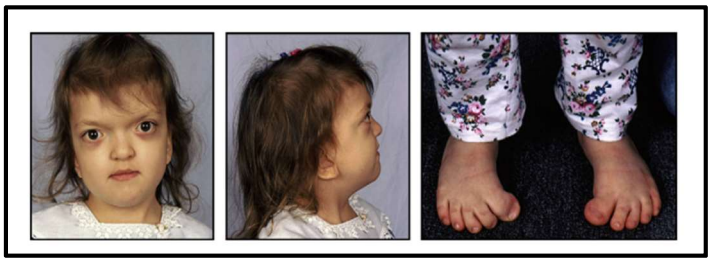
Crouzon syndrome is an autosomal dominant condition that affects one in every 25,000 live births.Crouzon syndrome is distinguished by the presence of bicoronal synostosis, brachycephaly, shallow orbits with ocular proptosis, hypertelorism, midface hypoplasia, and relative mandibular prognathism.Crouzon syndrome is characterised by maxillary deficit in the vertical, transverse, and sagittal dimensions, as well as an anterior open bite, posterior and anterior crossbites, and significant crowding of the maxillary arch.14,15,16 Because to severe teeth-to-arch size disparities, teeth frequently become impacted (typically canines) or erupt labially/palatally. Lip incompetence and localised gingival irritation are common in those with severe midface hypoplasia.17, 18

C. Apert Syndrome

Although the majority of Apert syndrome cases are sporadic, an autosomal dominant inheritance pattern has been seen. It affects one in every 100,000 live births.19 It presents similarly to Crouzon syndrome, but with more severe midface hypoplasia and syndactyly of the fingers and toes. Apert syndrome is distinguished by a 1- to 2-year delay in dental development, delayed tooth eruption, crowding of upper teeth, and skeletal discrepancy between the maxilla and mandible.According to Boulet and colleagues, 40% of patients with syndromic craniosynostosis have Apert syndrome. Because those with Apert syndrome have hypoplastic maxillary growth and airway constriction, resulting in mouth breathing and anterior open bites, orthodontic intervention during growth could be critical in decreasing the impact of the growing dentofacial deformity. Apert syndrome is distinguished by the presence of bulbous lateral palatal swellings that create the appearance of a

pseudocleft.19 Food retention and inflammation of adjacent tissues are prevalent in such circumstances. Patients with syndactyly are usually unable to follow basic oral hygiene procedures, resulting in poor oral hygiene, an increased risk of caries, and gingivitis.20, and 21 D. Pfeiffer Syndrome

Pfeiffer syndrome is autosomal dominant and affects one out of every 100,000 live births. Pfeiffer syndrome is classified into three subtypes: type I Pfeiffer syndrome, which presents with midface hypoplasia, brachydactyly, and variable syndactyly. The usual presentation of type II is a cloverleaf head, Pfeiffer hands/feet, and elbow ankyloses. Except for the Cloverleaf skull, type III has all of the characteristics of type II. Type III patients also have severe ocular proptosis, a very short anterior cranial base, and visceral abnormalities.22

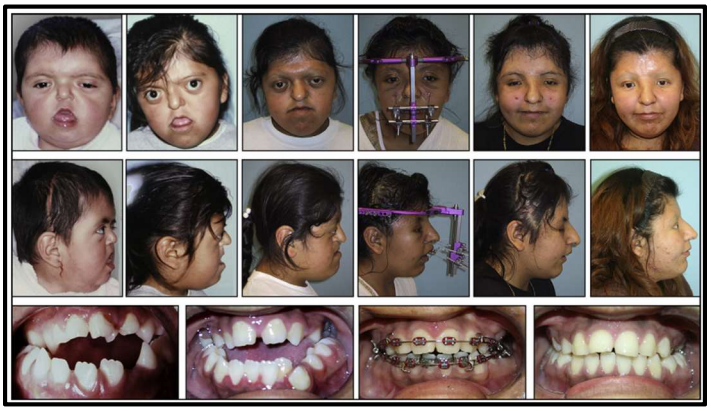


(Fig.4. Extraoral features of Pfeiffer syndrome)

Orthopaedic and orthodontic treatment of patients with craniofacial synostosis (CFS):

Sutural growth of the cranial base and maxillary-zygomatic complex is substantially impeded in this category of craniofacial defects, and there is mostly pathological appositional growth, resulting in considerable vertical dento-alveolar growth. As a result, maxillary orthopaedic treatment may be approached differently than in normal patients. There is no evidence in the literature on the precise indications of when it is possible to extend the palate in a child with CFS. Ferraro et al. proposed that individuals with CFS avoid fast palatal growth. Schuster reported that such a surgery might be reserved for patients under the age of five, with only a 2-3 mm expansion and then checking the real enlargement with an occlusal X-ray of the palate. If the expansion appears to be solely dental, the expansion device should be withdrawn to avoid severe mobilisation and early primary tooth loss. Rapid palatal extension with surgical assistance may then be explored early.23

Any device used to encourage maxillary growth should be avoided in children with CSF because these patients have early congenital fusion of the cranial base and malar sutures. However, in circumstances where patients got distraction osteogenesis of the midface via an external device and the distraction device was withdrawn early for one reason or another, a facial mask may be effective in the retention phase.



(Fig.5. Facial morphology and occlusal changes from early childhood through surgical and orthodontic treatment to adulthood in a patient with Apert syndrome.)

Instead of improving tooth aesthetics, an important goal of orthodontic therapy in CFS patients is to prepare the patient for future surgical stages, such as the requirement for Le Fort III and rigorous external fixation, as close interaction with the surgeon is constantly required. The majority of CSF patients have significant skeletal open bites that necessitate orthognathic surgery to posteriorly impact the maxilla with a clockwise rotation. The maxillary incisors are retroclinated as a result of this surgery.24 Presurgical orthodontics should target the inclination of these teeth to be more proclined for this purpose. Crowding is usually severe enough that permanent teeth must be extracted. The need for surgical tooth uncovering is common and should be considered.

3. Syndrome Branchial arch disorders

Hemifacial microsomia (HFM), Goldenhar syndrome, and Treacher-Collins syndrome are all linked to abnormalities of the first and second branchial arches.

A. Hemifacial microsomia

HFM affects the development of the lower half of the face, most notably the ears, mouth, and mandible, but it can also affect the eye, cheek, neck, and other regions of the skull, as well as nerves and soft tissue. Asymmetric midface hypoplasia, mandibular hypoplasia, TMJ ankylosis, macrostomia, and CL and/or CP identify it. Goldenhar Syndrome, also known as Oculo-Auriculo-Vertebral syndrome, is a rare congenital disorder in which the ear, nose, soft palate, lip, and jaw do not develop normally. Other observations include a V-shaped palate, severe class II malocclusion, increased mandibular plane angle, mandibular retrognathism, and CL/CP.

Orthopaedic and orthodontic treatment of patients with 1st and 2nd branchial arch syndromes:

Because this craniofacial group's anomalies almost all share facial and occlusal traits, orthodontic treatment options for HFM patients will be described in the next section, which might be methodically handled for additional anomalies.

Orthopaedic treatment for patients with HFM:

This topic is fraught with disagreement in the literature, as it is with mandibular orthopaedic treatment for otherwise normal growing patients with defective mandibles. There is no empirical evidence that a functional appliance can influence mandibular growth, according to the American Association of Orthodontics in 2005.25

Several case reports on how HFM patients responded to functional simulation. The majority of these cases are "Pseudo-HFM," or misdiagnosed HFM individuals with severe non-congenital mandibular asymmetries, most likely as a result of very early trauma.

According to Vargervik, the genuine response of HFM patients to functional treatment is usually fairly mild and time restricted. In moderate circumstances, orthopaedic treatment can correct an asymmetry by gaining primarily dentoalveolar compensation while accepting some degree of skeletal asymmetry. Some writers recommend using asymmetrical or hybrid functional applications to maintain a less oblique occlusal plane and to engage the musculature on the afflicted side, resulting in better facial symmetry.

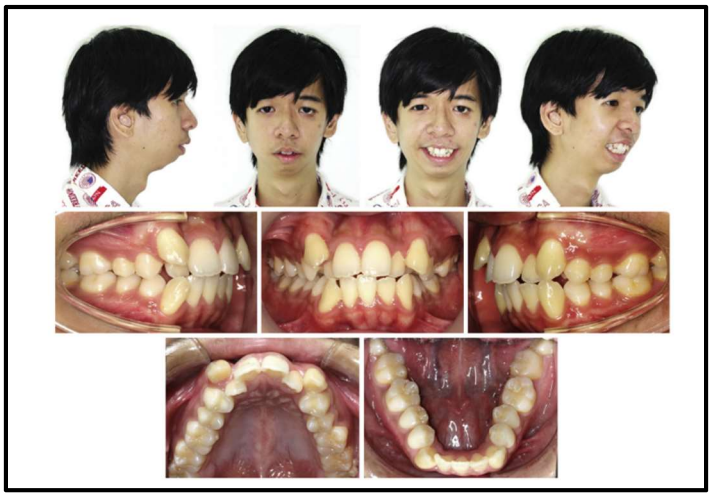
Pre- and post-surgical functional orthopaedics has also been proposed to strengthen the stability of the surgical result when costochondral grafting or pre and after distraction osteogenesis is required. However, this treatment was discovered to be incapable of long-term maintenance of postsurgical mandibular skeletal symmetry.26

Orthodontic treatment for patients with Hemifacial microsomia (HFM):

HFM patients may have maxillary crowding and constriction on the afflicted side. Given the correct shape, a quick palatal expansion could be beneficial. The midline location should be reviewed with the surgeon who will conduct the future osteotomies in order to lessen the child's burden of care and avoid round tripping of teeth. Orthodontic treatment in adults is typically used to prepare for orthognathic surgery and follows the same concepts as presurgical orthodontics in asymmetries.

B. Treacher-Collins syndrome

Treacher Collins Syndrome is distinguished by malar and mandibular abnormalities, a convex facial profile, macrostomia due to lateral clefting and CP with or without CL, and class II anterior open bite malocclusion.



(Fig.6. Extraoral and intraoral findings of Treacher-Collins syndrome)

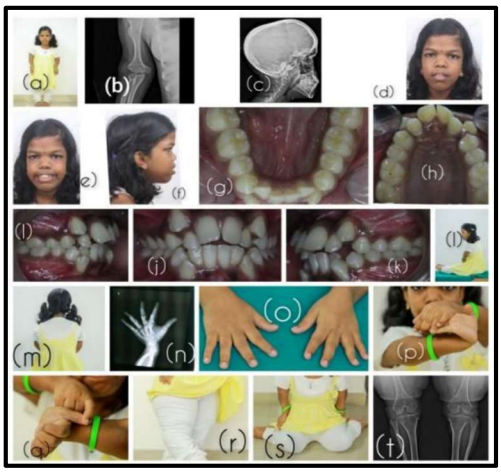
Orthodontic treatment for patients with Treacher-Collins syndrome

The surgical goals for this patient's facial and jaw bone repair were raising ramal height and mandibular body length, restoring facial harmony, and extending the posterior airway through skeletal framework expansion. Presurgical orthodontic treatment aims to eliminate three-dimensional dental compensation, which includes crowding relief, proper tooth alignment, retroclination of mandibular anterior teeth, creation of a larger overjet, coordination of arch forms, and elimination of occlusal interferences. Camouflage orthodontics, orthodontics with anticlockwise maxillomandibular advancement (MDO), and orthodontics with maxillomandibular advancement (MMA) are some of the other techniques available.27, 28

4) Syndrome Syndromes affecting bone/cartilage

a) Achondroplasia

Achondroplasia is a kind of dwarfism characterised by stunted stature and excessive limb shortening. Achondroplasia is of particular interest in dentistry due to its distinctive craniofacial traits, which include relative macrocephaly, a depressed nasal bridge, and maxillary hypoplasia. The presence of a big head, an implanted shunt, airway blockage, and difficulty controlling the head necessitates additional measures during dental management. Orthodontic treatment for patients with Achondroplasia.29



(Fig.7. a-whole body of the patient,b- rhizomelic disproportion of the limbs, c-pretreatment lateral cephalogram,d,e,f- Pretreatment extraoral, g,h,I,j,k- Pretreatment intraoral,l- lumbar lordosis, myphosis,n- handwrist radiograph,o- trident configuration,phypermobile wrist,q- hypermobile thumb,r,s- hypermobile knees,t bowing of legs).

Achondroplasia treatment includes both orthodontic and orthognathic surgical treatments. To rectify the cross-bite malocclusion and gain space, orthodontic treatment should be started as soon as possible with a palatal expansion device. Myofunctional therapy to prevent tongue thrusting should be continued throughout orthodontic treatment29. When the difference between the maxilla and mandible is not significant or the skeletal deformity is not the primary issue, the treatment decision in patients with achondroplasia may be confined to orthodontic treatment exclusively.

The literature on orthognathic surgery and achondroplasia is sparse. Surgical techniques are often determined by the degree of the facial skeletal abnormalities. The problem analysis clearly shows that numerous components of the face skeleton must be moved into new positions in order to achieve occlusion correction. Both the upper and lower midface appear to require synchronous motions in opposite directions to normalise the typical skeletal abnormality. However, when evaluating the pathophysiology, the key aberration to rectify is retrusion of the midface.

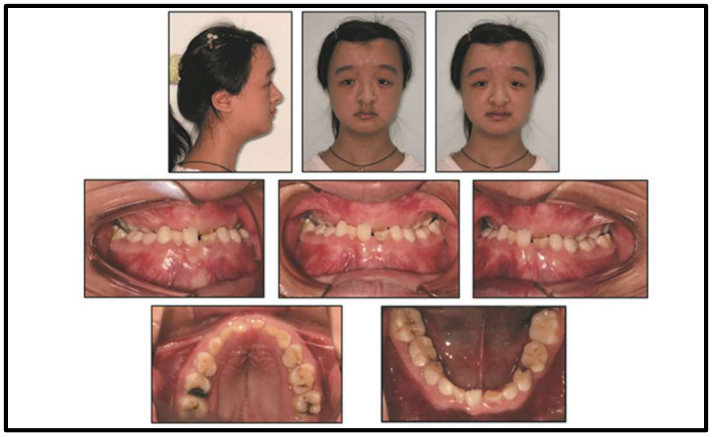
Satisfactory craniofacial function and aesthetics have been achieved in severe cases with thorough correction employing various craniofacial surgery procedures, such as frontofacial advancement and Le Fort I and vertical subsigmoid osteotomy30. A simple combination and application of common craniofacial surgery techniques in achondroplastic patients resulted in a very good outcome. However, regardless of the approach used, the main aberration is connected to the cranial-base limitation.

Following the completion of active growth, further surgery to treat the remaining bone abnormalities may be performed. The dentoalveolar component of a skeletal abnormality can be managed apart from the craniofacial component. 24 Patients suffering from achondroplastic disease can be treated in phases. Karpagam et al describe a 14-year-old female achondroplasia patient with an anterior openbite,

vertical maxillary excess, significant maxillary retrusion, and Class I molar relation with lip incompetence31. They recommended first correcting the dental component of the anterior open bite, followed by treatment of the upper midface, including the nasal complex.

b) Cleido-cranial dysplasia

Cleidocranial dysplasia (CCD), an autosomal dominant condition with a one-in-a-million frequency, is mostly caused by mutations in Runx2, a gene needed for osteoblastic development. It's distinguished by hypoplastic clavicles, a small thorax, and delayed or absent fontanel closure. Notably, its orofacial symptoms, such as midfacial hypoplasia, retained primary teeth, and impacted permanent and supernumerary teeth, substantially impair affected individuals' well-being32. Successful treatment of orofacial disorders necessitates the collaboration of dental professionals. However, because to the rarity of CCD and the intricacy of the treatment, only a few successful cases have been reported.



(fig.8. Extra and intraoral findings of Cleido-cranial dysplasia)

Individuals suffering from CCD require a thorough diagnostic work-up as well as a long-term therapy plan. The UCSF (University of California, San Francisco) therapy protocol combines the Bronx and Belfast-Hamburg techniques and is divided into five phases. It entails the precise placement of supernumerary and retained primary teeth, surgical exposure of impacted permanent teeth, orthodontic extrusion and alignment, Le Fort I advancement, and implant retained prosthesis33.

CONCLUSION

To obtain the greatest long-term aesthetic and functional results, orthodontic therapy for patients with craniofacial anomalies is more complex, requires more time and clinical resources, and should be based on exact collaboration with numerous dental, surgical, and medical professionals.

Because orthodontic management is frequently required prior to most surgical procedures involving craniofacial anomalies, management protocols should be based on a precise understanding of the exact nature of the anomalies, as certain mechanics may be provided efficiently, safely, and with acceptable durability, while other techniques may be ineffective with some complications.

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