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Significances of Distraction Osteogenesis in Craniofacial Deformities – A Review of Literature

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Abstract

A number of craniofacial dysplasia [40] have been reported around the world from the past till date. Some of these syndromes include Treacher collin syndromes, craniofacial/hemifacial microsomia[1],syndromic or non-syndromic robin sequence, cleft palate, nagers syndrome, stickler syndrome[14,17,42]. Infants and older children are mainly affected by these congenital and acquired deformities, resulting from a variety of disabilities ranging from life threatening situation to facial disfigurement thereby hampering their social life. Thus strict measures should be planned for the treatment of such patients .From the past various surgical techniques has been practiced for the same and it was concluded that craniofacial distraction osteogenesis is the most effective and novel treatment modality for the correction of these defect [3,40].Thus this present paper reviews about the distractor devices and its importance in craniofacial deformities.

Keywords: Distraction Osteogenesis, Craniofacial Deformities, Tracheostomy, OSA.

Introduction

Orthognathic surgery is a most versatile and preferred treatment option for the correction of dentofacial deformity among surgeons and orthodontist around the world .But this technique served only mild to moderate bony advancements which was insufficient for the correction of the craniofacial anomalies .Thus the limitations of orthognathic surgery led to a major breakthrough of distraction osteogenesis (DO) in the treatment of patients with craniofacial abnormalities [41].

Distraction osteogenesis is a surgical procedure in which bone is subjected to corticotomy[6,22] and later by gradual and controlled tractional force between the mechanically separated bone segments[4]new bone is formed [,3,9,10,14,16,35,41].During this procedure simultaneous adaptive response of surrounding functional soft tissue matrix along with bone augmentation takes place .Thus this phenomenon is termed as distraction histiogenesis[14,16,27,32,33,36].It is also known by other names like callotasis[4,14,34,36,41] osteodistraction[36].

The journey of distraction osteogenesis started from Ilizarov with the correction of deformities of long bones [17,35,42].Snyder was the first one to experiment mandibular reconstruction in canine mandibles [10].Later this technique

was successfully applied to the craniofacial region by McCarthy who lengthened the malformed human mandible[7,9,11,14,24].Chin and Toth was first to report ADO (alveolar distraction osteogenesis using internal distractor device. The first report of midface advancement by distraction osteogenesis was published in cleft patients by Cohen et al . Other authors like Molina, Ortiz- Monesterio and Muhlbauer also employed the same technique for the advancement of the maxillary segment and midfacial advancement respectively. It had changed the entire idea of craniofacial reconstruction especially in patients with CLP presenting severe maxillary hypoplasia [14]. Polley and Figueroa also have studied the outcomes of distraction osteogenesis in cleft lip and palate patients and reported to be huge success [29].In course of time a new method of maxillary expansion using a transpalatal multi component bone anchored distractor has been reported.

Figure I - Classification Of Craniofacial Distractors[12 ,14,17, 19, 33 ,32,36]

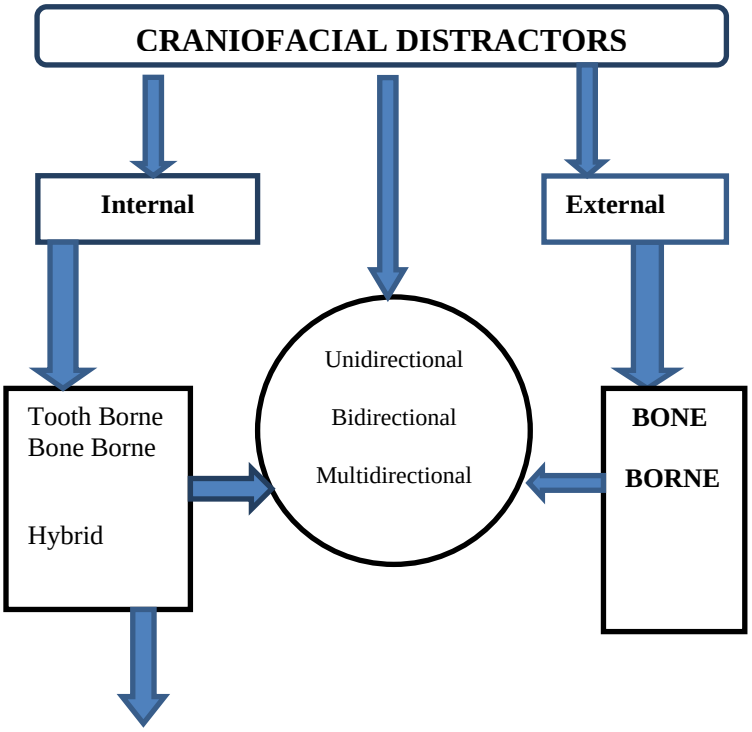

Table I - Based On The Site Of Application

Mandibular Devices[14,17]	Ramus and Body Distractors Symphyseal distractor Alveolar Distractors ROD Device Distractor - Implant Device Transport Distractor
Maxillary , Midface Devices[14,17]	Modular Internal Device HYRAX Appliances Palatal Distractors RED Device Zygomatic Distractors Transport Distractor
Cranial Devices[43]	Riediger Distractors Arnaud Marchac Cranial-Orbital Distractor Molina Orbital – Malar Distractor Matthews Tessier Distractor

1. **Mandibular Distraction**

The precise treatment planning for craniofacial deformity include the assessment of the severity of deformity, selection of distraction vector, osteotomy site, pin site, consideration of the location of the inferior alveolar nerve [2],location of the teeth and also selection of devices used in each circumstance .The age factor plays a significant

role in the treatment planning of distraction osteogenesis which includes children less than 2 years are not good candidates unless they have having airway compromise [19]. Apart from these exceptions this technique should be ideally deferred until the patient has attained skeletal maturity [14,36].The most common syndromes for which unilateral mandibular distraction has been planned include hemifacial/craniofacial microsomia, trauma, TMJ (Temporomandibular) ankylosis, juvenile idiopathic arthritis and obstructive sleep apnea. Similarly bilateral mandibular distraction is planned for Pierre Robin sequence, Class II mandibular hypoplasia, Treacher Collins syndrome, OSA (Obstructive sleep apnea) and TMJ ankylosis[22].The internal device can be used for mandibular advancement of 25 mm or more whereas external devices are employed if 40 mm of advancement has to be established.

Application Of Distraction Osteogenesis In Different Craniofacial Syndromes

1.1)Hemifacial microsomia is one of the frequent craniofacial malformations in children. The term was first coined by Gorlin and Pindborg [24]. This was classified and described by Pruzansky in the year 1969 based on the severity of the mandibular hypoplasia as Type I,Type 11 and Type 111[11,24].In this syndrome vertical lengthening of the ramus has served the purpose[27].

1.2)In pierre robin syndrome, airway obstruction occurs as a result of retro-positioning of tongue which in turn causes the impingement and narrowing of the posterior pharyngeal space. It is a life threatening condition and prompt management for the same is crucial [9].Thus the primary objective is to relieve airway obstruction in the patients accompanied with micrognathia and glossoptosis [2].Callister in the year 1937 was the first one to attempt the surgical intervention for treating PRS patients.[24] Following his work, several authors have reported other surgical techniques like tongue-lip adhesion, tracheostomy and MMA (maxillomandibular advancement) to improve airway obstruction in these patients. Whereas the limitations of the above mentioned techniques brought distraction osteogenesis into the limelight for the reduction of obstructive airway symptoms. In this technique, tongue and the suprahyoid muscles are pulled in the forward direction, following gradual lengthening of the mandible thereby increasing the pharyngeal airway space[9,21].It has been observed the horizontal pattern of lengthening of the mandibular body in patients with Pierre Robin syndrome[27].

1.3) Newborns with maxillomandibular deficiency should be first treated with non - surgical intervention such as prone positioning, nasopharyngeal tube/stenting, prolonged intubation[8] followed by surgical intervention as described previously. Later with time tracheostomy is replaced with distraction osteogenesis. Thus MDO is the best procedure when all other options fail to improve airway space in these patients[5].Below mentioned are some of the indications which make mandibular distraction osteogenesis highly imperative in the paediatric population such as, infants who show repeated cyanotic episodes with antero-posterior disharmony of maxillo-mandibular arch greater than 8 mm, patients who fail to gain weight because of difficulty in breathing during feeding[21].Mandibular lengthening attained through distraction osteogenesis provides better airway management in infants with obstructive sleep apnea who has micrognathia and retrognathia [19].As the mandible is lengthened, the tongue base moves forward by its anterior muscular attachments to the mandible, increasing the airway space and relieving airway obstruction.

Mandibular distraction of 8 mm or more, increased the cross-section of the airway to a satisfactory rate[5,21,43].

1.4) TMJ ankylosis is a structural disorder of the joint resulting in functional disturbance of the joint. This in turn interferes with speech, mastication, restricted airway space, mild to severe facial disfigurement, resulting in increased stress in patient's quality of life[7].Indications for the reconstruction of the TMJ using DO include horizontal defects, vertical defects, and combination of both the defects, patients with compromised and failed total joint prosthesis[29].Thus transport distraction osteogenesis of condyle provides several advantages like absence of donor site morbidity, occurrence of ankylosis is minimized to a larger extent, reduction of bone necrosis and resorption remarkably[14,37].Kaban et al in the year 2009,has recommended the use of transport distraction osteogenesis as an alternative modality reconstruction of the ramus–condyle unit in ankylosis patients[3,7].Surgical treatment of ankylosis requires the correction of both the deficient vertical portion of ramus & the horizontal portion of body by distraction osteogenesis followed by the freeing of TMJ ankylotic mass by gap arthroplasty.Thus clinician has control over both the distracted segments, thereby avoiding pressure against the new surgically created joint[23]. Recently interpositional arthroplasty has been combined with DO to correct TMJ ankylosis associated with micrognathia as it increases compliance[3].

1.5) Dental implants are the ideal treatment options for rehabilitation of missing teeth. But if the alveolar ridges are resorbed and atrophic, several conventional techniques like Guided tissue regeneration (GTR), ridge splitting, alloplastic materials can be applied to augment the ridge. Later with time alveolar distraction technique has been employed for the augmentation of the alveolar ridge, in both vertical and horizontal direction in atrophic ridges [5,18,21].Alveolar distractor devices along with dental implants have been devised which made the procedure more patient comfortable[18].The key indication for this technique involves the reconstruction of the vertical defects of anterior maxilla and mandible[25].Thus this technique resulted in better implant stability when compared with the traditional methods discussed above[5]

Table II-Classification Of Mandibular Distractor Devices[10,14,27,36]

Body	**Ramus**	**Transport**
Horizontal distractor	Unidirectional distractors	Threadlock
Intraoral unidirectional distractor	Bidirectional	Herford
Resorbable distractor	Intraoral ramus distractor	Dynaform device with a reconstruction plate
Dynamic osteosynthesis distractor	Zurich Pediartric ramus distractor	Frankfort Craniofacial System
CMF	Wood Zurich Intraoral distractor	Molina Distractors
	Logic Mandibular distractor	3DXternal Distractor
		Moses – Stucki Distractor

Alveolar	**Symphyseal**	**ROD Devices**
DISIS–Implant Distractor	Tooth-supported	Type1Tooth borne
OGD-ACE Alveolar Osteogenic	Bone-supported Rotterdam Midline Distractor	Type2 Hybrid

Distractor		
GDD	Hybrid – Bologna Midline Distractor	Type3Tooth borne
LEAD system TRACK system	Bone Supported - Modus	Type4 Hybrid
Osteomed Quick-fix System	Bone Supported - Surgi-Tec.	Type 5 - Hybrid
MAINZ Distractor		

2. **Maxillary And Midface Distraction**[14]

2.1) Management of cleft lip palate deformity in patients requires a interdisciplinary team of maxillofacial surgeons, orthodontist, plastic surgeons ,speech therapist etc. In the past these patients were treated by orthognathic surgery alone which resulted in high degree of relapse such as scarring of tissue and velopharyngeal insufficiency[18].Thus in such circumstances distraction osteogenesis technique provided better tissue regeneration potential with no relapse [24].The two devices used for the advancement of deficient midfacial segment in cleft patients include facemask distraction device and RED distractor devices[6,23] Amongst the two latter device is more preferred than the former as it offers a more controlled force over the midfacial segments with greatest advancement of the segments[40].

2.2) Ideal candidates for distraction osteogenesis in patients with OSA[2,24] include infants and children with congenital micrognathia or midface hypoplasia resulting in airway obstruction. Adult patients above the age of 40 years concerned with the risk of nerve injury and patients with compromised soft tissue are ideal candidates for MMA by DO. The vector of lengthening of mandible should be forwarded to advance the mandible and hyoid bone, thus enlarging the airway space for these patients.

Hence forth if distraction of the mandible is carried out without controlling the vector it can cause asymmetry or a clockwise rotation of the mandible resulting in an open bite and the ineffective forward traction of the mandible [4]. The amount of advancement obtained to manage OSA successfully in adults is less than in patients with congenital or infant airway obstruction. It is reported that the growing patients shows greater rotations of their palatal plane and the mandibular plane. Henceforth an overcorrection of at least 20% is advised during the growth to obtain a reasonable result after surgery. The versatility of DO in the midface includes distraction of the zygoma and orbit, nasal bone distraction in hypertelorism and the distraction of scarred soft tissue before secondary bone grafting.

Table III - Classification Of Midfacial Transport Devices and Palatal Distractor Devices [14, 36]

Midfacial Transport Devices	**Palatal**
Modular Internal Device	Rotterdam Palatal Distractor
RED Device	Magdeburg distractor
Zygomatic Distractor	Mommaerts distractors
Liou Cleft Distractor	Transpalatal distractor
	HYRAX appliance

3. Recent Advancements

There has been thorough research in this field in the recent past and several advances has been employed for the quick healing of osteotomized segments [16] and to obtain better results with minimal relapse from the procedure. Some of these techniques employed are administration of growth factors to enhance bone healing[4,9,10,15] administration of resorbable distractor[9],technique of continuous distraction osteogenesis such as micromotor, micro-hydraulic cylinder, portable syringe, and infusion

pump have been used to drive the distractor device during distraction. Other advances include 3- D computer modelling in distraction osteogenesis treatment planning[9],extracellular matrix and chemical signaling within the distraction site ,and the advances in cellular and the biochemical signaling are being carried out to accelerate and optimize bone healing. Hyperbaric oxygen will enhance the growth of regenerate, especially when used early during the distraction period. In addition, the use of resorbable distraction devices to reduce the number of surgical procedures, increase patient comfort, and decrease soft tissue scarring is being studies[8].Thus further research in the field of distraction osteogenesis is required to offer the finest treatment modality for the reconstruction of craniofacial deformities[17,38]

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