Rama Univ. J. Dent. Sci. 2019 March 6(1):22-26 ISSN No. 2394-417X (print), 2394-4188(online)

Distraction Ontogenesis in Orthodontics

Dr. Nishi Singh[1], Dr. Ankita Sethi[2] , Dr. Varun Gupta [3], Dr. Karuna Singh Sawhny[4]

[1.] *Postgraduate student, Dept. of Orthodontic and Dentofacial Orthopedics, Rama Dental College, Hospital and Research Centre, Kanpur, Uttar-Pradesh, India*

[2.] *Postgraduate student, Dept. of Orthodontic and Dentofacial Orthopedics, Rama Dental College, Hospital and Research Centre, Kanpur, Uttar-Pradesh, India*

[3.] *Postgraduate student, Dept. of Orthodontic and Dentofacial Orthopedics, Rama Dental College, Hospital and Research Centre, Kanpur, Uttar-Pradesh, India*

[4.] *Reader, Dept. of Orthodontic and Dentofacial Orthopedics, Rama Dental College, Hospital and Research Centre, Kanpur, Uttar-Pradesh, India..*

Abstract

Distraction orthogenesis (DO) being one of the recent and most successful treatment option for various skeletal deformities. It is a biological process of ossification between the surfaces of bone segments that are slowly disarticulated by incremental traction. Orthodontists play an vital role in treatment planning and the orthodontic treatment of patient undergoing distraction ontogenesis. The Orthodontist evaluates the craniofacial skeleton and occlusal function pre & post distraction with the routine follow up. Currently, Distraction Orthogenesis in dentistry have a wide range of application in various maxillomandibular skeletal deformities and cleft palate cases.

Key words: - Distraction orthogenesis, orthodontics, craniofacial

Introduction

Distraction orthogenesis is a surgical procedure for correction of various jaw, skeletal and alveolar deformities. [1]

Osteotomy divides the bone into segments, or if there is an intervention of suture or PDL, the bone resisting movement is removed. The most common distraction device used in orthodontics is an surgically assisted RPE. Distraction of the PDL is a procedure carried out for achieving rapid tooth movement. For DO of the maxilla mandibular and alveolar segments, the osseous segments are progressively moved apart generating new bone in the defect. The desired position of the segments is achieved in the distraction phase and these segments are retained and allowing the gap to fuse and the newly generated bone remodels into a more mature structure. A particular advantage of distraction osteogenesis is the simultaneous increase in length and volume of the investing soft tissues. [2]

Historical aspects: - Gavril Ilizarov, an Russian surgeon, made an distinctive contribution within the development of distraction orthogenesis. In early 1728, Fauchard described the use of the expansion..3

The 1st surgical procedure for the correction of a craniofacial deformity was reported in 1848, by Hullihen.

Rosenthal in 1927 performed the first mandibular osteodistraction by using an intraoral tooth-borne appliance that was gradually activated over a period of one month. Crawford, in 1948, applied gradual incremental traction to the fractured callus of the mandible. Kole, in 1959, described a way for surgically correcting an anterior open bite thanks to maxillary anterior deformity. In the same year Kole developed the rapid canine distraction method. Using this type of device in 1989, McCarthy & colleagues were the 1st to clinically apply extraoral distraction osteogenesis.[4-6]

Classification of distraction orthogenesis techniques. [7]

Classification is done on the basis where tensional stress was induced;

a) Callotasis: distraction of the fractured callus.
b) Physeal distraction: distraction of the growth plate of endochondral bones
   -Distraction epiphysiolysis
   -Chondrodiatasis.

Distraction epiphysiolysis: First experimentally demonstrated by Ring (1958) & Palskin (1967) introduced the term. It involves relatively rapid rate of bone segment separation which ranges from 1 to 1.5 mm/day. The rapid increase in tension at the growth plate produces a fracture of the physis. The subsequent gradual separation of the epiphysis from the metaphysis leads to the bone.

Chondrodiatasis: In 1978, Noble first reported the evidence of chondrodiatasis. De Bustian & colleagues carried out an experiment where an constant tension was applied across the rabbit growth plate & introduced this term. Stretching of the growth plate without a fracture is seen due to a very slow rate of bone segment separation (less than 0.5 mm/day).

Accelerated osteogenesis is achieved due to the tensional stress develops between the bone and it results in biosynthesis activity of cartilage cells.

Distraction histogenesis: Tensional stresses are created in the surrounding soft tissues following distraction forces which leads to active histogenesis in different tissues like skin, facial, blood vessels, nerves, muscles ligaments, cartilage, periosteum and is generally accompanied by distraction orthogenesis.

The principle stages of Distraction orthogenesis are summarized in table no.1

Various types of Distracter used in Orthodontics

Based on site-

- Mandibular
- Midface or maxillary
- Alveolar
- Transport (Reconstruction of neo-mandible/ neocondyle) [10]
- Rigid external distractor (RED)

Based on use-

External distracter

- Unidirectional (activated in one plane of space)
- Bidirectional (activated in two plane of space)
- Multiplanner (activated in three plane of space)
- Rigid external distraction (RED) system

Internal distractor

- Mandibular intraoral distracter
- Modular internal distracter (MID)
- Tooth borne distracter e.g. rapid canine distracter, alveolar distracter

Indications -

a. Lower face (mandible)

1. Hemifacial microsomia.
2. Vertical distraction of alveolar segments [11]
3. Horizontal distraction across the midline to correct cross bite deformities.[14]
4. Transport distraction to generate a neo-condyle in severe joint ankylosis.[12]

b. Mid face (maxilla, orbits)

1. Advance the lower maxilla at the LeFort I level13
2. Complete mid facial advancement at the LeFort III level.
3. Upper face (fronto-orbital, cranial vault).
4. Advancement of the fronto-orbital structure, alone or in combination with the mid face [13]
5. Zygomatic distraction in cases of deficient zygoma.

c. Craniofacial DO include

1 Nonsyndromic Craniofacial Syndrome - Coronal (bilateral or unilateral) or sagittal.

2 Syndromic Craniofacial Syndrome (Apert, Crouzon, Pierre Robin syndrome, Treacher Collins syndrome, Goldenhar syndrome, Brodie Syndrome and Pfeiffer syndromes).

Contraindication

1 Severe infection
2 Metal allergy
3 Severe osteoporosis
4 Poor patient compliance
5 Immuno-compromised patients
6 Blood coagulopathies
7 Bleeding disorders
8 Poor bone stock availability

Advantages

1 Large maxillo-mandibular advancement possible [15]

2 Can be done at any age. There have been reports of rapid,early mandibular distraction to prevent tracheotomy in a newborn with micrognathia that was causing severe airway obstruction.Minimized need for orthognathic surgery, hence reduce complication [15]

3 Minimized relapse because of histogenesis during distraction

4 Distraction Osteogenesis is a safe and effective surgical procedure.[16]

5 Distraction can be Suitable for both growing and nongrowing patients.

6 The Distraction can be done as uniplanar, bi-directional or multidirectional [16]

7 Does not appear to negatively affect temporomandibular joint (TMJ) anatomy or function.[11]

8 Distraction produces less neurosensory problems than traditional techniques.[17]

9 Shorter hospital stay

10 No bone graft required

11 New bone formed in distraction orthogenesis is more native and permit orthodontic tooth movement

Disadvantages

1 The procedure leaves residual cutaneous scarring resulting from the transcutaneous fixation pins. This is taken care of by careful placement of the incision i.e. the scar lies in the minimal tension

in the submandibular fold. The intra-oral approach for osteotomy and pin insertion has evolved as the approach of choice [2]

2 Incorrect displacement vector will produce less satisfactory occlusal results.[18]

3 Distraction Orthogenesis does not correct underlying growth disturbance.

4 A second surgery is required to remove the distraction device.

5 Mineral content and radio density of generated tissue is less than normal.

6 Detractors used are bulky and might be uncomfortable to the patient.

7 Certain degree of relapse might occur

Treatment Planning For Distraction Osteogenesis [19-20]

Preoperative Clinical Examination - Before distraction, the function of the TMJ and the motor and the sensory nerve functions of the patient are recorded. After distraction, transitory limitation in opening can occur. Thus it's important to document mandibular excursion and original interincisal opening to be used an objective goal during post distraction physiotherapy.

Diagnostic records

Photographs – Frontal, lateral, oblique, submental and intraoral.

Lateral and poster anterior cephalograms [21]

Three – dimensional cephalometrics

Orbital rims, Perform aperture, upper & lower jaws and occlusal planes are the usual landmarks seen in the 3-D cephalometric image advantage being that it can be rotated on the computer screen to assess the various degrees of craniofacial skeletal asymmetries and to plan the surgical distraction correction.

Orthodontic Management of craniofacial Distraction Orthogenesis-

The role of orthodontics in treatment using distraction osteogenesis falls into three temporal phases.

1 Predistraction treatment planning and orthodontic preparation

2 Orthodontic/orthopaedic therapy during distraction and consolidation

3 Post consolidation orthodontic/orthopedic management

1 **Pre surgical preparation-** Maxillary and mandibular dental arches are prepared for distraction orthogenesis by leveling and alignment decomposition, and correction of curve of spee. Any sort of mechanical interference to the tooth bearing segment must be eliminated during the gradual distraction.

The patients with severe retrognathic mandible may have a transverse maxillary deficiency. Expansion of the maxilla either before or during distraction to accommodate the width of the advanced mandible is congruous. Distraction stabilization appliances are fabricated and routinely inserted before surgery in order to facilitate vector control during distraction.[22]

2 **During Distraction and Consolidation** The use ofvarious appliances such as acrylic guidance appliance, maxillary expansion and functional appliances or using bands, brackets, elastics etc. to bring the tooth bearing segments to their post distraction positions is done during this phase.[23]Inter-arch elastics during the mandibular distraction phase influence the vector and are useful in remodeling of regenerated bone and close the open bite. Unilateral mandibular distraction (hemifacial microsomia) can lead to crossbite on normal side and posterior open bite on distraction side.

In order to correct developing transverse and vertical discrepancies, expansion of maxillary arch and use of inter arch elastics can be done. Bite blocks are given in order to level the occlusal canting and open the bite by supra erupting the posterior dentition or by means of using light vertical elastics from maxillary to mandibular arch during the consolidation and post consolidation phase.

During the active phase, the use of elastic traction is necessary in order to control laterognathism.

3 **Post distraction orthodontics and retention-** Post distraction orthodontics should be initiated after the consolidation phase which is aimed at finishing and settling the occlusion. Possibility of having orthognathic surgery or distraction osteogenesis as a treatment modality in the future must be considered in the beginning itself while treating growing children specifically. Orthodontic finishing in non-growing bilateral distraction patients is completed at this time. The crossbite resulting from mandibular shift across the midsagittal plane seen in unilateral distraction may be corrected by a combination of transpalatal arches, lingual arches, intermaxillary cross elastics and a palatal expansion device.

The open bite is at first maintained by the placement of a unilateral posterior bite plate and body size deficiency may be addressed by oblique device placement. In order to adequately maintain

the canine width and anterior alignment, fixed lower canine-to-canine wire can be used, but cannot be expected to aid in maintaining any posterior expansion.

Consequently, a Hawley retainer with integral lingual support wire can be given as it provides good form of mandibular retention.

Periodontal ligament distraction

One of the most common aims of research in modern orthodontic practice is to reduce the orthodontic treatment time and controlling the anchorage loss.
Rapid canine distalization was first introduced by Liou and Huang In 1998 stating it being the cornerstone for these goals. As Individual canine retractors are not available in the market and the long-term effects are unknown because of which the rapid canine distalization through distraction of the periodontal ligament are limited Shortening of treatment time, eliminating the need for additional anchorage, and rapid retraction of incisors using the new bone tissue distal to the lateral incisors are some of the major advantages of rapid distalization.

Distraction protocol

Distraction device is activated 0.35 mm a day, twice daily. Canine has to be moved into the extraction socket within the 1st 2 weeks, otherwise root resorption increase & anchor unit starts moving forward. [24]

Conclusion

Orthodontists are compatible to manage and use this new clinical procedure thanks to their knowledge of biomechanics and long-term patient management.

As distraction orthogenesis is gaining more clinical acceptance, it's become important for orthodontists to know subsequent generation of internal distraction devices and find out how to integrate distraction orthogenesis into their treatment plan. A brief and short review is provided in this article; in depth evaluation and understanding the procedures are important before implementing distraction orthogenesis.

Reference

[1] Orthodontic current principle and Techniques ;Graber vanersdall vig
[2] Grayson BH, Santiago PE; Treatment planning and biomechanicsof distraction osteogenesis from an orthodontic perspective;Semin Orthod 1999;5(1):9-24.
[3] Weinberger BW; The history of orthodontia:;Part 6. Int J Orthod 1916; 2: 103-17.
[4] Wescott A. A case of irregularity. Dent Cosmos 1859;1:60-8.
[5] Angle EH. Treatment of irregularity of the permanent or adult teeth. Dent Cosmos1860; 15(4):599-600.
[6] Goddard CL. Separation of the superior maxilla at the symphysis. Dent Cosmos 1893;35:880.
[7] Contemporary Treatment of Dentofacial Deformity: WilliamR. Proffit, Raymond P. White,David M. Sarver(Textbook)
[8] Bouletreau PJ, Warren SM, and Longaker MT. The molecular biology of distraction osteogenesis. J Craniomaxillofac Surg. 2002; 30(1):1-11.
[9] Aql ZS, Alagl AS, Graves DT, Gerstenfeld LC, and Einhorn TA. Molecular Mechanisms Controlling Bone Formation during Fracture Healing and Distraction Osteogenesis. J Dent Res. 2008; 87(2):107-118.
[10] McCormick SU. New York University Medical Center: Reconstruction of the mandibular condyle using transport distraction osteogenesis. J Craniofac Surg 1997;8:48-52.
[11] Nocini PF, Wangerin K, Albanese M, Kretschmer W, Cortelazzi R. Vertical distraction of a free vascularized fibula flap in a reconstructed hemimandible: case report. J Craniomaxillofac Surg. 2000; 28:20-24
[12] Baskaran M, Arularasan SG, Divakar TK, Thirunavukkarasu R. Treatment of Micrognathia by Intraoral Distraction Osteogenesis: A Prospective Study. Ann Maxillofac Surg. 2017; 7(1):37-44.
[13] .Mehrotra D, Howladar D, Bhutia DP. Simultaneous maxillomandibular distraction Osteogenesis in hemifacial microsomia: Report of 7 cases. J Oral Biol Craniofac Res. 2017; 7(2):147-152 .
[14] Hegab AF, Shuman MA. Distraction Osteogenesis of the Maxillofacial Skeleton: Biomechanics and Clinical Implications. Open Access Scientific Reports. 2012; 1(11):509 15.
[15] Cohen SR, Simms C, Burstein FD. Mandibular distraction osteogenesis in the treatment of upper airway obstruction in children with craniofacial deformities. Plast Reconstr Surg 1998;101:312-8.
[16] Davies J, Turner S, Sandy JR. Distraction osteogenesis: A review. British Dent J. 1998;185:462-67.
[17] Block MS, Daire J, Stover J, Mattews M. Changes in inferior alveolar nerve following mandibular lengthening in the dogs using distraction osteogenesis. J Oral Maxillofac Surg.1993;51:652
[18] Arun T, Kayhan F, Kiziltan M.Treatment of condylar hypoplasia wit Distraction Osteogenesis: a case report. Angle Orthod 2002;72:371-376
[19] Grayson BH, LaBatto FA, Kolber AB, McCarthy JG. Basilar multiplane cephalometric analysis. Am J Orthod Dentofacial Orthop 1985;88:503-516.
[20] Grayson BH, Cutting CB, Bookstein FL, Kim H, McCarthy JG. The three-dimensional cephalogram: Theory,technique and clinical application. Am J Orthod Dentofacial Orthop 1988;94:327-337.
[21] Pamela R. Hanson and Michael B. Melugin. Orthodontic Management of the Patient Undergoing Mandibular Distraction Osteogenesis. Semin Orthod 1999;5:25-34.

[22] Conley R, Legan H. Mandibular symphysial distraction osteogenesis: Diagnosis and treatment planning considerations. Angle Orthod2003;73:3-11.
[23] Hanson PR. Treatment planning and orthodontic management of patient undergong mandibular distraction osteogenesis. Craniofacial distraction osteogenesis. 1st ed. St. Louis: Mosby; 2001:156-67.
[24] 2Ilizarov GA. The tension-stress effect on the genesis and growth of tissues: part II, the influence of the rate and frequency of distraction. Clin Orthop Rel Res 1989; 239:263- 85.

To cite this article: Distraction Ontogenesis in Orthodontics Dr. Nishi Singh, Dr. Ankita Sethi , Dr. Varun Gupta , Dr. Karuna Singh Sawhny, Rama Univ. J. Dent. Sci. 2019 March; 6(1): 18-21

Table no 1-Principle Stages of Distraction Osteogenesis [8-9]

Phases	Mechanism and Biological Events
1. OSTEOTOMY	Mechanical dividing of bone-Simultaneous function of osteo-progenitor cells followed by osteo-induction.
2. LATENCY (5-7 days)	Normal healing process occurs -After the onset of traction bone division starts which leads to organization of hematoma, bone end necrosis, angioinvasion and cellular inflammatory phase lasting 1-3 days eventually forming soft callus.
3. DISTRACTION	Application of traction forces stimulates cellular changes, angiogenesis and fibroblast proliferation by 2nd week of distraction which slowly but steadily increases inter segmental gap.
4.CONSOLIDATION	Complete mineralization of the bone segments is done which allows their regeneration. The period of cessation of removal of the device ranges from 8-12 weeks till there is radiographic appearance of new bone.
5. REMODELLING	6 weeks after consolidation phase Complete remodelling occurs which includes haversian system widening and osteoclastic resorption.