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Distraction Osteogenesis: A Review

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ABSTRACT:

Distraction osteogenesis (DO) is a method of new bone formation followed by a corticotomy or an osteotomy and by gradual distraction with the aid of distraction devices(1). DO is a process involving formation of new bone between the surfaces of bone segments that are gradually separated by incremental traction with the help of mechanical devices which is designed to control both the traction rate and movement vector. DO is instigated when a traction force is applied to bone segments and continues as long as the callus tissue is stretched. forces applied to bone during the process of distraction create tension in the surrounding soft tissues, thereby initiating a sequence of adaptive changes termed distraction histogenesis This topic gives an overview on distraction osteogenesis and its application in the field of oral and maxillofacial surgery.

Keywords: Distraction Osteogenesis, Oral And Maxillofacial Surgery, Bone Formation

Introduction:

Distraction osteogenesis (DO) is a bone tissue engineering method to regenerate new bone. The application of DO in the field of oral and craniomaxillofacial surgery has provided an encouraging alternative as the distraction osteogenesis process can be integrated with conventional surgical technique for bone lengthening or expansion to restore the discrepancies associated with the deformities. Distraction osteogenesis (DO) can be integrated and incorporated with various oral and craniomaxillofacial surgical techniques to generate new bone via stretching the surgically osteotomized bone with the help of a mechanical device which is designed to control the traction rate as well as the movement vector. This technique utilizes the healing properties that occur naturally in the human body by inducing regeneration and remodelling of callus between osteotomized sites, also known as distraction gap(2). Callus present in between the distraction gap will be stretched with the help of the distraction device to apply a uniform traction force, thus allowing formation of new bone. Distraction osteogenesis involves the process of formation of new bone; it also stimulates a process called neohistiogenesis, where the surrounding soft tissues simultaneously expand and cover the newly formed callus.

The evolution of DO in clinical application was first introduced in the field of orthopedics has now been widely applied as treatment alternative in oral and craniomaxillofacial surgery in case deficient maxilla or midface, deficient hypoplastic mandible, deficient alveolar bone prior to implants placement, also in craniomaxillofacial region particularly for the management of congenital and acquired complex craniofacial structural defects.The use of DO in the field of oral and craniomaxillofacial region allows higher structural expansion and bone lengthening to restore the important functional discrepancies associated with these deformities(-- severely atrophic alveolar ridge, micrognathia (small mandible) or maxillary hypoplasia leading to respiratory issue as well as complex craniofacial deformities causing restriction of intracranial spaces and potential eye problems).

HISTORY: [2,3]

Hippocrates		Placement of traction on broken bones
De chauliac	14th century	Used pulley system that consisted of weight attached to the leg by a cord
banan	1826	First to perform a surgical division of a bone or osteotomy
Codivilla		combined de chauliac and banon's techniques to perform the first limb lengthening using external skeletal traction after an oblique osteotomy of the femur.
Gavril Ilizarov	1951	designed apparatus for bone fixation which consists of two metal rings that are joined together with three or four threaded rods later developed low energy, subperiosteal osteotomy technique (corticotomy) and a unique protocol for limb lengthening utilizing a latency period of 5-7 days, distraction at a rate of 1mm per day performed in four increments of 0.25 mm
Fauchard	1728	described use of expansion arch
Wescott	1859	reported placement of mechanical forces on bones of maxilla
Angle	1860	introduced palatal expansion screw
Kinsley	1866	used extra oral traction for functional appliances
Hullihen	1848	partial osteoplastic resection of prognathic mandible
Goddard	1893	standardized the palatal expansion protocol by a stabilization period after activation to allow deposition of osseous material in the created gap.
Blair		horizontal ramus osteotomy
Eiselberg, Pehr, Gadds		introduced various osteotomies
Rosenthal	1927	First - mandibular osteodistraction
Kazanjian	1937	mandibular osteodistraction with incremental traction
Crawford	1948	gradual incremental traction to fracture callus of mandible after mandibular symphyseal fracture
Kole	1959	Introduced the method of surgically correcting anterior open bite
Zavialov and Plaskin	1967	Introduced distraction epiphysiolysis and reported its first clinical application -- involves a relatively rapid rate of bone segment separation, usually ranging from 1.0 to 1.5 mm per day.
Snyder	1973	introduced Ilizarov's principles to craniofacial skeleton
De Bastiani		described- chondrodiatasis this process utilizes a very slow rate of bone segment separation (less than 0.5 mm per day).
Guerrero	1987	first Intraoral tooth- borne device for Osteodistraction
Ilizarov	1989	revolutionized the concept of distraction osteogenesis with his technique for limb lengthening-- Percutaneous Subperiosteal

		Corticotomy - followed by a latency period before initiation of incremental traction.
McCarthy	1989	first to apply clinically an external fixation device for mandibular lengthening).
Guerrero	1990	first to report Intraoral mandibular widening.
McCarthy	1992	application of the distraction osteogenesis with the help of Hoffman Mini Lengthener attached to the osteotomized bone segments with two pairs of 2 mm half pins.
McCarthy	1994	intraoral bone-borne- Uniguide Mandibular Distraction Device was developed similar to their extraoral device.
Karp and co-workers		conducted experimental study with a more comprehensive analysis of distraction regenerates at different stages of formation
Molina & Ortiz-Monasterio,	1995	Bidirectional Mandibular Osteodistraction
Chin and Toth	1996	first to apply Alveolar Mandibular Distraction Osteogenesis.
Wangerin	1997	designed Intraoral Titanium Mandibular Distraction Device.
Diner et al,	1997	developed two types of intraoral bone-borne distraction devices for mandibular lengthening based on the anatomic location of distraction.
Razdolsky et al	1998	series of tooth- borne & hybrid devices (ROD)
Eric JW Liou and C. Shing Huang	1998	proposed the concept of ‘Distracting the Periodontal Ligament’ - to elicit rapid canine retraction.

CLASSIFICATION :

Classification based on the location where tensional forces induced

Distraction Osteogenesis is classified as

1)callotasis

2)physeal distraction-a) distraction epiphysiolysis

b) chondriodiatasis

DO is a method used commonly to activate bone regeneration in

• Non-unions of fractures

• Osseous defects

• Lengthening procedures of tubular bones

Biological Sequence involved in distraction osteogenesis:

1. Osteotomy phase
2. Latency phase
3. Distraction phase
4. Consolidation phase
5. Remodeling phase

Osteotomy phase:

Osteotomy phase DO Technique involves Sectioning of a bone & the subsequent deliberate controlled movement of the opposing sectioned edges to lengthen, widen or reposition a bone or all three.

Latency phase: latency period is the time which is required for the formation of callus. Ilizarov suggested that the latency period should be around 5–7 days, but this depends on the microvasculature and physiological state of bone formation over the distraction site. At cellular level, hypoxia occurs over the osteotomized structure inducing angiogenic response and migration of mesenchymal cells to help produce collagen synthesis. Latency period should be of shorter duration for bone to prevent calcification and longer enough for adequate callus formation.

Distraction Phase: distraction phase is characterized by the application of traction forces to the osteotomized bone segments. application of traction forces leads to Bone segments being pulled apart gradually, when the bone segments are pulled apart tensional stress develops and normal process of fracture healing is interrupted. This stimulates changes at cellular & subcellular level.

Rate of distraction - If the amount of distraction is too small, there is a risk of premature consolidation. whereas If the rate of distraction is too big a rate of distraction may induce stress on the soft callus, resulting in thinning of all dimensions in the mid portion of the regenerate distraction is found to be 1 mm per day.

Rhythm of distraction - Ilizarov suggested 0.25 mm four times a day activation.

Histological changes that are seen during distraction phase over a period of time are as follows:

During the 1st week of the distraction phase, capillaries grow into fibrous tissue, their terminals actively invade the fibrous tissue, supplying the less differentiated cells. The less differentiated cells differentiate into fibroblasts, chondroblasts, or osteoblasts[13]. During the 2nd week, primary trabeculae begin to form. Osteogenesis is initiated at the existing bone walls & progress towards the centre of the distraction gap. By the end of 2nd week, the osteoid present in the distraction gap begins to mineralize. During this time the distraction regenerated specific zonal structures. This specific zonal distribution of newly formed tissues present in the distraction regenerate remains until the end of the distraction period. In addition, two new zones of primary trabeculae remodelling may become evident at the junction of the regenerate & host bone segments.

Consolidation phase: it is the time between the cessation of traction force & the removal of the distraction device. This phase allows the maturation & corticalization of the regenerated tissue. The fibrous interzone present in between the distraction gap gradually ossifies & one distinct zone of fibre bone completely bridges the gap(5). As the distraction regenerates matures, the zone of primary trabeculae present in the distraction regenerate significantly decreases & later is resorbed completely.

Remodelling phase: It is the period from the application of full functional loading to the complete remodelling of the newly formed bone(6). The initially formed bony scaffold is reinforced by the parallel-fibered lamellar bone. In this phase Both the cortical bone & marrow cavity are restored. It takes a year or more before the structure of newly formed bony tissue is comparable to that of the pre-existing bone.

Biomechanical parameters :(12,14)

Extrinsic or fixator-related

Intrinsic or tissue-related

Distraction device orientation

Distraction vector orientation

Biologic parameter: (11)

Low power osteotomy - with a almost preservation of all osteogenic tissues and periosteal / endosteal blood supply

Adequate duration of latency - to allow development of the fracture callus,

Stable, but not rigid-fixation of the bone segments, allowing their dimensional movement while preserving axial micro motion

direction of distraction -Which is precisely calculated

TREATMENT PLANNING: (10)

Detailed clinical examination to reveal and structural abnormalities and functional deviations that require correction.

Accurate orthodontic/surgical records such as -lateral and posteroanterior cephalometric radiographs, computed tomography with three-dimensional reconstruction, photographs, and models

treatment planning is done with the available information and understanding of the patient's expectations to finalize the treatment goals and pre distraction, intradistraction, and post distraction treatment objectives.

1. Osteotomy design and location,
2. Selection of a distraction device,

3. Determination of the distraction vector,
4. Duration of the latency period,
5. Rate and rhythm of distraction
6. Duration of the consolidation period.

Indications of Distraction Osteogenesis in Craniofacial Region: [1,4]

- Craniofacial microsomia – unilateral on bilateral
- Nager's syndrome
- Treacher Collins syndrome
- Pierre Robin Syndrome
- TMJ ankylosis
- Post traumatic growth disturbances
- Developmental micrognathia
- Midface hypoplasia (craniofacial synostosis syndromes)
- Hypoplastic maxilla
- Condylar regeneration
- Correction of CI II skeletal discrepancies with underdeveloped mandible due to other causes.
- Expansion of mandibular symphysis – brodie syndrome
- Mandibular symphyseal distraction to resolve arch length discrepancies.
- Ridge augmentation procedures
- Maxillary development in cleft lip and palate.
- Patients with prior bone grafting and before bone grafting
- Non Union of fractures Ridge augmentation procedures
- Surgically assisted rapid palatal expansion.
- Rapid canine retraction

Classification, advantages and disadvantages of distraction devices:

1)External device

Advantages:

- Multidirectional lengthening with angular adjustment possible during distraction
- Relatively simple to apply intraoperatively
- Easy for patient to activate
- and it Can be removed without the need for second operative procedure

Disadvantages :

- Patient apprehension to wear bulky external devices
- Potential permanent facial scarring

2) Internal device

Advantages:

- Absence of facial scars
- Inconspicuous nature of device

- Better stability of device to bone

Disadvantages:

- Designs are limited due to size of device and restricted access to oral cavity

INDICATIONS OF DO: [7,8]

Site of DO	Direction of DO	Conditions
Mandible	Vertical (Ridge) Width (Ridge) Lengthening (Body) Vertical (Ramus) Transverse (Symphysis)	Severely atrophic ridge Knife edge ridge Micrognathia Hemifacial microsomia Micrognathia in transverse
Maxilla	Vertical (Ridge) Advancement Transverse	Severely atrophic ridge Maxillary hypoplasia in AP (craniofacial syndrome, cleft maxilla) Maxillary hypoplasia in transverse
Craniofacial[15]	Posterior expansion Fronto-orbital Monobloc	Syndromic craniosynostosis (increased in ICP) Syndromic craniosynostosis (increased in ICP, severe exorbitism) Syndromic craniosynostosis (increased in ICP, severe exorbitism, OSA)
Other:Transport Reconstructed jaw	Vertical Anterior–posterior (AP) Vertical	Facial cleft Zygoma Severe alveolar ridge defect (trauma, post-ablative) Vascularized or non-vascularized reconstructed jaw (e.g. fibula, iliac, etc.)

CONCLUSION:

"Distraction osteogenesis is not a technique in search of applications. Its use should be focused on conditions that are not well addressed by conventional techniques and where the distraction osteogenesis can give a truly superior result."

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REFERENCES:

1. Contemporary Treatment of Dentofacial Deformity: William R. Proffit, Raymond P. White, David M. Sarver

2. Samchukov ML, Cherkashin AM, Cope JB. Distraction osteogenesis: Origin and Evolution. 1998. http://www.globalmednet.com/do.

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; 1: 540-4, 599-600.

6. Goddard CL. Separation of the superior maxilla at the symphysis. Dent Cosmos 1893;35:880-2.

7. Molina F, and Ortiz Monasterio, F. Extended indications for mandibular distraction: Unilateral, bilateral and bidirectional. Int. Craniofac. Congress 5:79,1993.

8. Grayson BH, McCormick SU, Santiago PE, McCarthy, JG. Vector of device placement and trajectory of mandibular distraction. J Craniofac Surg 1997; 8:473-480.

9. Grayson BH, LaBatto FA, Kolber AB, McCarthy JG. Basilar multiplane cephalometric analysis. Am J Orthod Dentofacial Orthop 1985;88:503-516.

10. 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.

11. Pamela R. Hanson and Michael B. Melugin. Orthodontic Management of the Patient Undergoing Mandibular Distraction Osteogenesis. Semin Orthod 1999;5:25-34.

12. Barry H. Grayson and Pedro E. Santiago .Treatment Planning and Biomechanics of Distraction Osteogenesis From an Orthodontic Perspective Semin Orthod 1999;5:9-24.

13. Ilizarov 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.

14. Samchukov ML, Cope JB, Harper RP, Ross JD. Biomechanical considerations for mandibular lengthening and widening by gradual distraction using a computer model. Am J Oral Maxillofacial Surg 1998;56:51-9

15. Samchukov M, Cope J, Cherkashin A. Craniofacial Distraction Osteogenesis. St. Louis: Mosby; 2001.