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Distraction Osteogenesis and its Implication in Oral and Maxillofacial Region – A Review.

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Abstract

Distraction osteogenesis is a biologic process of new bone formation and regeneration along with surrounding soft tissue by a gradual traction of surgically osteomized bone segments. It is based on Ilizarov tension-stress principle. Clinical application of distraction osteogenesis varies and has wide application in oral and maxillofacial region in the correction of craniofacial defect. Clinical implication is affected by the tissue as well as distraction device related factors. The distraction devices can be placed either intraorally or extraorally. Distraction osteogenesis is an emerging field as an appropriate treatment modality and is replacing the conventional surgical treatment for congenital or acquired bone deformities. In this article, distraction osteogenesis is reviewed on the basis of classification, procedure of distraction and its implication.

Keywords: Distraction Osteogenesis, Oromaxillofacial region, Mandible, Maxilla.

Introduction

Distraction Osteogenesis (DO) is a biologic process of formation of new bone between the osteotomized segmented surfaces of bone which are gradually segmented by incremental traction.[1] In other words it is a process of osteogenesis following an osteotomy or corticotomy by gradual distraction, hence the name. It is also called Callus distraction, osteodistraction, distraction histiogenesis, and callotasis. This process of formation of new bone is based on the tension-stress principle proposed by Ilizarov, “Aplication of gradual traction on living tissues can stimulate regeneration and growth.”[2] The gradual distraction of bone will lead to mechanical stimulation which will induce biologic responses and ultimately will lead to the formation of new bone or regeneration of bone. This process occurs by a series of biologic processes such as differentiation of pluripotent cells, angiogenesis, osteogenesis and lastly mineralization and maturation of bone.[3] Distraction osteogenesis was first described by Codivilla in the field of orthopaedic.[4] Following the success of distraction osteogenesis procedure in orthopaedic , it came in application in oral and maxillofacial region. Use of distraction osteogenesis in oral and maxillofacial region has increased over past few years in cases with bone deficiencies. Mc Carthy et al reported the clinical application of distraction osteogenesis in the treatment of four childrens with either bilateral or unilateral mandibular hypoplasia.[5] Since then Distraction osteogenesis has been widely applied in craniofacial region and has been successfully performed in multiple cases. The techinique of distraction osteogenesis

has become an appropriate and accepted mode of treatment in bone deficiencies.

Steps included in distraction osteogenesis are:[6]

a. Osteotomy/ Corticotomy and placement of distraction device.
b. Latency phase for callus organization.
c. Gradual distraction of about 1 mm per day.
d. Consolidation phase for callus mineralization and maturation.

Distraction osteogenesis (DO) can be classified as [7]: a) Monofocal, b) Bifocal, c) Trifocal.

a) Monofocal DO: The surgical fracture forms a distraction gap for traction of separated segments of bone.
b) Bifocal DO: In this, the surgically formed segments of bone are moved along the defect, from one extremity to other. The moving segment is known as Transport disc. This is usually done in mandibular reconstruction procedure after tumor ablation.
c) Trifocal DO: Here, two transport disc are formed from two extremities of defect and are moved towards each other until they meet. This is usually performed when major surgical corrections are needed.

Distraction osteogenesis devices based on their relation with skin are classified as [8]: a) Extraoral, b) Intraoral

a) Extraoral devices: These appliances are connected externally to bone with the help of fixation clamps and pins. Distraction rods are attached to the clamps and when get activated moves the attached bone segments apart.
b) Intraoral devices: These are placed subcutaneously either above or below the mucosal level or under the soft tissue. Depending on the type of anchorage these are further classified as:

1) Tooth borne: The appliance is supported only by tooth.
2) Bone Borne: The appliances is supported only by bone.
3) Hybrid: The appliance takes the support of both.

Distraction osteogenesis devices based on the material used are classified as: a) Bioresorbable and b) Non bioresorbable.

Patient criteria for Distraction osteogenesis include- Patients with maxillofacial defieciencies, TMJ ankyloses, microsmia, midface hypoplasia, micrognathia, zygomatic deficiencies, cleft lip and cleft palate patient, post oncologic ablation and transverse discrepancies etc. [9]

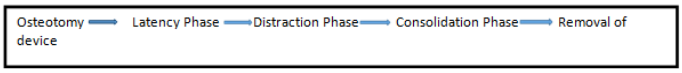
Discussion

Deficiency of bone is one of the most common finding associated with Oromaxillofacial region, distraction osteogenesis is a new and promising method in the treatment of osteodeficiencies. Hence, is widely in use since past few years. As stated above the Phases after the application of distraction devices include : Latency phase, Distraction phase and Consolidation phase.

a) Latency Phase: It is the time period between osteotomy and the beginning of distraction during which a soft callus is formed. Time period of this phase is about 0-7 days. Initial defect of approximately 1 mm is created by providing osteotomy cuts. Pins and screws are placed with care so as to avoid risk of failure of distraction process by an inadequate fixation. In this phase, the mesenchymal stem cells begins to recruit within 3 days of placement of distraction device, granulation tissue is formed and becomes fibrous due to the presence of collagen and appearance of new capillaries occurs leading to increase in vascularity.[10]
b) Distraction Phase: this phase last for about one to two weeks. In this phase traction is applied to the transport bone fragment and in between formation of immature woven bone occurs by regeneration procedure. In this

phase the distraction device is activated at the rate of about 1mm per day in four increments of 0.25mm, by turning the attached screws. This leads to the formation of tissues parallel to distracted segments. There is an increase in spindle shaped fibroblasts like cells which produces collagen. Increase is vascular growth of abouth 10 times is observed as compared to normal repair ,thus inreases the supply of blood to the mesenchymal cells which differentiate to form osteoblast and chondroblast. Daily distraction will cause the alignment of collagen fibers in parallel bundles. The soft callus formed must be immobilized in this phase.[11]

c) Consolidation Phase: In this phase maturation of regenerated bone occurs. Time period is about 3-4 weeks in childrens and about 6-12 weeks in adults. After the distraction process, the fibrous and ostoid area ossify and mineralize converting the immature bone into a mature one.[12]



Application of Distraction osteogenesis in oral and maxillofacial region:

Maxilla and midfacial region: Treatment of hypoplastic maxilla, correction of midface hypoplasia, Closure of alveolar cleft , Zygomatic distraction in cases of deficient zygoma, Craniofacial syndromes such as crouzan syndrome, aperts syndrome, trencher Collins syndrome etc, Midfacial and maxillary advancement, Hemifacial microsomia, Antero-posterior deformity of maxilla, Facial asymmetry, Bimaxillary deficiencies, In cases of insufficient alveolar height prior to implant[13]

Mandible: In cases of bilateral mandibular advancement for the correction of micrognathia, in the correction of cross bite horizontal distraction can be done, unilateral distraction in cases of hemifacial mirosomia, in TMJ ankylosis to generate neocondyle by transport distraction, insufficient alveolar height prior to implant etc[14]

The devices can be intra oral or extra oral selection is based on the defect to be treated. Rigid external distraction uses a halo that is anchored to skull. It allows greater distraction in 3 planes. It offers a better control over lengthening and can be easily removed. But the drawback of Extraoral device include high risk of trauma during use,increase possibility of pin loosening, increase chances of penetration of parietal bone due to traumatic forces and also it is socially uncomfortable for the patient to wear the device for long time, moreover, after removal of the appliance it results in visible scars. Intrao oral devices provides with accurate lengthening as the device are in direct contact with bone. These are invisible thus, patient compliance is more and risk of trauma is less with intraoral devices.

Alveolar Distraction osteogenesis process is more appropriate then autogenous bone graft procedure as there is no need for donor site for graft which will lead to donor site morbity. The clinical results of distraction osteogenesis depends on device related factors and tissue related factors. The device related factors include number of pins, diameter of fixation pins, length of fixation pins, rigidity of distractor device, and the material of distractor device affects the clinical result of distraction.[15] The tissue related factors include: Cross sectional area of bone, density of bone, geometric shape, surrounding soft tissue tension, length between the two osteomized segments etc.[16]

Complications associated with distraction osteogenesis includes:[17]

a) Intraoperative complications: which may be damage to nerve during placement, malfracturing of bone, unstable and improper placement of device etc.

b) Intra distraction complications: which may be pain, infection, or premature consolidation etc.

c) Post distraction complications: such as persistent nerve damage, malunion of bone, relapse etc.

Conclusion

There are many treatment modalities of bone defects, distraction osteogenesis has proved to be advantageous with respect to mechanism of bone formation, and clinical results. At present this method of bone formation has been used to treat various bony defects with relatively lower incidence of complication. Distraction Osteogenesis in oral and maxillofacial is becoming a popular alternative to conventional surgical procedure. It is a useful and well established treatment modality for bone deformities. It allows for improved bone regeneration with the help of growth factors, stem cells and molecular mediators. Further research in this field will bring more outstanding contribution in the treatment of bone defects.

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