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Distraction Osteogenesis-A Review

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ABSTRACT

As an alternative to many traditional orthognathic surgical treatments, distraction osteogenesis of the craniofacial skeleton has grown in popularity. It involves the gradual separation of bone segments by incremental traction, which results in the production of new bone between their surfaces. Applying controlled traction at the site of surgically created bone disturbance during its healing process is known as distraction osteogenesis. By establishing and sustaining an active region of bone formation in the surgically generated gap, the approach capitalizes on the regenerative potential of bone while directing the mechanical forces primarily away from the location. Both the bone and its envelope lengthen. Ilizarov provided the scientific foundation for this idea in the 1950s and demonstrated that long bones may be lengthened using this technique without the need for a graft material. The fundamental method consists of surgically breaking the malformed bone, inserting the device, resting for five to seven days, and then gradually separating the bony segments by activating them followed by a consolidation period. Hence, the purpose of this article is to review the historic development ,histology, classification and orthodontic implications distraction osteogenesis.

1. INTRODUCTION

Distraction osteogenesis is a biological process which creates new bone between the surfaces of bone segments that are progressively pulled apart by incremental traction.[1] This process lasts as long as the callus tissues connecting the split bone segments are stretched, and it starts when distraction pressures are applied to them. Tension created by the traction promotes the growth of new bone parallel to the distraction vector.Through the establishment and maintenance of an active region of bone production in the surgically generated gap, the procedure capitalizes on the regeneration potential of bone. Both the bone and its envelope lengthen. [2]Adjacent tissues such as gingiva, skin, fascia, muscle, cartilage, blood vessels, and peripheral nerves experience active histogenesis when tensional pressures brought on by progressive distraction are present. [3]Larger skeletal movements are made possible by these adaptive soft tissue modifications, which also reduce the risk of recurrence that comes with acute orthopedic adjustments.

2. HISTORY

In 1927 Wassmund claims that Rosenthal used an intraoral tooth-borne appliance that was gradually activated over the course of a month to accomplish the first mandibular osteodistraction surgery.

Fig1

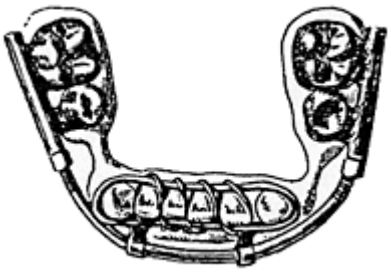


Fig 2

who was followed by Kazanjian (1941) and Crawford (1948). Subsequently, Allan (1948) incorporated a screw device to control the rate of distraction.

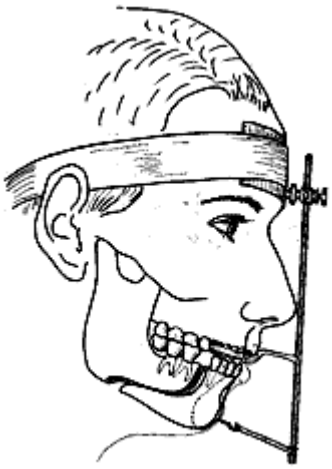


Fig 3
Kazanjian's "over the face" appliance for gradual advancement of the mandible.

Gavril Ilizarov (1969) created a method for fixing complicated fractures or long bone nonunion in 1951. Ilizarov's method was predicated on the biology of bone and the surrounding soft tissue's capacity for tension-induced regeneration. He made the surgery safer and was able to lessen the frequency and intensity of the difficulties. In 1990, Guerrero et al. employed an intraoral distractor that was affixed to the teeth by orthodontic bands and to the bone by bendable forked arms Constantino et al. did fi rst application of transport distraction osteogenesis for reconstructing segmental mandibular defects. Mandibular distraction in humans using an extraoral distractor in patients with hemifacial microsomias was fi rst reported in 1992.

3. HISTOLOGY OF DISTRACTION OSTEOGENESIS

The present notion of five histomorphologic zones with four transitional areas between the zones was described by Karp et al. in animal experiments.
The centre zone, the two paracentral zones, and the two proximal/distal zones are the five zones. The two regions of mineralization fronts and the two regions of vasculogenesis make up the four transitional areas. The most cellular and blastema-like zone is the center one. New trabeculae in perfect alignment with the line of tensile stress are visible in the mineralization front's transitional area.[1]

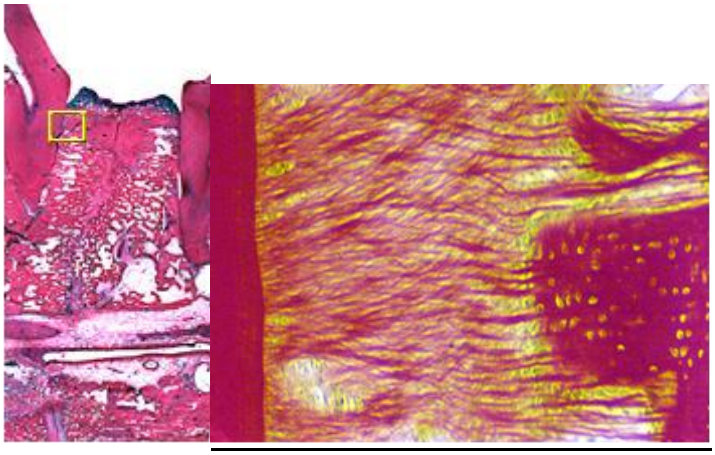


Fig 4

Indications of Mandibular Distraction Osteogensis[5]

1. Severe mandibular retrognathia/micrognathia
2. Craniofacial syndromes: hemifacial microsomia.Treacher Collins syndrome, Nager syndrome, Pierre Robin sequence
3. Severe mandibular asymmetry
4. Post-traumatic deficient mandibular growth and temporomandibular joint ankylosis
5. Revision mandibular orthognathic surgery
6. Mandibular retrognathia with temporomandibular joint disease or juvenile rheumatoid arthritis

Advantages of Distraction Osteogensis [5]

1. Allows greater mandibular lengthening of 10–30 mm
2. Can be applied to unusual bony and soft tissue anatomy
3. Allows slow gradual soft tissue adaptation to extreme mandibular lengthening
4. Minimal to no skeletal relapse after extreme mandibular lengthening
5. Can be applied to neonates, infants, and pediatric patients with obstructive sleep apnea
6. Less invasive surgery compared with bone-grafting procedures
7. Avoids intermaxillary fixation
8. Avoids bone grafting and potential donor-site morbidity
9. Can be used for mandibular widening
10. Fewer adverse temporomandibular joint effects in response to asymmetric lengthening
11. Decreased hospitalization time and cost compared with bone grafting
12. Less need for blood transfusion

Drawbacks of Distraction Osteogenesis [5]

1. Skin scars
2. Technique sensitive surgery, equipment sensitive surgery
3. Possible need for second surgery to remove distraction device and patient compliance
4. Transient changes in temporomandibular joint
5. An adequate bone stock is necessary to accept the distraction appliances and to provide suitable
6. opposing surface capable of generating a healing callus
7. Damage to tooth germ
8. Premature consolidation
9. Damage to inferior alveolar nerve
10. Bilateral Coronoid Ankylosis
11. Tendency towards clockwise rotation

4. DEVICE

A distractor is a screw-jointed device that is attached to the bone or tooth that needs to be distracted. Screw activation causes segments to become distracted over a few weeks.
The maxillofacial region's distractors can be categorized by their location, including mandibular, alveolar, midface or maxillary, or transport (neo-mandible/neocondyle reconstruction). Devices can also be categorized based on how they are used.

Internal Distractors can be implanted beneath or above the oral mucosa, whereas Rigid External Distractors are fixed to the bone with percutaneous pins, fixation clamps, and distraction rods.

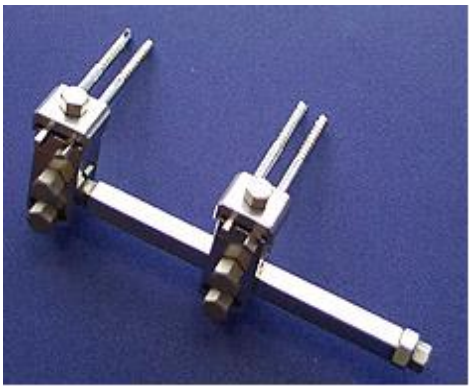
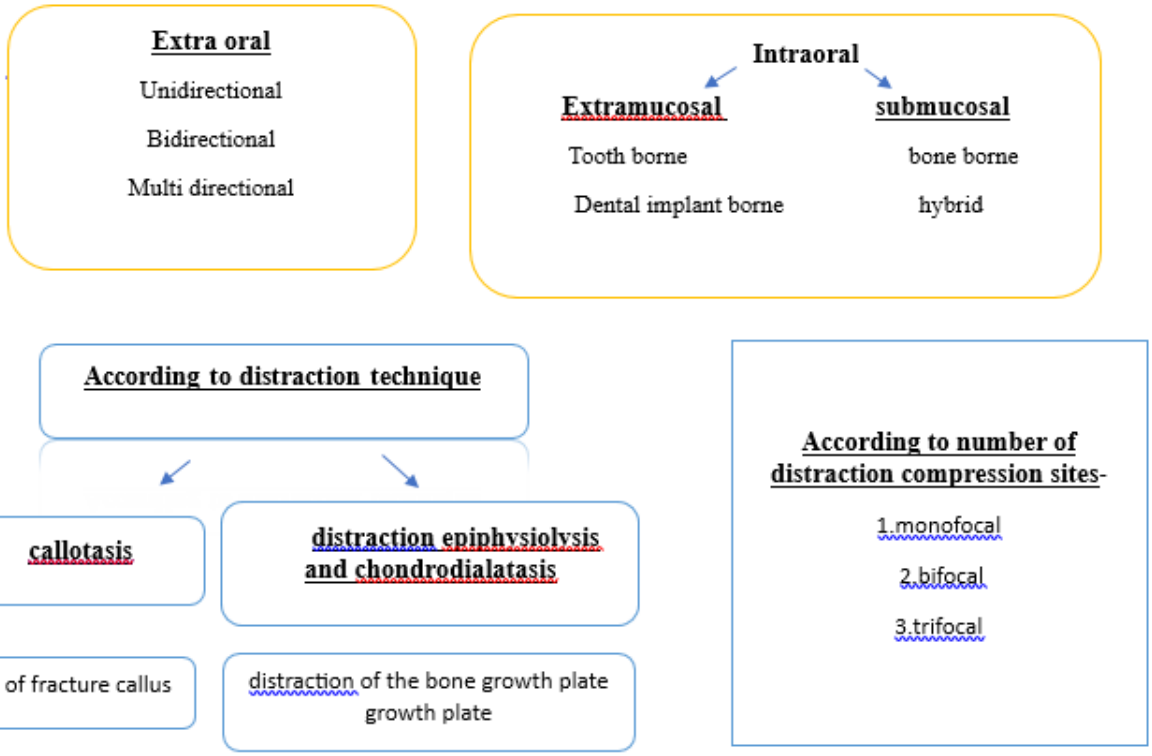


Fig 5 Hoffman Mini Lengthener device (Stryker Leibinger, Kalamazoo, MI, USA).

fig 6- Mandibular lengthening using an extraoral distraction

5. CLASSIFICATION



6. DISTRACTION PROTOCOL

Distraction phases
1.latency phase
2.distraction phase
3.consolidation phase

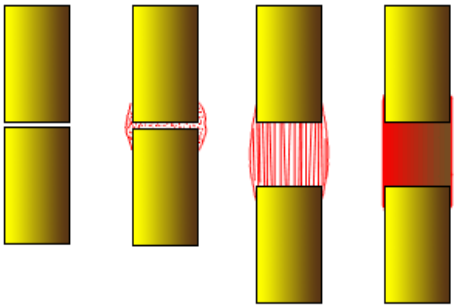


Fig 7 -Schematic drawings demonstrating 4 sequential periods of distraction osteogenesis: osteotomy (left), latency (center left), distraction (center right), and consolidation (right).

Latency phase
The time frame is between 0 and 7 days.
It is the period between osteotomy and start of distraction during which soft callus is formed
During this phase, the initial clot formed is transformed into granulation tissue by the third day. This tissue becomes progressively fibrous due to the accumulation of collagen and more vascular as new capillaries begin to form. Additionally, there is the initiation of mesenchymal stem cell recruitment from the bone marrow and surrounding periosteum.[1]

Distraction phase
This phase typically lasts 1-2 weeks, during which traction alters the usual course of the regeneration process. A dynamic microenvironment is established, leading to tissue formation aligned with the distraction vector, along with an increase and extension of angiogenesis.[1]
formation of new woven and parallel- fibered bone is seen.
During distraction, four distinct zones develop:-
A central fibrous area with low vascularity and collagen fibers aligned with the distraction vector
A transition zone where early bone formation
A bone remodeling zone
Mature bone at the ends.[6]
Usually the distraction device is activated at the rate of 1 mm and rhythm of 4 (increments of 0.25 mm each) done using axial screw.[5]

Consolidation Phase
The consolidation phase is the period during which the regenerated bone matures and undergoes corticalization. Generally, this phase lasts twice as long as the activation phase. In craniofacial bones, 3-5 weeks phase is recommended for children and 6-12 weeks phase for adults. After sufficient distraction has been achieved, the device is left in place to allow the regenerated bone to grow and change. In order to show bone movement throughout the healing phase, the distractor needs to be sufficiently rigid. A fibrous non-union could happen if there is movement, which could be caused by either improper fixation or earlier removal of the device.[1]

7. RATE OF DISTRACTION

According to Ilizarov's tension-stress rule, the ideal distraction rate for bone repair during distraction osteogenesis is 1 mm per day. Collagen fibers are aligned into parallel bundles by daily distraction, which directs perivascular cells and developing arteries into longitudinal compartments[4]. On the other hand, because of the greater distraction force and relative significant movement, intermittent distraction causes microtrauma in the distraction zone. Micro-haematomas are created and vessels are disturbed.
A higher rate of distraction is linked to severe soft-tissue contractures, nerve issues, and inadequate bone development. A decreasing rate of 0.5 mm per day results in early consolidation.[4]

Rhythm of distraction
According to Illizarov, a distraction rhythm of 0.5 mm twice day or 0.25 mm four times daily is recommended. Excessive expansion pressure can result in ischemia, which can cause periodontal issues, muscle, nerve, and soft tissue tearing.[4]

Stabilization/consolidation period
When the fragments stabilize in their final position following the conclusion of the distraction, this is known as consolidation. This is accomplished by turning off the distractor and using it as a rigid fixation device. The duration of this phase ranges from 8 to 12 weeks. In the osseous gap, callus mineralization takes place throughout this time.

8. CLINICAL IMPLICATIONS

Distraction operations will be delayed until growth maturity in patients with rapid growth because of the flexibility of their bones.
For younger people, osseodistraction combined with external cortical corticotomy is recommended. Adults are less likely to fail because their internal cortex is more resistant.[6]

Dento-Alveolar Distraction

fig 8

Compared to tissue regeneration or grafting, osteodistraction of the alveolar process works better for three-dimensional restoration. For implant implantation and orthodontic tooth movement, alveolar ridge distraction is recommended to increase bone volume.

9. MANDIBULAR DISTRACTION

Guerrero and McCarthy used external distractions to treat mid-symphyseal enlargement with a hyrax-type screw and congenital facial abnormalities, respectively. Patients with respiratory problems, facial dysmorphism, and disorders such Pierre Robin syndrome, Treacher Collins syndrome, micrognathia, etc were treated using these approaches.

Fig 9

fig 10

Wangerin's horizontal and vertical mandibular distraction device (Medicon eG, Tuttlingen, Germany

Intraoral or transcutaneous (submandibular) incisions are required for the implantation of external or intraoral devices. Distraction-based osteotomies provide several advantages over traditional ones, including -earlier surgery, quicker operations, less postoperative complications (like transfusions), and a lower requirement for follow-up surgeries (like grafts). Furthermore, relapse rates are reduced as muscles and soft tissue above (distraction histogenesis) get longer or expand over time.

10. ORTHODONTIC OSTEOGENESIS CONSIDERATIONS IN DISTRACTION

Pre-surgical Orthodontic Preparation:
To ensure that the maxillomandibular skeletal relationship is not hampered by the current dental malocclusion, the teeth should be positioned ideally relative to the basal bone.[5]

Pre-distraction orthodontic therapy includes decompensation, alignment, leveling, and coordination of the mandibular and maxillary arches.[3]
The fabrication of a distraction stabilizing device is a crucial component of pre-distraction orthodontic treatment. Before surgery, distraction devices are typically placed in patients undergoing distraction osteogenesis. These devices preserve the mediolateral dental interarch relationship and can be applied to patients with low compliance who don't need precise tooth movement. A banded maxillary expansion appliance and a mandibular lingual arch with lingual and buccal ball hooks positioned symmetrically make up the distraction appliance.[5]

Orthodontic Treatment during Distraction and Consolidation
The surgical operation is carried out following the completion of the pre-surgical orthodontic preparation. This orthodontic treatment may involve the use of headgear, acrylic guidance devices, bands, brackets, distraction stability devices, elastics, functional appliances, maxillary expansion devices, etc. to initiate movement towards the post
distraction position. These measures also helps in controlling clockwise or counterclockwise rotation of distracted segments based on clinical requirements.
The orthodontist uses a skeletal appraisal to assess and choose the preferred vector during pre-distraction planning. The following four factors are thought to have an impact on the observed vector:
1. The particular biomechanical properties of the chosen distraction device
2. The distraction device's alignment with the mandibular structure
3. The impact of neuromuscular
4. Forces from outside sources.

Orientation of distraction device to the mandibular anatomy
1.For the vertical elongation of the ramus- vector of the distraction is perpendicular or acute to the patient's occlusal plane
2. For the sagittal advancement- vector of distraction is parallel to the patient's occlusal plane
3. For both ramus and body lengthening-placement of distraction device oblique to the occlusal plane[5]

When the observed vector diverges from the intended vector, multidirectional distraction devices can alter it. Additionally, as the distraction increases, they enable the addition of differential vertical, horizontal, or transverse vector components.
Distraction causes patients to gradually change their occlusion, leading to the development of functional compensations. In order to help with masticatory function, these individuals frequently move their mandible anteriorly or laterally to regain occlusal connections that were lost during distraction. The course of the tooth-bearing segment is probably influenced by the recurring force represented by these functional positioning variations. Furthermore, the tooth-bearing segments are subject to stresses from the soft tissue environment and orofacial musculature that may change the direction of their movement.
external forces are applied by the clinician and consist of angular, transverse, or linear activation of the distraction device and orthodontic/orthopedic manipulation of the tooth-bearing segment.
Distraction vectors in the vertical, anteroposterior, and transverse directions have been demonstrated to be impacted by interarch elastic tension applied during distraction. Class II interarch elastics can be used to address Class II malocclusion caused by distraction. Class III interarch elastics can be used to correct a Class III malocclusion. Protraction headgear may be used to further support Class III elastic traction.

Post-consolidation orthodontic/ orthopedic management:[5]
After consolidation, the distraction device is removed and the tooth-bearing segment of the mandible derives its support from the new bone that was formed across the distraction gap.
In the growing bilateral distraction patient, overcorrection of mandible can be a temporary treatment objective in order to compensate for the deficient mandible.
In unilateral distraction patients, the post distraction orthodontic therapy will most likely involve occlusal plane management, correction of the dental midlines, and correction of the maxillomandibular transverse disharmony.[5]

11. CONCLUSION

Although orthognathic surgery has gained a generalized acceptance for maxillomandibular deformity correction, several limitations are associated with acute advancement of osteotomized bone segments. Large skeletal discrepancies require such extensive bone movements that the surrounding soft tissues might not adapt to their new position, resulting in relapse or compromised function and esthetics. The application of osteodistraction offers novel solutions for surgical-orthodontic management of developmental anomalies of the craniofacial skeleton as bone may be molded into different shapes along with the soft tissue component gradually thereby resulting in less relapse.

REFERENCES

[1] Ilizarov GA. The tension-stress effect on the genesis and growth of tissues: Part I, the infl uence of stability of fi xation and soft tissue reservation. Clin Orthop Rel Res 1989:238:249-81.

[2] Ilizarov GA. The tension-stress effect on the genesis and growth of tissues: Part II, the infl uence of the rate and frequency of distraction. Clin Orthop Rel Res 1989:239:263-85.

[3] Dr. Viraj Shyam Ingale Distraction Osteogenesis in Orthodontics: A Comprehensive Review International Journal of Innovative Science and Research Technology ISSN No:-2456-2165

[4] Natu SS, Ali I, Alam S, Giri KY, Agarwal A, Kulkarni VA. The biology of distraction osteogenesis for correction of mandibular and craniomaxillofacial defects: A review. Dental research journal. 2014 Jan;11(1):16.

[5] Vedavathi H.K.1, Chirag Arora2,*, Bharath Reddy3, Sowmya K.S.4, Goutham N5 The role of orthodontist in distraction osteogenesis Indian Journal of Orthodontics and Dentofacial Research, July-September 2017;3(3):141-147

[6] Grayson BH, Santiago PE. Treatment planning and biomechanics of distraction osteogenesis from an orthodontic perspective. InSeminars in orthodontics 1999 Mar 1 (Vol. 5, No. 1, pp. 9-24). WB Saunders.

[7] Tehranchi A, Behnia H. Treatment of mandibular asymmetry by distraction osteogenesis and orthodontics: a report of four cases. The Angle Orthodontist. 2000 Apr 1;70(2):165-74.

[8] Kişnişci RŞ, İşeri H, Tüz HH, Altug AT. Dentoalveolar distraction osteogenesis for rapid orthodontic canine retraction. Journal of oral and maxillofacial surgery. 2002 Apr 1;60(4):389-94.

[9] Natu SS, et al. The biology of distraction osteogenesis for correction of mandibular and craniomaxillofacial defects: A review: Dental research journal (Isfahan). 2014 Jan Feb;11(1):16-26. .

[10] Menon S, et al. Distraction Osteogenesis in management of mandibular deformities: Med J Armed Forces India. 2005 oct;61(4):345-347. [3].

[11] Birch JG. A brief history of limb lengthening: J Pediatrorthop. 2017 sep;37(suppl 2):S1-S8. [4].

[12] Spiegelberg B, et al. Ilizarov principles of deformity correction. Ann R CollSurg Engl. 2010 Mar;92(2):101 105.

[13] Ilizarov GA. Clinical application of the tension-stress effect for limb lengthening. Clin Orthop Rel Res 1990:250:8-26.

[14] Guerrero C, Bell WH, Flores A, Modugno VL, Contasti G, Rodriguez AM, et al. Intraoral mandibular distraction osteogenesis. Odontol Dia 1995:11:116-32.

[15] Costantino PD, Shybut G, Friedman CD, Pelzer IIJ, Masini M, Shindo ML, Sisson GA SR. Segmental mandible regeneration by distraction osteogenesis. Arch Otolaryngol Head Neck Surg 1990; 116:535-545.

[16] Cano J, Campo J, Moreno LA, Bascones A. Osteogenic alveolar distraction: A review of the literature. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;101:11-28

[17] Karp NS, McCarthyJG, SchreiberJS, Sissons HA, Thorne CH. Membranous bone lengthening: A serial histologic study. Ann Plast Surg 1992;29:2-7

[18] McCarthyJG, SchreiberJ, Karp N, Thorne CH, Grayson BH. Lengthening of the human mandible by gradual distraction. Plast Reconstr Surg 1992;89:1-8..

[19] Molina F, Ortiz Monasterio E Mandibular elongation and remodeling by distraction: A farewell to major osteotomies. Plast Reconstr Surg 1995;96:825-840.

[20] Cohen SR, Rutrick RE, Burstein FD: Distraction osteogenesis of the human craniofacial skeleton: Initial experience with a new distraction system. J Craniofac Surg 6:368, 1995

[21] Polley JW, Figueroa AA, Charbel FB, et al: Monobloc crani omaxillofacial distraction osteogenesis in a newborn with se vere craniofacial synostosis: A preliminary report. J Craniofac Surg 6:421, 1995

[22] Diner PA, Kollar EM, Martinez H, et al: Intraoral distraction for mandibular lengthening: A technical innovation. J Craniomax illofac Surg 24:92, 1996 .

[23] Block MS, Cervini D, Chang A, et al: Anterior maxillary advance ment using tooth-supported distraction osteogenesis. J Oral Maxillofac Surg 53:561, 1995

[24] Wolford LM, Wardrop RW, Hartog JM. Coralline porous hydroxylapatite as a bone graft substitute in orthognathic surgery. Journal of Oral and Maxillofacial Surgery. 1987 Dec 1;45(12):1034-42.

[25] Trauner R, Obwegeser H. The surgical correction of mandibular prognathism and retrognathia with consideration of genioplasty: Part I. Surgical procedures to correct mandibular prognathism and reshaping of the chin. Oral surgery, oral medicine, oral pathology. 1957 Jul 1;10(7):677-89.

[26] Schendel SA, Epker BN. Results after mandibular advancement surgery: an analysis of 87 cases. Journal of oral surgery (American Dental Association: 1965). 1980 Apr;38(4):265-82.