TREATMENT OF MICROGNATHIA BY DISTRACTION OSTEOGENESIS - A PROSPECTIVE STUDY

Dissertation submitted to

THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY

In partial fulfillment for the Degree of

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BRANCH - III

ORAL AND MAXILLOFCIAL SURGERY

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

Chennai – 600 032

2012-2015

CERTIFICATE BY THE GUIDE

This is to certify that this dissertation entitled **"TREATMENT OF MICROGNATHIA BY DISTRACTION OSTEOGENESIS"** is a bonafide research work done by **Dr. S.Gidean Arularasan** under my guidance during his postgraduate study period between **2012- 2015.**

This Dissertation is submitted to **THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY**, *in partial fulfillment for the degree of* **MASTER OF DENTAL SURGERY** *in* **ORAL AND MAXILLOFACIAL SURGERY BRANCH -III .** *It has not been submitted partially or fully for the award of any other degree or diploma.*

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ENDORSEMENT BY PRINCIPAL / HEAD OFTHE INSTITUTION

This is to certify that the dissertation entitled “**TREATMENT OF MICROGNATHIA BY DISTRACTION OSTEOGENESIS**”, is a bonafide research work done by **Dr. S.Gidean Arularasan** under the guidance of **Dr. M. Baskaran, M.D.S.,FRDSRCS(Eng)** Professor and Head**,** Department of Oral and maxillofacial surgery, Rajas Dental College and Hospital, Kavalkinaru, Thirunelveli-627105.

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I dedicate this dissertation to my friend **Late. Dr .Vijay anand**

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DCI Recognition NO : DE-3(44)-93/2246 Dated 09-11-1993

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This ethical committee has undergone the research protocol submitted by **Dr.S.Gidean arularasan**, Post Graduate Student, Dept of Oral and Maxillofacial Surgery under the title **"Treatment of micrognathia by distraction osteogenesis"** under the guidance of **Dr.M.Baskaran MDS, FDSRCS (Eng)** for consideration of approval to proceed with the study.

This committee has discussed about the material being tested/patients participating/experimental animals involved with the study, the qualification of the investigator, the present norms and recommendation from the Clinical Research scientific body and comes to a conclusion that this research protocol fulfills the specific requirements and the committee authorizes the proposal.

I. E. C. & R. B. RAJAS DENTAL COLLEGE & HOSPITAL ETHICAL COMMITTEE & REVIEW BOARD.

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ABSTRACT

THESIS TITLE : TREATMENT OF MICROGNATHIA BY DISTRACTION OSTEOGENESIS - A PROSPECTIVE STUDY

Background:

Maxillofacial deformities are always psychologically and physically distressing to the patients and is also challenging to the treating surgeons. The term Micrognathia verbally means a “small jaw”. True micrognathia ,where the maxilla or the mandibular skeleton does not grow to the full size can be congenital or acquired and it most often occurs due to failure of growth of one or both condyle. Distraction osteogenesis has taken perecedence over orthognathic surgery in treating micrognathia as a treatment option among the surgeons since the amount of mandibular lengthening needed is more than 10mm.Distraction osteogenesis also called as callus distraction or callostasis or osteodistraction or distraction histogenesis is a biological process of regenerating newly formed bone and adjacent soft tissue by a gradual and controlled traction of surgically separated bone segments. The advantages of intraoral devices are elimination of skin scarring caused by fixation of transcutaneous pins, improved patient compliance during consolidation, improved stability in terms of attachment of the device to the bone and minimal risk of injury to facial and inferior alveolar nerve, however there is a difficulty in orientation of the device. The purpose of this dissertation is to assess the versatility of distraction osteogenesis in the treatment of micrognathia.

Materials and methods:

Four patients (three males and one female)with micrognathia mandible who reported to Rajas Dental College, were included in this prospective study. The patients were between the age group of 10-20 years. A power of 90% and P value was fixed at <0.05 to be statistically significant. A convenient sampling was done and sample size of four was arrived.In all the four patients, the following treatment protocol was carried out:

1. Osteotomy and placement of intraoral distraction device under general anaesthesia.
2. Latency phase (5-7 days)
3. Activation period-rate 1.5mm per day
4. Consolidation period of 8 weeks

5. Removal of distraction device under local anaesthesia.

The patients were assessed post operatively for wound infection. The length of the body of the mandible and ramus of mandible were evaluated using cephalometric analysis and CT scans pre and post operatively. The posterior pharyngeal space were measured using lateral cephalograms pre and post operatively. Mouth opening was assessed by maximal incisal opening (MIO),mid line shift, occlusion, facial symmetry and chin prominence, protrusive movement, laterotrusive movements and Hyomental distance were assessed on clinical examination.

Statistical analysis:

The data was analysed using SPSS (software package for social sciences) version 20.

In the first part of the analysis, the descriptive analysis of the parameters of age, gender, etiology, distraction side was done. Second test done was Paired sample t test to compare the means of Ramus height, Body length, Hyomental distance and Posterior airway space pre and post operatively. Third test was done for parameters like Occlusion, Midline shift, Chin Projection and Facial symmetry (pre op vs post op). First two parameter chi -square test was used and the last two Fisher exact test was done

Results:

Analysis of the demographic data revealed that the mean ages of the patients included in the study were 15.25±3.86, and the average mouth opening of the patients were 32.5±2.21. 75% of patients were male and secondary deformity due to ankylosis was the cause of micrognathia in 75% of patients and in 50% of patients the side to be distracted was left side. The quantitative data assessed were ramus height, body length, hyo mental distance and posterior airway space. Paired t test was done to assess the difference in these parameters pre and post operatively. The mean pre-operative ramus height was 40.6±6.1 mm and post-operative ramus height achieved was 49.8.± 6.5mm and the p value attained was.001 showing a statistically significant improvement in the ramus height post operatively. The mean pre-operative body length was 54.6±11.12mm and the mean body length attained post operatively was 65±11.47mm with a p value of .000 which is statistically significant. The mean Hyomental distance pre and post operatively was 2±1.41, and 4.75±.95 cm respectively with a statistically significant p value of .010. The mean posterior airway space was 4.75mm±1.5mm pre operatively and

7.75±1.25mm post operatively. Using a paired t test a significant p value of .005 was achieved. The pre op and post op occlusion and mid line shift were compared using chi square test and was found to have a statistical significant difference. The pre and post op chin projection and facial asymmetry were analyzed using Fischer's exact test and there was a significant difference statistically.

Summary and conclusion:

With an impressive success rate reported in this study intra oral distraction osteogenesis is definitely a feasible option for treating micrognathia of mandible as it is relatively simple to carry out with minimal complications and good results, however distraction osteogenesis is a highly technique sensitive surgical treatment procedure and an accurate treatment planning and execution of the planned treatment is needed to achieve best results.

ABBREIVATIONS

TMJ	**-**	Temporomandibular joint.
Pre op	**-**	Pre operatively
Post op	-	Post operatively
OPG	-	Orthopantamogram
CT	-	Computed tomogram.
DO	-	Distraction osteogenesis

CONTENT

INTRODUCTION

Maxillofacial deformities are always psychologically and physically distressing to the patients and is also challenging to the treating surgeons. The term Micrognathia verbally means a "small jaw". True micrognathia, where the maxilla or the mandibular skeleton does not grow to the full size can be congenital or acquired and it most often occurs due to failure of growth of one or both condyles. Congenital deformities leading to mandibular hypoplasia are Hemifacial microsomia, Treacher Collins syndrome, congenital micrognathia, Pierre-robin syndrome, Nagers syndrome, Goldenhar syndrome, Arthrogryposis, Condylar Hypoplasia. Acquired causes of micrognathia usually occurs due to trauma or TMJ ankylosis.[1]

Ankylosis a greek word meaning "stiff joint" is defined as fibrous or bony adhesions between the components of the Temporomandibular joint.[2] Trauma to the condyle is the leading cause for the formation of temporomandibular joint ankylosis however the pathogenesis of condylar fractures leading to ankylosis depends on several factors such as the period of immobilisation, extent of damage to the disc, age of the patient and the type of condylar fracture[3].

Micrognathia leads to facial asymmetry leading to psychosocial problems in the affected patients. Micrognathia is associated with deviation of chin to affected side, vertical deficiency of maxilla and mandible on the affected side, retrognathic mandible with short ramus, convex facial profile, absent or deficient cervico mental angle, fullness of face on the affected side, flattening of face on the unaffected side and prominent antegonial notch In case of bilateral micrognathia the patients present with a bird face appearance in profile view.[4]

The intraoral features includes an occlusal cant with deviation of maxillary and mandibular midline towards affected side, class ii malocclusion although class I malocclusion may occasionally be seen ,posterior cross bite ,severe oral hygiene problems leading to caries and dental problems. In bilateral micrognathia patients there may be an associated open bite.[5]

The main objectives of the treatment of microgntha are to restore joint function, allow for mandibular growth, improve the patient’s facial aesthetics and balance.

Micrognathia should be treated as soon as the condition is recognized in order to minimize the restriction of facial growth. In view of the technical difficulties and high incidence of relapse the surgical management of micrognathia poses a significant challenge to the both surgeon and the patient. The micrognathia leads to a narrowed airway and obstructive sleep apnoea and it is this aspect of micrognathia which complicates the condition even more.

Distraction osteogenesis has taken precedence over orthognathic surgery in treating micrognathia as a treatment option among the surgeons since the amount of mandibular lengthening needed is more than 10mm.

Distraction osteogenesis also called as callus distraction or callostasis or osteodistraction or distraction histogenesis is a biological process of regenerating newly formed bone and adjacent soft tissue by a gradual and controlled traction of surgically separated bone segments.[6]

It was described first by Codvilla in 1905 however this technique gained popularity after the extensive works of Ilizarov in limb lengthening procedures.[7] Mc Carthy is credited for performing the first human mandibular distraction in 1995 using an external distractor in patients with hemifacial microsomia.[8]

The healing process in distraction osteogenesis differs from that of fracture healing in two basic aspects at the histological level, one being controlled micro trauma and the second aspect is that the ossification mechanism is membranous and not endochondral.[9]

The first and foremost step in distraction osteogenesis is either a full thickness osteotomy or a low energy corticotomy to separate the bone into segments. This is followed by a latency phase for about 5-7 days which is the period between the osteotomy and beginning of distraction and it is during this phase that soft callus is formed. The next phase is the distraction phase in which gradual traction forces are applied to separate the fractured segments and elongate the intersegmentary gap under tension which in turn depends on the vector and rate and rhythm of distraction, the usual rhythm being 0.25mm four times a day and new immature woven bone is formed. The final phase of distraction osteogenesis is the consolidation periodation where the maturation and corticalization of the regenerated bone takes place lasting for approximately 8 weeks.[10]

In contrast to conventional mandibular osteotomies distraction has an upper hand such as permitting surgery at a younger age without the need for bone grafts, blood transfusions, and prolonged surgeries and hospitalisation. Another major advantage of distraction osteogenesis over orthognathic surgeries are the amount of lengthening achieved and stability of the results. Distraction histogenesis leads to adaptive changes in the soft tissues thereby decreasing the risk of relapse.[11] However distraction osteogenesis is very technique sensitive in terms of vector and device orientation.

The vertical vector is defined as one which is 90 degrees to the occlusal plane and is indicated when there is a vertical deficiency of the ramus. In patients with severe micrognathia associated with mandibular body deficiency the horizontal vector parallel to the maxillary occlusal plane is selected. The oblique vector is selected when there is both mandibular ramus and body deficiency.[12]

The distraction devices can be classified as external or internal devices. The external devices are attached to the bone by percutaneous pins connected externally to fixation clamps. These clamps in turn are joined by a distraction rod.

Internal devices can be tooth borne or bone borne or hybrid type. They can be placed subcutaneously or intra orally where it can be placed extra mucosal or submucosal. Depending on the direction of lengthening the devices can be unidirectional, bidirectional or multidirectional.[13]

The advantages of intraoral devices are elimination of skin scarring caused by fixation of transcutaneous pins, improved patient compliance during consolidation, improved stability in terms of attachment of the device to the bone and minimal risk of injury to facial and inferior alveolar nerve, however there is a difficulty in orientation of the device.[14]

The purpose of this dissertation is to assess the versatility of distraction osteogenesis in the treatment of micrognathia.

AIMS AND OBJECTIVES

To evaluate the efficacy of distraction osteogenesis (DO) in the treatment of micrognathia.

OBJECTIVES:

PRIMARY OBJECTIVE:

1. To evaluate the facial symmetry& aesthetic harmony achieved.

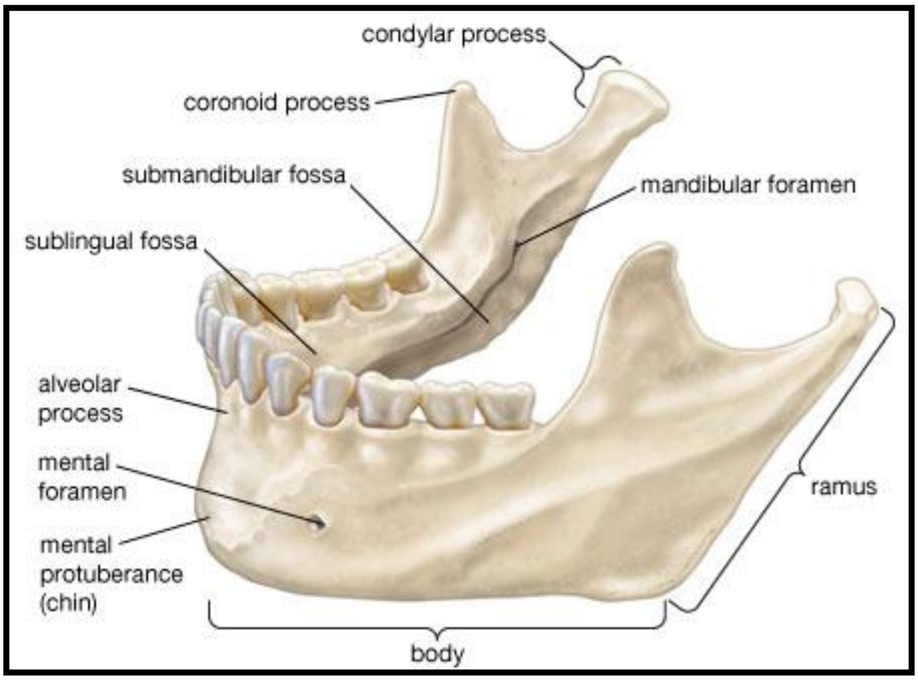
SECONDARY OBJECTIVES:

1. To assess the amount of growth achieved
2. CT evaluation of newly formed bone
3. To evaluate the clinical stability
4. To evaluate intra operative risk factors and it's after effects on clinical and functional recovery.

SURGICAL ANATOMY

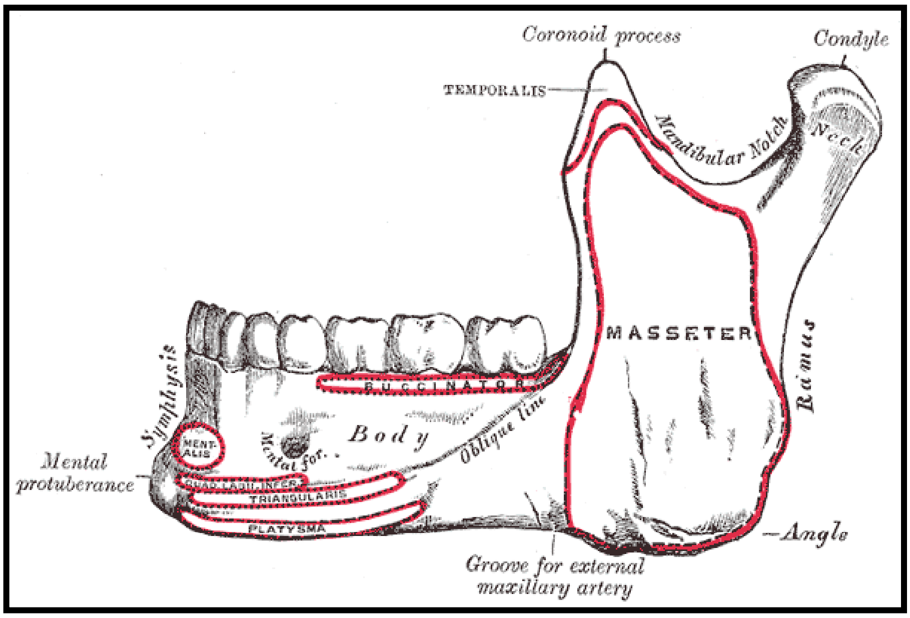
Surgical anatomy of mandible:

The **mandible,** the largest and strongest bone of the face, serves for the reception of the lower teeth. It consists of a curved, horizontal portion, the **body** and two perpendicular portions, the **rami,** which unite with the ends of the body nearly at right angles.



The Body (*corpus mandibulæ*):The body is curved somewhat like a horseshoe and has two surfaces and two borders.

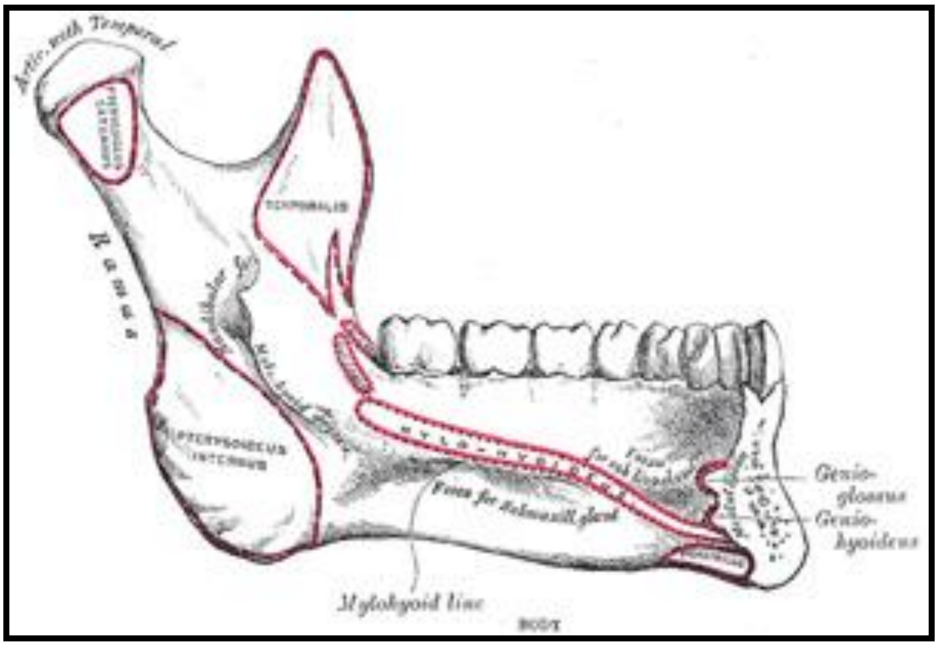
Surfaces -The **external surface** is marked in the median line by a faint ridge, indicating the **symphysis** or line of junction of the two pieces of which the bone is composed at an early period of life. This ridge divides below and encloses a triangular eminence, the **mental protuberance,** the base of which is depressed in the centre but raised on either side to form the **mental tubercle.** On either side of the symphysis, just below the incisor teeth, is a depression, the **incisive fossa,** which gives origin to the Mentalis and a small portion of the Orbicularis oris. Below the second premolar tooth, on either side, midway between the upper and lower borders of the body, is the **mental foramen,** for thepassage of the mental vessels and nerve. Running backward and upward from each mental tubercle is a faint ridge, the **oblique line,** which is continuous with the anterior border of the ramus; it affords attachment to the Quadrates labii inferioris and Triangularis; the Platysma is attached below it.



Mandible: Outer surface Side view.

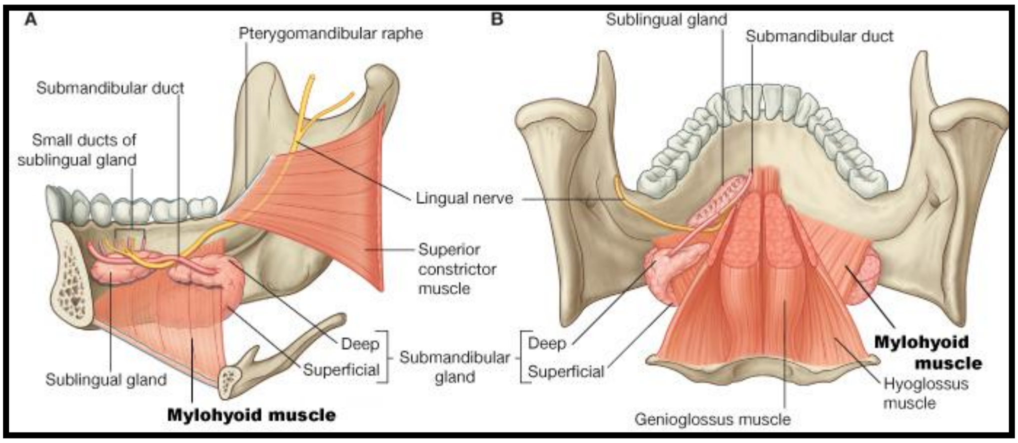
The **internal surface** is concave from side to side. Near the lower part of the symphysis is a pair of laterally placed spines, termed the **mental spines,** which give origin to the Genioglossi. Immediately below these is a second pair of spines, or more frequently a median ridge or impression, for the origin of the Geniohyoid. Below the mental spines, on either side of the middle line, is an oval depression for the attachment of the anterior belly of the Digastric. Extending upward and backward on either side from the lower part of the symphysis is the **mylohyoid line,** which gives origin to the Mylohyoid; the posterior part of this line, near the alveolar margin, gives attachment to a small part of the superior Constrictor, and to the pterygomandibular raphé. Above the anterior part of this line is a smooth triangular area against which the sublingual gland rests, and below the hinder part, an oval fossa for the submandibular gland.

Borders -The **superior** or **alveolar border,** wider behind than in front, is hollowed into cavities, for the reception of the teeth; these cavities are sixteen in number, and vary in depth and size according to the teeth which they contain. To the outer lip of the superior border, on either side, the Buccinator is attached as far forward as the first molar tooth. The **inferior border** is rounded, longer than the superior, and thicker in front than behind; at the point where it joins the lower border of the ramus a shallow groove; for the external maxillary artery, may be present.



Mandible. Inner surface. Side view.

The Ramus (*ramus mandibulæ; perpendicular portion*) - The ramus is quadrilateral in shape, and has two surfaces, four borders, and two processes.



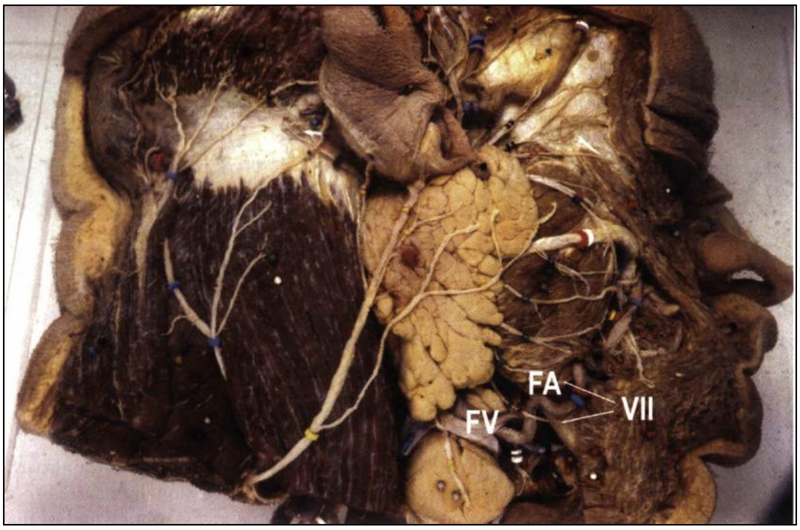
Surfaces - The **lateral surface** is flat and marked by oblique ridges at its lower part; it gives attachment throughout nearly the whole of its extent to the Masseter. The **medial surface** presents about its centre the oblique **mandibular foramen,** for the entrance of the inferior alveolar vessels and nerve. The margin of this opening is irregular; it presents in front a prominent ridge, surmounted by a sharp spine, the **lingulamandibulæ,** which gives attachment to the sphenomandibular ligament; at its lower and back part is a notch from which the **mylohyoid groove** runs obliquely downward and forward, and lodges the mylohyoid vessels and nerve. Behind this groove is a rough surface, for the insertion of the Pterygoideusinternus. The **mandibular canal** runs obliquely downward and forward in the ramus, and then horizontally forward in the body, where it is placed under the alveoli and communicates with them by small openings. On arriving at the incisor teeth, it turns back to communicate with the mental foramen, giving off two small canals which run to the cavities containing the incisor teeth. In the posterior two-thirds of the bone the canal is situated nearer the internal surface of the mandible; and in the anterior third, nearer its external surface. It contains the inferior alveolar vessels and nerve, from which branches are distributed to the teeth. The **lower border** of the ramus is thick, straight, and continuous with the inferior border of the body of the bone. At its junction with the posterior border is the **angle of the mandible,** which may be either inverted or everted and is marked by rough, oblique ridges on each side, for the attachment of the Masseter laterally, and the Pterygoideusinternus medially; the stylomandibular ligament is attached to the angle between these muscles. The **anterior border** is thin above, thicker below, and continuous with the oblique line. The **posterior border** is thick, smooth, rounded, and covered by the parotid gland. The **upper border** is thin, and is surmounted by two processes, the **coronoid** in front and the **condyloid** behind, separated by a deep concavity, the **mandibular notch.**

The **Coronoid Process** (*processuscoronoideus*) is a thin, triangular eminence, which is flattened from side to side and varies in shape and size. Its *anterior border* is convex and is continuous below with the anterior border of the ramus; its *posterior border* is concave and forms the anterior boundary of the mandibular notch. Its *lateral surface* is smooth, and affords insertion to the Temporalis and Masseter. Its *medial surface* gives insertion to the Temporalis, and presents a ridge which begins near the apex of the process and runs downward and forward to the inner side of the last molar tooth. Between this ridge and the anterior border is a grooved triangular area, the upper part of which gives attachment to the Temporalis, the lower part to some fibers of the Buccinator.

The **Condyloid Process** (*processuscondyloideus*) is thicker than the coronoid, and consists of two portions: the **condyle,** and the constricted portion which supports it,the **neck.** The **condyle** presents an articular surface for articulation with the articular disk of the temporomandibular joint; it is convex from before backward and from side to side, and extends farther on the posterior than on the anterior surface. Its long axis is directed medialward and slightly backward, and if prolonged to the middle line will meet that of the opposite condyle near the anterior margin of the foramen magnum. At the lateral extremity of the condyle is a small tubercle for the attachment of the temporomandibular ligament. The **neck** is flattened from before backward, and strengthened by ridges which descend from the forepart and sides of the condyle. Its posterior surface is convex; its anterior presents a depression for the attachment of the Pterygoideusexternus.

The **mandibular notch,** separating the two processes, is a deep semilunar depression, and is crossed by the masseteric vessels and nerve.[15]

Surgical anatomy of submandibular incision:



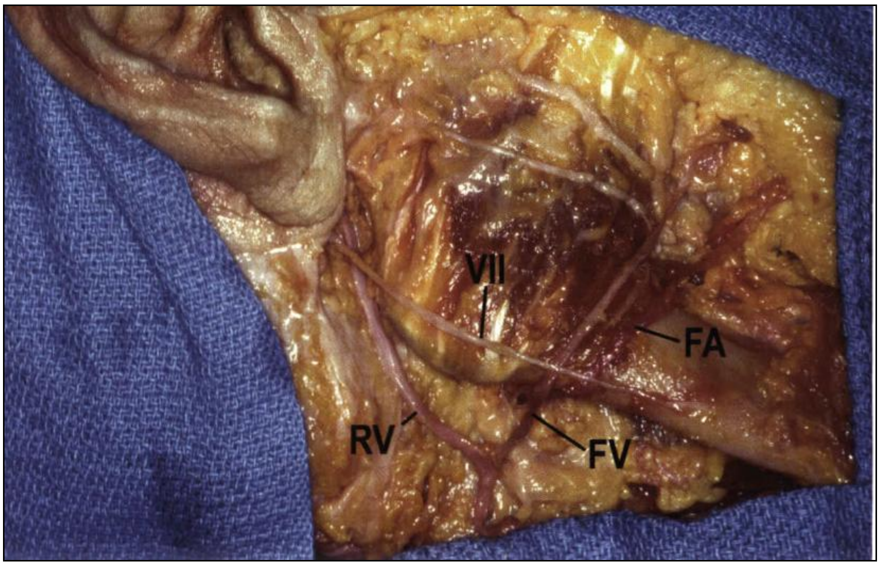
Anatomic dissection of the lateral face showing the relation of the parotid gland,submandibular gland, facial artery (FA) and vein (FV), and marginal mandibular branches of the facial**nerve *(VII).* Two marginal mandibular branches are present in this specimen, one below the inferior**border of the mandible.

Marginal Mandibular Branch of the Facial Nerve:

After the facial nerve divides into temporofacial and cervicofacial branches, the marginal mandibular branch originates and extends anteriorly and inferiorly within the substance of the parotid gland. The marginal mandibular branch or branches, which supply motor fibers to the facial muscles in the lower lip and chin, represent the most important anatomic hazard while performing the submandibular approach to the mandible.

Studies have shown that the nerve passes below the inferior border of the mandible only in very few individuals. In the Dingman and Crabb[16] classic dissection of facial halves, the marginal mandibular branch was almost I cm below the inferior border in 19% of the specimens. Anterior to the point where the nerve crossed the facial artery, all dissections in the above study displayed the nerve above the inferior border of the mandible.

Ziarah and Atkinson[17] found more individuals in whom the marginal mandibular branch passed below the inferior border. In 53% of76 facial halves, they found the marginal mandibular branch passing below the inferior border before reaching the facial vessels, and in 6%, the nerve continued for a further distance of almost 5 cm before turning upward and crossing the mandible. The farthest distance between a marginal mandibular branch and the inferior border of the mandible was 1.2 cm. In view of these findings, most surgeons recommend that the incision and deeper dissection be at least 5 cm below the inferior border of the mandible.Another important finding of the study by Dingman and Crabb[16] was that only 21% of the individuals had a single marginal mandibular branch between the angle of the mandible and the facial vessels; 67% had two branches 9% had three branches, and 3% had four.



Anatomic dissection of the lateral face showing the relation of the submandibular gland,facial artery (FA) and vein (FV), retromandibular vein *(RV)*, and marginal mandibular branch of the facialnerve *(VII)* (parotid gland has been removed). Only one marginal mandibular branch is present in this**specimen and it is superior to the inferior border of the mandible.**

Facial Artery

After it originates from the external carotid artery, the facial artery follows a cervical course during which it is carried upward medial to the mandible and in fairly close contact with the pharynx. It runs superiorly, deep to the posterior belly of the digastric and stylohyoid muscles, and then crosses above them to descend on the medial surface of the mandible, grooving or passing through the submandibular salivary gland as it rounds the lower border of the mandible. It is visible on the external surface of the mandible around the anterior border of the masseter muscle. Above the inferior border of the mandible,it lies anterior to the facial vein and is tortuous.

Facial Vein

The facial (anterior facial) vein is the primary venous outlet of the face. It begins as theangular vein, in the angle between the nose and eye. It generally courses along with thefacial artery above the level of the inferior mandibular border, but it is posterior to the artery. Unlike the facial artery, the facial vein runs across the surface ofthe submandibular gland to end in the internal jugular vein.[18]

REVIEW OF LITERATURE

EXPERIMENTAL STUDIES ON DISTRACTION OSTEOGENESIS:

Kara Harju – Suvanto et al (1992)[19]in their study on DO of sheep mandible reported that the cutting of the intra medullary blood, vessels or overlying periosteum does not affect bone healing.

Yoshi hiro sawaki et al (1996)[20] investigated an approach to DO of the mandible using Osseo integrated implants and an intra oral device on 5 adult dogs and concluded than an intra oral device using osseointegrated dental implant can serve as a mechanism for DO in maxillofacial skeleton.

Ulrich Meyer et al (1999)[21] studied the effect of magnitude and frequency of inter fragmentary strain on the tissue response to DO. and suggested that the magnitude and not the frequency of mechanical loading controls the differentiation of bone cells and subsequent formation of bone tissue.

Wiliam.H.Bell et al (1999)[22] reported a study to analyze the skeletal and dental positional changes and histomorphology of the distraction regenerates and mucogingival periosteal tissues that occurred after simultaneous widening and bilateral lengthening of the mandible in baboons by a miniaturized intra oral bone-borne distraction appliance and concluded that the orientation of the mandibular distractors must be parallel to the common vector of distraction, which should be parallel to the maxillary occlusal plane. The formation of a bone regenerate in the alveolar region depends on the presence of an adequate bone interface on either side of the distraction.

Lindsey R.Douglas et al (2000)[23] did a study to determine the feasibility of using an intra oral bone and tooth – anchored appliance to distract baboon mandibles using the principles of DO and indicated that this is an effective method to produce mandibular lengthening.

Franciso J. Castono et al (2001)[24]studied the proliferation of masseter myocytes after DO of the porcine mandible and results of the study suggested distraction induces myocyte proliferation in the masseter muscle and proliferative response may contribute to improved long term stability of mandibular expansion.

Jing Hu et al (2001)[25] did a study to investigate the changes in the inferior alveolar nerve after mandibular lengthening with different rates of distraction on 8 goats and concluded that degenerative changes in the inferior alveolar nerve occur after mandibular lengthening by DO. The distraction rate of 1mm/day appears to be tolerable and safe for the inferior alveolar nerve but rapid distraction may cause serious degeneration.

Lobaa et al (2004)[26] on their study on mechano biology of mandibular DO in a rat model concluded that the daily tension made by the distraction device causes little trauma to the tissues thus activating neo formation of mesenchymal tissues.

Kessler et al (2005)[27] studied the effects of distraction forces and frequency of distraction on bony regeneration and concluded that continuous osteodistraction resulted in intra membranous regeneration of bone whereas intermittent osteodistraction caused chondroid ossification in the regeneration of the bone.

Li Wu Zheng et al (2006)[28]evaluated the dose and time dependent response of recombinant human bone morphogenetic protein 2 (rh BMP-2) to the formation of bone in mandibular DO on rabbits and concluded that a single injection of rh BMP-2 at the end of distraction phase was as effective as multiple injections.

K. Marukawa et al (2006)[29] examined the expression of bone morphogenetic protein-2 (BMP-2) and proliferating cell nuclear antigen (PCNA) during DO in the mandible in rabbits and immune histochemcial analysis showed that BMP-2 and PCNA appeared initially at the edge of osteogenesis but tended to disappear after 14 days.

UK-Kyu Kim et al (2006)[30] reported on comparison of bone regeneration of conventional DO and on mandibular DO combined with compression stimulation and proposed that this protocol of adding compression during the early consolidation period appears to provide faster and denser bone regeneration.

Byun et al (2007)[31] did a study on expression of vascular endothelial growth factor and its receptors after mandibular DO in six mongrel dogs and concluded that 7 days after distraction there was a significant increase in expression level of VEGF and its receptors and those levels were maintained for 14 days and after 28 days of distraction, VEGF vs VEGFR-1 were expressed only weakly, moderately in the osteoblasts and no VEGFR-2 expression was detected in cellular component of distracted bone.

Masaru Soto et al (2007)[32] did a study on morphological and immunohistochemical changes in muscle tissue in association with mandibular distraction osteogenesis on Japanese white rabbits and concluded that although minute injuries were induced in muscle fibers in association with distraction osteogenesis, the muscle fibre regenerate during the distraction period and adapts to the environment.

Sencimen et al (2007)[33] did a histomorphometrical analysis of new bone obtained by distraction osteogenesis and osteogenesis by periosteal distraction in rabbits and suggested that the newly formed bone tissue obtained by periosteal distraction was suitable for occlusal forces as it was rich in interstial fatty tissue compared to DO.

Miloro et al (2007)[34] did a study on low level laser effect on mandibular DO on nine adult white Newzealand rabbits and concluded that LLL accelerates the process of bone regeneration during the consolidation phase after DO.

DJasim et al (2007)[35] made an attempt to formulate recommendations for craniofacial DO protocols for animal experimental research and concluded that in general in rat and rabbit studies a latency period of 5-7 days is sufficient to allow initial healing whereas in pig and sheep studies a latency period is not necessary at all and distraction rate of 1mm/day and consolidation period of 6-8 weeks should be sufficient.

Xie et al, (2011)[36] conducted a study of the effect of low intensity pulsed ultrasound on new bone formation during mandibular DO in rabbits and concluded that the LIPUS accelerated new bone formation occurred only during the distraction period and 2 wks after the distraction and stated that the effective time for using LIPUs is in the early stage of DO.

Apaydin et al (2011)[37] conducted a study to investigate soft tissue changes in DO depending on various distraction and consolidation periods and suggested that when a massive amount of bone is to be obtained, instead of distracting the bone at once, it is thought to give better results if the total amount of distraction is divided into several time periods.

Zachary S.Peacock et al (2013)[38] did a study to determine if automated continuous DO at rates faster than 1mm/day results in bone formation by clinical and radiographic criteria in a mini pig model and reported that continuous DO at rates of 1.5 and 3mm / day produces better bone formation compared with discontinuous DO at rates faster than 1mm/day.

Hiroko Hagino et al (2001)[39] did a experimental study on the fate of developing teeth in mandibular lengthening by distraction on ten mongrel dogs and concluded that the root became irregular but the teeth erupted within the distraction area.

Kourosh et al (1998)[40] conducted a study to assess the role of latency in mandibular distraction on 22 sheep and suggested that the change in latency does not alter the properties of the regenerated bone in mandibular DO and indeed no latent interval may be necessary at all in craniofacial distraction.

Ploder W. Mayer et al (1999)[41] did a preliminary study to assess the mandibular lengthening with an implanted motor driven device on three sheeps.

Ruhaimi et al (2001)[42] studied the effect of calcium sulphate on the rate of osteogenesis in distracted bone and concluded that the application of calcium sulphate to newly distracted bone increased the rate of osteogenesis and calcification.

Mehrara et al (1999)[43] demonstrated that TGF-BETA mRNA is a major regulator of osteogenesis during endochondral bone formation and protein synthesis coincides with osteoblast migration, differentiation and extracellular matrix synthesis.

Warren et al (2001)[44]confirmed marked elevation of TGF along with collagen I during consolidation period of gradual distraction with acute lengthening. In addition expression of tissue inhibitor of matrix metalloproteinase was also elevated suggesting that gradual DO promotes successful osseous bone repair by regulating expression of bone specific ECM molecules.

STUDIES ON DISTRACTION HISTOGENESIS:

Effect on skeletal muscles:

Guerrisi et al (1994)[45] performed bilateral mandibular lengthening in rabbits and histologically evaluated the surrounding tissues. Although no alterations in the muscle tissue was observed an increase in the synthetic and metabolic activities of muscle was observed.

Simpson et al (1995)[46] confirmed that slow rate of distraction provides better rate muscle accommodation to limb lengthening. On the other hand rapid rates of distraction are associated with gross changes such as disorganization of muscle structures, necrosis and significant accumulation of connective tissue in interstium.

Fisher et al (1997)[47] reported that muscles oriented in a plane parallel to the distraction force adapted with compensatory regeneration whereas muscles aligned in a plane perpendicular to the distraction force showed decreased protein synthesis and persistent evidence of atrophy.

Effect on nerves:

Karp et al (1990)[48]reported absence of myelinated nerve fibers in IAN of 5 dogs after 12mm of mandibular distraction. The authors concluded that these abnormalities developed either due to osteotomy or subsequent distraction.

Michaeli et al (1977)[49]found no observable histologic alteration in IAN after 5mm and 15mm mandibular lengthening.

Block et al (1993)[50] observed mild degenerative changes after 7 mm of mandibular distraction in dogs.

Makarov et al (1998)[51] concentrated on IAN function during DO in dogs and attributed that the evidence of acute IAN injury to be related to device construction and osteotomy technique.

Hu et al (2001)[52]showed that degenerative changes in IAN were more severe and more likely to be permanent in animals distracted 2mm per day vs 1mm per day.

Whitesides et al (2004)[53]concluded that stable mandibular advancement of 10mm or greater can be successfully accomplished by DO without producing significant damage to IAN.

Effect on blood vessels:

Row et al (1999)[54] in their studies reported that the no of blood vessels in distraction regenerate decrease significantly during later distraction period.

Effect on gingival tissue:

Bell et al (1999)[55] in their experimental studies concluded that the gingival tissue responds to injury depending on the degree of trauma. if the insult is minimal only inflammatory reactive changes occur such as hyperkeratinisation of gingiva.

Effect on periodontal ligament:

Samchukov et al (2001)[56]reported that the sequence of adaptive changes in PDL is affected based on whether distraction forces are applied directly to bone segment or teeth. The mechanism of PDL adaptation to gradual increment traction during craniofacial DO is similar to that of orthodontic tooth movement where tension and compression effect on teeth and associated PDL structures leads to bone resorption, osteogenesis and cementogenesis.

Block et al (1996)[57]reported craniofacial distraction with tooth borne devices result in lesser tooth movement than skeletal device.

STABILITY OF DO:

KO et al (2004)[58] reported on one year stability of unilateral mandibular DO on eleven patients who underwent multiplanar mandibular distraction. The one year follow up revealed that the new sagittal jaw relationship and mandibular body length were stable and achieved occlusal, interdigitation was well maintained but the ramus height and chin deviation demonstrated relapse of up to 16%.

Van Strijen et al (2004)[59] reported on mandibular stability after lengthening the mandible by means of distraction and concluded that high angle patients are at risk of more relapse and DO cannot prevent relapse in cases with a high mandibular plane angle but for low angle patients distraction is a safe and predictable procedure.

Wang et al (2005)[60] reviewed ten patients with mid face advancement using internal devices and reported a relapse rate of 8% at SNA.

Cheung et al (2006)[61] reported on 29 patients who had cleft lip and palate who were randomized to either DO or orthognathic surgery for maxillary advancement and a statistically significant rate of vertical relapse at A point was noted in orthognathic surgery group when compared with DO from 2nd -12th weeks.

Nadjmi et al (2006)[62]published results of 20 patient aged 8-48 years with maxillary and mid facial hypoplasia who were treated by trans sinusal maxillary distraction with a follow up period of 13-65 months and reported excellent stability at 6 months and results are more stable in adult patient whereas growth potential in children adds certain unpredictability to the final bony relationship and occlusion.

Shetye et al (2006)[63]reported on unilateral distraction in hemifacial microsomia in 12 patient and reported a relapse of 3.46 mm in ramus height after one year follow up and attributed this to bone remodeling of condylion and gonion.

Figueroa and Collegues et al (2007)[64] reported on a retrospective longitudinal cephalometeric study that reviewed the long term stability of repositioned maxilla in 17 cleft patients who underwent maxillary advancement with rigid external distractor and noted that these results were highly stable when compared with Lefort I advancement.

Baas et al (2012)[65]conducted a study to compare the post operative stability of the mandible after a bilateral lengthening procedure either by BSSO or DO and concluded that there is no post operative difference in the stability between BSSO and DO after mandibular advancement after 4 years.

SIMULTANEOUS GAP ARTHTOPLASTY AND DISTRACTION OSTEOGENESIS:

Dean and Alamillos et al (1999)[66] used simultaneous gap arthroplasty and distraction Osteogenesis for the treatment of mandibular deformity in their study on 3 patients.

Papa George and Apostolidis (1999)[67] reported that simultaneous gap arthroplasty and DO is a effective technique.

B.L. Padwa et al (1999)[68]described a technique of simultaneous maxillary and mandibular DO with semi buried device to simultaneously lengthen the mandible and maxilla and level a canted occlusal plane in 3 cases. .

Douglas et al (2000)[69]used a pin and tube device for intra oral distraction in an adult patient with micrognathia due to TMJ ankylosis. The authors achieved a lengthening of 10mm in their patient which remained stationary after surgery.

Yonehara et al (2000)[70] used bilateral distraction osteogensis of the mandible with Lefort I osteotomy of the maxilla (with Orthodontic rubber band fixation) in a patient with TMJ ankylosis and mandibular deformity. The authors achieved a lengthening of 23.5mm in the ipsilateral mandibular body and 21mm on the contralateral side.

Yoon and kim (2002)[71] successfully used gap arthroplasty with intra oral mandibular distraction osteogenesis in two patients with TMJ ankylosis and mandibluar deformity. Both the patients had undergone failed gap arthroplasty and Costochondral graft interpositioning. This study reported a positive result with a total follow up of 2 years.

Krishna Rao et al (2004)[72] conducted a study on six children with TMJ ankylosis and mandibular deformity in whom the role of simultaneous gap arthroplasty and distraction osteogenesis were done and concluded that this is a effective technique.

Ehab A.A.Shehata et al (2007)[73] studied the efficacy of modified simultaneous maxillary mandibular distraction to correct facial asymmetry in patients with compensated occlusion and a canted occlusal plane and concluded that it is a robust technique.

Distraction osteogenesis of mandible:

Adi Rachmiel et al (1995)[74]published an article of lengthening of mandible by DO and concluded that developing an intra oral distraction device may offer the advantage of avoiding a cutaneous incision and resulting scar.

Oya Kocabalkan et al (1995)[75] reported a case report on repeated mandibular lengthening in Treacher Collins syndrome and suggested that DO may be applied to the mandible at the site of previous distraction.

Martin Chin et al (1996)[76] reported on a review of five cases on distraction osteogenesis in maxillofacial surgery using internal devices and concluded that the advantage of internal devices are:

1. Elimination of skin scarring caused by translation of transcutaneous fixation pins.
2. Improved patient compliance during fixation / consolidation phase.
3. Improved stability of the attachment of the device to the bone.

Diner et al (1997)[77]reported a new technique of submerged intra oral device for mandibular lengthening on 7 patients with hemifacial microsomia. The amount of mandibular lengthening ranged from 12-28mm. . The follow up period ranged from a minimum of 5 months to maximum of 44 months.

Mikhail L.Samchukov et al (1998)[78] evaluated the biomechanical effects of linear distractors placed parallel to the body of mandible or parallel to the axis of distraction and concluded that distraction appliances must be oriented parallel to axis of distraction to prevent adverse bio mechanical effects during bilateral mandibular lengthening. Additional ramus osteotomies, using hinged devices for angular correction may be necessary to compensate for rotational movements of mandibular condyle secondary to midline osteodistraction.

Carls et al (1998)[79] reported on their seven years clinical experience with mandibular distraction in children where the mandibles were elongated by up to 18mm and respiratory distress symptoms resolved in all patients.

Juenger et al (1999)[80]performed a study on 14 patients on the application of ultra sound in callus distraction of the hypoplastic mandible and found that sonography was found to be a meaningful supplement in the clinical monitoring of callus distraction.

Mikhail L. Samchukov et al (1999)[81] did a study on the effect of sagittal orientation of the distractor on the bio mechanics of mandibular lengthening and concluded that distractors placed parallel to the inferior border of the mandible without regard to maxillary occlusal plane created a vertical translation of distal bone segment resulting in an anterior open bite .The magnitude of anterior open bite was proportional to the angle between vector of distraction and maxillary occlusal plane and to the amount of distraction. Placement of the distractors parallel to maxillary occlusal plane eliminated the tendency for an anterior open bite.

Pilar Rubia – Bueno et al (2000)[82] reported the role of distraction osteogenesis of the ascending ramus for mandibular hypoplasia using intra oral or extra oral devices on 8 patients in which intra oral device was used on 5 patients and extra oral device on 3 patients and suggested that intra oral device can be used as the method of choice for DO of the ascending ramus of the mandible in patients with large deficiencies.

Cope et al (2000)[83] evaluated the force level and strain patterns on the mandible during bilateral osteodistraction with devices oriented either parallel to the body of the mandible or parallel to the sagittal axis of distraction and reported that significantly greater lateral forces were seen when the devices were oriented parallel to the mandibular body, With this device orientation increased tensile strains are seen at the labial symphysis and medial ramus and increased compressive strains were found at the lingual symphysis and lateral ramus. However when the devices were oriented parallel to axis of distraction the forces and strains were not detected.

Adi Rachmiel et al (2001)[84]performed mandibular lengthening in 11 patients by intra oral distraction osteogenesis in Hemifacial microsomia and concluded that advantages of this method are that it allows device placement along the ramus permitting ramus elongation, prevents damage to the tooth buds, injury of the inferior alveolar nerve.

Mattick et al (2001)[85] presented three case reports of bilateral mandibular advancement by MDO using the intraoral bone-borne device in Class II adult patients (mean age 22 years). At the end of fixed orthodontic treatment (4–7 months post-distraction), cephalometric analyses revealed a mean 4.78 decrease in ANB, a mean 11.1 mm increase in total effective mandibular length, and a 1.88 decrease in lower incisor angulation.

Randolph C.Robinson et al (2001)[86]conducted a study on clinical and laboratory data correlation of mandibular distraction force and results were that average torque for distracting the human mandible 0.5mm twice a day was 4.2± 1.6 N/cm. The average slope of the invitro data showed that 4.2 N/cm of torque were equivalent to a force of 356N.

Azumi et al (2004)[87] studied the positional and morphological changes of the mandibular condyle after mandibular DO in skeletal class II patients and concluded that most of the condyles were displaced in an upwards and backward direction in the glenoid fossa and amount of displacement is correlated with amount of mandibular lengthening and also reported a variable lateral posterior open bite following change in ramus length.

Breuning et al (2004)[88] did a study to find out long term results of treatment of CLII malocclusion by intra oral mandibular distraction and concluded that it was a successful but more expensive treatment.

Van strijen et al (2004)[89] conducted a study to investigate the stability after DO to lengthen the mandible in 50 patients and results showed that eight of 14 high angle patients had 57% of relapse and only 3 of (8.3%) low/normal angle group showed relapse and concluded that distraction osteogenesis cannot prevent relapse in cases with a high mandibular plane angle.

Karacay et al(2004)[90] presented a case report of MDO using the MD-DOS bone-borne appliance in a 20-year-old male with a hypoplastic maxilla (SNA = 868, ANB = 68) and excessive overjet (16 mm). At the end of consolidation (10 weeks after distraction at the time of device removal), the cephalometric analyses revealed a 48mm decrease in ANB, an 11 mm increase in total effective mandibular length, a 6 mm increase in corpus length, a 78degree increase in y-axis, a 158 degree increase in lower incisor angulation, and 4 mm increase in LL to E-line. At the 1- year follow-up appointment (17 months after removal of the distraction device), ANB relapsed to 28 degree, total mandibular length relapsed 4 mm, corpus length relapsed 2 mm, y-axis returned to the original pre-treatment value, lower incisors maintained their proclination, and the lower lip maintained protrusion relative to the E-plane.

Steinbacher et al (2005)[91]did a study to evaluate mandibular lengthening by DO to achieve decannulation of micrognathic children with permanent tracheostomies' and post distraction sleep studies demonstrated no obstructive apneic event and a mean O_2 saturation of 98% and four of the 5 patients have been successfully decannulated.

A.Rachimiel et al (2005)[92] published a study to present the method of mandibular DO in order to improve airway for respiratory distressed patients due to significant mandibular deficiency and to present the quantitative volumetric evaluation of mandible and upper airway using (3D-CT) before and after distraction. The results revealed successful mandibular advancement with increase of mandibular volume by an average of 28.24% and increase of upper airway volume with a mean of 71.92%.

Sadakah et al (2006)[93]conducted a study to assess the feasibility of transoral bimaxillary DO before releasing TMJ ankylosis using intra oral mandibular distraction on 9 patients and suggested that this is a feasible, advantageous technique.

Hamada et al (2007)[94]presented a case report of bilateral MDO using a bone-borne appliance for the treatment of obstructive sleep apnea syndrome (OSAS) in a 31- year-old male with severe retrognathia (SNB = 67.48). At the end of distraction, the cephalometric analyses revealed a 2.88 degree decrease in ANB, a 3.08 degree increase in mandibular plane angle (MPA), a 7.68 degree increase in lower incisor angulation, and a 3.5 mm increase in LL to E-line. After 3 years and 1 month of post-distraction orthodontic treatment, followed by 9 months in retention, ANB relapsed slightly (0.98) and the mandibular incisors further proclined (1.28), while the MPA remained constant.

Miloro et al (2010)[95] did a study to assess the effectiveness of mandibular DO for pediatric airway management and concluded that mandibular DO is a viable option for the pediatric patient with upper airway obstruction due to mandibular deficiency as there was mean increase in posterior airway space by 12mm and mandibular length by 15mm.DO not only treats the etiology of the disease process but also allows for future growth.

Aysegul et al (2011)[96] did a study to evaluate the response of mandibular ramus following vertical lengthening by means of DO on eight non syndromic adult patients with TMJ ankylosis and concluded that gradual vertical lengthening of ramus through ramus / condyle unit distraction osteogenesis maintained the initial vertical ramus height achieved for 24 months.

Hongtao shang et al (2012)[97] did a 4 year follow up of a case of modified internal mandibular DO in the treatment of micrognathia secondary to TMJ ankylosis and devised a new clinical protocol of

- A modified Internal mandibular DO without altering the pre existing occlusion.
- TMJ arthroplasty.
- Passive mouth opening exercise
- Orthodontic treatment

Which was a safe, effective, quick way to treat micrognathia OSAS secondary to TMJ ankylosis?

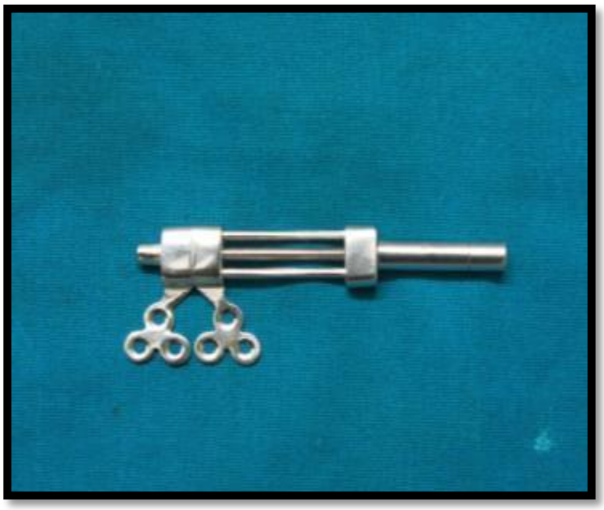
Hao Sun et al (2013)[98] did a study to investigate the errors in a (CAD / CAM) method of unidirectional mandibular DO and found that the because of the pull of the lateral pterygoid muscle and pseudoarthrosis the inter condylar distance decreased compared with the predicted value and concluded that these influencing factors should be considered when planning system is refined.

El-Bialy et al (2013)[99]conducted a prospective clinical study to evaluate the short term and long term skeletal changes after mandibular osteodistraction with tooth borne appliances in adult orthodontic patients and concluded that DO with tooth borne appliances offers a minimally invasive surgical method with stable results for correcting mandibular deficiency in non-growing patients.

Stereolithographic model:

Armamentarium:

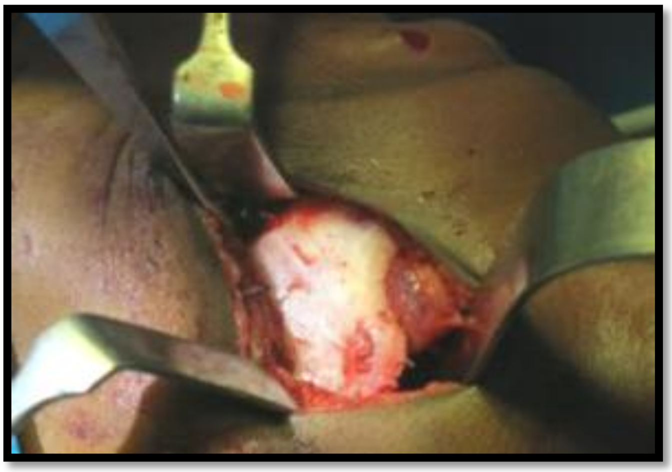
Distraction device:



Marking of incision

Dissection of pterygomassetric sling:

Exposure of the mandible:



Osteotomy :

Placement of distraction device:

Closure:

MATERIALS AND METHODS

Study design:

This single group nonrandomised and uncontrolled interventional study is a prospective study carried out from April 2012 to November 2014 following review and ethical clearance by the scientific review board and institutional ethical committee and informed consent was obtained from each patient in the regional language (Tamil) explaining the nature of the surgical procedure and the study.

Sample size:

Four patients (three males and one female) with micrognathia mandible who reported to Rajas Dental College, were included in this prospective study. The patients were between the age group of 10-20 years. A power of 90% and P value was fixed at <0.05 to be statistically significant. A convenient sampling was done and sample size of four was arrived.

Inclusion Criteria:

1) Patients with micrognathia of mandible.
2) Patients within age group of 10-20 years.
3) Patients presenting with no systemic contraindication for surgical procedure.
4) Patients who are motivated enough to comply with treatment Regime.
5) Patients willing for regular follow-up.

Exclusion Criteria:

1) Patients who are not compliant with the distraction procedure
2) Patients who present a systemic contraindication for the procedure.

Tools and data collection:

Facial asymmetry was the chief complaint of all the patients. In three cases there was a history of ankylosis and all the three patients had undergone gap arthroplasty for ankylosis and had an adequate mouth opening of 30mm. The micrognathia in one patient was diagnosed as Hemifacialmicrosomia.

Pre-operative assessment of the patients included thorough history and clinical examination, photographs in frontal, profile, worm's views and intra oral photographs. Assessment of clinical parameters included maximal incisor opening, lateral excursions and protrusive movements and deviation of midline and occlusion.

Radiographic analysis included Orthopantomogram (OPG),PA and lateral cephalograms. PA cephalogram and lateral cephalogram were taken to assess the orthodontic evaluation of skeletal pattern, occlusion and facial symmetry.CT scans was taken in all the three planes (axial, coronal, sagittal) and 3Dreconstruction to assess the extent of the deformity.

Stereolithographic models were done to know the three dimensional extent of the deformity and to simulate the surgical procedure and polysomnography was done to rule out obstructive sleep apnoea.

The amount of distraction was determined by simply drawing a triangle, two sides of which represents the amount of mandibular corpus and ramus shortening respectively. The angle between these two sides is equal to gonial angle, the third side of triangle indicates the amount of distraction.

- Amount of distraction can also be calculated using a formula,

  Distraction amount = Dc+Dr -2(Dc*Dr)* Cos a

Where Dc= corpus deficiency

Dr= ramus deficiency

a= gonial angle

In all the four patients, the following treatment protocol was carried out:

1. Osteotomy and placement of intraoral distraction device under general anaesthesia.
2. Latency phase (5-7 days)
3. Activation period-rate 1.5mm per day
4. Consolidation period of 8 weeks
5. Removal of distraction device under local anaesthesia.

The patients were assessed post operatively for wound infection. The length of the body of the mandible and ramus of mandible were evaluated using cephalometric analysis and CT scans pre and post operatively. The posterior pharyngeal spaces were measured using lateral cephalograms pre and post operatively. Mouth opening was assessed by maximal incisal opening (MIO),mid line shift, occlusion, facial symmetry and chin prominence, protrusive movement, laterotrusive movements and Hyomental distance were assessed on clinical examination.

Data analysis:

The data was analysed using SPSS (software package for social sciences) version 20

First part of the analysis the descriptive analysis of the parameters of age, gender, etiology, distraction side was done. Second test done was Paired sample t test to compare the means of Ramus height, Body length, Hyomental distance and Posterior airway space pre and post operatively. Third test was done for parameters like Occlusion, Midline shift, Chin Projection and Facial symmetry (pre op vs. post op). First two parameter chi -square test was used and the last two Fisher exact tests was done

SURGICAL PROCEDURE:

Surgical Procedure:

The surgical management of all the cases of micrognathia were under general anaesthesia with nasoendotracheal intubation.

Step-1: Intubation:

After intubation, patients were kept in supine position with head tilted laterally towards the opposite side. The ear and preauricular area was prepared using Povidone iodine (Beta dine) surgical scrub and draped with sterile drapes.

The external ear was lightly packed with Vaseline gauze to prevent the entry of blood and subsequent coagulation on the tympanum.

Step-2: Marking the incision:

Risdon's submandibular incision was mapped out with marking ink (Toluidine blue). The incision is placed 1.5to 2 cm inferior to the mandible. The incision is placed parallel to the inferior border of the mandible.

Step -3: Infiltration of vasoconstrictor:

A Vasoconstrictor (Adreraline) with saline in a concentration of 1 in5, 00,000 injected subcutaneously in the area of incision to minimise bleeding during the surgical procedure.

Step-4: Skin incision:

The initial incision is carried through the skin and subcutaneous tissues to the level of the platysma. The superior portion of the incision is undermined approximately1cm; the inferior portion is undermined approximately 2 cm or more. The ends of the incision can be undermined extensively to allow retraction of the skin anteriorly or posteriorly to increase the extent of mandibular exposure.

Step-5: incising the platysma muscle:

Retraction of the skin edges reveals the underlying platysma muscle, the fibres of which run supero inferiorly. Division of the fibres was performed sharply. A scalpel was used to incise the muscle from one end of the skin incision to the other. The platysma muscle passively contracts once divided, exposing the underlying superficial layer of deep cervical fascia.

Step-6: dissection to pterygomassetric sling:

The facial artery and vein was identified and ligated and the dissection continued until the only tissue remaining on the inferior border of the mandible is the periosteum (anterior to the premasseteric notch) or the pterygomasseteric sling (posterior to the premasseteric notch).

Step -7: Division of the Pterygomasseteric Sling and Submasseteric Dissection:

The sharp end of a periosteal elevator was drawn along the length of the periosteal incision to strip the masseter muscle from the lateral ramus.

Step -8: osteotomy cut:-

The osteotomy cut was placed at the angle to achieve a lengthening of both the ramus and body.

Step -9: placement of distraction device:

The distraction device was placed obliquely to achieve both ramus and mandibular lengthening.

Step -10: closure

The wound was closed layer wise using 3-0 vicryl and 4-0 prolene. The activating arm of the distraction device was exposed extraorally through a separate stab incision in one patient and intraorally in three patients.

Postoperative phase:-

All patients were extubated and recovery was uneventful. Postoperatively all the patients were administered appropriate antibiotic and analgesics for 5 days. Sutures were removed on the

10th day. The following postoperative protocol was followed in all patients

- A latency period of 7 days
- The distraction rate was 1.5mm with a rhythm of .75mm twice a day
- The distraction period was 10-15 days.
- The consolidation period was 6 weeks OR until a stable cortical outline is visible in the radiographs
- Following the consolidation phase the distractor device was removed under local anaesthesia.

Regular follow-up was carried out weekly for first one month and once in two weeks for 3 months and once in a month for next 2 months.

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CASE REPORT - 1

Name: Master Haribalaji

Age: 10 Years

Sex: Male

Chief complaint: Deviation of jaw on mouth opening

History of present illness: h/o fall four years back after which there was progressivedecrease in mouth opening and the patient had undergone surgery for ankylosis one year back

Past medical, surgical history: The patient had undergone surgery for ankylosis one year back.

General examination: Moderately nourished,no signs of pallor, clubbing, jaundice,pedal oedema.

Clinical examination:

Extra oral:

- Facial asymmetry with deviation of chin to the right side
- Micrognathia
- Microgenia
- Condylar movements not palpable on the right side
- Lateral excursions not possible towards the left
- Prominent antegonial notch on the right side
- Maximum incisor opening: 30 mm

Intraoral:

- Devation of midline to the right
- Class ii malocclusion on right side

Investigations:

- OPG
- CT Scan-axial, coronal and 3-d reconstruction
- PA Cephalogram
- Lateral cephalogram
- Stereolithographic model

Pre operative assessment:

Normal side(left)

- Body length(Go-Pg)-68 mm
- Ramus height(Co-Go)-52mm

Right side:

- Body length(Go-Pg)-36mm
- Ramus height (Co-Pg)-33mm

Hyomental distance- 1 cm

Posterior airway space: 3mm

Provisional diagnosis: **Micrognathia of mandible** on the right side

Treatment plan:Distraction osteogenesis

CASE REPORT - 2

Name: Selvam

Age: 17 Years

Sex: Male

Chief complaint: Deviation of jaw on mouth opening

History of present illness: Had undergone surgery for reconstruction of condyle using costochondral graft seven years ago.

Past medical, surgical history: Had undergone surgery for reconstruction of condyle using costochondral graft seven years ago.

General examination: Moderateralynourished,no signs of pallor, clubbing, jaundice,pedal oedema

Clinical examination:

Extra oral:

- Facial asymmetry with deviation of chin to the left side
- Micrognathia
- Condylar movements not palpable on the left side
- Lateral excursions not possible towards the right
- Maximum incisor opening: 35 mm

Intraoral:

- Devation of midline to the left
- Class ii malocclusion on left side

Investigations:

- OPG
- CT SCAN-axial,coronal and 3-d reconstruction
- PA CEPHALOGRAM
- LATERAL CEPHALOGRAM
- Stereolithographic model

Pre operative assessment:

Left side:

- Body length(Go-Pg)-64mm
- Ramus height(Co-Go)-40 mm

Right side:

- Body length(Go-Pg)-79.mm
- Ramus height (Co-Pg)-65mm

  Hyomental distance: 4cm

  Posterior airway space:6mm

Provisional diagnosis: Hemifacial microsomia of **mandible**

Treatment plan:Distraction osteogenesis

CASE REPORT - 3

Name: Miss.Meghala

Age: 15 Years

Sex: Female

Chief complaint: Deviation of jaw on mouth opening

History of present illness: h/o fall seven years back after which there was progressivedecrease in mouth opening and the patient had undergone surgery for ankylosis five years back.

Past medical, surgical history: The patient had undergone surgery for ankylosis five years back.

General examination: Moderatelynourished,no signs of pallor, clubbing, jaundice,pedal oedema

Clinical examination:

Extra oral:

- Facial asymmetry with deviation of chin to the left side
- Micrognathia
- Microgenia
- Condylar movements not palpable bilaterally
- Lateral excursions not possible
- Prominent antegonial notch on the right and left side
- Maximum incisor opening: 32 mm

Intraoral:

- Devation of midline to the left
- Class ii malocclusion on both sides

Investigations:

- OPG
- CT Scan-axial,coronal and 3-d reconstruction
- PA Cephalogram
- Lateral Cephalogram
- Stereolithographic model

RADIOGRAPHIC EXAMINATION:

left side

- Body length(Go-Pg)-54mm
- Ramus height(Co-Go)-39mm

Right side:

- Body length(Go-Pg)-57mm
- Ramus height (Co-Pg)-41mm

Hyomental distance:2cm

Posterior airway space:4mm

Provisional diagnosis: **Micrognathia of mandible**

Treatment plan:Bilateral Distraction osteogenesis.

CASE REPORT – 4

Name: Govindaraj

Age: 19 Years

Sex: Male

Chief complaint: Deviation of jaw on mouth opening

History of present illness: h/o fall ten years back after which there was progressivedecrease in mouth opening and the patient had undergone surgery for ankylosis six years back.

Past medical, surgical history: The patient had undergone surgery for ankylosis six years back.

General examination: Moderaterly nourished,no signs of pallor, clubbing, jaundice,pedal oedema.

Clinical examination:

Extra oral:

- Facial asymmetry with deviation of chin to the left side
- Micrognathia
- Microgenia
- Condylar movements not palpable on the left side
- Lateral excursions not possible towards the right
- Prominent antegonial notch on the left side
- Maximum incisor opening: 34mm

Intraoral:

- Devation of midline to the left
- Class ii malocclusion on left side

Investigations:

- OPG
- CT SCAN-axial,coronal and 3-d reconstruction
- PA Cephalogram
- Lateral Cephalogram
- Stereolithographic model

Pre operative assessment:

Normal side (right side)

- Body length(Go-Pg)- 79.1 mm
- Ramus height(Co-Go)- 66.2 mm

Left side:

- Body length(Go-Pg)- 62mm
- Ramus height (Co-Pg)- 50mm

Hyo mental distance-1cm

Posterior airway space-6mm

Provisional diagnosis: **Micrognathia of mandible** on the left side

Treatment plan:intra oralDistraction osteogenesis

FRONTAL VIEW

Pre op

Post Op

PROFILE VIEW

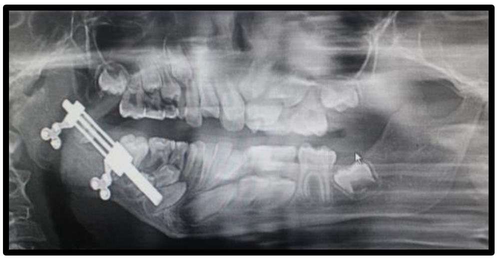
Pre op

Post Op

OPG

Pre op

With distraction device



Post op

PA CEPHALOGRAM

Pre op

Post op

LATERAL CEPHALOGRAM

Pre op

Post op

CT SCAN

Pre op

Post op

FRONTAL VIEW

Pre op

Post op

PROFILE VIEW

Pre op

Post op

OPG

Pre op

With distraction device

Post op

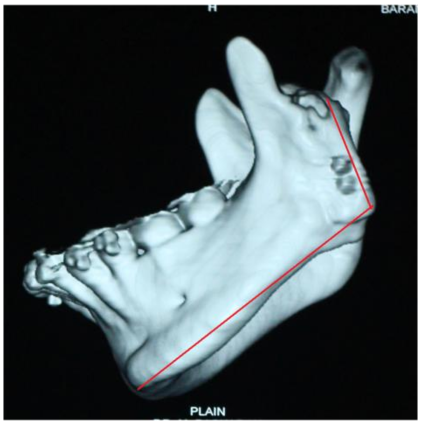
PA CEPHALOGRAM

Pre op

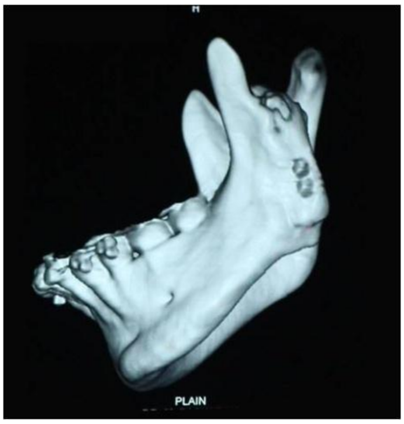
Post op

CT SCAN

Pre op



Post op



FRONTAL VIEW

Pre op

Post op

PROFILE VIEW

Pre op

Post op

OPG

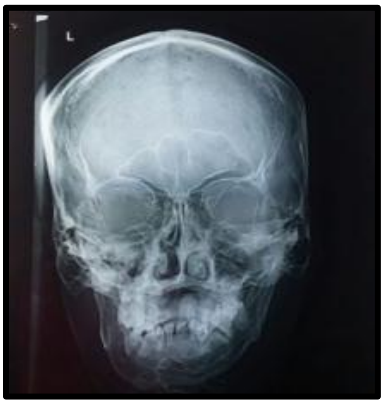
Pre op

Post op

Post op

PA CEPHALOGRAM

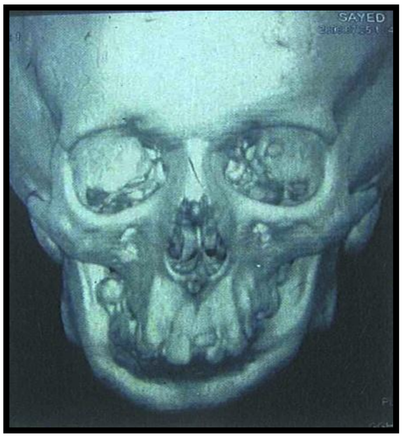
Pre op



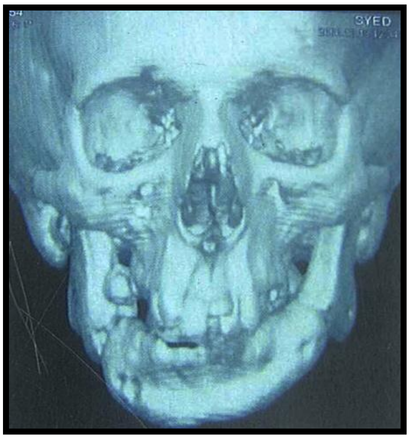
Post op

CT SCAN

Pre op



Post op



FRONTAL VIEW

Pre op

Post op

PROFILE VIEW

Pre op

Post op

OPG

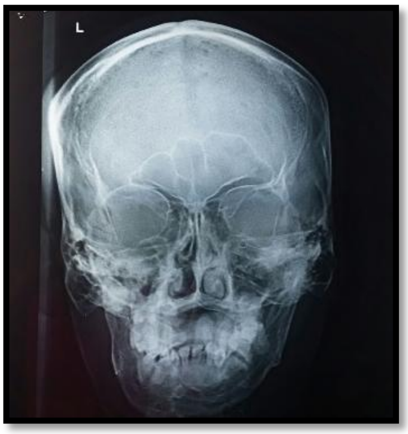
Pre op

With distraction device

Post op

PA CEPHALOGRAM

Pre op

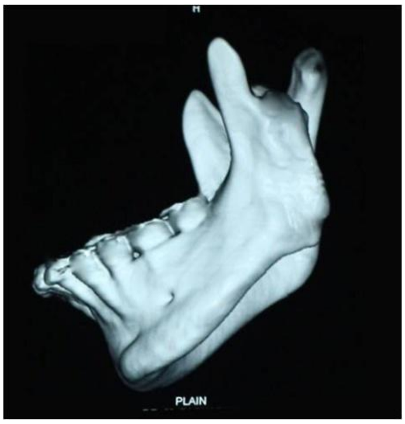


Post op

CT SCAN

Pre op

Post op



OBSERVATION AND RESULTS

In this study four patients with mandibular micrognathia in the age group of 10-20 years were evaluated with a follow up period of 3 months. The parameters assessed were:

- Pre and post-operative ramus height
- Pre and post-operative body length
- Clinical evaluation of occlusion
- Pre-operative and post-operative mid line shift
- Chin prominence and
- Hyomental distance.

In three of four patients micrognathia of the mandible was the result of postankylotic deformity, trauma being the cause of ankylosis in all patients. In one patient, micrognathia was attributed to Hemifacialmicrosomia and 3 patients were male and one patient was a female with a mean age of 15.2 $\pm$ 3.8 years.

The ramus height was measured from condylion to gonion and the body length was measured from gonion to pogonion in lateral cephalogram. The mean increase in ramus height achieved was9.2 $\pm$ 2.17mm and the mandibular body length achieved was 10.4$\pm$1.67mm. Intraorally there was a shift in occlusion to class I molar relation in three patients and there was posterior open bite in one patient.

Marked correction of facial asymmetry was noticed in all cases both clinically and in PA cephalogram. There was a restoration of dental as well as lip midline and improved lip competence.

There was a significant improvement in chin projection and occlusal cant however further chin correction was needed in one case by means of advancement genioplasty. There was an average increase in Hyomental distance of 2.75cm $\pm$ 0.9 cm postoperatively showing a definitive improvement in the airway. The posterior pharyngeal space measured from the lateral cephalogram preoperatively ranged from 3-6mm and post operatively from 6-9mm.In all patients intra oral distraction device was placed with activating arm placed subcutaneously for convenience of activation.

The intra oral distraction device was found to be well tolerated by all patients as they were able to perform their normal daily activities without great discomfort. The distraction process was uneventful in all cases without any infection or other major complications.

The formations of bone between the distracted ends were assessed by ultra sonogram, and panoramic radiographs taken one month of distraction demonstrated elongation of both ramus and body. The expanded area was filled with bone that was slightly less radio dense than the adjacent bone. Orthopantomograms taken three months after the distraction showed complete bone regeneration between the distracted bone ends.

There was transient paraesthesia of the inferior alveolar nerve in one patient but by the time the distraction device was removed, the patient had normal sensation. No sensory disturbances of lingual nerve were noted.

During the active distraction period, one patient experienced strain on the temporomandibular joint however limited mouth opening was not seen. There were no signs of facial palsy of the mandibular branch of facial nerve.

Interpretation of statistical analysis:

Analysis of the demographic data revealed that the mean ages of the patients included in the study were 15.25±3.86, and the average mouth opening of the patients were 32.5±2.21. 75% of patients were male and secondary deformity due to ankylosis was the cause of micrognathia in 75% of patients and in 50% of patients the side to be distracted was left side. The quantitative data assessed were ramus height, body length, Hayomental distance and posterior airway space. Paired t test was done to assess the difference in these parameters pre and post operatively. The mean pre-operative ramus height was 40.6±6.1 mm and post-operative ramus height achieved was 49.8±6.5mm and the p value attained was.001 showing a statistically significant improvement in the ramus height post operatively. The mean pre-operative body length was 54.6±11.12mm and the mean body length attained post operatively was 65±11.47mm with a p value of .000 which is statistically significant. The mean hyomental distance pre and post operatively was 2±1.41, and 4.75±.95 cm respectively with a statistically significant p value of .010. The mean posterior airway space was 4.75mm±1.5mm pre operatively and 7.75±1.25mm post operatively. Using a paired t test a significant p value of .005 was achieved. The pre op and post op occlusion and mid line shift were compared using chi square test and was found to have a statistical significant difference. The pre and post op chin projection and facial asymmetry were analysed using Fischer's exact test and there was a significant difference statistically.

Table 1: Demographic data

S. No	Age	Sex	Etiology Of Micrognathia	Mouth Opening In Mm	Distraction side
1.	10	M	Ankylosis	30mm	Right
2.	17	M	Hemifacialmicrosomia	35mm	Left
3.	15	F	Ankylosis	32mm	Bilateral
4.	19	M	Ankylosis	34mm	Left

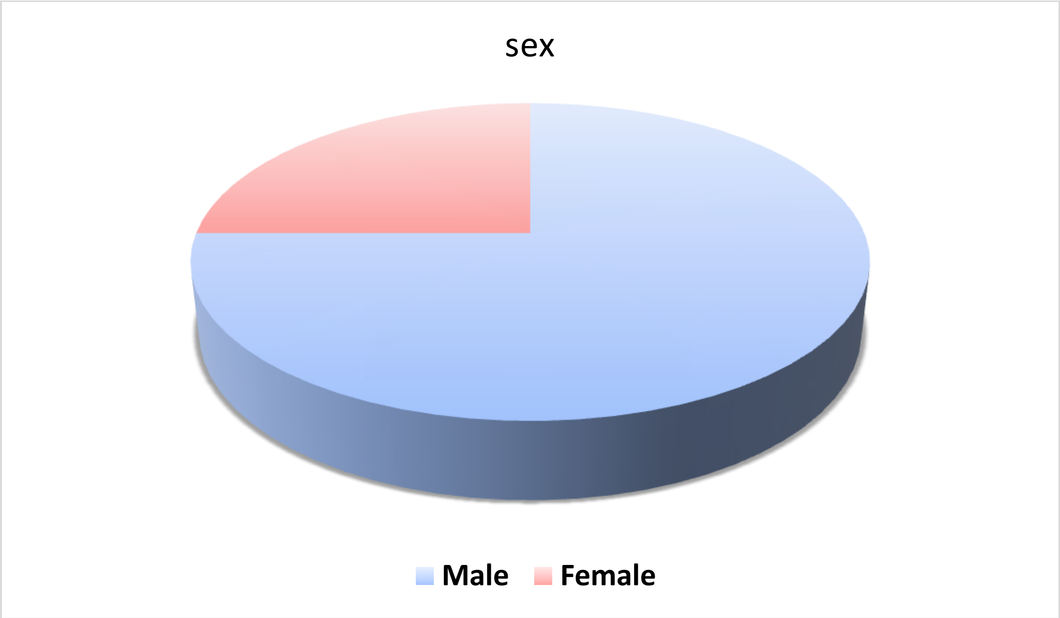


Figure 1: Distribution of sex

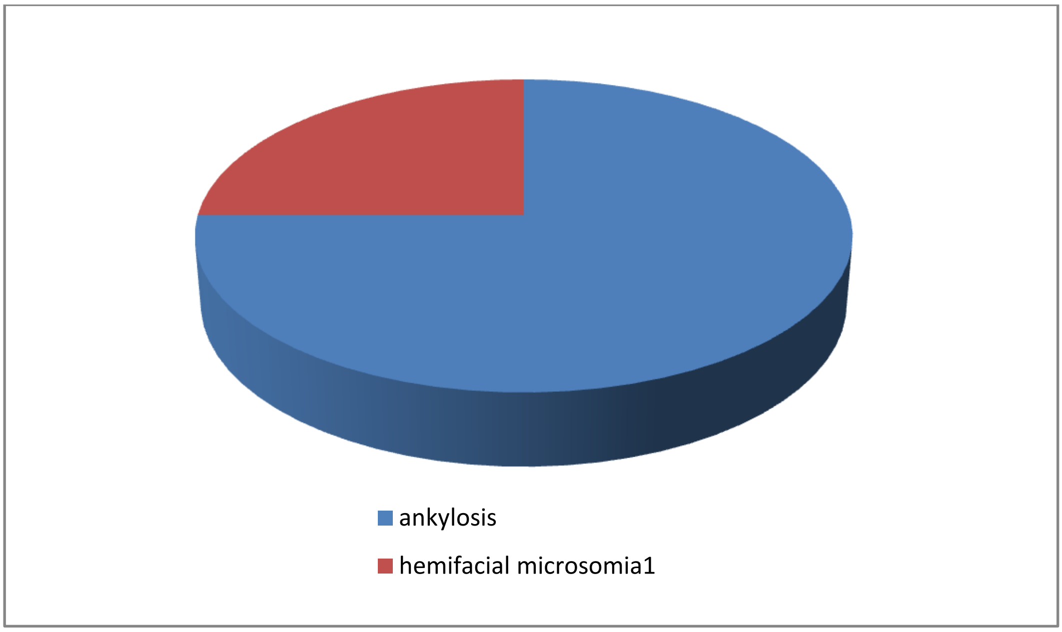


Figure 2: Etiology of micrognathia

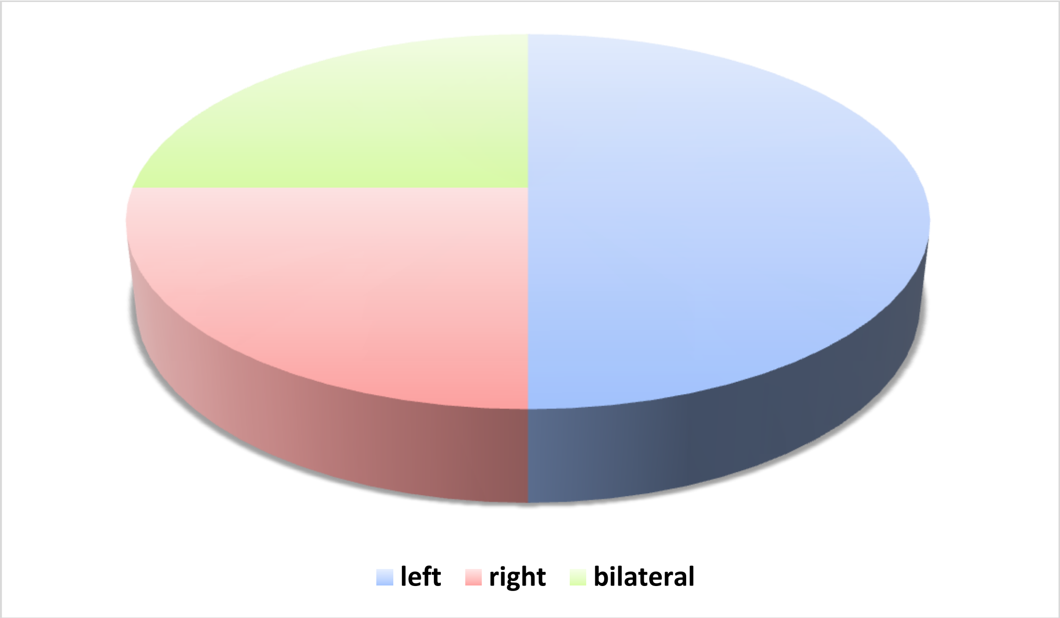


Figure 3: Distribution of distraction side

Table 2: Ramus height

S.No	Ramus height in mm	
	Pre operative	**Post operative**
1.	33	41
2.	40	52
3.	Right-41 Left-39	Right-52 Left-46
4.	50	58

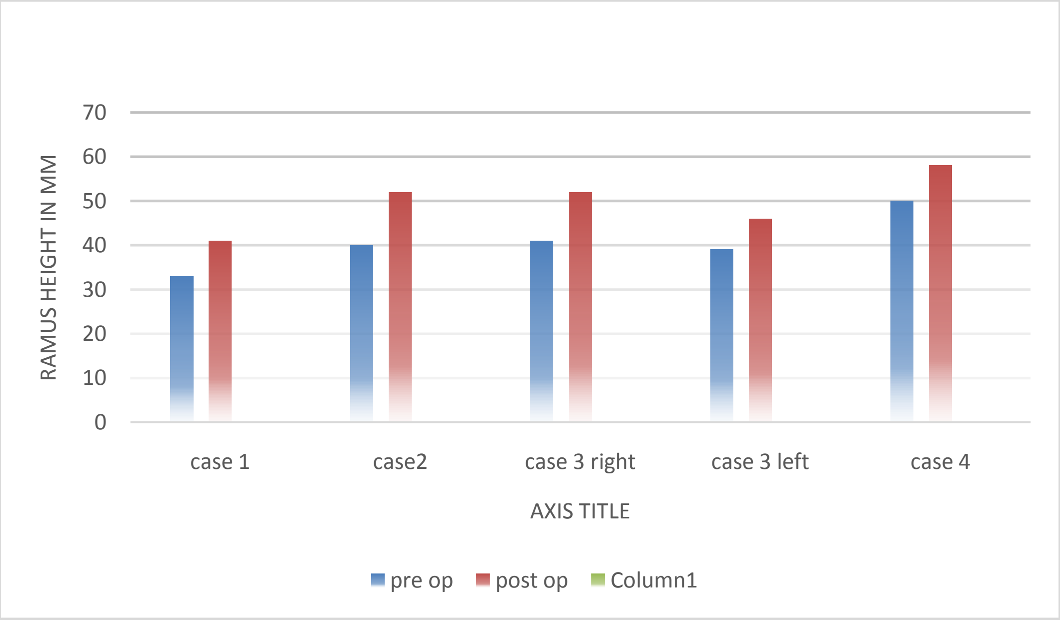


Figure 4: Ramus height in mm

Table 3:Body length

S. No	Body length in mm	
	Pre op	**Post op**
1.	36	46
2.	64	75
3.	Right-57 Left-54	Right-70 Left-63
4.	62	71

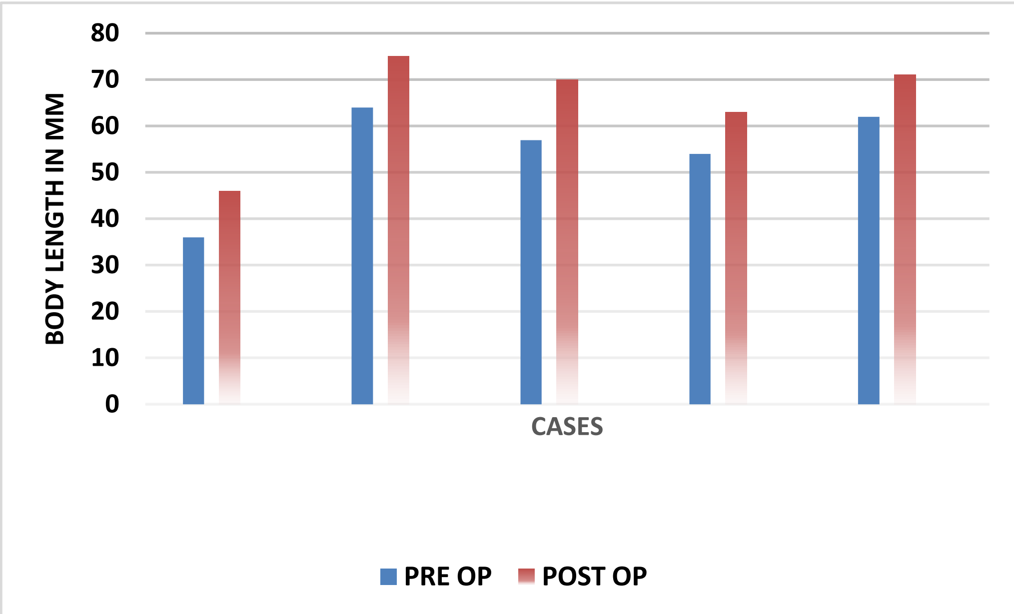


Figure 5: Body length in mm

Table 4: Hyomental distance

S. No	Hyomental distance in cm	
	Pre op	Post op
1.	1	4
2.	4	6
3.	2	4
4.	1	5

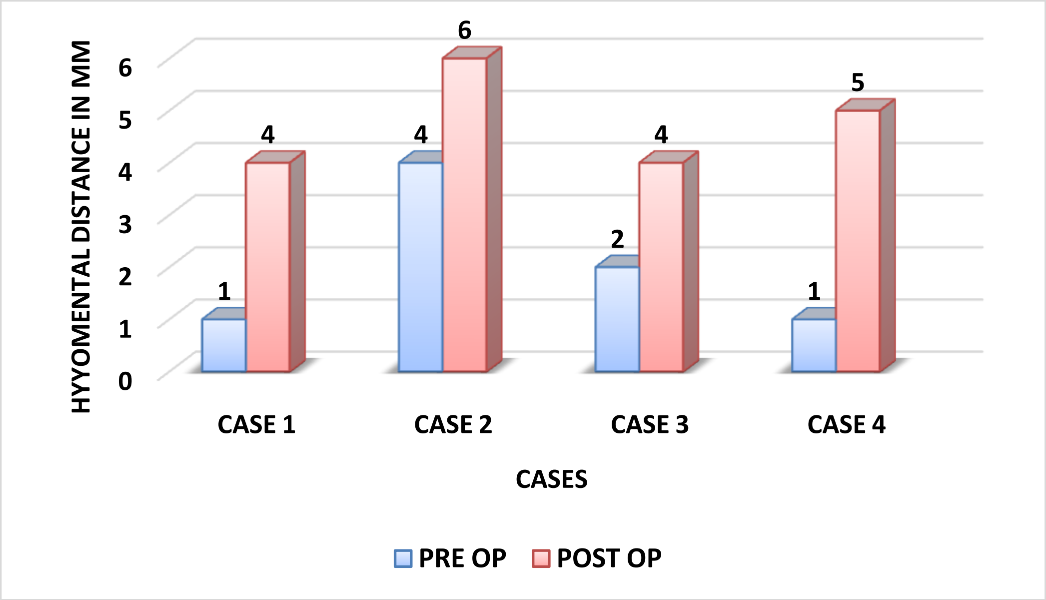


Figure 6: Hyomental distance

Table 5: Posterior airway space

S.No	Posterior airway space in mm	
	Pre op	Post op
1.	3	6
2.	6	9
3.	4	8
4.	6	8

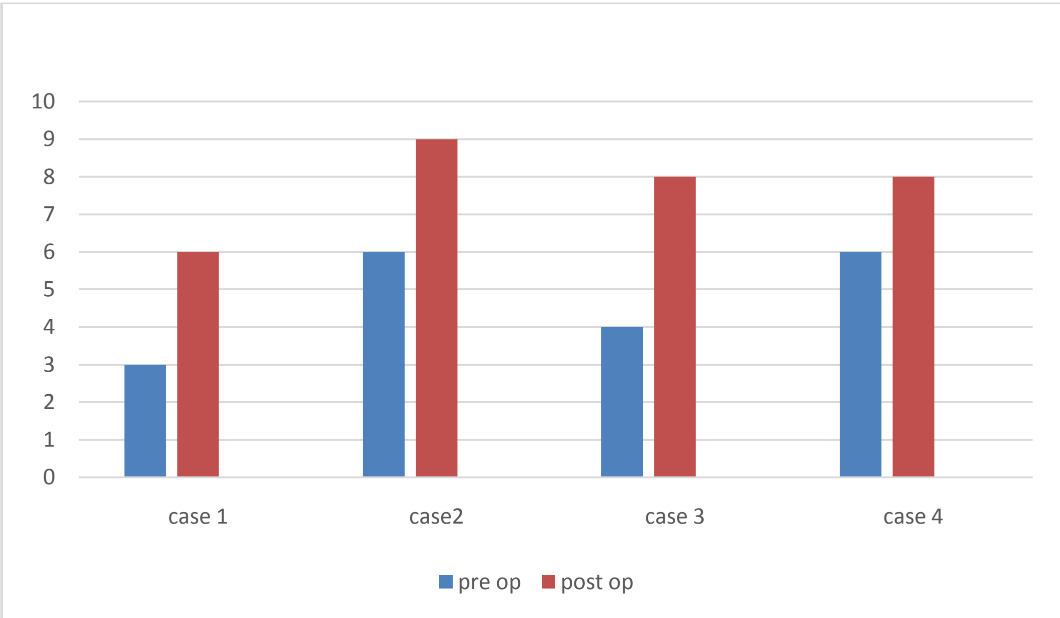


Figure 7: Posterior airway space

Table 6:

S. No	Occlusion		Midline shift		Chin projection		Facial symmetry	
	Pre op	**Post op**	**Pre op to**	**Post op**	**Pre op**	**Post op**	**Pre op**	**Post op**
1.	Class II	Class I	Right	No midline shift	Retrogenia	Chin prominent	Asymmetry present	Symmetrical
2.	Class II	Class I	Left	No midline shift	Retrogenia	Chin prominent	Asymmetry present	Symmetrical
3.	Class II	Class I	Right	No midline shift	Retrogenia	Chin prominent	Asymmetry present	Symmetrical
4.	Class II	Posterior open bite	Left	No midline shift	Retrogenia	Chin prominent	Asymmetry present	Symmetrical

STATISTICAL ANALYSIS

Descriptive Statistics:

DEMOGRAPHIC DATA

Table 7: Descriptives

Descriptive Statistics							
	N	**Range**	**Minimum**	**Maximum**	**Mean**		**Std. Deviation**
	Statistic	**Statistic**	**Statistic**	**Statistic**	**Statistic**	**Std. Error**	**Statistic**
Age	4	9.00	10.00	19.00	15.2500	1.93111	3.86221
Mouth opening	4	5	30	35	32.75	1.109	2.217
Valid N (list wise)	4						

Table 8: Frequencies

Statistics				
		Gender	**Etiology of micrognathia**	**Distraction side**
N	Valid	4	4	4
	Missing	0	0	0

Gender					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Male	3	75.0	75.0	75.0
	Female	1	25.0	25.0	100.0
	Total	4	100.0	100.0	

Etiology of micrognathia					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Ankylosis	3	75.0	75.0	75.0
	Hemifacialmicrosomia	1	25.0	25.0	100.0
	Total	4	100.0	100.0	

Distraction side					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Right	1	25.0	25.0	25.0
	Left	2	50.0	50.0	75.0
	Bilateral	1	25.0	25.0	100.0
	Total	4	100.0	100.0	

Paired Samples Statistics					
		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1	Ramus height in mm Pre op	40.6000	5	6.10737	2.73130
	Ramus height in mm Post op	49.8000	5	6.49615	2.90517
Pair 2	Body length in mm pre op	54.6000	5	11.12654	4.97594
	Body length in mm post op	65.0000	5	11.46734	5.12835
Pair 3	Hyomental distance in cm pre op	2.0000	4	1.41421	.70711
	Hyomental distance in cm post op	4.7500	4	.95743	.47871
Pair 4	Posterior airway space pre op	4.7500	4	1.50000	.75000
	Posterior airway space post op	7.7500	4	1.25831	.62915

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	Ramus height in mm Pre op& Ramus height in mm Pos top	5	.943	.016
Pair 2	Body length in mm pre op & Body length in mm post op	5	.989	.001
Pair 3	Hyomental distance in cm pre op &Hyomental distance in cm post op	4	.739	.261
Pair 4	Posterior airway space pre op& Posterior airway space post op	4	.839	.161

Paired Samples Test									
		Paired Differences					t	df	**Sig. (2-tailed)**
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
					Lower	**Upper**			
Pair 1	Ramus height Pre op – Ramus height Post op	-9.20000	2.16795	.96954	-11.89186	-6.50814	-9.489	4	**.001**
Pair 2	Body length in mm pre op – Body length in mm post op	-10.4000	1.67332	.74833	-12.47770	-8.32230	-13.898	4	**.000**
Pair 3	Hyomental distance in cm pre op – Hypomental distance in cm pos top	-2.75000	.95743	.47871	-4.27348	-1.22652	-5.745	3	**.010**
Pair 4	Posterior airway space pre op – Posterior airway space post op	-3.00000	.81650	.40825	-4.29923	-1.70077	-7.348	3	**.005**

Table 9: Crosstabs

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Group * Occlusion pre op	8	100.0%	0	0.0%	8	100.0%
Group * Midline shift pre op	8	100.0%	0	0.0%	8	100.0%
Group * Chin projection pre op	8	100.0%	0	0.0%	8	100.0%
Group * Facial symmetry pre op	8	100.0%	0	0.0%	8	100.0%

Table 10: Group * Occlusionpreop

Crosstab					
Count					
		Occlusion pre op			Total
		Class I	Class II	Post Open Bite	
Group	Pre op	0	4	0	4
	Post op	3	0	1	4
Total		3	4	1	8

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	**8.000[a]**	**2**	**.018**
Likelihood Ratio	11.090	2	.004
Linear-by-Linear Association	1.000	1	.317
N of Valid Cases	8		
a. 6 cells (100.0%) have expected count less than 5. The minimum expected count is .50.			

Table 11: Group * Midline shift preop

Crosstab					
Count					
		Midline shift pre op			**Total**
		No Midline Shift	**Right**	**Left**	
Group	Preop	0	2	2	4
	Postop	4	0	0	4
Total		4	2	2	8

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	**8.000[a]**	**2**	**.018**
Likelihood Ratio	11.090	2	.004
Linear-by-Linear Association	5.727	1	.017
N of Valid Cases	8		
a. 6 cells (100.0%) have expected count less than 5. The minimum expected count is 1.00.			

Table 12: Group * Chin projection pre op

Crosstab				
Count				
		Chin projection pre op		Total
		Retrogenia	Chin prominent	
Group	Pre op	4	0	4
	Post op	0	4	4
Total		4	4	8

Chi-Square Tests					
	Value	**df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson Chi-Square	8.000[a]	1	.005		
Continuity Correction[b]	4.500	1	.034		
Likelihood Ratio	11.090	1	.001		
Fisher's Exact Test				**.029**	**.014**
Linear-by-Linear Association	7.000	1	.008		
N of Valid Cases	8				
a. 4 cells (100.0%) have expected count less than 5. The minimum expected count is 2.00.					
b. Computed only for a 2x2 table					

Table 13: Group * Facial symmetry preop

Crosstab				
Count				
		Facial symmetry pre op		**Total**
		Asymmetry	**Symmetry**	
Group	Pre op	4	0	4
	Post op	0	4	4
Total		4	4	8

Chi-Square Tests					
	Value	**df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson Chi-Square	8.000[a]	1	.005		
Continuity Correction[b]	4.500	1	.034		
Likelihood Ratio	11.090	1	.001		
Fisher's Exact Test				**.029**	.014
Linear-by-Linear Association	7.000	1	.008		
N of Valid Cases	8				
a. 4 cells (100.0%) have expected count less than 5. The minimum expected count is 2.00.					
b. Computed only for a 2x2 table					

DISCUSSION

According to Illizarov *et* al[6] and other studies bone formation is markedly increased during distraction osteogenesis. The increased activity has been attributed to stimulatory effect on bone forming cells by the tension produced. Bone formation activity during distraction osteogenesis is significantly increased in the range of 200-400 μm/day compared to normal fracture healing process.

Although it has not yet been proved there are clinical reports that suggest an increase in the soft tissue mainly the muscles of mastication on distraction of the mandible.

According to Moss and salentijin[100], the explanation for this is that the functional matrix for development of craniofacial skeleton is influenced by the function of the attached neuromuscular tissue and associated spaces. Enlow[101] also demonstrated that mandibular growth is dependent on development of masticatory muscles and eruption of the teeth. There was an increase in soft tissue mainly muscles of mastication in the present study as a result of distraction.

Ilizarov reported that the rhythm of distraction has a significant influence on the bony regeneration[102]. The rate of distraction was 1.5mm/day in the present study since animal studies have shown that a distraction rate of 2mm/day resulted in delayed union or non union in the distracted area[110, 44, 27, 35] On the contrary a slow distraction rate of 0.3-0.5mm/day produced premature consolidation hence the distraction rate in the current study was 1.5mm/ day and there was biologically favorable bone formation in all the cases.

The mineralization of the newly regenerated bone is low (24.3%) immediately after lengthening and increases mainly during the 6 week retention period (77.8%). One year in the post distraction period, it is nearly equal (95%) to the non distracted bone. Total new bone volume and bone formation indices increased significantly in distracted callus region.

During the age of mixed dentition in patients with Hemifacialmicrosomia and a hypoplastic mandible, the unerupted molar buds are located high in the retromolar region and can be damaged by an osteotomy cut in this region Moreover the ramus is wider in the retromolar region than superiorly, therefore, an oblique osteotomy results in more bony surfaces on both sides of the osteotomy for regeneration of bone. A recent experimental study in tibial bone by Richards et al [103] has demonstrated that when the osteotomies were created at a 30^0 angle to the bony axis there were changes in the distribution of gap strain, which caused increased shear on the osteoblasts resulting in deposition of more osteoid and mineralized bone.

One of the important phases in distraction osteogenesis is determination of vector of distraction. In the treatment of Hemifacialmicrosomia or a postankylotic deformity, elongation of the hypoplastic ramus and body are the key elements. During distraction the vector of elongation in the mandibular ramus should be in a downward and forward direction. For downward and forward elongation of the mandible the force should be applied along the posterior part of ramus. The distraction vector determines the osteotomy, direction of placement of screws or pins and orientation of the device. Placement of the device parallel to inferior border of mandible will result in an anterior open bite. Posterior placement of device can achieve elongation of ramus with slight anterior movement. Keeping this principle in mind since a vertical elongation and forward advancement of mandible was needed, an oblique osteotomy was made in the angle of mandible and the device was placed obliquely to achieve a simultaneous increase in ramus height and body length in all patients in the present study and since the device was oriented parallel to occlusal plane there was no evidence of anterior open bite. This vector determination should be decided pre operatively because there is no possibility of changing the vector of elongation during lengthening in intra oral DO as can be done with the extra oral method.

In the mandible, it is better to perform an osteotomy rather than corticotomy to allow better movement of the segments and increased control of the planned vector of elongation because the intra oral devices are not rigid enough to move the segment in the planned direction without an osteotomy. The osteotomy should be completed at the posterior border of ramus to allow downward distraction and to prevent an open bite. Hence in the current study since an intra oral device was used, osteotomy was done rather than a corticotomy.

A study performed by Williams et al[104] demonstrates expansion of mandibular framework with advancement of base of tongue that leads to increased pharyngeal airway. This is determined on the basis of cephalometric study where the advancement of hyoid bone along the axis of mandibular body is measured after distraction.

A study by A.Rachmiel*et*al[92] supports that the distraction of the micrognathic mandible increases the volume of upper airway, increases the mandibular volume and advances the hyoid bone, thereby improving the glossoptosis and airway obstruction eliminating symptoms of OSA. A study by Miloro et al[95] suggest a 12mm increase in posterior airway space .Even though none of our patients had OSA as polysomnography was done in all patients, there has been a definitive increase in the posterior pharyngeal airway space and Hyomental distance suggesting a improvement in airway similar to the above mentioned studies.

In Orthognathic surgery it has been shown that up to 10mm increase in body length can be obtained without significant relapse using BSSO in sufficiently broad, thick and well developed mandible.

But since the deficiency was more than 10mm in all the patients involved in the current study distraction osteogenesis was the better option in view of large discrepancies in these patients.

A study by Aysegulet al[96] shows that they were able to obtain a linear increase in length of 13mm in ramus height measured in lateral cephalometric radiographs and 18mm in PA cephalometric radiographs and this increase was maintained over the period of the study and no skeletal relapse in 24 months post consolidation.

In another study on intra oral distraction osteogenesis by Sadakah et al[93], there was a total mandibular elongation from 17-25mm (20.7mm) and occlusal canting decreased to 0^0 in 7 patients and 1^0 in 2 patient (mean 0.2^0). In a study by El-Bialy et al[99] on bilateral mandibular distraction osteogenesis using an intra oral tooth borne device the total mandibular length and corpus length increase achieved were 5mm and 4.6mm respectively. This amount of distraction is less than bone –borne studies. In another study by Michael Miloroet al[95] on mandibular DO for pediatric airway management, there was a mean increase in mandibular length of 15mm.

In a study by Padwaet al[68] on simultaneous maxillary and mandibular distraction osteogenesis with a semi buried device a mean increase of 10mm of mandibular body length was achieved. In a study by Van strijen et al[89] the mean lengthening of the mandible achieved was 7.6mm (range 8-10mm). In a study by Jansma et al[105] the mean increase in ramus length was 13mm(range 10-16) .

Similar to these studies, in the present case series, there was a mean increase of 10.4mm in mandibular body length and 9.2mm increase in ramus height.

In a study on long bones it has been emphasized that an intact intra medullary blood circulation with overlying periosteum is essential to allow bone regeneration after lengthening. KaraHarju – Suvantoet al[19] have reported from their study on sheep that the cutting of the intra medullary blood vessels or overlying periosteum does not affect bone healing. In the present study, the inferior alveolar nerve was kept intact at all times and periosteum was not stripped extensively to preserve mandibular bone volume and maintain the integrity of the inferior alveolar nerve.

Contrary to the study by white sides and Roger[53], temporary hypothesia was not encountered in all the patients in the present study.

There has been some controversy as to when distraction should begin after the osteotomy procedure. For long bones, Ilizarov recommended a 5-7days delay before starting gradual distraction. With mandibular distraction, snyder et al[106] indicated a period of 1 week while Karp et al[48] and constantino et al[107] all waited for 10 days. Considering the healing capacity of mandibles and relatively young age of the patients in this study, a waiting period of 5-7 days was applied and was found to be optimal.

The disadvantage of the extra oral distractors is that they leave scars along the cheek; possibility of a fall may result in loosening of the pins or breakage of the device. On the contrary these disadvantages do not occur with intra oral distractors (Diner et al 1996)[14].hence we favored intra oral distractors for all patients in the present study. However these devices do not allow for multi directional lengthening with adjustments during the distraction period.

In a study by Jansma[105] et al the mean increase in ramus length was 13mm(range 10-16) similar to our study.

In a study by Jansma et al [105]the chin was brought into facial midline analogous to this even in the current study there was definite increase in chin projection and the midline shift was corrected although over correction is often advised this was not possible in this study because the developing opposite cross bite became the limiting factor.

Akin to the studies by Rubio-Bueno et al[82], good occlusion was achieved after lengthening the ramus and corpus with distraction osteogenesis with intra oral device in this study.

In agreement with recommendation of Mommaerts and Nagy[108], distraction osteogenesis was performed in all patients in the second stage of dental development.

The least predictable feature in the case series was the posterior open bite. It is assumed that unilateral lengthening of ramus leads to a transverse shift of the mandible to the opposite side, which minimizes the vertical effect that is increase in ramus height in the molar region on the distraction side. This mandibular shift to the opposite side was also described by Diner et al[77]. They stated that this laterognathism often masks the vertical lengthening of ramus and prevents the creation of the desired unilateral open bite on the distracted side. An open bite was present only in one of the case, the use of an intra oral device could be the reason for this lack of getting a desired open bite on the distracted side which could favor the downward growth of maxilla. Jansma[105] et al suggests placement of an orthodontic bite block on the opposite side either pre or post operatively if an intra oral distraction device is used.

There have been no long term studies on stability after treatment of hemifacial microsomia by DO. Kusnoto et al [109]found 1mm shortening of the mandibular ramus after DO. With 5-8% over correction and referred to this phenomenon as settling of the regenerate. And also reported 2% more growth of the mandibular body occurred on the distracted side than on the opposite side.

But in the current study the follow up period is just three months and a longer follow up period is necessary to assess the relapse rate.

During the distraction period, forces tend to push the condyle up into the glenoid fossa. This could explain the pain in the ipsilateral TMJ in 2 cases during early distraction period.

Rubio Bueno et al[82] reported anterior rotation of the condylar segment immediately after the operation because of rotation of bony segment around the single external screw probably because of temporalis muscle pull but in view of the fact that an intra oral device with 4 screws were fixed on each side of the osteotomy, this complication was not encountered in the current study.

From the patients point of view the distraction period was not an uncomfortable experience. No major discomfort was noted at the distraction site. The only disadvantage of distraction osteogenesis using intra oral distraction device seems to be the necessity of two operations under general anesthesia and frequent visits to the clinic during the activation period.

SUMMARY AND CONCLUSION

Distraction Osteogenesis is definitely a boon to the oral and maxillofacial surgeons in treating large deficiencies of mandible in terms of stability.

Young patients with mandibular hypoplasia who are resistant to functional orthodontic therapy can be treated effectively by means of DO to lengthen the mandible.

The lengthening of all the anatomical structures skin, muscles, ligaments, vessels and nerves is an added advantage of DO. The main difficulties encountered in using DO are selection of the device, determination of the vector of distraction, the planning of the osteotomy area and the patients co-operation. The advantage of intra oral devices are higher quality distraction due to proximity between the bone and the frame, possibility of using implants as both distraction and prosthetic pillars and unaltered social life for the patient.

A definite improvement in all parameters such as body length,ramus height,chin projection,occlusal cant was observed in all patients. Moreover thepatients were subjectively satisfied with the outcome of the results. It is important to note that the psychological inhibition which was present before surgery is entirelyalleviated.

With an impressive success rate reported in this study intra oral distraction osteogenesis is definitely a feasible option for treating micrognathia of mandible as it is relatively simple to carry out with minimal complications and good results, however distraction osteogenesis is a highly technique sensitive surgical treatment procedure and an accurate treatment planning and execution of the planned treatment is needed to achieve best results.

BIBLIOGRAPHY

1. **Iatrou I, Theologie-Lygidakis N, Schoinohoriti O.** Mandibular distraction osteogenesis for severe airway obstruction in Robin Sequence. Case report.J Craniomaxillofac Surg. 2010; 38:431-5.
2. **Vasconcelos BC, Bessa-Nogueira RV, Cypriano RV.** Treatment of temporomandibular joint ankylosis by gap arthroplasty.Med Oral Patol Oral Cir Bucal.2006; 11:E66–9.
3. **Rowe NL.** Ankylosis of the temporomandibular joint. J R CollSurgEdinb 1982;27:67–79.
4. **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.
5. **Peter wardbooth**-Oral and maxillofacial surgery-second edition
6. **Ilizarov GA.** The tension-stress effect on the genesis and growth of tissues: Part I. The influence of stability of fixation and soft tissue preservation. Clin Orthop. 1989; 238:249–281.
7. **Codivilla A.** On the means of lengthening in the lower limbs, the muscles and tissues which are shortened through deformity. Am J Orthop Surg.1905; 2: 353- 357.

8. **McCarthy JG, Schreiber J, Karp N, Thorne CH, Grayson BH.** Lengthening the human mandible by gradual distraction. Plast Reconstr Surg. 1992; 89: 1-8.

9. **Samchukov ML, Cope JB, Cherkashin AM**. Biological basis of new bone formation under the influence of tension stress. In: Craniofacial distraction osteogenesis.2001. 21 St Louis.

10. **Cope JB, Samchukov ML, Cherkashin AM.** Mandibular distraction osteogenesis: A historic perspective and future directions. Am J Orthod Dentofacial Orthop.1999; 115: 448-460.

11. **Swennen G, Schliephake H, Dempf R, Schierle H, Malevez C**. Craniofacial distraction osteogenesis: a review of the literature: Part 1: clinical studies. Int J Oral Maxillofac Surg.2001; 30: 89-103.

12. **Cope JB, Samchukov ML, Cherkashin AM, Wolford LM, Franco P.** Biomechanics of mandibular distractor orientation: an animal model analysis. J Oral Maxillofac Surg.1999; 57: 952-962.

13. **Samchukov ML.** Cranifacial Distraction Osteogenesis. 1st ed. Misssouri, USA: Mosby, Inc; 2001.

14. **Diner et al.** Intraoral distraction for mandibular lengthening: a technical innovation. J Craniomaxillofac Surg.199624: 92–95.

15. **Gray's anatomy** –thirty seventh edition-anatomy of head and neck.

16. **Dingman RO, Crabb we.** Surgical anatomy of the mandibular ramus of the facial nerve based on the dissection of 100 facial halves. Plast Reconstr Surg. 1962; 29:266.

17. **Ziarah HA, Atkinson ME.** The surgical anatomy of the cervical distribution of the facial nerve. Br J Oral Maxillofac Surg. 1981; 19:159.

18. **Edwardellis, Michael F.Zide**-Surgical approaches to facial skeleton-second edition.

19. **Kara Harju – Suvanto et al.**Distraction osteogenesis of the mandible.J Oral Maxillofac Surg. 1992; 21: 118–121.

20. **Yoshihiro sawaki et al.** Mandibular lengthening by distraction osteogenesis using osseointegrated implants and an intra oral device.J Oral Maxillofac Surg. 1996; 54: 594-600.

21. **Ulrich meyer et al.** The effect of magnitude and frequency of interfragmentary strain on the tissue response to distraction osteogenesis. J Oral Maxillofac Surg.1999; 57:1331-1339.

22. **William H Bell et al.** Intra oral widening and lengthening of the mandible in baboons by distraction osteogenesis.J Oral Maxillofac Surg.1999; 57: 548 – 562.

23. **Hindsey R. Douglas et al.** Intra oral distraction osteogenesis in the baboon mandible using a tooth and bone anchored appliance.J Oral Maxillofac Surg.2000; 58 : 49-54.

24. **Franciso J. Castano et al.** Proliferation of masseter myocytes after distraction osteogenesis of the porcine mandible.J Oral Maxillofac Surg.2001; 59: 302-307.

25. **Jing hu et al.** Change in the inferior alveolar nerve after mandibular lengthening with different rates of distraction.J Oral Maxillofac Surg. 2001; 59: 1041- 1045.

26. **Hi wizheng et al.** Evaluation of recombinant human bone morphogenetic protein – 2 in mandibular distractionosteogenesis in rabbits: Effect of dosage and number of doses on formation of bone.Br J Oral Maxillofac Surg.2001; 44: 487- 494.

27. **Kessler et al.** Effects of distraction forces and frequency of distraction on bony regeneration.Br J Oral Maxillofac Surg. 2005; 43: 392 -398.

28. **Li Wu Zheng et al.**Effect of Recombinant Human Bone Morphogenetic Protein-2 on Mandibular Distraction at Different Rates in a Rabbit Model.J Craniomaxillofac Surg.2006; 34:263-269.

29. **Marukawa et al.** Expression of bone morphogenetic protein -2 and proliferating cell nuclear antigen during distraction osteogenesis in the mandible in rabbits.Br J Oral Maxillofac Surg. 2006; 44:141-145.

30. **Uk – kyukim et al.** Bone regeneration in mandibular distraction osteogenesis combined with compression stimulation. J Oral Maxillofac Surg. 2006; 64: 1498- 1505.

31. **Byun et al.** Expression of vascular endothelial growth factor and its receptors after mandibular distraction osteogenesis. Int. J. Oral Maxillofac Surg. 2007; 36: 338- 344.

32. **Masarusato et al.** Morphological and immunohistochemical changes in muscle tissue in association with mandibular distraction osteogenesis.J Oral Maxillofac Surg.2007; 65:1517 – 1525.

33. **Sencimen et al.** Histomorphometrical analysis of new bone obtained by distraction osteogenesis by periosteal distraction in rabbits. Int J Oral Maxillofac Surg.2007; 36: 235-242.

34. **Miloro et al.** Low level laser effect on mandibular distractionosteogenesis. J Oral Maxillofac Surg. 2007; 65: 163-176.

35. **D Jasim et al.** Recommendations for optimal distraction protocols for various animal models on the basis of a systematic review of the literature. Int J Oral Maxillofac Surg. 2007; 36: 877- 883.

36. **Xie et al.** A preliminary study of the effect of low intensity pulsed ultrasound on new bone formation during mandibular distraction osteogenesis in rabbit. Int J Oral Maxillofac Surg.2011; 40: 730- 736.

37. **Apaydin et al.** Soft tissue changes during distraction osteogenesis. Int J Oral Maxillofac Surg. 2011; 40: 408-12.

38. **Zachary S. Peacock et al.** Automated continuous distraction osteogenesis may allow faster distraction rates: a preliminary study. J Oral Maxillofac Surg.2013; 71: 1073 – 1084.

39. **Hiroko hagino et al.** The fate of developing teeth in mandibular lengthening by distraction: an experimental study. J Craniomaxillofac Surg. 2001; 29:94-99.

40. **Kourosh et al.** The role of latency in mandibular osteodistraction. J Craniomaxillofac Surg. 1998; 26: 209-219.

41. **Ploder et al.** Mandibular lengthening with an implanted motor driven device: a preliminary study in sheep. Br J Oral Maxillofac Surg.1997; 37: 273- 276.

42. **Ruhaimi et al.** Effect of calcium sulphate on the rate of osteogenesis in distracted bone. Int J Oral Maxillofac Surg.2001; 30:228-233.

43. **Mehrara et al.** Rat Mandibular distraction osteogenesis II. Molecular analysis of transforming growth factor beta-1 and osteocalcin gene expression. Plast Reconstr Surg.1999: 103: 536-547.

44. **Warren et al.** Rat mandibular distraction osteogenesis part III. Gradual distraction versus acute lengthening. Plast Reconstr Surg.2001; 107: 441-453.

45. **Guerrissi et al.** lengthening of mandible by distraction osteogenesis- experimental work in rabbits. J Craniofac Surg.1994; 5: 313-317.

46. **Simpson et al.** The response of muscle to lengthening.J Bone Joint Surg . 1995; 99:366.

47. **Fisher et al.** Histopathologic and biochemical changes in muscles affected by distraction osteogenesis of the mandible. Plast Reconstr Surg.1997: 99: 366- 372.

48. **Karp et al.** Bone lengthening in the cranio facial skeleton. Ann Plast Surg.1990; 24: 231.

49. **Micheli et al.** Lengthening of mandibular body by gradual surgical orthodontic distraction. J Oral Surg. 1977: 35: 187.

50. **Block et al.** Changes in the inferior alveolar nerve following mandibular lengthening in the dog using distraction osteogenesis. J Oral Maxillofac Surg.1993; 51: 652.

51. **Makarov et al.** Evaluation of inferior alveolar nerve function during distraction osteogenesis. J Oral Maxillofac Surg. 1998; 56: 1417 – 1423.

52. **Hu et al.** Changes in the inferior alveolar nerve after mandibular lengthening with different rates of distraction. J Oral Maxillofac Surg.2001; 59 1041- 1045.

53. **White Sides et al:** Effects of distraction osteogenesis on severe hypoplastic mandible and inferior alveolar nerve function. J Oral Maxillofac Surg.2004; 62: 292- 297.

54. **Row et al.** Angiogenesis during mandibular distraction osteogenesis. Ann Plast Surg. 199l; 42: 470-5

55. **Bell et al .**Intra oral widening and lengthening of mandible by distraction osteogenesis. J Oral Maxillofac Surg. 1999; 57: 548.

56. **Samchukov et al.**The effect of gradual traction on periodontal ligament. Cranio facial distractionosteogenesis. st. Louis Mo: mosby: 2001; 110-117.

57. **Block et al.** Anterior maxillary advancement using tooth supported distraction osteogenesis. J Oral Maxillofac Surg.1995; 53: 561.

58. **Ko et al.** Correction of Facial Asymmetry with Multiplanar Mandible Distraction: A One-Year Follow-Up Study. Cleft Palate Craniofac J.2004; 41: 5-12.

59. **Van strijen et al.** Stability after distraction osteogenesis to lengthen the mandible .J Oral Maxillofac Surg.2004; 62: 304 – 307.

60. **Wang, X., Yi, B., et al.** Internal midface distraction in correction of severe maxillary hypoplasia secondary to cleft lip and palate. Plast Reconstr Surg.2005; 116:51-60.

61. **Cheung et al.** Bilateral sagittal split osteotomies and mandibular distraction osteogenesis a randomized controlled trial comparing skeletal stability: Oral Surg Oral Med Oral Pathol Oral Radiol.2005; 109: 17-23.

62. **Nadjmi N, Schutyser F, Van Erum R.** Trans-sinusal maxillary distraction for correction of midfacial hypoplasia: Long-term clinical results. Int J Oral Maxillofac Surg. 2006;35:885-96

63. **Shetye PR, Boutros S, Grayson BH, et al.** Midterm follow-up of midface distraction for syndromic craniosynostosis: a clinical and cephalometric study. Plast Reconstr Surg. 2007; 120:1621–1632.

64. **Figuerao et al.** Management of severe left maxillary deficiency with DO; procedure and results. Am J Orthod Dentofacial Orthop.1999; 115: 1-12.

65. **Bass et al.** Long term stability of mandibular advancement procedures: Bilateral sagittal split osteotomy versus distraction osteogenesis. Int J Oral Maxillofac Surg.2012; 41:137- 141.

66. **Dean, Alamillos F.** Mandibular distraction in temporomandibular joint ankylosis. Plast Reconstr Surg.1999; 104: 2021- 2031.

67. **Papa George, Apostolidis**. Simultaneous mandibular distraction and arhroplasty in a patient with temporomandibular joint ankylosis and mandibular hypoplasia.J Oral Maxillofac Surg. 1999; 57: 328-33.

68. **Padwa et al.** Simultaneous maxillary and mandibular distraction osteogenesis with a semi buried device. Int J Oral Maxillofac Surg.1999; 28:2-8.

69. **Douglas et al.** Intra oral mandibular distraction osteogenesis in patient with severe micrognathia secondary to TMJ ankylosis using a tooth and bone anchored device: a case report. J Oral Maxillofac Surg .2000; 58: 1429-1433.

70. **Youhara et al.** Correction of micrognathia attributable to ankylosis of TMJ using distraction technique. J Oral Maxillofac Surg.2000; 58:1415-1418.

71. **Your and kin et al.** Intra oral mandibular distraction osteogenesis in facial asymmetry patients with unilateral

temporo mandibular joint bony ankylosis. Int J Oral Maxillofac Surg. 2002; 31: 544-548.

72. **Rao K et al.** The role of simultaneous gap arthroplasty and distraction osteogenesis in management of temporomandibular joint ankylosis. J Craniomaxillofac Surg.2004; 32:38- 42.

73. **Ehab. A.A shehata et al.** Modified bimaxillary distraction osteogenesis: a technique to correct facial asymmetry. Br J Oral Maxillofac Surg.2007; 45: 471- 477.

74. **Adi racchmiel.** Lengthening of mandible by distraction osteogenesis. J Oral Maxillofac Surg.1995;53:838-846

75. **O.Kocabalkan.** Repeated mandibular lengthening in treacher Collins syndrome: a case report. Int J Oral Maxillofac Surg.1995;24:406-408.

76. **Martin chin et al.** Distraction osteogenesis in maxillofacial surgery using internal devices. J Oral Maxillofac Surg.1996; 54:45-53.

77. **Diner et al.** Submerged intraoral device for mandibular lengthening. J Craniomaxillofac Surg.1997 ;25:116-123

78. **SamchukovML, Cope JB et al.** Biomechanical considerations of mandibular lengthening and widening by gradual distraction using computer model. J Oral Maxillofac Surg.1998; 56:51-59.

79. **Carls et al.** Seven years clinical experience with mandibular distraction in childhood. J Craniomaxillofac Surg.1998; 26:197-208.

80. **Juenger et al.** application of ultrasound in callus distraction of the hypoplastic mandible: an additional method for the follow up. J Craniomaxillofac Surg.1999; 27:160-167.

81. **Samchukov et al.** effect of sagittal orientation of the distractor on the biomechanics of mandibular lengthening. J Oral Maxillofac Surg.1999; 5:1214-1221.

82. **Rubio Bueno et al.** Distraction osteogenesis of the ascending ramus for mandibular hypoplasia using extraoral or intraoral devices: a report of 8 cases. J Oral Maxillofac Surg.2000;58:593-598.

83. **Jason B. Cope et al:** Force level and strain patterns during bilateral mandibular osteodistraction. J Oral Maxillofac Surg.2000;58:171-178.

84. **AdiRachmiel et al:** intraoral distraction osteogenesis of the mandible in hemifacialmicrosomia. J Oral Maxillofac Surg. 2001; 59:728-733.

85. **Mattick et al.** Mandibular Advancement Using an Intra-Oral Osteogenic Distraction Technique: a report of three clinical cases.J Orthod.2001;28:105-114.

86. **Randolph C.Robinson et al.**Mandibular Distraction Force: Laboratory Data and Clinical Correlation. J Oral Maxillofac Surg. 2001; 59:539-544.

87. **Azumi et al.** positional and morphological changes of condyle after distraction osteogenesis in skeletal class II patients: World J Orthod.2004;5:32-39.

88. **Breuning et al.** Outcome of treatment of class II malocclusion by intraoral mandibular distraction. Br J Oral Maxillofac Surg.2004; 42:520-525.

89. **Van Strijen et al.**Stability after distraction osteogenesis to lengthen the mandible: results in 50 patients. J Oral Maxillofac Surg.2004; 62:304-307.

90. **Karacay S, Akin E, Okqu KM, Olmez H, Mermut S.** Cephalometric evaluation of patients treated by maxillary anterior segmental distraction: A preliminary report. J Craniomaxillofac Surg.2004; 35:302–10.

91. **Steinbacher et al.** Mandibular advancement by distraction osteogenesis for tracheostomy – dependent children with severe micrognathia. J Oral Maxillofac Surg.2005; 63:1072-79.

92. **A.Rachimiel et al.** Bilateral mandibular distraction for patients with compromised airway analyzed by three-dimensional CT. Int J Oral Maxillofac Surg.2005; 34:9-18.

93. **Sadakah et al.** Intraoral distraction osteogenesis for the correction of facial deformities following temporomandibular joint ankylosis: a modified technique. Int J Oral Maxillofac Surg; 35:399-406.

94. **Hamada et al.** mandibular distraction osteogenesis in a skeletal class II patient with obstructive sleep apnoea. Am J Orthod Dentofacial Orthop.,.2007;131:415-425.

95. **Michael Miloro.** Mandibular distraction osteogenesis for pediatric airway management.J Oral Maxillofac Surg.2010; 68:1512-1523.

96. **Aysegul et al**: response of ramus following vertical lengthening with distraction osteogenesis.J Craniomaxillofac Surg.2011; 39:420-424.

97. **Hongtaoshang et al.** Modified internal mandibular distraction osteogenesis in the treatment of micrognathia secondary to temporomandibular joint ankylosis. J Craniomaxillofac Surg.2012; 40:373-378.

98. **Hao sun et al.** Error analysis of a CAD/CAM method for unidirectional mandibular distraction osteogenesis in the treatment of hemifacialmicrosomia.Br J Oral Maxillofac Surg.2013;51:892-897.

99. **El – Bialy et al.** long term results of bilateral mandibular distraction osteogenesis using an intraoral tooth borne device in adult class II patients.2013;42:1446-1453.

100. **Moss ML, Salentjin L.** The primary role of functional matrices in facial growth. Am J Orthod. 1969; 55(6):566-77.

101. **Enlow DH, Harris DB.** A study of the postnatal growth of the human mandible**.** Am J Orthod. 1964; 50:25–50.

102. **Ilizarov GA .**The principles of the Ilizarov method. Bull Hosp Jt Dis Orthop Inst. 1988;48: 1-11.

103. **Richards M, Goulet JA, Weiss JA, Waanders NA.Schaffler MB, Goldstein SA**. Bone regeneration and fracture healing.

Experience with distraction osteogenesis model. Clin Orthop Relat Res. 1998:S191–204.

104. **Williams JK, Maull D, Grayson BH, et al.** Early decannulation with bilateral mandibular distraction for tracheostomy-dependent patients.Plast Reconstr Surg. 1999; 103:48–57.

105. **Jansma et al.** intra oral distraction osteogenesis to lengthen the ascending ramus experience with seven patients. Br J Oral Maxillofac Surg.2004; 42:526-531.

106. **Snyder CC, Levine GA, Swanson HM, Browne EZ., Jr.**Mandibular lengthening by gradual distraction. Preliminary report. Plast Reconstr Surg. 1973; 51:506–8.

107. **Costantino PD, Friedman CD.** Distraction osteogenesis: Applications for mandibular regrowth. Otolaryngol Clin North Am. 1991; 24:1433–43.

108. **Mommaerts MY, Nagy K.** Is early osteodistraction a solution for the ascending ramus compartment in hemifacialmicrosomia? A literature study. J Craniomaxillofac Surg.2002; 30:201-7.

109. **Kusnoto et al.**A longitudinal three-dimensional evaluation of the growth pattern in hemifacialmicrosomia treated by mandibular distraction osteogenesis: a preliminary report.J Craniofac Surg.1999; 10:480-86.

110. **Paccione, Michael et al.** Rat Mandibular Distraction Osteogenesis: Latency, Rate, and Rhythm Determine the Adaptive Response. J Craniofac Surg.2001;12:175-182.

ANNEXURE

CASE REPORT FORM

Distraction osteogenesis for mandibular micrognathia:

Patient's Name : ____

Age/ Sex : ____

Patient's Identification No. : __________________________________

Contact Address : ____

____

Contact No: ____

Institution: S.A.RAJA'S Dental College & Hospital,

TIRUNELVELI

Centre: Dept. of Oral & Maxillofacial Surgery,

Patient's Identification/ OP. No. _______________ Date: _________________

Details of Surgery

Procedure followed :

INTRA ORAL DISTRACTION OSTEOGENESIS OF MANDIBLE

Duration of Surgery :

Any other information :

Details of Drug therapy :

Name of the Investigator :

Signature of Investigator :

சுய ஒப்புதல் படிவம்

ஆய்வு செய்யப்படும் தலைப்பு

முறிவெலும்பு விலக்கல் மூலமாக எலுமபாக்கம் செய்யும் அறுவைச்சிகிச்சை முறையில் சிறுதாடை குறைப்பாட்டினை சரிசெய்தல்

ஆராய்ச்சி நிலையம் : ராஜாஸ் பல் மருத்துவமனை,
காவல்கிணறு, திருநெல்வேலி

பங்கு பெறுபவரின் பெயர் :

பங்கு பெறுபவரின் எண் :

பங்கு பெறுபவரின் பிறந்த தேதி:

அறுவைச்சிகிச்சை சம்பந்தமாக நான் மேலே கூறப்பட்டதகவல்ப் படிவத்தை முழுமையாக படித்து பார்த்தேன் என்று உறுதிக் கூறுகிறேன். நான் இது தொடர்பான அனைத்துக் கேள்விகளுக்கும் நிறைவான பதில்கள் பெறப்பட்டேன். இந்த ஆய்வின் எனது பங்கு தன்னிச்சையானது என்றும் எந்த நேரத்திலும் இந்த ஆய்விலிருந்து சட்ட உரிமைகள் பாதிக்கப்படாமல் விலகிக்கொள்ள சம்மதிக்கிறேன் மருத்துவ ஆய்வு அதிகாரிகள் எனது சிகிச்சை தொடர்பான பதிவேடுகளை பார்வையிடவும் எந்த நேரத்திலும் இந்த ஆய்விலிருந்து நான் விலகினாலும் பார்வையிட சம்மதிக்கிறேன். இந்த ஆய்வு அறிக்கைகளை பயன்படுத்தவும் வெளியிடவும் நான் சம்மதிக்கிறேன். ஆய்வாளர் எனது மருத்துவக் குறிப்புகளை வெளியிட தடையாக இருக்கமாட்டேன் என உண்மையாக சம்மதிக்கிறேன்.

பொது உணர்வகற்றல் மருத்துவ முறையின் மூலம் எனது கீழ்த் தாடையில் அறுவைச்சிகிச்சை கீறல் மூலமாக முறிவெலும்பு விலக்கல் கருவி பொருத்தப்பட்டு எலுமபாக்கம் செய்து எனது சிறு தாடை குறைபாடு சரிச்செய்யப்படும் என்பதை நான் அறிந்துக் கொண்டேன் இந்த அறுவைச்சிகிச்சை முறையில் ஏற்படும் அனைத்து பக்கவிளைவுகளையும் மருத்துவர் மூலம் அறிந்துக் கொண்டு இந்த ஆய்விற்கு என்னை உட்படுத்திக்கொள்கிறேன்.

இந்த ஆய்வு அறிக்கைகளை பயன்படுத்தவும் வெளியிடவும் நான் சம்மதிக்கிறேன்.

ஆய்வாளர் எனது மருத்துவக் குறிப்புகளை வெளியிட தடையாக இருக்கமாட்டேன் என உண்மையாக சம்மதிக்கிறேன்.

பங்கு பெறுபவரின் கையொப்பம்: இடம்: தேதி:

கட்டைவிரல் ரேகை:

பங்கு பெறுபவரின் பெயர் மற்றும் விலாசம்:

ஆய்வாளரின் கையொப்பம்: இடம் தேதி:

ஆய்வாளரின் பெயர்:

INFORMED CONSENT

ROLE OF DISTRACTION OSTEOGENESIS IN TREATMENT OF MICROGNATHIA OF MANDIBLE

Patient's Identification No: ____________ Patient's Name: ________________
Patient's DOB:_____________ dd ____________
mm___________________yyyy

I confirm that I have read and understood the Information Sheet for the above study. I have had the opportunity to ask questions and all my questions and doubts have been answered to my complete satisfaction. I understand that my participation in the study is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected. I understand that the Clinical study personnel, the Ethics Committee and the Regulatory Authorities will not need my permission to look at my health records both in respect of the current study and any further research that may be conducted in relation to it, even if I withdraw from the study. I agree to this access. However, I understand that my identity will not be revealed in any information released to the third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from this study. I agree not to withhold any information about my health from the investigator and will convey the same truthfully.

I agree to take part in the above study and to comply with the instructions given during the study and to faithfully co-operate with the study team and to immediately inform the study staff if I suffer from any deterioration in my health or well being or any unexpected or unusual symptoms.

I hereby consent to participate in this study & I understand that I'll be treated by surgical procedure under general anaesthesia for my facial deformity and I was well informed about the complications associated with it &I agree for the same.

I consent to give my medical history, undergo complete physical examination and diagnostic tests including haematological, biochemical and urine examination etc.

Signature / Thumb Impression: _______ Place_________Date____________

Patient's Name & Address: ____

____

Signature of the Investigator: ___________Place__________ Date_________

Study Investigator's Name: _____________________________________

Institution: ____

* Signature of the Witness: ______________Place_______ Date__________

* Name & Address of the Witness __________________________________

____

*Mandatory

For uneducated patients (Where thumb impression has been provided above)

CASE SHEET PROFORMA

NAME:

AGE:

CHIEF COMPLAINT:

HISTORY OF PRESENT ILLNESS:

HISTORY OF DRUG ALLERGY:

PAST MEDICAL HISTORY:

PAST SURGICAL HISTORY:

PAST DENTAL HISTORY:

PERSONAL HISTORY:

FAMILY HISTORY:

GENERAL EXAMINATION:

LOCAL EXAMINATION:

EXTRA ORAL EXAMINATION:

INTRA ORAL EXAMINATION:

INVESTIGATIONS:

- Complete hemogram
- Chest x-ray
- OPG
- PA cephalogram
- Lateral cephalogram
- CT scan

PROVISIONAL DIAGNOSIS:

TREATMENT PLAN: