Maxillary Advancement Using an Intra Oral Distraction Device: A Cephalometric Evaluation

Dr. Shweta Rai
Senior Lecturer

Dr. Anurag Rai

Dr. B. R. Ambedkar Institute of Dental Sciences & Hospital, Patna

Abstract

Distraction osteogenesis has become an accepted and often preferred technique for the treatment of severe midfacial hypoplasias. The extra oral and intra oral devices are being used for maxillary advancement in such cases internal device provide us with many advantages when compared to the external devices. This study is designed to evaluate the clinical efficacy of internal device for maxillary advancement by cephalometric assessment.

The internal distraction device was used in 10 patients aged range 6 to 30 years.

Distraction osteogenesis was successful in all 10 cases, resulting in a mean saggital bone gain of 7.0 mm. However 1patient out of 10 of our patients had occlusal disharmony due to incorrect vector at the end of the active distraction phase.

Key words: Distraction Osteogenesis; Maxilla; Internal Distractors; Cephalometrics

Introduction

Distraction osteogenesis is a biologic process of new bone formation between the surfaces of bone segments that are gradually separated by incremental traction. Distraction forces applied to bone initiate a sequence of adaptive changes in the soft tissues allowing larger skeletal movements.[1]

Among its innumerable clinical applications, craniofacial distraction procedures have been widely used for correction of severe anteroposterior, transverse and vertical deformities of craniofacial skeleton. [2,3.]

The concept of applying distraction osteogenesis to the treatment of craniofacial deformities was not conceived until 1972 when Snyder used a Swanson external fixator to lengthen a canine mandible.

The external device often do not maintain stability of the osteotomized segment, are visible, disturb the daily activities of the patients. Activation by the patient or his or her parents are difficult in many cases.[2] The primary criticism of the extra oral distraction appliances is the resulting scars.[4]

The requirements of the extraoral maxillary distractors include adequate cranial bone and dentition (primary or permanent) for fixation of the halo and intraoral splint respectively.[5]

Maxillary advancement with internal devices has solved the problem of facial scarring,the daily activities of the patients can be carried out ,as the device is hidden behind the lips.[3,4,6.] Intra oral maxillary distraction appliances significantly reduce physical and psychological stress on patients when compared with extra oral ones.[7]

Methodology

Ten patients, out of which 6 were female patients and 4 were male patients aged 6 to 30 years of age visiting A.B. Shetty Memorial institute of dental sciences, Mangalore were entered into this study. They all had antero posterior maxillary hypoplasia with adequate stable bone for the placement of the distraction device who required maxillary advancement greater than 8-10mm. This study is designed to evaluate the efficacy of the internal distractors for maxillary advancement. Routine records for the purpose of diagnosis and treatment planning along with Panoramic and lateral cephalograms were obtained for all the patients.

Pre operative, immediate post distraction, 6 months post distraction, lateral cephalograms were used for analysis. All radiographs were taken in the same machine using standardized technique. The radiographs were traced on 0.003 inch acetate paper and predetermined hard and soft tissue landmarks were recorded. Based on the anatomic landmarks recorded skeletal, dental and soft tissue measure-

Table - 1
CEPHALOMETRIC ANALYSIS DESCRIPTIVE STATISTICS

	N	PRE				POST				6 MONTHS			
		MIN	MAX	MEAN	STD.DEV	MIN	MAX	MEAN	STD.DEV	MIN	MAX	MEAN	STD.DEV
SNA	10	65.00	88.00	73.7000	7.2579	67.00	90.00	80.4000	9.1433	66.00	88.00	78.5000	8.9846
SNB	10	70.00	90.00	79.7000	7.1032	67.00	90.00	78.9000	6.6408	68.00	90.00	78.8000	6.1065
ANB	10	-10.00	9.00	-3.8000	6.30344	-2.00	10.00	4.1000	4.12176	-2.00	10.00	2.9000	4.14863
NA-PG	10	-35.00	-4.00	-17.6000	9.60555	-12.00	13.00	1.5000	8.52773	-13.00	6.00	-2.9000	6.36745
NA	10	-13.00	-5.00	-9.4000	3.6469	-2.00	5.00	.8000	2.7749	-6.00	1.00	-2.0000	3.2404
NB	10	-8.00	8.00	-1.8000	6.1806	-8.00	0.00	-4.6000	2.9665	-6.00	1.00	2.6000	2.7019
ANS PNS	10	35.00	65.00	44.2000	8.77876	38.00	65.00	49.4000	8.46168	37.00	65.00	47.7000	8.69291
GO-PG	10	59.00	84.00	74.7000	9.53415	60.00	89.00	76.3000	9.40508	59.00	89.00	75.1000	9.81439
AFH	10	100.00	127.00	114.3000	9.11714	107.00	135.00	118.2000	8.09389	103.00	128.00	115.5000	7.86342
PFH	10	57.00	92.00	78.4000	11.77757	63.00	91.00	80.1000	9.91576	59.00	92.00	78.9000	10.81614
RATIO	10	57.00	75.60	68.2500	6.14062	58.70	73.90	67.3219	5.92125	56.70	75.40	67.9600	6.06176
⊥NA	10	17.00	45.00	24.1000	9.10982	18.00	48.00	25.0000	9.82061	17.00	47.00	24.1000	9.76900
T MP	10	77.00	93.00	77.5000	8.69611	79.00	101.00	85.3000	5.29539	79.00	103.00	80.7000	4.77732
⊥ SN	10	65.00	120.00	96.3000	19.69800	70.00	115.00	105.3000	12.79800	70.00	119.00	104.5000	12.93789
Naso lab. Ang	10	35.00	113.00	75.0000	35.2349	69.00	107.00	89.4000	17.0382	70.00	120.00	90.8000	19.2146
U.lip – E line	10	-19.00	-2.00	-6.6000	4.69515	-14.00	00.00	-4.300	3.86005	-7.00	-1.00	-4.3000	2.00278
L.lip – E line	10	-2.00	7.00	5.0000	2.62467	3.00	9.00	6.3000	2.00278	3.00	8.00	5.7000	1.70294
N.tip – H line	10	2.00	19.00	10.5000	5.35931	2.00	22.00	12.1000	6.31489	2.00	20.00	11.5000	5.79751
Facial Angle	10	87.00	104.00	93.2000	4.70933	77.00	105.00	84.2000	27.65780	84.00	105.00	93.6000	6.13188

Table - 2
PAIRED SAMPLE TEST

	N	PRE OPERATIVE				POST OPERATIVE				POST 6 MONTHS			
		MEAN	STD.DEV	Z	P	MEAN	STD.DEV	Z	P	MEAN	STD.DEV	Z	P
SNA	10	-6.7000	6.0562	2.812	0.005hs	-4.8000	6.6131	2.201	0.028sig	1.9000	2.6854	2.034	.042 sig
SNB	10	.8000	2.7809	.914	.361ns	.9000	3.5730	.595	.552ns	.1000	1.5239	.333	.739ns
ANB	10	-7.90000	7.51960	2.657	.008hs	-6.70000	7.70353	2.371	.018sig	1.20000	3.19026	1.109	.268ns
NA - PG	10	-19.10000	12.21520	2.805	.005hs	-14.70000	12.028221	2.805	.005hs	4.40000	6.02218	2.615	.009hs
NA	10	-10.20000	3.9623	2.032	.042sig	-7.40000	5.3198	1.826	.068ns	2.80000	3.0332	1.633	.102ns
NB	10	2.80000	5.2154	1.342	.18ns	.8000	6.0992	.271	.786sig	-2.0000	3.0000	1.511	.311ns
ANS - PNS	10	-5.20000	4.10420	2.673	.008hs	-3.50000	5.23344	1.963	.05sig	1.70000	2.62679	1.992	.046sig
GO-PG	10	-1.60000	3.89301	1.304	.192ns	-.40000	3.16930	.431	.666ns	1.20000	2.04396	1.802	.072ns
AFH	10	-3.90000	3.78447	2.405	.016sig	-1.20000	2.57337	1.420	.156ns	2.70000	2.16282	2.825	.005sig
PFH	10	-1.70000	3.26769	1.637	.102ns	-.50000	2.71825	1.015	.31ns	1.20000	1.47573	2.145	0.032sig
RATIO	10	.92810	2.63854	.968	.333ns	.29000	2.16253	.153	.878ns	-.63810	1.40159	1.274	.203ns
⊥ NA	10	-.90000	4.04008	1.798	.072ns	.0000	3.74166	.949	.343ns	.90000	.31623	3.0000	.003hs
⊤ MP	10	-2.80000	8.31064	.703	.482ns	-3.20000	7.53953	1.491	.136ns	-.40000	2.59058	.299	.765ns
⊥ SN	10	-9.00000	17.34615	1.634	.102ns	-8.20000	15.56206	1.479	.139ns	.80000	5.61348	1.063	.288ns
Nasolab. Ang	10	-14.4000	23.8914	1.214	.225ns	-15.8000	42.7867	.405	.686ns	1.40000	21.5940	.135	.893ns
U.lip – E line	10	-2.30000	1.15950	2.844	.004sig	-2.30000	4.19126	2.636	.008hs	.00000	3.23179	1.438	.15ns
L.lip – E line	10	-1.30000	2.98329	1.414	.157ns	-.70000	2.11082	.921	.357ns	.60000	1.07497	1.604	.109ns
N. tip – H line	10	-1.60000	1.07497	2.558	.011sig	-1.00000	.66667	2.640	.008hs	.60000	.69921	2.121	.034sig
Facial Angle	10	9.00000	26.69582	.051	.959ns	-.40000	2.31900	.512	.609ns	-9.40000	28.10773	.425	.671ns

ments were calculated.

Surgical Technique

A vestibular mucosal incision was made in the maxilla, and the mucoperiosteal flap was raised. A high Le Fort I osteotomy was performed avoiding damage to the tooth buds. Every effort was made at the time of surgery to make an osteotomy cut that will direct the maxillary segment with the appropriate horizontal and vertical vectors to prevent creation of an anterior open bite or changing elongation of the lower face.

The pterygoid process was separated from the maxillary tuberosity as well as from the nasal septum. The maxilla was gently mobilized without down fracturing. The distraction device was planed at the zygomatic buttress. Immediate activation of the distraction device was done, as it is important to prove that there is sufficient mobility of the midface and the maxilla and to control the direction of distraction. After that the distractor was deactivated, and the wound was closed so that the activation port exists through the mucosa. The distraction rods were then bend and hidden behind the upper lip. Following a latency period of 5 days the device was activated 0.5 mm twice a day that is 1 mm /day. The latency period was necessary to allow granulation tissue to fill the osteotomy gap. Post operatively antibiotic was prescribed to all the patients for 1 week to all the 10 patients, but analgesic was prescribed for 3days to 7 of our patients as they complained of pain. Oral hygiene was stressed using a disinfecting mouth rinse four times a day.

After the active distraction phase all the 10 patients were discharged with distraction device in situ and recalled for check up monthly till the distraction device was removed.

None of the patients had any problems of avascular necrosis or gingival injury, neither discomfort or loosening if the distraction device.

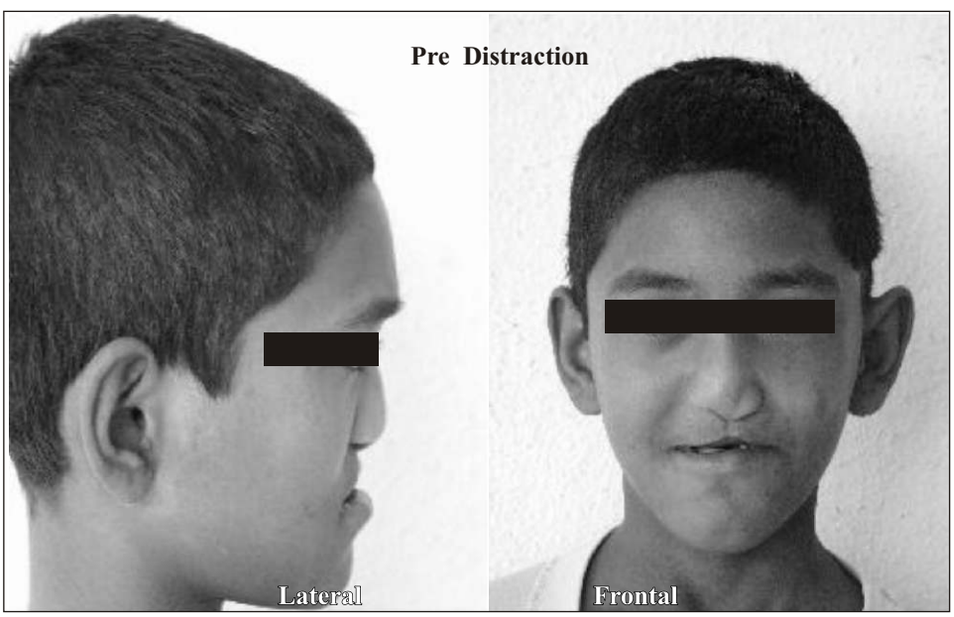
However 1 out of 10 of our patients had occlusal disharmony due to incorrect vector at the end of the active distraction phase.

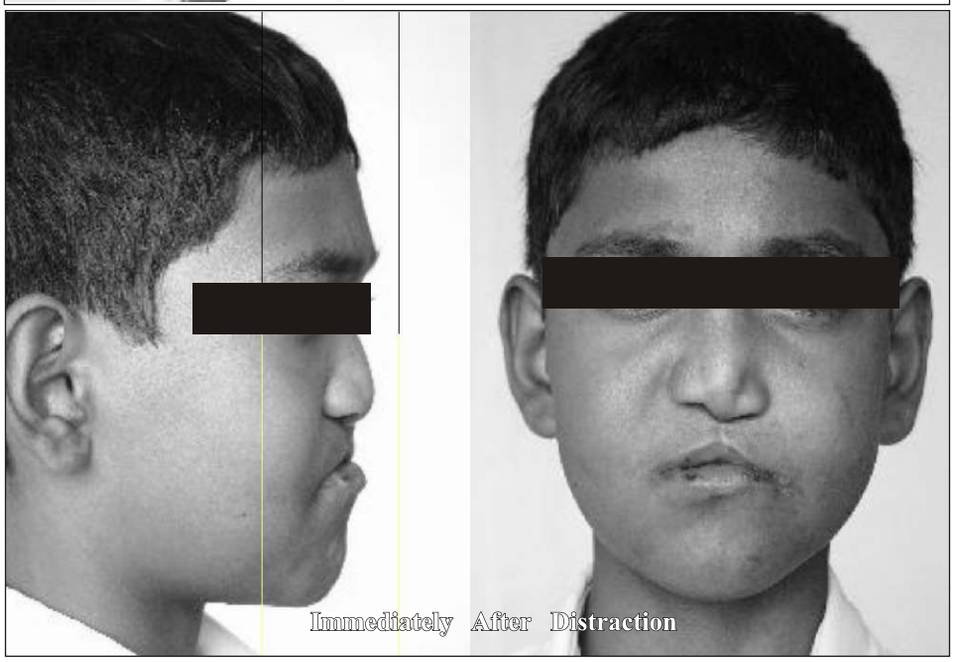
Active distraction is begun on the sixth post operative day at a rate and frequency of one turn twice daily, until the desired amount of maxillary movement has been achieved.

Once the appropriable distraction is achieved the device is left in place for 8-12 weeks to permit bone consolidation followed by which the device is removed. The device is removed only after the confirmation of the formation of sufficient bone at the distraction site radiographically.

Results

All study involving 10 patients for maxillary advancement using internal distractor was carried out for the evaluation of clinical efficacy of the device and also cephalometric analysis in the post treatment and 6 months post treatment results of the surgery and internal distraction device placement in our series was performed by a





single surgeon. Pre-operative antibiotics were routinely used. All patients routine oral hygiene was maintained using disinfectant mouthwash and an unrestricted soft diet 24 hours post operatively.

No intermaxillary fixation or bone grafts were used. There were no problems with bleeding or infections, none of the patient required a blood transmission, there was no problem of dental injuries, avascular necrosis or gingival injury. There was no complication with wearing the internal device, including pain, discomfort or loosening during the distraction process. However 1 out of 10 of our patients had occlusal disharmony due to incorrect vector, at the end of the active distraction phase. Pre treatment , immediate post treatment and 6 month post treatment stastical and cephalometric analysis was done for skeletal , dental and soft tissue changes which is mentioned in table 1 and table 2.

Discussion

Maxillary hypoplasia is a common finding in patients with orofacial clefting. Traditional surgical and orthodontic treatment for these patients often fall short of expectations particularly in achieving adequate functional results and normal facial proportions[7] .

In contrast to conventional orthognathic surgery, distraction osteogenesis can be used in still growing persons in whom expansion and new generation of covering soft tissue is necessary [8,9].

Distraction osteogenesis is the treatment of choice for the surgical correction of hypoplasias of the craniofacial skeleton. The principle is that osteogenesis can be induced if bone is expanding (distracted) along to long axis at the rate of 1 mm/day. This process induces new bone formation along the vector of pull without the use of bone graft. Distraction forces applied to bone creates tension in the surrounding soft tissues, initiating sequences of adaptive changes in the soft tissues allowing larger skeletal movements while minimizing the relapse[7].

For patients with midfacial hypoplasia , the second advantage may be of even greater importance as they lack bone and soft tissue. The slowly moving bony structures of the midfacial region are used as a framework for the overlying and expanding soft tissues[10,11]. The new bone that is formed by distraction osteogenesis is of the same morphology as the bones of the midface and maxilla[12].

There is no need for autogenous bone grafting. There is no donor site morbidity Clinically we have five sequential periods each having its own significances[12].

1. **Osteotomy:** It is the surgical separation of a bone into two segments.
2. **Latency:** It is the period from bone division to the onset of traction and represents the time required or reparative callus formation between osteotomized bone segments. Shorter latency periods are generally associated with decreased callus volumes and inadequate osteogenesis, whereas longer latency periods are usually associated with premature consolidation.
3. **Distraction Period:** It is that time when a traction force is applied to bone segments and new bone or distraction regenerative is formed within the intersegmentary gap.

   Two major parameters are of clinical importance during this period are rate and rhythm of distraction. Rate of distraction represents the total amount of bone segment movement per day, while the rhythm of distraction is the number of increments per day.
4. **Consolidation Period:** It begins after achieving the desired amount of lengthening when traction forces are discontinued. This period allows mineralization and corticalization of the newly formed bone tissue prior to distraction device removal.
5. **Remodeling Period:** The remodeling period is the period from the application of full functional loading to the complete remodeling of the newly formed bone. During this period, the initially formed bony scaffold is reinforced by parallel fibered lamellar bone.

   Maxillary distraction with the use of internal distraction devices offers several unique advantages:

a. Maxillary and midface distraction osteogenesis with internal distraction permits full correction of the midfacial deficiencies including both skeletal and soft tissue deficiencies[29,31].

b. The problem of facial scaring is solved with intraoral distractors[29,31]
c. The intraoral devices are well tolerated and the school age patients can continue at school[29]
d. Maxillary distraction techniques offer exciting treatment possibilities by eliminating the need for rigid skeletal fixation, blood transfusion, prolonged hospitalization or intermaxillary fixation.

Because the internal maxillary distraction devices are bone borne, they use stable bone for the placement of the distraction device. The zygomatic region of human skull is the most favorable for the fixation of bone borne distractors in maxilla. Fixation screws of 2mm in diameter in either triangular or straight miniplates produce good stabilization for internal distractors.

Cephalometry Uses

Cephalometry is an effective tool to study the relationship of individual components of craniofacial skeleton in sagittal and vertical plane. It also helped us to evaluate the changes in skeletal and soft tissues following distraction osteogenesis.[4]

Skeletal Changes

The present study showed a significant increase in the angle SNA during post distraction period. This indicated the forward movement and placement of maxilla achieved due to distraction process, which was clinically as well as statistically significant. This has resulted in the correction of severe maxillary hypoplasia, over a period of 8-12 weeks of consolidation period. The skeletal changes have resulted in the correction of the facial profile as affected in the significant improvement in the facial convexity angle.

The amount and the degree of advancement achieved in this present study suggest that the distraction osteogenesis with the formation of new bone can certainly be considered as one of the treatment modalities for severe maxillary hypoplasia.

Since the apical base of the mandible as noted by angle SNB did not have any appreciable changes during the study period. However, statistically positive correction of maxillary mandibular apical base angle (angle ANB), strongly reflects the anterior position of the maxilla.

However 6 months post distraction evaluation indicated certain degree of relapse, which is statistically not significant in the result obtained. Decrease in angle SNA, angle ANB and facial convexity angle suggested that the maxillary advancement achieved through internal maxillary distractors was stable enough clinically much better pleasing profile was maintained, even after 6 months. .

All patients had a great aesthetic improvement, as the concave, dish face like appearance was reduced by distraction treatment.

Linear measurements

This study showed a significant forward placement of apical base of the maxilla and increase in the length of the maxilla during post distraction period. This indicates that there was significant amount of new bone formation at the distraction site.

However, 6 months post distraction evaluation indicated certain degree of relapse, which is statistically significant but clinically not significant. This relapse might be due to earlier operated soft tissue or scar response.

There was an increase in anterior facial and posterior positioning of the apical base of the mandible indicating the forward movement and placement of maxilla with clockwise rotation of the mandible.

Soft tissue changes

The increase in the nasolabial angle following distraction suggests the soft tissue response with protrusion of upper lip or an effective horizontal anteroposterior advancement of maxilla.

There was very little relapse seen in the soft tissues as compared to that of skeletal changes, suggesting for increase in the period of retention for skeletal stability.

P. Kebler et al evaluated on distraction osteogenesis of maxilla and midface using a subcutaneous device.In his study of four patients all patients cephalometric relation of the midface region had returned to normal values. The subcutaneous distraction devices were well tolerated by school age patients. He stressed on using the Deliare mask to avoid early relapses [3].

The major shortcomings of the distractor used in this study was,a secondary surgery was needed for the removal of the distractor which can be overcome by the use of resorbable distraction device,and the vector,the device used in this study allows no control of the vector after the placement of the distraction device,which can be overcome by multiplanar distractors

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