Original Article - Prospective Study

Changes in posterior airway space and mandibular plane hyoid distance following mandibular advancement DO

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ABSTRACT

Aim: To study the changes in posterior airway space (PAS) and mandibular plane hyoid (MPH) distance following mandibular advancement using distraction osteogenesis (DO). **Subjects and Methods:** A prospective study was conducted at a tertiary care dental center from May 2009 to May 2014. Twenty-five consecutively operated patients of mandibular hypoplasia who underwent mandibular advancement using distraction with at least 12 months follow-up were included in the study. The study group comprised 15 males and 10 females with an age range of 15–30 years (mean 22 years). Presurgical and postsurgical cephalometric changes were compared to determine the changes in PAS and MPH distance. **Results:** The mean distraction achieved was 14.50 mm. The mean preoperative MPH was 18.88 mm and mean postoperative MPH was 13.16 mm with a resultant reduction by 32%. Mean preoperative PAS was 6.48 mm and mean postoperative PAS was 11.08 mm. Mean increase in PAS was 75%. Mean preoperative and postoperative SNB values were 75.4° and 79.52°, respectively. The results were statistically analyzed using paired "Student's *t*-test." **Conclusion:** From this study, it is concluded that statistically significant changes were achieved in MPH and SNB. Although change in PAS was statistically insignificant, it may have clinical applications, especially in the field of Phase II surgical management of obstructive sleep apnea.

Keywords: Distraction osteogenesis, mandibular advancement, mandibular plane hyoid distance, posterior airway space

INTRODUCTION

The impact of craniofacial discrepancies cannot be truly and completely registered on the overall health of an individual. It can range from poor social acceptance due to imperfect esthetics to functional debilitation involving respiratory disorders, masticatory insufficiency, and speech-related problems. Mandibular hypoplasia is a common dentofacial deformity noticed in clinical settings with a prevalence of 10% in the United States; about 3% require surgical correction.[1] The incidence of Class II malocclusion in the Indian population is 14.5%.[2] Mandibular hypoplasia has multiple etiological factors such as (a) congenital factors such as hemifacial microsomia, Treacher Collins syndrome, (b) developmental malocclusions, and (c) acquired, for example, trauma, temporomandibular joint ankylosis.

Clinical manifestations of mandibular hypoplasia range from mild esthetic discrepancies to functional imbalances such as masticatory insufficiency to obstructive sleep apnea (OSA). It is often noticed that patients with mandibular hypoplasia have

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a compromised posterior airway space (PAS) (normal value 11 ± 1 mm) and increased mandibular hyoid distance (normal value 15.4 ± 3 mm). Such individuals are at potential risk of developing OSA, especially with increasing age and body mass index.[3]

Orthognathic surgery has gained wide acceptance and popularity in the treatment of dentofacial deformities. The scope of these surgeries is wide as it allows the repositioning of the entire midface, the mandible, or the entire dentoalveolar segment to its desired location. The soft palate, tongue, hyoid bone, and associated muscles are attached directly or indirectly to the maxilla and the mandible; hence, this would result in volumetric alteration in the oro-nasal cavities, and PAS depending on the direction and magnitude of the skeletal movements. Orthognathic surgery for the correction of mandibular hypoplasia includes advancement following bilateral sagittal split ramus osteotomy (BSSRO) or body osteotomy. However, mandibular advancement with BSSRO has limitations in achieving mandibular advancement >8–10 mm.[4]

Distraction osteogenesis (DO) is a useful and versatile technique to generate bone which causes adaptive histogenesis of soft tissues in the craniofacial region.[5,6] Thus, it can be employed for the correction of deficiencies in patients with mandibular hypoplasia. In this study, the aim was to observe using extensive cephalometric examination, the quantitative changes in PAS, and mandibular plane hyoid (MPH) distance in 25 patients of mandibular hypoplasia following mandibular advancement using DO.

SUBJECTS AND METHODS

A prospective study was conducted at tertiary care dental center, Army Dental Centre (Research and Referral), Delhi Cantonment from May 2009 to May 2014 on 25 adult patients of mandibular hypoplasia with no other craniofacial deformity. The prime concern of the patients seeking treatment was poor esthetics. The main cause of mandibular hypoplasia in the study group was developmental (skeletal) followed by temporomandibular joint ankylosis.

Inclusion criteria

1. Adult patients having skeletal Class II jaw relationship with severe mandibular hypoplasia requiring mandibular advancement of more than 10 mm as the treatment of choice
2. Patients who needed only mandibular advancement surgery without any adjunctive procedures. Individuals requiring single jaw surgery were included in the study
3. The patient with no history of previous orthognathic or cosmetic surgery involving the middle and/or lower face.

Syndromic cases were excluded from the study; the study was approved by the Local Institutional Ethical Committee. There were 15 males (60%) and 10 females (40%) with age range of 15–30 years (mean 22 years), and follow-up range was 12–36 months (mean 28 months). Patients complying for at least 12 months follow-up were included in the study.

An institutional composite treatment plan was formulated in consultation with the treating orthodontists. All individuals underwent presurgical orthodontics. Cephalometric analysis was done to diagnose retrognathia, calculate the amount of advancement required, and evaluate the upper airway space in two dimensions [Figure 1 adapted from Tiner BD, Waite PD].

Cephalometric variables used in the study were:

a. SNB: Mean in normal subjects is 80 ± 2°
b. PAS: PAS was determined on a line drawn from point B through the gonion (Go) intersecting the base of the tongue and extending to the posterior pharyngeal wall. Mean value in normal subjects is 11 ± 1 mm
c. MP-H: The position of the hyoid bone is determined by drawing a perpendicular line from the mandibular plane (MP) to the hyoid bone (H). The mean MP-H distance for normal subjects is 15.4 ± 3 mm[3] as shown in Figure 1.

All patients were operated by the same surgical team under general anesthesia. Patients underwent bilateral sagittal split osteotomy followed by the placement of body distractors bilaterally with vectors parallel to the occlusal plane. The latency period of 4 days was followed; the rate of DO was 1 mm/day and rhythm of DO was 0.5 mm/12 h/day. Interarch elastics were used following distraction for callus molding. Distractors were removed 8 weeks postoperatively under general anesthesia.

In the follow-up period, the patients were initially assessed clinically followed by postoperative cephalometric analysis at 12 months. Presurgical and 12 months postsurgical cephalometric changes were compared to determine the changes in PAS, MPH distance, and angle SNB.

RESULTS

All patients (n = 25) were satisfied with their appearance postoperatively [Figures 2-11]. The mean value of distraction achieved was 14.50 mm. Preoperatively, the mean MPH was 18.88 mm (range 14–25 mm). Mean preoperative PAS was 6.48 mm, and mean preoperative SNB was 75.4° [Table 1].

Mean postoperative MPH was 13.16 mm with 6.16 mm (32%) of mean decrease in MPH, revealing a significant P = 0.000 [Figure 13]. Mean postoperative PAS was 11.08 mm with mean increase in PAS of 4.84 mm (75%), although P = 0.145 was insignificant [Figure 12]. In addition, mean postoperative SNB was 79.52° with P = 0.003 revealing a significant increase in SNB with mandibular advancement [Figure 14].

The mean value of distraction achieved was 14.50 mm. Thus, it can be postulated that for every 3 mm of distraction the increase in the PAS was 1 mm. Similarly, 2.35 mm of mandibular distraction would result in 1 mm decrease in MPH. It also implicated that 3.59 mm of mandibular distraction resulted in 1° change in SNB.

DISCUSSION

This study was carried on mixed urban Indian population. Although none of the patients had OSA or snoring, all patients were evaluated preoperatively in the Department of Respiratory Medicine. Retrognathic mandible decreased PAS/retroglossal

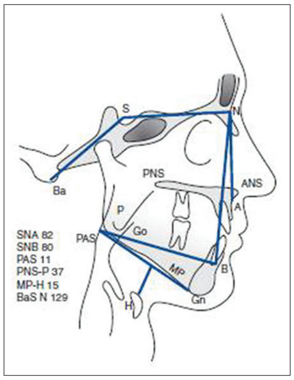

Figure 1: Cephalometric airway assessment (Figure adopted from Tiner BD, Waite PD)

Figure 3: Sleep study in patient 1

Figure 5: Intraoperative- BSSRO and placement of distractor

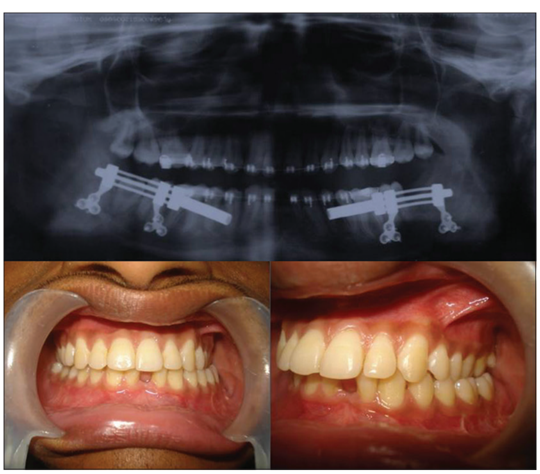

Figure 7: Orthopantomogram on completion of distraction and postoperative occlusion - patient 1

Figure 2: Preoperative frontal, profile and occlusal views- patient 1

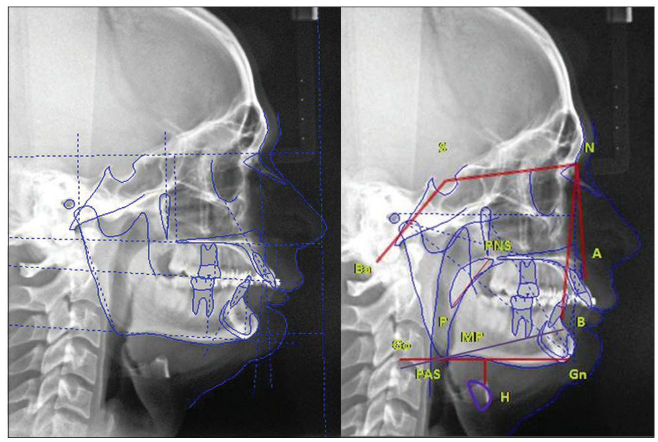

Figure 4: Preoperative COGS and airway analysis -Patient 1

Figure 6: Postoperative frontal view, profile view and airway analysis- patient 1

Figure 8: Preoperative evaluation of patient 2

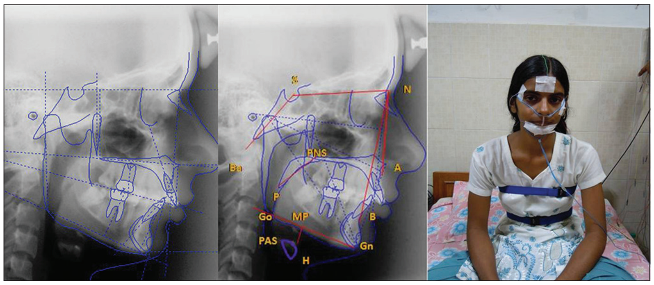

Figure 9: Preoperative COGS, airway analysis and sleep study-Patient 2

Figure 11: Postoperative frontal view, profile view and occlusion- patient 2

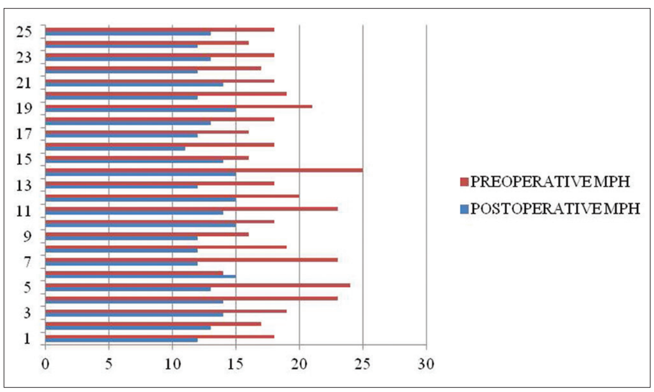

Figure 13: Correlation between preoperative and postoperative MPH

space and increased MP to hyoid distance were the common cephalometric findings.

The most frequently used surgical technique for the advancement of the mandible is BSSRO. Mandibular advancement using BSSRO has its limitation of the extent of advancement; a maximum of 8–10 mm can be performed with stable results.[4] Advancement more than 10 mm requires long split which is technically difficult to achieve and seriously compromises the long-term stability as it is associated with sudden stretching and change in orientation of muscles of mastication and condylar position in the glenoid fossa.[4] In 1989, McCarthy *et al*. introduced a novel method of corpus lengthening by DO.[5] DO is a biologic process of new bone formation between vascularized margins of bone segments gradually separated by incremental traction. The traction force generates tension in the callus that connects the bone segments. This in turn stimulates bone formation. Distraction force also creates tension in the soft tissues including blood vessels, nerves, ligaments, cartilage, muscles, and gingiva which initiates a sequence of adaptive changes and this is termed as "Distraction Histiogenesis."[6]

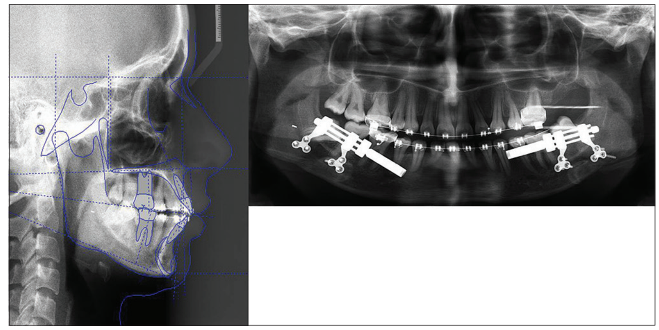

Figure 10: Postoperative COGS and orthopantomogram post distraction - patient 2

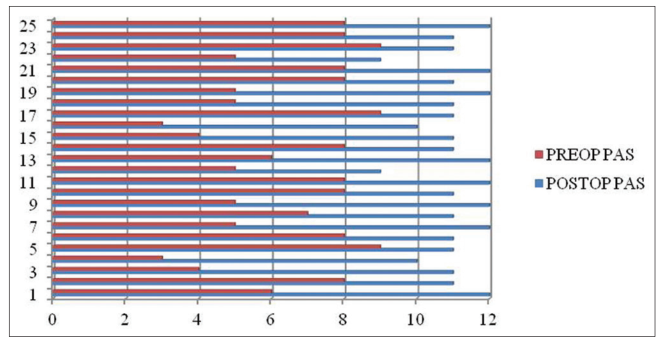

Figure 12: Correlation between preoperative and postoperative PAS

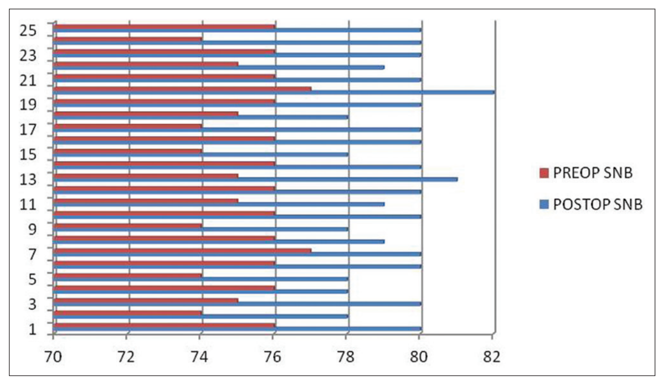

Figure 14: Correlation between preoperative and postoperative SNB

Kuo *et al*., in 1979,[7] and Bear and Priest, in 1980,[8] were the first to document that surgical advancement of the mandible improved OSA. Turnbull and Battagel[9] found that the advancement improved the retropalatal and retrolingual dimensions of the airway significantly. Furthermore, there was increased intermaxillary space and decreased tongue proportion. These findings were confirmed by several authors who noted an increase in the PAS after mandibular advancement and decrease in MPH distance.[10,11]

Rachmiel *et al*. analyzed bilateral mandibular distraction with compromised airway by three-dimensional computed tomography (CT) scan and concluded that DO of hypoplastic mandible, volume of the hypoplastic mandible, and upper airway increases eliminating the symptoms of OSA and prevented tracheostomy.[12]

Table 1: Master chart

Age of years/sex	Diagnosis	Management	BMI	Advancement/distraction done	SNB		PAS		Mandibular plane hyoid distance MPH		Apnea hypopnea index			Lowest mean oxygen saturation			Epworth sleepiness scale	
					Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative 3 months	Postoperative 6 months	Preoperative	Postoperative 3 months	Postoperative 6 months	Preoperative	Postoperative
21/male	Class II division 1 with moderate OSA	DO	26.20	17	76	80	6	12	18	12	15	5	0	82	98	100	12	8
19/female	Class II division 1 with moderate OSA	DO	25.32	14	74	78	8	11	17	13	16	5	2	84	99	99	14	9
17/female	Class II division 1 with moderate OSA	DO	24.6	14	75	80	4	11	19	14	18.2	7.8	7	88	98	97	11	7
41/male	Class II division 1 with Severe OSA	DO	27.8	11	76	78	3	10	23	14	35.2	20.8	19	74	96	96	19	6
32/male	Class II division 1 with severe OSA	DO	28.9	14	74	78	9	11	24	13	40.6	20.6	20	78	94	92	22	9
22/male	Class II division 1 with moderate OSA	DO	26.35	14.5	76	80	8	11	14	15	18	10	11	72	98	96	16	5
25/male	Class II division 1 with severe OSA	DO	35.4	12	77	80	5	12	23	12	32	10	10	84	98	96	20	9
43/female	Class II division 1 with severe OSA	DO	25.0	12	76	79	7	11	19	12	48.2	22.2	20	80	96	96	18	8
23/male	Class II division 1 with moderate OSA	DO	26.2	14	74	78	5	12	16	12	19.2	10	9	84	99	99	14	7

Contd...

Table 1: Contd...

Age of years/sex	Diagnosis	Management	BMI	Advancement/distraction done	SNB		PAS		Mandibular plane hyoid distance MPH		Apnea hypopnea index			Lowest mean oxygen saturation			Epworth sleepiness scale	
					Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative 3 months	Postoperative 6 months	Preoperative	Postoperative 3 months	Postoperative 6 months	Preoperative	Postoperative
26/male	Class II division 1 with moderate OSA	DO	28.3	14	76	80	8	11	18	15	26	12	10	80	94	96	13	6
32/female	Class II division 1 with severe OSA	DO	26.2	16	75	79	8	12	23	14	42.5	18.2	18	74	92	90	19	10
24/female	Class II division 1 with moderate OSA	DO	24.8	14	76	80	5	9	20	15	18	10	8	78	96	98	12	5
36/female	Class II division 1 with moderate OSA	DO	25.9	14	75	81	6	12	18	12	28	10	11	76	94	95	15	4
17/male	Bilateral TMJ ankylosis operated with Severe OSA	DO	25.4	16	76	80	8	11	25	15	46	5	3	78	94	96	20	10
18/male	Class II division 1 with moderate OSA	DO	26.6	12	74	78	4	11	16	14	18	10.6	10	76	90	92	10	4
17/female	Class II division 1 with moderate OSA	DO	25.4	16	76	80	3	10	18	11	24	12	10	79	98	98	16	9
19/male	Class II division 1 with moderate OSA	DO	29.7	21	74	80	9	11	16	12	28	10	12	84	99	98	12	8
18/female	Class II division 1 with moderate OSA	DO	24.9	12	75	78	5	11	18	13	26.2	8.4	6	88	96	98	10	7

Contd...

Table 1: Contd...

Age of years/sex	Diagnosis	Management	BMI	Advancement/distraction done	SNB		PAS		Mandibular plane hyoid distance MPH		Apnea hypopnea index			Lowest mean oxygen saturation			Epworth sleepiness scale	
					Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative 3 months	Postoperative 6 months	Preoperative	Postoperative 3 months	Postoperative 6 months	Preoperative	Postoperative
18/male	Bilateral TMJ ankylosis operated with Severe OSA	DO	28.5	16	76	80	5	12	21	15	38	5	5	72	90	92	22	10
19/female	Class II division 1 with moderate OSA	DO	24.9	15	77	82	8	11	19	12	18	5	2	78	94	98	18	9
19/male	Class II division 1 with moderate OSA	DO	27.8	16	76	80	8	12	18	14	16	7	6	76	98	99	12	6
16/female	Class II division 1 with moderate OSA	DO	24.5	12	75	79	5	9	17	12	19.8	5	5	72	92	94	11	5
17/male	Class II division 1 with moderate OSA	DO	27.8	16	76	80	9	11	18	13	22	10	11	88	98	99	13	5
15/male	Class II division 1 with moderate OSA	DO	28.9	18	74	80	8	11	16	12	18	10	5	86	94	96	15	4
18/male	Class II division 1 with moderate OSA	DO	29.23	12	76	80	8	12	18	13	28	12	10	78	98	99	22	10

OSA=Obstructive sleep apnea; DO=Distraction osteogenesis; TMJ=Temporomandibular joint; MPH=Mandibular plane hyoid; PAS=Posterior airway space; BMI=Body mass index

LaBanc and Epker stressed that the immediate postoperative changes in the hyoid bone position were highly variable, but tended to be anterior in nature.[13]

Farole *et al*.[14] and Yu *et al*.[15] evaluated the anteroposterior dimensions of the oropharynx in patients who had undergone mandibular advancement surgery. They concluded that although there was an increase in the dimensions of the oropharynx, it was unpredictable and tended to decrease with time. However, the quantification of the results has been lacking.

In this study, standard caliberated lateral cephalograms were used to quantify the results in respect of changes in the PAS and MPH distance.

Inferences made out of this study are as follows: (1) mandibular distraction of 3 mm would increase PAS by 1 mm, (2) mandibular distraction of 2.35 mm resulted in 1 mm decrease in MPH, and (3) mandibular distraction of 3.59 mm would result in 1° increase in SNB.

CONCLUSION

In this prospective study, 25 patients of mandibular hypoplasia were studied for changes in PAS and MPH following DO. Significant changes were observed in MPH and SNB. However, changes in PAS were statistically insignificant which could be due to a small sample size. This negates a further study on a larger sample size. Mandibular advancement by distraction may have many clinical applications, especially in the field of Phase II surgical management of OSA. Advanced diagnostic imaging techniques, such as cone beam computed tomography, CT, magnetic resonance imaging, and acoustic pharyngometry-based volumetric analysis would be more appropriate for authentication; however, factors such as uniformity of diagnostic standard for the whole study population, multiple radiation exposure, cost, and uninterrupted easy availability of standard radiographs for a large study group cannot be overlooked. Hence, conventional radiography was used in this study.

However, the authors advocate the use of advanced diagnostic tools for volumetric study in a larger study group to authenticate the results achieved. Such a study may be helpful in documenting mandibular advancement as a permanent cure for the patients of OSA associated with mandibular retrognathia.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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