EVALUATION OF UPPER AIRWAY DIMENSIONAL CHANGES AFTER MANDIBULAR CORPUS DISTRACTION OSTEOGENESIS : A RETROSPECTIVE CEPHALOMETRIC STUDY

Abhijeet Kadu[a], Balakrishnan Jayan[b], NandKishor Sahoo[c],Amrit Thapa[d], Uday kamat[e], P K Chattopadhyay[f]

ABSTRACT

Background : Mandibular corpus distraction osteogenesis(DO) is emerging as the standard of care in the management of mandibular deficiencies exceeding 8 mm. Mandibular retrognathia has been regarded as a risk factor for airway deficiency and sleep disordered breathing. In view of the above this retrospective cephalometric study was conducted with the aim to evaluate upper airway dimensional changes and hyoid position variations in adult patients with mandibular deficiency treated by mandibular DOand to establish the ratio of mandibular advancement to increase in airway dimensions.

Materials and Method: Pre and post treatment lateral cephalograms of 12 adults (7 females and 5 males) with severe mandibular deficiency treated by combined orthodontics and mandibular DO were evaluated for changes in posterior airway space (PAS), Superior airway space (SAS), minimum airway space (MAS), hyoid bone position (MP-H), effective mandibular length (Co-Gn), mandibular corpus length (Go-Pg) and pogonion position (N perpendicular- Pg). The cephalograms were manually traced by a single operator and the data was analyzed using MINITAB 13.2 version software.

Results: There was statistically highly significant (p d" 0.0001) increase in PAS, SAS, MP-H, Co-Gn and Go-Pg. The mean ratio of mandibular advancement to increase PAS, SAS, and MAS was 1:0.49, 1:0.37 and 1:0.45 respectively. Hyoid bone moved superiorly and anterior direction by 3.6±1.8 mm and was found to be statistically highly significant (p d" 0.0001).

Conclusion: The study showed an overall improvement in airway dimensions and in hyoid position after mandibular lengthening suggesting that the procedure is a viable treatment option in correction of upper airway deficiencies and sleep disordered breathing.

INTRODUCTION

Antero posterior size of airway space differs among individuals with normal mandible, retrognathism and prognathism.[1]Class II patients have a narrower anteroposterior pharyngeal dimensions and this is specifically noted at retroglossal area of the oropharynx. It is often seen that patients with hypoplastic mandible have a backwardly postured tongue and inferiorly and posteriorly placed hyoid bone.[2]Thus a direct relationship between the position of the mandible and the airway space has been established and relationship between upper airway problems , mandibular growth pattern and head posture has been documented. [3,4]In cases of hypoplastic mandible, increasing the length of the mandible remains the treatment of choice. The mandibular lengthening can be accomplished either by conventional orthognathic surgery where mandibular advancement is done in one increment after Bilateral Sagittal split ramus Osteotomy (BSSRO) or by applying incremental traction between the osteotomised segments called Mandibular corpus distraction osteogenesis(DO). Distraction osteogenesis is emerging as the standard of care in the management of mandibular deficiencies exceeding 8 mm. The basic concept of the procedure is induction of new bone formation along the vector of pull obviating the need for a bone graft. Distraction force also creates tension in the soft tissues including blood vessels, ligaments, cartilage,

[a] Graded Specialist, Orthodontics, Army Dental Centre
[b] Consultant, Orthodontics, Army Dental Centre
[c] Commandant and Command Dental Advisor,CMDC
[d] Graded Specialist, Orthodontics, Command Military Dental Centre
[e] Classified Specialist, Orthodontics, Army Dental Centre
[f] Senior Specialist, Oral and Maxillofacial Surgery , Army Dental Centre

Fig 1 a : Pre treatment extra oral photographs of 16.5 yr old male showing convex profile, incompetent lips, excessive incisal display, lip trap and non-consonant smile arc

Fig 1b : Pre treatment intra oral photographs suggestive of Class II Div 1 malocclusion with excessive overjet, deep impinging bite and scissors bite in relation to left premolars

Fig 1c : Pre treatment orthopantamogram

Fig 1d : Pre treatment lateral cephalogram showing classical Class II Div 1 presentation due to mandibular deficiency and reduced superior and posterior airway space.

Fig 1e: Intra oral photograph showing placement of intra oral mandibular corpus distractors and end of distraction showing 1 mm of reverse overjet catering for relapse.

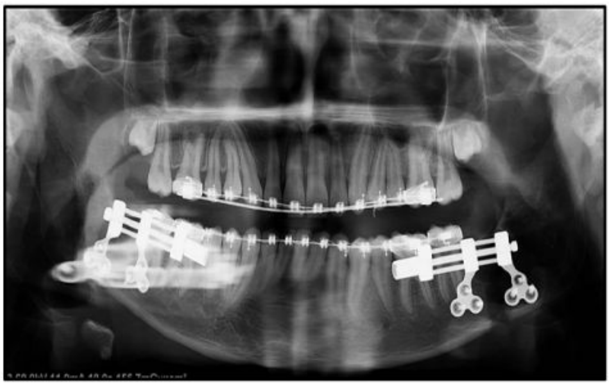

Fig 1f : OPG recorded at the end of distraction.

Fig 1g : Post treatment extra oral photographs showing gross improvement in facial profile and dento facial esthetic.

Fig 1h : Post treatment intra oral photographs showing Class I molar and canine relationship with optimized overjet and overbite.

Fig 1i : Post treatment OPG showing evidence of well consolidated distracted bone distal to lower second molars

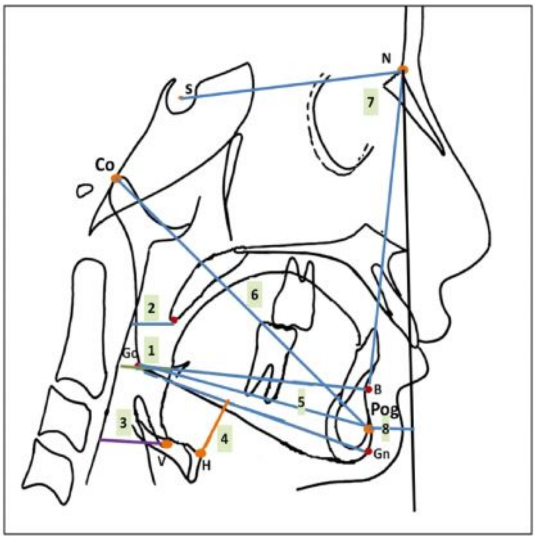

Fig 2 : Cephalometric Tracing . Landmark plotted : S- Sella, N- Nasion, Co- Condylion, Go- Gonion, Gn- Gnathion, Pog- Pogonion, B- Point B, V- Vallecula, H- Antero-superior point of hyoid

muscles, nerves which initiate a sequence of changes termed as distraction histiogenesis. Prime advantage of DO is slow stretching of soft tissues and bone formation allowing greater advancement than standard techniques. Advancing the mandible in this manner will allow the enhancement of the upper airway volume gradually. Airway dimensional changes following mandibular lengthening is an intensely researched topic in recent years. [5-7] But none of the study has compared the amount of mandibular advancement by DO with increase in the posterior airway dimensions and hyoid positioning and established ratio of mandibular advancement by DO to increase in posterior airway space.

Fig 1j : Post treatment lateral cephalogram with Class I skeletal bases and enhanced airway dimensions as salient feature.

This retrospective cephalometric study was conducted with the aim to evaluate upper airway dimensional changes and hyoid position variations in adult patients with skeletal class II malocclusion treated by mandibular advancement with distraction osteogenesis. The objective of the study included:

· Quantifying and evaluating the mandibular advancement to upper airway dimensional changes and hyoid position variations

· To establish the ratio of mandibular advancement to increase in airway dimensions

MATERIALS AND METHOD

This retrospective cephalometric study was carried outonthe records of 12 adult patients (7 Female and 5 male with age ranging from 16.5 yrs – 31 yrs with mean age of 19.7 yrs) with severe mandibular hypoplasia who underwent mandibular advancement by DO, obtained from the archives of Armed Forces Medical College Pune and Army Dental Centre Research and Referral Delhi. . A standard DO protocol was followed which included latency period of 4 days followed by distraction at the rate of 1 mm/day with rhythm of twice daily. A consolidation period of 4 months was followed and consolidation was confirmed subjectively and by an ultrasonography and orthopantamogram.A representative case of a 17 yr old male with skeletal Class II malocclusion and airway deficiency treated by mandibular DOis presented vide Fig 1a – 1j and pre and post airway parameters with objective improvement depicted vide Table 1

Lateral cephalograms of patients with hypoplastic mandible who had undergone bi jaw surgery, syndromic cases, genioplasty, tongue and upper airway surgery, stained and poor quality films were excluded from the study.

Variable	Pretreatment	Posttreatment
PAS	4 mm	9 mm
SAS	6 mm	9.5 mm
MAS	3 mm	8 mm
MP-H	9mm	8 mm
SNB	73^0	80^0
Co-Gn	104 mm	112.8 +2.5
N-Pg	-8 mm	2.1 +2.3
Go-Pg	69 mm	78.8 + 3.4

Table 1 : Pre and post airway parameters of the representative case

S.No	Cephalometric measurement	Definition
1	PAS (mm)	Posterior airway space. Distance from posterior tongue margin to posterior pharyngeal wall measured on the line B-Go.
2	SAS (mm)	Superior airway space. Distance from the tip of the soft palate to the posterior pharyngeal wall measured parallel to maxillary plane.
3	MAS (mm)	Minimum airway space. The narrowest antero posterior dimensions of the upper airway space measured from vallecula to the pharyngeal wall.
4	MP-H (mm)	Perpendicular distance from the antero superior point on the hyoid bone to mandibular plane.
5	Go-Pog (mm)	Linear measurement from Gonion to Pogonion for recoding the length of the corpus of the mandible.
6	Co-Gn (mm)	Linear measurement from Condylion to Gnathion to measure the effective length of the mandible.
7	SNB (degree)	Angle Sella- Nasion- point B to determine the relation of the mandible to cranial base.
8	N-Pog (mm)	Linear measurement from Nasion perpendicular to Pogonion for evaluating the saggital relation of the mandible to vertical plane.

Table 2 : Airway parameters Measured on Lateral Cephalogram

Variable	Mean (Pretreatment)	Mean (Posttreatment)	Mean Change	Percentage Change	P Value	Ratio
PAS	9.4 +2.03	13.61 +2.73	4.21 +2.21	44.78%	0.0001	0.49
SAS	11.5 +2.3	14.6 +2.42	3.1 + 1.73	26.95%	0.0001	0.37
MAS	6.63 +2.8	10.5 +2.15	3.87 +2.1	58.37%	0.0001	0.45
MP-H	14.8 +2.6	11.2 +2.23	-3.6 + 1.8	24.32%	0.003	0.41
SNB	71.3^0+2.03^0	79.2^0+2.6^0	7.9^0+2.73	11.07%	0.001	-
Co-Gn	104.2 +2.6	112.8 +2.5	8.6 + 3.2	8.25%	0.006	-
N-Pg	-8 +2.6	2.1 +2.3	10.1 +2.58	126.26%	0.0001	-
Go-Pg	69.8 +2.2	78.8 + 3.4	9.0 + 3.3	12.89%	0.0002	-

Table 3 : Pre and Post treatment changes in airway parametres

Lateral cephalogram were recorded at pretreatment (T1) and 1 year post distractor removal (T2) using standard cephalometric technic at natural head posture at end expiration in centric occlusion using Planeca PM2002 LC Prolix, Helsinki, Finland cephalostat machine.

The various cephalometric landmarks, reference points, linear and angular measurements used in the study are depicted vide Figure 2 and Table 2. Single operator (ABK) manually performed all the composite tracings. Ten cephalograms were traced twice after a gap of a week to ensure intra observer reliability which found to be good (kappa = 0.90).

STATISTICAL ANALYSIS

The data collected was entered in MS Excel worksheet and MINITAB 13.2 version software was used for statistical analysis. After ascertaining normal distribution of data, the inter group pre and post comparison for all the variables was done using unpaired't' test. The statistical significance was set at Pd" 0.05. The ratio of change in effective mandibular length to change in airway parameters was calculated using formula:

$$\frac{\text{T2- T1 (change in airway parameters)}}{\text{T2- T1 (Change in effective mandibular length i.e Co-Gn)}}$$

RESULTS

Pre and post treatment airway parameters and mean change with percentage improvement of cephalometric measurements with comparison of pre and post treatment variables of the study sample are depicted vide Table 3. The mean PAS increased by 4.21 ± 2.21 which was statistically highly significant ($p<0.0001$) with percentage increase of 44.78%. The mean SAS, MAS increased by 3.1 ± 1.73and,3.87 ± 2.1 respectively which was statistically highly significant ($p<0.0001$) with percentage increase by 26.95% and 58.37%.For every 1 mm of increase in effective mandibular length (Co-Gn), PAS increased by 0.49 mm, SAS increased by 0.37 mm and MAS increased by 0.45 mm.

The pre and the post treatment comparison of the hyoid bone position is suggestive of antero superior movement by 3.6 ± 1.8 mm with amounting to 24.32% change and was found to be statistically significant ($p<0.003$). The ratio of effective mandibular advancement (Co-Gn) to hyoid position change (mean MP- H differential) was estimated to be 1:0.41.

The relationship of mandible to cranial base studied vide SNB angle increased by 7.9^0± 2.73 and was found to be statistically significant ($p<0.001$).Mean increase in the length of mandibular corpus (Go-Pog)was9.0 ± 3.3 mm which was statistically highly significant ($p<0.0002$) with percentage increase of 12.89%. Effective mandibular length (Co-Gn) increased by 8.6 ± 3.2 mm which was statistically significant ($p<0.006$)with percentage increase of 8.25%. There was improvement in sagittal position of the chin as change in the pogonion point to nasion verticalwas 10.1 ± 2.58 which was statistically highly significant ($p<0.0001$) with percentage increase of 126.26%.

DISCUSSION

Evaluation of the vital human airway and spatial relationship of jaws and its effect on the airway are most profoundly researched topic in contemporary literature. There are various identified craniofacial risk factors for compromise in the airway diameter resulting in sleep disordered breathing which include mandibular deficiency, retrognathism, high arched palate, inferiorly and posteriorly placed hyoid bone and long face problems. [8-10]Out of these risk factors mandibular deficiency and increased hyoid distance are considered as most important for development of sleep disordered breathing. [9]

In cases of mandibular deficiency, lengthening of the mandible either by BSSRO or DO remains the treatment of choice not only for esthetic optimization but also for improving airway. Mandibular advancement and genial advancement probably work by changing the position of mandible and hyoid bone with subsequent effect on genioglossus and hyoglossus muscle. [11]One of the most important advantage of DO is distraction histiogenesis of the soft tissue. The application of a continuous stretching force on the two bone segments through the use of a device triggers the conditions for growth. The undifferentiated cells in the bone marrow evolve into osteoblasts and begin formation of interlaced bone tissue orientated into parallel lines. Muscle and soft tissue mass increase via a process referred to as distraction histiogenesis. Clinically, this offers a distinct advantage as several craniofacial anomalies have soft tissue hypoplasia, in addition to deficient bony structures. This is especially effective in the stretch of the supra hyoid group of musculature along with histiogenesis in and around the tonsillar fossa with resultant effect in the palatoglossus and palatopharyngeous musculature resulting in an increase in the posterior pharyngeal airway space facilitating smooth and unlaboured breathing activity. [12]

There are not very many studies quantifying the relationship of mandibular advancement of upper airway dimensional changes. In our study the increase in effective length of mandible (Co-Gn) was 8.6 ± 3.2 mm which was 8.25%.The mean PAS increased by 4.21 ± 2.21 with percentage increase of 44.78%. The mean SAS, MAS increased by 3.1 ± 1.73 and, 3.87 ± 2.1 respectively with percentage increase by 26.95% and 58.37%. For every 1 mm of increase in effective mandibular length (Co-Gn), PAS increased by 0.49 mm, SAS increased by 0.37 mm and MAS increased by 0.45 mm. Our study clearly indicates that there is improvement in the upper airway parameters with mandibular advancement. This finding of the study is in concurrence with many other studies.[13-16] However the means of mandibular advancement in most of the studies was BSSRO and there is paucity of literature regarding airway evaluation and quantification in mandibular DO. Lee KK et al [13], Riley RW et al [14] and Farole et al [15] have reported an increase of 42% to 51 %. and Mehra et al, reported 76% increase in oropharyngeal dimensions.[16] Sahoo et al evaluated the airway changes following BSSRO and has established ratios for airway parameter changes per mm of mandibular advancement. In their study it was seen that the ratio of effective mandibular advancement to increase in PAS, SAS, MAS was 1:0.35 mm, 1:0.34 mm & 1:0.24mm respectively.[17] Greater improvement seen on DO as compared to BSSRO may be attributed to soft tissue histiogenesis and better neuro-muscular adaptation owing to gradual and incremental traction in DO as compared to sudden advancement in BSSRO.

One of the objectives of the study was to evaluate change in position of hyoid bone following mandibular advancement by DO. Inferiorly and posteriorly placed hyoid is considered as one of the risk factors for airway collapsibility. Hyoid bone moves anteriorly and superiorly with mandibular advancement is a well-documented fact.[18-20] In our study mean antero superior movement of hyoid was seen to be 3.6 $\pm$ 1.8 mm , amounting to 24.32% change. The ratio of effective mandibular advancement (Co-Gn) to hyoid position change (mean MP- H differential) was estimated to be 1:0.41. These findings were in agreement with study done by Sahoo et al where mean anterior superior movement of hyoid bone was 2.1 $\pm$ 2.78mm and the estimated ratio was 1: 0.32.[17]

CONCLUSION

The study showed an overall improvement in airway dimension and in hyoid position after mandibular lengthening by DO. The ratio of increase in effective length of mandible to increase in PAS, SAS, MAS and improvement in MP-H was found to be 1:0.49, 1:0.37, 1 :0.45 and 1:0.41respectively. Mandibular DO may be considered as a viable treatment option in correction of upper airway deficiencies and sleep disordered breathing. However, prospective studies with larger sample size with long term follow up are required to substantiate findings of the study.

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