Journal of Advanced Medical and Dental Sciences Research

@Society of Scientific Research and Studies ***NLM ID:*** *101716117*

Journal home page: www.jamdsr.com doi: 10.21276/jamdsr Index Copernicus value = 85.10

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Original Research

Effects of first premolar extraction on pharyngeal airway dimension and position of hyoid bone in bimaxillary proclination patients

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ABSTRACT:
Objective: The goal of the present study was evaluate how first premolar extraction affected pharyngeal airway dimensions and position of hyoid bone in adults with bimaxillary proclination. **Materials and method:** For the present retrospective cephalometric study, pre and post orthodontic treatment records of 20 adult patients with bimaxillary proclination, treated with fixed orthodontic therapy utilising the MBT 0.022 (AO mini master)appliance were assembled.Linear airway measurements in sagittal plane (HP-PNS, BP-PNS, SPW-SPPW, U-UPPW, PgT-PPTW, UPA, LPA) , in vertical plane(TAL) and liner hyoid bone measurements (H-Pg,H-Hp,C3-H,PTM-H) in sagittal plane were measured manually on the cephalogram. To analyse changes in pre and post treatment values, a paired t-test was utilised, and Pearson's correlation coefficient was used to determine the reliability of all the parameters. **Results**: There was no statistically significant change between pre and after treatment outcomes in the mean values of Nasopharyngeal dimension (HP-PNS) and Total Airway Length (TAL) ($p > 0.005$). All other airway parameters (BP-PNS, SPW-SPPW, U-UPPW, PgT-PPTW, UPA, LPA, UPA, LPA) and hyoid parameters (H-Pg, H-Hp, C3-H, PTM-H) revealed statistically significant differences ($p \leq 0.001$). For all airway and hyoid measures, Pearson's correlation coefficient indicated statistically substantial reliability ($p \leq 0.001$). **Conclusion:** The retraction of anterior teeth in the extraction space reduced the oropharynx and hypopharynx dimension, but not the nasopharynx dimension or overall airway length and the hyoid bone move posteriorly and inferiorly.
Key words: Pharyngeal airway, hyoid bone, first premolar extraction.

Received: 20 May, 2021 Accepted: 26 June, 2021

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This article may be cited as: Vaishya D, Trivedi K, Shah A, Patel S, Barot M. Effects of first premolar extraction on pharyngeal airway dimension and position of hyoid bone in bimaxillary proclination patients. J Adv Med Dent Scie Res 2021;9(7):162-168.

INTRODUCTION

The upper and lower incisors are proclined and protrusive in bimaxillary proclination, resulting in a convex profile, acute nasolabial angle, and enhanced lip procumbency[1]. With FMA 170-280, Keating stated that upper incisor inclination of 1150 and lower incisor inclination of 990, along with an interincisal angle of 1250 or less, are features to identify bimaxillary proclination and average growth pattern of mandible[2].

Bimaxillary proclination appears to be complex, with genetic and environmental factors such as mouth breathing, tongue thrusting, and lip sucking practises, as well as increased tongue volume all playing a role[3]. One of the main reason for bimaxillary proclination is Arch length tooth size discrepancy . The purpose of orthodontic treatment for bimaxillary proclination is to improve the patient's profile by reducing the proclination of the maxillary and mandibular incisors, resulting in a decrease in soft-tissue procumbency and convexity[4].

Because most extraction spaces in patients with bimaxillary proclination are used for incisor retraction and lip procumbency correction, it's important to consider that changing incisor and soft tissue position and arch dimension will change tongue position, and hence airway dimensions.

Approximately 66.5 percent of the extraction space is used for the retraction of the front segment in cases involving the extraction of four first premolars, according to one study. Retraction of the anterior section takes up 56.3 percent of the extraction area in cases involving extractions of maxillary first and mandibular second premolars[5]. The aim of this study was to determine whether the first premolar extraction affected pharyngeal airway dimensions and hyoid bone position in patients with bimaxillary proclination.

MATERIALS AND METHODS

The pre- and post treatment lateral cephalograms of individuals with bimaxillary proclination treated with four first premolars extraction were used in this retrospective investigation. The study included 20 adult patients (11 women, 9 men) with bimaxillary proclination who were treated with fixed orthodontic therapy MBT 0.022 (AO mini master) and group A anchorage (77 % anterior retraction and 25 % molar protraction) and had a mean age of 18-23 years.

Pre- and post-treatment lateral cephalograms were obtained from the department and manually traced using acetate tracing paper that was properly adhered to the radiographs. The first investigator traced these cephalograms manually using a 0.5mm lead pencil on 0.003" acetate matte tracing paper in one sitting, and then a second investigator randomly rechecked them for anatomic contour and landmark identification, as well as tracing superimpositions, to rule out any errors. The tracing technique was carried out in a dimly lit room with the viewing screen blanked out, leaving only the radiograph visible. Using a radiopaque metal ruler that had been used retrospectively before and after obtaining radiographs, all of the radiographs were corrected for magnification and calibrated according to an uniform magnification factor (1:1). For linear measurements, we used a ruler and vernier calliper to the nearest 0.1 mm, and for angular measurements, we used a protractor to the nearest 1°.

THE RADIOGRAPHS WERE SELECTED ACCORDING TO FOLLOWING INCLUSION CRITERIA

- Bimaxillary proclination with upper incisor to maxillary plane angle (UI/Max plane ≥ 115º), lower incisor to mandibular plane angle (LI/Mand plane ≥ 99º), and interincisal angle less than ≤ 125º with average growth pattern FMA 17º-28º prior to treatment.
- Adequate diagnostic quality pre- and post-orthodontic lateral cephalograms.
- Skeletal class I patients.
- Pretreatment class I molar and class I canine relationship.
- Patients treated with MBT 0.022(AO mini master) orthodontic appliance.

EXCLUSION CRITERIA

- Patients with craniofacial deformity.
- Patients with skeletal class II and III.
- Patients with respiratory problems,obstructive sleep apnea,adenoids,tonsils.

The same investigator performed all lateral cephalometric measurements. For each cephalogram, landmarks for sagittal airway measurements and hyoid bone position were identified, producing 12 linear measures. Table 1 shows Definition of various landmarks identified for sagittal airway measurements and hyoid bone position on cephalogram.

Table 1: Definition of various landmarks identified for sagittal airway measurements and hyoid bone position on cephalogram

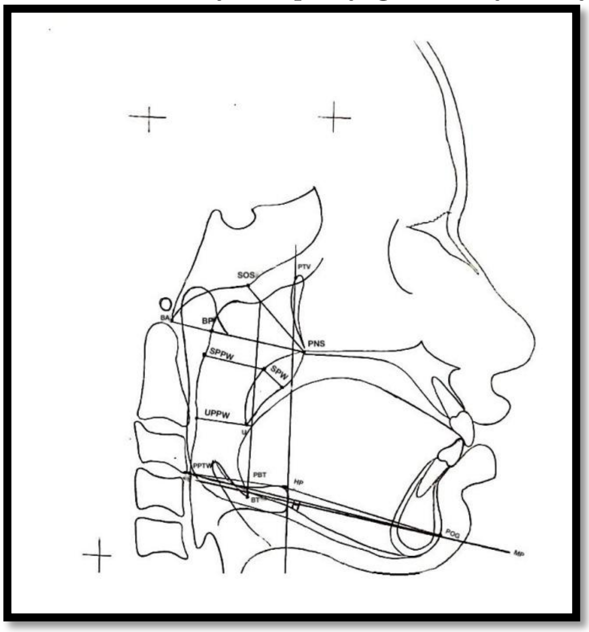
Landmarks	Definition
Sos	Most inferior point of spheno-occipital synchondrosis
PNS	Posterior Nasal Spine
HP	Point of intersection of line from Sos to PNS on the posterior pharyngeal wall
Ba	Lowermost point on anterior margin of foramen Magnum
BP	Point of intersection of posterior pharyngeal wall and line PNS-Ba
SPPW	Point of intersection of line from soft palate centre perpendicular to posterior pharyngeal wall
SPW	Point of intersection of line from soft palate centre perpendicular to posterior pharyngeal wall on the posterior margin of soft palate
U	The tip of the uvula
UPPW	Foot point of perpendicular line from point U to posterior pharyngeal wall
PPTW	Point of intersection of posterior pharyngeal wall and extension of line Pg-Go
PgT	Point of intersection of postero-dorsal tongue surface and extension of line Pg-Go
Bt	The most posteroinferior point on the base of the tongue
PBt	Foot point of perpendicular line from point V to posterior pharyngeal wall
E	Base of epiglottis
C3	The most anteroinferior point of the third Vertebra
H	The most superior and anterior point of hyoid bone
Pg	The most protrusive point of retrognathion
Hl	Foot point of perpendicular line from Pg to C3
S	Sella
Go	Gonion

Table 2: Definition of the different airway and hyoid measurements for sagittal airway and hyoid bone position Airway (mm)

Airway (mm)	
HP-PNS	Distance between HP and PNS
BP-PNS	Distance between BP and PNS
SPW-SPPW	Distance between SPW and SPPW
U-UPPW	Distance between U and UPPW
PgT-PPTW	Distance between PgT and PPTW
TAL	Vertical airway length, distance between HP and Bt
UPA	Minimum distance between the upper soft palate and the nearest Point on the posterior pharynx wall
LPA	Minimum distance between the point where the posterior tongue contour crosses the mandible and the nearest point on the posterior pharynx wall
Hyoid (mm)	
H-Pg	Distance between H and Pg
H-Hp	Distance between H and Hp
C3-H	Distance between C3 and H
PTM-H	Distance between PTM and H

The pharynx is divided into three sections: the nasopharynx, oropharynx, and hypopharynx, each with its unique set of components and structures. These three portions, as well as the hyoid location, were assessed. Correspondingly,12 measurements were made, which consist of 8 airway parameters and 4 hyoid bone parameters (Table 2 Definition of the different airway and hyoid measurements for sagittal airway and hyoid bone position Airway (mm),Figure 1 The cephalometric landmarks and analyses of pharyngeal airway and hyoid bone).The lateral cephalogram measurements were done on pretreatment (before start of treatment) and posttreatment (after debonding) cephalogram by the same investigator.

Fig 1: The cephalometric landmarks and analysis of pharyngeal airway and hyoid bone position



STATISTICAL EVALUATION

The Statistical Package for Social Sciences was used to conduct the statistical analysis (version 18; SPSS, Chicago, Ill). The pre and post treatment values were compared using a paired t-test. (Tables 3 Descriptive statistics, with mean, standard deviation , method error calculations and paired t test analysis for airway parameters (n=20) and 4 Descriptive statistics, with mean, standard deviation , method error calculations and paired t test analysis for hyoid parameters(n=20)). With a 95 percent confidential limit, significance was predetermined at 0.001 and 0.005 levels. Pearson's correlation coefficient is used to assess the reliability of airway parameters (Table 5 Reliability of airway parameters using Pearson’s correlation coefficient (n=20) and Table 6 Reliability of hyoid parameters using Pearson’s correlation coefficient (n=20)).

RESULTS

The mean values of nasopharyngeal PNSHP (>0.005) and total airway length TAL (>0.005) in pre and post treatment groups showed no statistically significant difference, whereas the mean values of oropharyngeal and hypopharyngeal PNSBP (≤ 0.001), SPPSPPW (≤ 0.001), UUPPW (≤ 0.001), PgTPPTW (≤ 0.001), BtPBt (≤ 0.001), UPA (≤0.001), and LPA(≤0.001) showed no statistically significant difference (Table 3 Descriptive statistics, with mean, standard deviation , method error calculations and paired t test analysis for airway parameters). Pre and post treatment mean values of hyoid bone position HPg (≤ 0.001), C3H (≤ 0.001), HHp (≤ 0.001), and PTMH (≤ 0.001) indicated statistically significant differences (Table 4 Descriptive statistics, with mean, standard deviation , method error calculations and paired t test analysis for hyoid parameters).

Table 3: Descriptive statistics, with mean, standard deviation , method error calculations and paired t test analysis for airway parameters (n=20)

Paired T-Test for Airway Parameters					
	Paired Differences		T	Df	Sig. (2-tailed) P Value
	Mean	Std. Deviation			
HP-PNS PreT - HP-PNS2 PostT	.000	.459	.000	19	1.000 (NS)
BP-PNS1 PreT - BP-PNS2 PostT	1.375	1.422	4.323	19	.001
SPW-SPPPW1 PreT - SPW-SPPPW2 PostT	1.150	1.101	4.669	19	.001
U-UPPPW1 PreT - U-UPPPW2 PostT	1.025	2.093	2.190	19	.041
PgT-PPTW1 PreT - PgT-PPTW2 PostT	1.425	1.042	6.115	19	.001
TAL PreT - TAL PostT	.500	3.000	.745	19	.465 (NS)
UPA PreT - UPA PostT	1.700	1.418	5.362	19	.001
LPA PreT - LPA PostT	1.300	.979	5.940	19	.001

P value ≤ 0.001 Highly significant(HS),P value <0.005 Significant, P value > 0.005Non significant(NS)

Table 4: Descriptive statistics, with mean, standard deviation , method error calculations and paired t test analysis for hyoid parameters(n=20)

Paired T-Test for Hyoid Parameters					
	Paired Differences		T	Df	Sig. (2-tailed) P Value
	Mean	Std. Deviation			
H-Pg PreT - H-Pg PostT	1.200	.951	5.640	19	.001
H-Hp PreT - H-Hp PostT	1.150	.745	6.902	19	.001
C3-H PreT - C3-H PostT	1.650	1.268	5.819	19	.001
PTM-H PreT - PTM-H PostT	1.650	1.387	5.320	19	.001

P value ≤ 0.001 Highly significant (HS),P value <0.005 Significant, P value > 0.005Non significant(NS)

In Pearson's correlation coefficient PNS-HP (≤ 0.001), PNSBP (≤ 0.001), SPPSPPW (≤ 0.001), UUPPW (≤ 0.001), PgTPPTW (≤ 0.001), BtPBt (≤ 0.001), TAL (≤ 0.001), UPA (≤ 0.001), and LPA (≤ 0.001) (Table 5 Reliability of airway parameters using Pearson's correlation coefficient) and hyoid bone parameters HPg (≤ 0.001), C3H (≤ 0.001), HHp (≤ 0.001), and PTMH (≤ 0.001) exhibited statistically significant reliability (Table 6 Reliability of hyoid parameters using Pearson's correlation coefficient).A significance level of ≤ 0.001 showed highly significant result whereas < 0.005 showed statistically significant result.

Table 5: Reliability of airway parameters using Pearson's correlation coefficient (n=20)

Pearson's Correlations Coefficient for Airway Parameters			
	N	Correlation	Sig. P Value
HP-PNS PreT & HP-PNS2 PostT	20	.937	.001
BP-PNS1 PreT & BP-PNS2 PostT	20	.897	.001
SPW-SPPPW1 PreT & SPW-SPPPW2 PostT	20	.921	.001
U-UPPPW1 PreT & U-UPPPW2 PostT	20	.735	.001
PgT-PPTW1 PreT & PgT-PPTW2 PostT	20	.967	.001
TAL PreT & TAL PostT	20	.950	.001
UPA PreT & UPA PostT	20	.935	.001
LPA PreT & LPA PostT	20	.955	.001

P value ≤ 0.001 Highly significant(HS),P value <0.005 Significant, P value > 0.005Non significant(NS)

Table 6: Reliability of hyoid parameters using Pearson's correlation coefficient (n=20)

Paired Correlations Coefficient for Hyoid Parameters			
	N	Correlation	Sig. P Value
H-Pg PreT & H-Pg PostT	20	.978	.001
H-Hp PreT & H-Hp PostT	20	.874	.001
C3-H PreT & C3-H PostT	20	.946	.001
PTM-H PreT & PTM-H PostT	20	.987	.001

P value ≤ 0.001 Highly significant(HS),P value <0.005 Significant, P value > 0.005Non significant(NS)

DISCUSSION

In the orthodontic literature, the consequences of extraction versus non-extraction treatment on the dental, skeletal, and soft tissue are still being debated.The choice whether or not to extract premolars is intricate, often involving relationships between arch size, occlusion, vertical control, and aesthetics[6].

The scope of orthodontics has increased in the recent years. Function and overall effect of health of oral environment is given more importance and not just the aesthetics. Recently, it has been suggested that before beginning orthodontic treatment with premolar extractions, airway health should be prioritised. Proponent of non-extraction treatment emphasis expansion rather than extraction with main argument being potency of airway. Extraction of premolars leads to reduction in the oral cavity space which pushes the tongue backward thus causing compression of airway. The present study probed this assertion, and analyzed the effect of premolar extraction on oropharyngeal airspace.

The hyoid bone also aids in the protection of the pharyngeal airway. The postion of tongue and the hyoid bone have a favourable relationship. The hyoid bone moves in response to changes in the tongue position. The extraction of the first premolars causes the tongue to shift, causing the hyoid bone to shift as well.

The purpose of this retrospective study was to see how premolar extraction affected pharyngeal airway dimensions and hyoid bone location in patients with bimaxillary proclination. Airway dimensions and hyoid bone position changes owing to extraction of the first premolar were measured using lateral cephalometric radiography.

According to the findings of this study, extraction of first premolars in bimaxillary proclination results in significant reduction in oropharyngeal and hypopharngeal airway volume due to reduction in oral cavity space due to retraction of incisors into the extraction space that results in decrease space for the tongue to accommodate. Furthermore, according to the study, extraction causes a shift in the location of the hyoid bone, which affects the patients' airway. Extraction places the hyoid bone in a posterior and inferior position, limiting the patient's airway.

Wang, Jia, Anderson, Wang, Lin 2012[7] reported that in bimaxillary protrusive adult patients, extraction of four premolars with incisor retraction affected velopharyngeal, glossopharyngeal and hypopharyngeal dimensions, and hyoid bone position.In the present study also, the extraction of first premolars leads to reduction in the oropharyngeal and hypophyngeal airway. Changes in the location of the hyoid bone have also been seen. The hyoid bone is a bony structure that moves posteriorly and inferiorly. As a result, there is a positive relationship between the extraction and hyoid bone's position and reduction of airway space.

Lt Col S. Bhatia et al 2016[8] stated that after retraction of the incisors in extraction space, the size of the pharyngeal (velopharyngeal and glossopharyngeal) airway was reduced, and the hyoid bone position changed in bimaxillary protrusive adult patients, which correlates with the current study, which is due to the reduced space for the tongue to accommodate pushing the tongue backward, leading to airway compression.

Nuvusetty et al 2016[9] stated that the effect of first premolar extraction in bimaxillary proclination patient leads to reduction in velopharyngeal, oropharyngeal and hypopharyngeal airway and inferior positioning of hyoid bone. Whereas in the present study there is reduction in oropharyngeal and hypopharyngeal airway and inferior and posterior positioning of hyoid bone.

Priyanka Patel et al 2017[10] found out that despite significant changes in dentoalveolar measurements, extractions of either the upper first premolars alone or the upper and lower premolars in Class II Division 1 malocclusion subjects as well as Class I bimaxillary protrusion patients did not cause any significant pharyngeal airway dimensional changes or hyoid bone position. Whereas, in the current study, bimaxillary proclination patients had a significant change in pharyngeal airway dimension and hyoid bone position.

Sunilkumar Nagmode et al, 2017[11] claimed that, first premolar extraction causes an increase in upper airway space and a decrease in inferior airway space in adolescents, and the position of the hyoid bone was not taken into account.Whereas in the present study there is no change in nasopharyngeal airway and reduction in oropharyngeal and hypopharyngeal airway and inferior and posterior positioning of hyoid bone.

Alqahtani Nasser et al, 2019[12] stated that, first premolar extraction and orthodontic retraction of incisor teeth reduce soft palate thickness and superior and middle airway dimensions significantly.In contrast to that in the present study there is reduction in middle and inferior airway space following premolar extraction.

However study done by Valiathan et al[13] found out that, oropharyngeal volumes did not change significantly after orthodontic treatment with the excision of four premolars in teenagers, owing to lymphoid tissue deterioration in adolescents. In the present study there is reduction in oropharyngeal and hypopharyngeal airway do to premolar extraction in adult patients.

When analysing the size of the pharyngeal airway, the effect of growth may play a role. It was discovered that the soft-tissue measures of the posterior pharyngeal wall changed at a faster rate between the ages of 6 and 9 years and 12 and 15 years.[16,17]. The age range for this study was 18 to 23 years to ensure that the oropharyngeal structures had attained adult size and that growth would not have an impact on the outcomes. Significant retroclination of the upper incisor to maxillary planes angle, lower incisor to mandibular planes angle, and retraction of lower incisor to A-Pog was noted after upper and lower first premolars extraction and retraction of the anterior segment. Because the goal of treatment was to diminish incisal proclination and lip procumbency, these outcomes were expected.

The limitation of the present study, was the use of lateral cephalometric radiographs to estimate airway dimensions. To assess the airway dimension, lateral cephalograms are used, which only provide a 2D picture of the pharyngeal airway.Further ,the volumetric analysis cannot be done by using lateral cephalometric radiographs. Recent armamentaria like Cone Beam Computed Tomography (CBCT) could also be a valuable tool; which provides 3D view of pharyngeal airway, and the volumetric analysis is also possible by using CBCT. But, the radiation exposure is more in CBCT as compared to conventional radiographs[18].The currently available CBCT units utilize radiation doses ranging from 87-206 μSv for a full craniofacial scan. These radiation doses are slightly higher than the conventional radiographs[19].

However, questions are also raised regarding the relaibilty of CBCT for airway assessment. According to, J.N. Zimmerman et al[20] the hypopharynx and nasopharynx volumes, as well as the overall minimal cross-sectional area, had low reliability. The only criterion with excellent intra- and inter-examiner reliability was oropharyngeal volume.Obelenis Ryan et al[21] also stated that, varied scanning times and patient regimens can result in variable 3D PAS findings. To limit the volumetric and craniocervical variations between different scanning sessions, a more controlled and uniform patient positioning strategy is required.

CONCLUSION

- In bimaxillary proclination patients, extraction of four premolars followed by retraction of anteriors into the extraction area reduced the space available for the tongue to accommodate, thus affecting the oropharyngeal and hypopharyngeal airway , and hyoid position. The oropharyngeal and hypopharyngeal airways both are constricted, indicating that tongue position had an impact on them.
- The hyoid bone has a tendency to migrate posteriorly and inferiorly. The hyoid was directly influenced by the tongue position after extraction, which can be linked to the hyoid's anatomical dependence on the hypoglossal muscle.
- In this study, anterior tooth retraction had no effect on the nasopharyngeal dimension (PNSHP) or Total Airway Length (TAL); this could be because the nasopharyngeal dimension and TAL are not influence by the tongue position.

CONFLICT OF INTEREST

There is no potential conflict of interest in my study. As the study is retrospective and pre-existing records of the patients are used there are no conflicts in regards to radiation exposure.

REFERENCES

1. Al Maaitah E, El Said N, Abu Alhaija ES. First premolar extraction effects on upper airway dimension in bimaxillary proclination patients. Angle Orthod 2012 july;82(1):853-9.
2. Keating PJ. Bimaxillary protrusion in the Caucasian: A cephalometric study of the morphological features. Br J Orthod. 1985 Oct;12(4):193–201.
3. Lamberton CM, Reichart PA, Triratananimit P: Bimaxillary protrusion as a pathologic problem in the Thai. Am J Orthod Dentofacial Orthop. 1980 Mar;77(3):320–329.
4. Bills DA, Handelman CS, BeGole A: Bimaxillary dentoalveolar protrusion: traits and orthodontic correction. Angle Orthod. 2005 May;75(3):333–339.
5. Williams R, Hosila FJ. The effect of different extraction sites upon incisor retraction.Am J Orthod 1976 April;69(4):388-410.
6. Krishna sharma, sunita shrivastav, narendra sharma, Kavita hotwani, michael d. Murrell. Effects of first premolar extraction on airway dimensions in young adolescents: A retrospective cephalometric appraisal. Contemporary Clinical Dentistry. 2014;Apr-Jun:5(2):190-194.
7. Qingzhu Wanga; Peizeng Jiab; Nina K. Andersonc; Lin Wangd; Jiuxiang. Line Changes of pharyngeal airway size and hyoid bone position following orthodontic treatment of Class I bimaxillary protrusion. Angle Orthodontist, 2012 Jan;82(1):115-21.
8. Lt Col S. Bhatia a, Brig B. Jayan b, Col S.S. Chopra. Effect of retraction of anterior teeth on pharyngeal airway and hyoid bone position in Class I bimaxillary dentoalveolar protrusion medical journal armed forces India. 2016 DEc;72(supply1):s17–s23.
9. Bhargavi Nuvusetty, Revathi Peddu, A Sai Prakash, M Kalyani, L Devikanth, Dharmendra Chadalawada.

Assessment of changes in pharyngeal airway size and hyoid bone position following orthodontic treatment of Class I bimaxillarydentoalveolar protrusion. Journal of Indian Orthodontic Society; Oct‐ Dec ;2016:50(4)215-221.

10. Priyanka Patel, Nagarag K, Abhishek Jain, Dhvani Doshi, Ankita Ringane. Assessment of cephalometric changes in pharyngeal airway involving first premolar extractions in Class II Division 1 Patients and Class I bimaxillary protrusion patients treated with fixed mechanotherapy: A retrospective study. Indian Journal of Orthodontics and Dentofacial Research, January-March 2017;3(1):31-36.
11. Sunilkumar Nagmode, Prasad Yadav, Manali Jadhav. Effect of First Premolar Extraction on Point A, Point B, and Pharyngeal Airway Dimension in Patients with Bimaxillary Protrusion. Journal of Indian Orthodontic Society. October-December: 2017 ;51(4):239-244.
12. Alqahtani Nasser, Rana Alshammari, Thikriat Al-Jewair, Mohammad Aldosari1, Albarakati Sahar. Post-orthodontic Pharyngeal Airway Changes Following First Premolar Extraction and Incisor Retraction in Bimaxillary Protrusion Patients–A Retrospective Study. Journal of Research in Medical and Dental Science; September 2019;7(5):29-38.
13. Valiathan M, El H, Hans MG, Palomo MJ. Effects of extraction versus non-extraction treatment on oropharyngeal airway volume. Angle Orthod 2010 Nov;80(6):1068-74.
14. Linder-Aronson S. Adenoids. Their effect on mode of breathingand nasal airflow and their relationship to cha racteristics of the facial skeleton and the denition. A biometric, rhino-manometric and cephalometro-radiographic study on children with and without adenoids. Acta Otolaryngol Suppl 1970 Jan;26(5):1-132.
15. Taylor M, Hans MG, Strohl KP, Nelson S, Broadbent BH. Soft tissue growth of the oropharynx. Angle Orthod. 1996 Oct; 66(5):393–400.
16. Linder-Aronson S, Leighton BC. A longitudinal study of the development of the posterior nasopharyngeal wall between 3 and 16 years of age. Eur J Orthod. 1983 Feb;5(1):47–58.
17. Langberg BJ, Todd A. Treatment of a class I malocclusion with severe bimaxillary protrusion. Am J Orthod Dentofacial Orthop. 2004 Dec;126(6):739–746.
18. Shahista Parveen, Uma Kulkarni, Rohan Mascarenha, Roopali Shetty. Awareness and Practice of Ethics and Guidelines with Cone‐ Beam Computed Tomography Prescription in Orthodontics. Journal of Indian Orthodontic Society. 2019 March;53(1):49-56.
19. Aaron D. Mole. Comparing Cone Beam Computed Tomography Systems from an OrthodonticPerspective. Seminars in Orthodontics. 2011March;17,(1):34-38.
20. Jason N. Zimmerman, Siddharth R. Vora and Benjamin T. Pliska. Reliability of upper airway assessment using CBCT. European Journal of Orthodontics.2019 june;41,(1):101–108.
21. Daniel Patrick Obelenis Ryan,Jonas Bianchi,Jaqueline Ign_acio,Larry Miller Wolford,and Joao Roberto Gonc¸alves. Cone-beam computed tomography airway measurements: Can we trust them?. Am J Orthod Dentofacial Orthop. 2019 July;156(1):53-60.