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Effect of First Premolars Extraction with Maximum Retraction on Airway and Hyoid Bone Position in Class I Bimaxillary Dentoalveolar Protrusion Cases

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Abstract

Background: The aim was to determine the effect of first premolars extraction with maximum incisor retraction on airway magnitude and hyoid bone position in cases with bimaxillary dentoalveolar protrusion.
Methods: Lateral cephalograms of patients with Class I skeletal and dental relationships were retrospectively recruited. Inclusion criteria were 15-30 years old patients having bimaxillary proclination who had undergone all first premolar extractions with maximum incisor retraction. Patients with dentofacial anomalies, chronic mouth breathing and those who had undergone tonsillectomy or adenoidectomy were excluded. Pre-and post-treatment lateral cephalograms were digitally analyzed for airway measurements and hyoid bone position. Paired samples T-test was used for statistical analysis. P-value<0.05 was considered statistically significant.
Results: A total of 33 patients, comprising 22 females and 11 males, with a mean age of 24.39 ± 6.92 years were included. Statistically significant differences were found in airway dimensions from pre-treatment to post-treatment; upper airway size between soft palate and posterior pharyngeal wall (SPP-SPPW) was reduced by 1.91mm (12.78%), at uvula & middle posterior wall (U-MPW) by 2.51mm (20.60%), at tongue base to posterior-inferior point on middle pharyngeal wall (TB-TPPW) by 3.39mm (24.26%) and vallecular to lower pharyngeal wall by 1.51mm (9.94%). The vertical position of hyoid bone also significantly reduced as indicated by inferior movement of hyoidale (H) by 4mm (3.8%). There was no significant changes in the horizontal position of the hyoid bone.
Conclusion: Premolar extraction with maximum retraction in bimaxillary protrusion cases can decrease the airway dimension and increase vertical position of hyoid bone.

Keywords: Bicuspid, Hyoid Bone, Malocclusion, Pharynx, Palate, Sleep Apnea Syndromes

Background

The upper airway can be divided into the nasopharynx, oropharynx, and laryngopharynx, among which the oropharynx has the least caliber of all and is most likely to be affected by the adaptive changes in tongue position and hyoid bone in response to orthodontic tooth movement (1). The orthodontic specialists should be well aware about this risk while treatment planning for patients and should be cautious of the pharyngeal soft tissue changes caused by tooth movement and possible reduction in airway (2).

Constriction of the oropharynx may lead to breathing problems during sleep varying from minor problems like snoring to severe conditions such as Obstructive Sleep Apnea (OSA). OSA is defined as a chronic sleep-related respiratory dysfunction (SRRD) caused by airflow cessation due to a collapsed upper airway (3). The patients suffering from OSA face severe problems during sleep, compromising their quality of life (4). The literature shows that cases with OSA have distinct anatomical features like small airway caliber, posteriorly positioned tongue, and inferiorly positioned hyoid bone, all of which leading to problems in normal breathing (5,6).

Orthodontists can play a significant role in identifying the possible risk factors for SRRD in susceptible patients (7) and preventing further airway construction secondary to tooth movement. However, this requires careful assessment of dentofacial features and malocclusion before deciding on the final treatment plan. One such malocclusion is bimaxillary dentoalveolar protrusion. This malocclusion is characterized by incisor proclination to an extent beyond the esthetic range, requiring orthodontic force to retract them within an esthetic limit which can most easily be achieved by extraction of all first premolars and maximum incisor retraction. (8,9)

Although multiple studies have investigated the effect of incisor retraction on airway dimensions and hyoid bone position, however the results still remain inconclusive (10-13). Studies by Nuvusettyet al. (10) and Wanget al. (11) have shown that in cases of all bicuspid extraction with maximum retraction of anterior teeth, there is reduced volume within the dental arches and consequently downward and backward positioning of tongue and ultimately narrowing of the lower airway. Similar studies by Maaitah et al. (12) and Maurya et al. (13) have found that orthodontic extractions do not affect any airway dimensions. Literature reviews do not provide conclusive evidence and suggest that the effect of orthodontic extractions on airway dimensions remains an underexplored area of research (14,15).

It is therefore of great importance to understand the effect of orthodontic extractions with maximum incisor retraction on airway dimension and hyoid bone position in order to prevent possible iatrogenic consequences in patients susceptible to OSA. The objective of this study was to determine the effect of all first premolars extraction with maximum incisor retraction on pharyngeal airway magnitude and position of the hyoid bone.

Methods

Study design and inclusion criteria

The protocol of this retrospective study was approved by the ethical committee of Foundation University Islamabad. Written informed consent was waived due to the study’s retrospective design. The patients’ orthodontic records along with pre- and post-treatment lateral cephalograms were retrieved from the archives of the department of orthodontics of Foundation University Islamabad and retrospectively reviewed.

We initially selected lateral cephalograms of 15-30 year-old patients who underwent fixed orthodontic therapy in our department from March 2018-December 2023. We included and retrospectively reviewed the data pertaining to patients with a Class I skeletal and dental relationship with bimaxillary proclination. Their treatment plan included extraction of all first mandibular and maxillary premolars followed by incisor retraction with fixed appliances and maximum anchorage. Exclusion criteria consisted of a history of orthopedic therapy, dentofacial anomalies, tonsil/adenoid hyperplasia and a history of tonsillectomy or adenoidectomy due to chronic mouth breathing.

Study procedure

All lateral cephalograms were analyzed digitally using Viewbox Version 4.1.0.12. The landmarks were determined by one evaluator, out of which 10 randomly selected radiographs were remarked by a second evaluator to determine the agreement. The intra- and inter-examiner reliability were compared using kappa value which came out to be greater than 0.75 suggesting excellent agreement between the two investigators. The landmarks incorporated for calculation of airway dimension and hyoid bone position (10) are given in Table 1 and Figure 1.

As displayed in Figure 2, the airway dimensions were assessed using the following values: the distance from posterior nasal spine to point R (R-PNS), pharyngeal airway size at soft palate and soft palate posterior wall (SPP-SPPW), uvula to middle pharyngeal wall (U-MPW), tongue base to posteroinferior point on middle pharyngeal wall (TB-TPPW), and vallecula to lower pharyngeal wall (V-LPW).

Table 1. Landmarks used for lateral cephalogram analysis

Landmark	Description
SPPW	Intersection of line from soft palate center perpendicular to posterior pharyngeal wall
SPP	Intersection of line from soft palate center perpendicular to posterior pharyngeal margin of soft palate
U	Uvula
R	Intersection of line from horizontal to PNS and posterior pharyngeal wall
MPW	Middle pharyngeal wall
TPPW	Intersection of posterior pharyngeal wall and extension of line
V	The most postero-inferior point on the base of the tongue valecula
LPW	Lower pharyngeal wall: Foot point of perpendicular line from point V to posterior pharyngeal wall
C3	Most antero-inferior point of third vertebra
H	The most anterio-superior point on hyoid bone
RGN	The most anterior point on retrognathion
H1	Foot point of perpendicular to a line drawn from RGN to C3

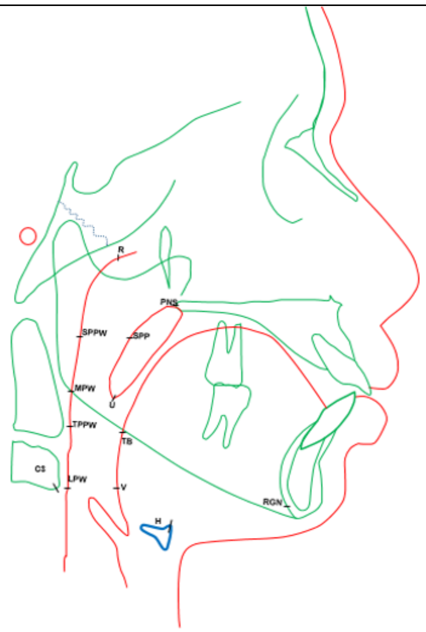

Figure 1. Diagrammatic representation of landmarks

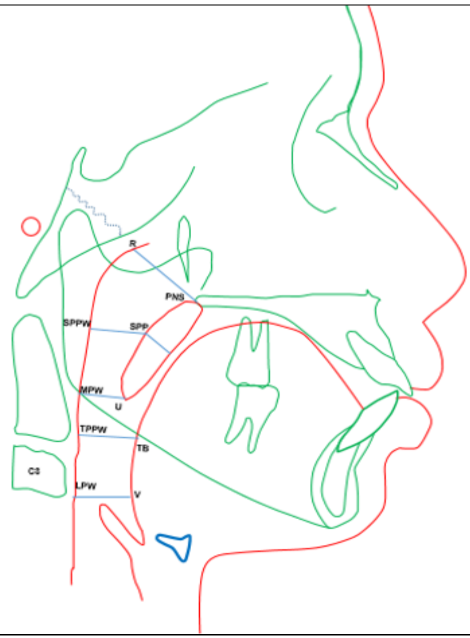

Figure 2. Dimensions of upper and lower airway measurements

Figure 3 shows the linear measurements used to assess the changes in the hyoid bone position. The distance between the hyoidale and the retrognathion (H-RGN) as well as the third cervical vertebra to the hyoidale (C3-H), were used to assess the horizontal position of the hyoid bone. In order to assess the vertical position, the distance between the hyoidale to H1 point (H-H1) and sella to hyoidale (S-H), were measured.

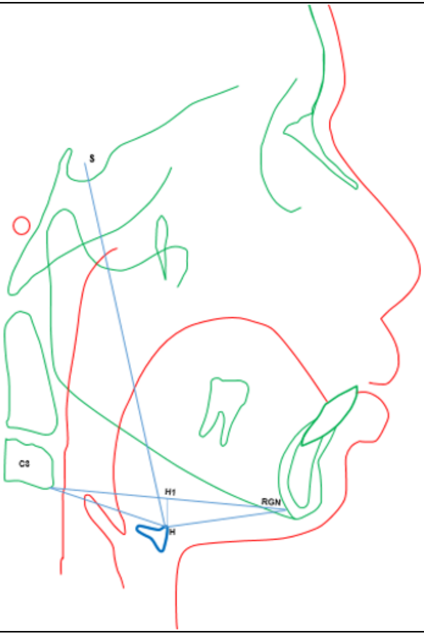

Figure 3. Measurements for assessing hyoid bone position

Sample size calculation and statistical analysis

The sample size was calculated using WHO sample size calculator, assuming a 5% margin of error and a 95% confidence level, with the study's statistical power of 80%. According to previous data published by Nuvusetty et al. (10), a pooled standard deviation of 1.4, population mean of 2.4 and anticipated mean of 1.96 (control group), were used to determine the sample size. The required sample size was established at 33 cases.

The data were analyzed using SPSS software (version 22.0, SPSS Inc., Chicago, USA). Continuous data were computed as mean and standard deviation. The qualitative data were calculated as frequency and percentages. Shapiro-Wilk test was used to examine if the data follow a normal distribution. The change in airway dimension and hyoid bone position were analyzed using paired samples T-test, as the data were distributed normally. The significance level was set as p-value less than 0.05.

Results

A total of 33 records, pertaining to 22(67%) female and 11(33%) male patients, were analyzed. Participants mean age was 24.39±6.92 years and ranged from 19-30 years.

Table 2 shows the values regarding the pre- and post-treatment position of the hyoid bone. The analyzed linear measurements showed significant changes in the vertical position of the hyoid bone as assessed by H1-H (P=0.03) and S-H (P=0.002) distances. Whereas, no statistically significant differences were observed in the horizontal position according to changes in H-RGN (P=0.35) and C3-H (P=0.96) values.

The pre- and post-treatment airway dimension values are presented in Table 3. According to paired samples T-test, after incisor retraction SPP-SPPW (P= 0.022), U-MPW (P< 0.001), TB-TPPW (P<0.001) and V-LPW (P=0.007) values were all significantly less compared to the pre-treatment values. Although there was a reduction in R-PNS values following orthodontic treatment, this difference was not proven to be statistically significant (P=0.906). Moreover, the least and greatest percentage of airway reduction was observed in the V-LPW and TB-TPPW distances, respectively. Figure 4 presents the percentage of airway dimension reduction in greater detail.

Table 1. Comparison of pre- and post-treatment position of hyoid bone

Variables	Pre-treatment (Mean±SD) (mm)	Post-treatment (Mean±SD) (mm)	P-Value
H- RGN	37.64±4.97	37.82 ±5.24	0.35
C3-H	35.70±2.54	35.73 ±3.61	0.96
H1-H	3.79 ±2.60	5.03±2.13	0.03*
S-H	105.3±5.8	109.3±7.6	0.002*

*A statistically significant difference between pre- and post-treatment values (P< 0.05).
SD: Standard deviation

Table 2. Comparison of pre-treatment and post-treatment airway dimensions

Variables	Pre-treatment (Mean±SD) (mm)	Post-treatment (Mean±SD) (mm)	P-Value
R- PNS	22.61 ± 3.50	22.48 ± 3.45	0.906
SPP-SPPW	14.94 ± 3.92	13.03 ± 2.47	0.022*
U- MPW	12.33 ± 2.91	9.79 ± 2.86	0.001*
TB- TPPW	13.97 ± 1.99	10.58± 2.57	0.001*
V- LPW	15.18 ± 2.44	13.67 ± 2.23	0.007*

*A statistically significant difference between pre- and post-treatment values (P< 0.05).
SD: Standard deviation

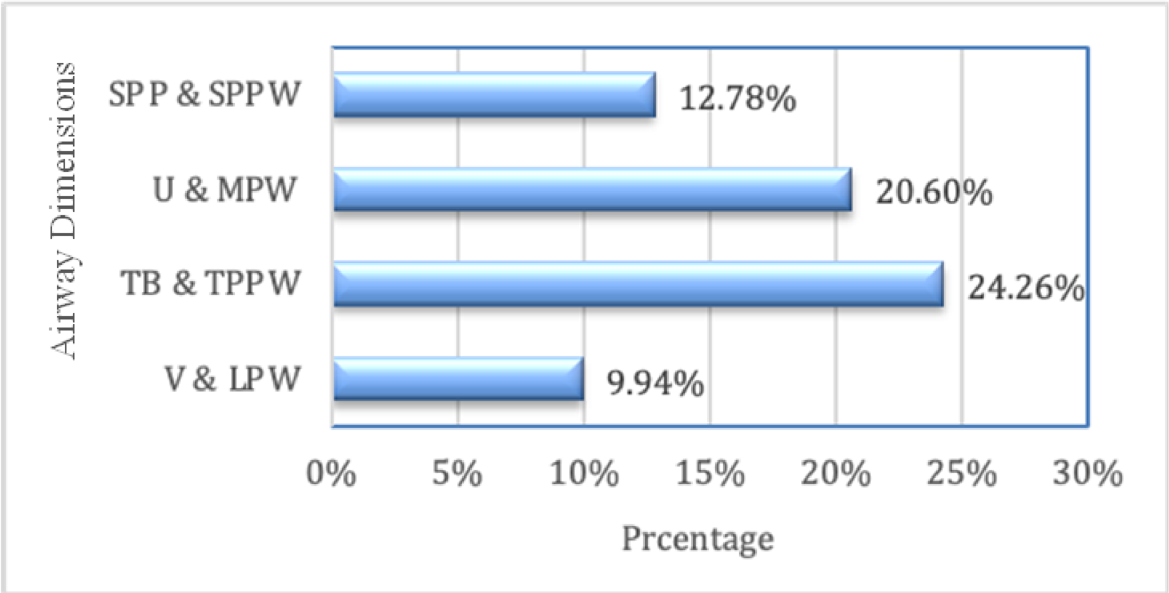

Figure 4. Percentage of reduction in airway dimensions following incisor retraction

Discussion

Orthodontic treatment may have a direct effect on airway dimensions and hyoid bone position through causing alterations in the tongue position. Although there is extensive literature on orthodontic treatment modalities that can cause such consequences, there is inconclusive evidence to determine the effect of all first premolar extractions followed by maximum incisor retraction on the airway magnitude and position of hyoid bone (14-16). This study aimed to assess the effect of all first premolars extractions with maximum incisor retraction on the hyoid bone position as well the airway dimension. Our findings revealed that this treatment modality significantly reduces the airway dimensions and changes the vertical position of hyoid bone to a more inferior level.

There has been a recent emphasis on airway dimensions in the literature and airway patency should be a major consideration while planning any orthodontic treatment (17,18). Retraction of teeth with high anchorage can move the teeth back to a level that retracts the tongue, reducing oral space and restricting oropharyngeal volume. Later in life, this may adversely affect the airway and may contribute to sleep related breathing disorders (19-21). The position of the hyoid bone shows the base of the tongue. Its position is well studied in orthodontic literature for determining the influence of orthodontic treatment on airway and OSA prone cases (22,23).

The results of our study show that the anteroposterior dimension of airway decreases following all first premolars extraction and maximum retraction of anterior teeth, reducing the pharyngeal airway dimension between the soft palate and posterior pharyngeal wall (SPP-SPPW) (P=0.22), uvula to middle pharyngeal wall (U-MPW) (P<0.001), tongue base to posterior pharyngeal wall (TB- TPPW) (P<0.001) and tongue base to lower pharyngeal wall (V-LPW) (P=0.007) showing that there is significant reduction in pharyngeal airway size after retraction.

Specifically, the velopharynx and glossopharynx which are surrounded by the posterior tongue and the soft palate anteriorly and the bony cervical vertebrae posteriorly is greatly affected by this change in the posture and position of tongue and soft palate. According to the results, the positive association between incisor retraction and the positional change of the velopharynx and glossopharynx prove that the more we retract the incisors the greater will be the reduction in the pharyngeal airway. A previous study by Nuvusetty et al. (10) on the Indian population reported that the reduction in velopharynx and glossopharynx was significant. Another study by Liu et al. (24) in China reported that premolar extraction and maximum retraction lead to a decrease in velopharyngeal, glossopharyngeal, and hypopharyngeal dimensions. Germec-Cakan et al. (25) also described similar findings.

In terms of changes in hyoid bone position, our study revealed a significant difference regarding its pre- and post-treatment vertical position. There was a statistically significant increase in the H1-H (P=0.03) as well as S-H (P=0.002) distances after treatment. While there was no significant difference in horizontal position of the hyoid bone according to H-RGN (P=0.35) and C3-H (P=0.96) values.

Previous studies have thoroughly investigated and explained the downward displacement of the hyoid bone in great detail (11,26,27). If the hyoid bone moves in the anteroposterior direction, it infringes the vital space of the oropharynx and laryngopharynx. To prevent this adverse effect, the hyoid bone and its associated structures must be guided to an inferior position to avoid compromising the airway. This suggests that stability and patency of the pharyngeal airway are significantly dependent on hyoid bone position. On the contrary, Maaitah et al. (12) and Maurya et al. (13) have shown that changes in vertical height of hyoid bone have no significant influence on the airway dimensions.

It is also noteworthy that the majority of orthodontic patients treated with all first premolars extractions are young and within the age in which sleep induced breathing problems are not usually reported, and the consequence of airway constriction is therefore poorly understood. It is not clear whether the narrowed airway will revert to its normal position after some years as part of a physiologic adaptation after orthodontics treatment or not. This requires long term follow up of these patients. Another limitation of this study is the use of two dimensional lateral cephalograms which only show linear distances, as compared to three-dimensional imaging techniques in which volumetric changes can be measured. However, the literature shows that lateral cephalograms can be reliably used for airway assessment instead of exposing the patients to unnecessary additional radiation (28).

Conclusion

Within the limitations of this study, it can be concluded that premolar extraction with maximum retraction in bimaxillary protrusion cases can decrease the airway dimension and vertical position of the hyoid bone. Careful assessment of the potential risk factors of OSA must be made and alternate treatment plans should be considered in high risk patients.

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