

A CEPHALOMETRIC STUDY TO EVALUATE AND COMPARE THE EFFECT OF UPPER PREMOLAR EXTRACTION ON PHARYNGEAL AIRWAY DIMENSION IN SKELETAL CLASS I AND CLASS II PATIENTS

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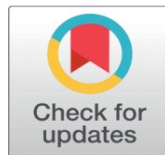
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ABSTRACT

The goal of this study was to evaluate and compare the effect of upper premolar extraction on pharyngeal airway dimension in skeletal class I and class II malocclusion patients. This retrospective study analyzed pre- and post-treatment orthodontic records of patients with skeletal Class I and Class II malocclusions to assess changes in the pharyngeal airway. ANB and WITS appraisal was employed to determine the skeletal pattern. Measurement parameters of Pharyngeal airway dimensions like superior, middle and inferior airway space were evaluated and compared between the two malocclusions. Lateral cephalograms of 100 patients (50 with Class I and 50 with Class II malocclusion) aged 18–26 years were used to measure airway dimensions, and data was compared to evaluate the impact of orthodontic treatment on pharyngeal space. Pre- and post-treatment cephalograms were obtained using standardized exposure settings and patient positioning. The data was analyzed using software SPSS 27.0 with Non-parametric test and the Wilcoxon signed-rank test at a 5% significance level was used. The results indicated that pharyngeal airway dimensions in skeletal Class I patients had a wider airway than Class II patients. Also, before treatment, Class I malocclusion patients had a wider pharyngeal airway than Class II patients while After-treatment, both groups experienced airway reduction, with Class I patients showing a more significant decrease.

Keywords: Retrospective Studies, Pharynx, Bicuspid, Malocclusion

1. INTRODUCTION

Modern orthodontics has extensively explored the relationship between skeletal malocclusions, encompassing Class I, II, and III, and also took into account the morphology of their soft tissues. [Paul et al. \(2025\)](#) The pharyngeal airway refers to the anatomical passage through which air travels from the nose and mouth to the lungs. It includes three primary segments: the nasopharynx, oropharynx, and laryngopharynx, each with distinct functional roles in respiration and speech. [Berkovitz and Moxham \(1988\)](#) The patency, or openness, of the pharyngeal airway is critical for adequate oxygen exchange and the prevention of airway obstructions, which may contribute to various conditions, including obstructive sleep apnea (OSA). [Sankri \(2012\)](#) The development of the pharyngeal airway occurs in tandem with overall craniofacial growth. During the early stages of life, facial structures including the maxilla, mandible, and the surrounding soft tissues undergo dynamic growth, which affects the shape and structure of the pharyngeal passage. As the individual ages, changes in the musculoskeletal framework and soft tissue structures can alter the size and shape of the airway. [Chuang et al. \(2022\)](#) Solow's hypothesis suggests that changes in the head posture, jaw, or tongue can affect the soft tissues in the oral and pharyngeal regions. This shift in posture alters the breathing pattern, causing the tongue and lower jaw to move downward while the head extends forward. [Sana et al. \(2022\)](#) Skeletal discrepancies, such as maxillary retrusion or mandibular deficiencies, may lead to reduced pharyngeal airway dimensions, potentially predisposing individuals to breathing disorders like OSA. [Rodrigues et al. \(2024\)](#) Individuals having Skeletal Class I malocclusion generally have more favorable airway dimensions, reflecting their balanced skeletal structure. In contrast patients having Skeletal Class II malocclusion typically display reduced airway volume and smaller cross-sectional areas, especially in the nasopharyngeal and oropharyngeal regions. The retruded mandible often seen in Class II cases can cause the tongue to shift posteriorly, further narrowing the space. As the nasopharynx becomes deeper, its back wall becomes more constricted. Moreover, people with Class I and Class II malocclusions or hyper divergent maturation typically have much constricted upper pharyngeal passage than those with natural development. [de Freitas et al. \(2006\)](#) The primary reasons for seeking orthodontic treatment are functional efficiency, aesthetic harmony, and structural balance. [Yadav et al. \(2024\)](#) Additionally, orthodontic interventions aimed at modifying craniofacial structures are known to have direct effects on airway morphology. [Shen et al. \(2023\)](#) When the upper airway becomes narrower, it can increase airflow resistance, potentially raising the susceptibility to snoring and, in more extreme scenarios can cause obstructive sleep apnea.

As an orthodontic intervention premolar extraction is a common orthodontic procedure performed to alleviate dental crowding and correct protrusive profiles. Treatments that involve anterior teeth retraction, such as in cases of premolar extraction, may cause result in a decrease in the pharyngeal passage size, especially in those having any pre-existing airway limitations. [Bhatia et al. \(2016\)](#) For instance, mandibular advancement procedures, which are often employed to treat Class II malocclusion, may result in an expansion in airway volume and improve airway patency. [Qahtani \(2016\)](#) Therefore, orthodontic treatment, particularly interventions aimed at altering maxillomandibular relationships, has a direct impact on the pharyngeal airway. Shift in tooth alignment and jaw structure can affect both the dimensions and form of the airway. Such changes are likely to influence the position of the tongue, which in turn may affect the pharyngeal passage space. Despite the recognized potential for these changes to occur, there is a lack of

comprehensive research on the specific effects that anterior teeth retrusion and the resulting dentofacial changes have on the pharyngeal airway dimensions. By initiating early orthodontic treatment, we can positively influence jaw growth and tongue posture, which helps in modifying and improving pharyngeal airway dimensions. This proactive approach can reduce the risk of airway-related issues such as mouth breathing, snoring, and even obstructive sleep apnea later in life. Early intervention allows for proper alignment and development of the dental arches, supporting better airway function and overall health.

2. POST OCCUPANCY EVALUATION (POE)

This retrospective study was conducted by analyzing the pre-treatment and post-treatment records of skeletal Class I and Class II patients (based on ANB and WITS analysis), aged 18–26 years, who had undergone orthodontic treatment involving first premolar extraction. Cephalometric parameters were analyzed at T0 (pre-treatment) and T1 (post-treatment) [Figure 1](#) The lateral cephalograms were taken with the CS 8000C system with standardized exposure settings (90 kV, 15 mA, 0.500 seconds) and consistent head positioning for accuracy. A single examiner recorded the readings. Observer reliability was ensured by initially tracing a random sample of 10 cephalograms before completing the full analysis.

Parameters which were used for classifying Class I and class II into group A and group B was defined by ANB and WITS appraisal. ANB angle is the angle formed by Nasion, point A and point B if the angle ranges $2^{\circ} \pm 2$, then it is considered as skeletal class I while Class II have an ANB angle greater than 4 degrees. Wits Appraisal is the distance between points A and point B measured on the occlusal plane. According to this measurement, values of -1mm for men and 0mm for women is considered as skeletal class I and values $> -1\text{mm}$ for men and values $> 0\text{mm}$ for women are considered as skeletal class II.

Pharyngeal airway dimensions were manually traced and measured from lateral cephalograms. For purpose of the study and correlation with skeletal parameters pharyngeal airway analysis was done and following parameters were evaluated. [Figure 2](#)

- 1) **Tongue length (TGL):** A line drawn from the tip of the tongue (TT) to the deepest point at the base of the epiglottic fold (EpB).
- 2) **Tongue height (TGH):** A perpendicular line from the dorsum of the tongue to the TGL, representing the maximum thickness of the tongue.
- 3) **Soft palate length (SPL):** Line extending from posterior nasal spine to tip of uvula (P)
- 4) **Soft palate thickness (SPT):** Maximum thickness of soft palate along a line perpendicular to posterior nasal spine (PNS) and tip of uvula
- 5) **Superior posterior airway space (SPAS):** A line drawn from the mid-point of dorsum of the soft palate to the posterior wall of the pharynx.
- 6) **Middle airway space (MAS):** A line passing through tip of uvula to posterior pharyngeal wall
- 7) **Inferior airway space (IAS):** A line extending through the posterior pharyngeal wall and the point where the posterior contour of the tongue meets the mandibular angle.
- 8) **Vertical airway length (VAL):** The distance between PNS and deepest point in the base of the epiglottic fold.

Figure 1

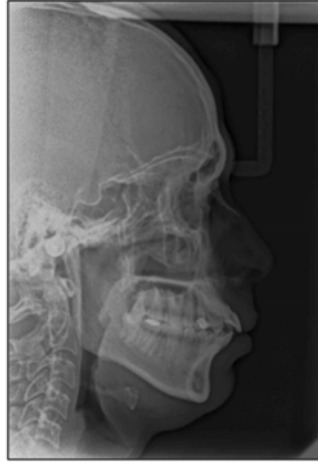


Figure 1 Lateral Cephalogram

Figure 2

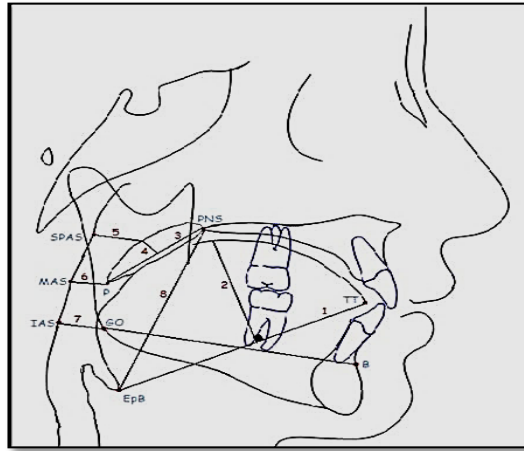


Figure 2 Pharyngeal Airway Space

The metrics for this research was recorded in Microsoft Excel 2010 and analysis was done with SPSS statistical software version 27.0. Descriptive statistics comprised calculations of frequency and percentage. Kolmogorov Smirnov test was used to check the normality of the data. Since the values did not follow a normal distribution, a non-parametric test was employed for analysis. The Wilcoxon signed-rank test was applied to evaluate the pre-treatment and post-treatment data obtained during the course. The significance level for this research was set at 5%.

3. FINDINGS AND DISCUSSION

The study analyzed pharyngeal passage parameters to evaluate how orthodontic intervention involving premolar extraction influences the upper respiratory tract in Skeletal Class I and Skeletal Class II patterns. The evaluation focused on key parameters, including the Superior Posterior Airway Space (SPAS), Middle Airway Space (MAS), Inferior Airway Space (IAS), and Vertical Airway Length (VAL), to determine whether the treatment led to significant changes in airway dimensions.

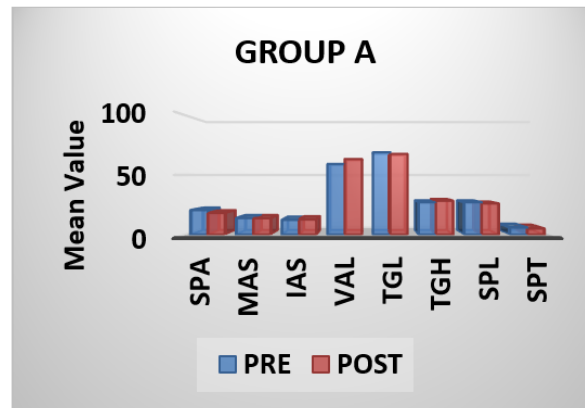
On intragroup comparison of pharyngeal airway space parameter in class I before and after premolar extraction, SPAS (-2.38 ± 1.259, p < 0.001); VAL (4.12 ± 1.272, p < 0.001); TGL (-1.34 ± 0.871, p < 0.001); TGH (0.9 ± 1.073, p < 0.001); SPL (-1.02 ± 0.684, p < 0.001); SPT (-0.84 ± 0.865, p < 0.001) showed significant difference whereas no significant difference was observed in MAS (-0.08 ± 0.944, p=0.312) and IAS (0.36 ± 3.205, p=0.508). similarly on comparing pharyngeal airway space parameter in class II before and after premolar extraction, SPAS (-2.46 ± 1.215, p < 0.001); MAS (-2.22 ± 1.130, p < 0.001); VAL (3.14 ± 0.969, p < 0.001); TGL (-1.12 ± 0.961, p < 0.001); TGH (1 ± 0.765, p < 0.001); SPL (-0.96 ± 0.807, p < 0.001); SPT (-1.02 ± 0.714, p < 0.001) showed significant difference . On the contrary, IAS showed no significant difference (0.92 ± 3.318, p= 0.058) [Table 1](#), [Graph 1](#),[Graph 2](#)

Table 1

Table 1 Changes in Pharyngeal Airway Dimension in Group A and Group B Before and After Orthodontic Treatment

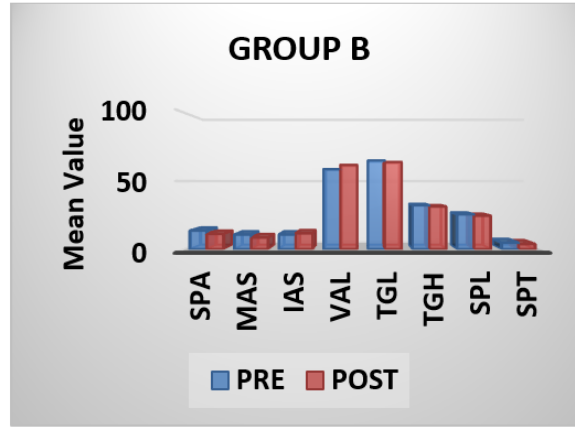
Variables	Group	Pre-Treatment Mean ± SD	Post-Treatment Mean ± SD	Mean Difference ± SD	p-value	S/NS
SPAS	A	20.640 ± 3.2056	18.260 ± 3.0426	-2.38 ± 1.259	<0.001	HS
	B	13.780 ± 1.4327	11.320 ± 1.8892	-2.46 ± 1.215	<0.001	HS
MAS	A	13.940 ± 1.9210	13.860 ± 1.9379	-0.08 ± 0.944	0.312	NS
	B	10.840 ± 1.8111	8.620 ± 1.8940	-2.22 ± 1.130	<0.001	HS
IAS	A	12.480 ± 3.0987	12.840 ± 3.0663	0.36 ± 3.205	0.508	NS
	B	10.840 ± 1.8111	11.760 ± 2.8180	0.92 ± 3.318	0.058	NS
VAL	A	59.200 ± 3.1493	63.320 ± 3.5768	4.12 ± 1.272	<0.001	HS
	B	58.760 ± 4.2357	61.900 ± 4.2630	3.14 ± 0.969	<0.001	HS
TGL	A	68.960 ± 5.2449	67.620 ± 4.9729	-1.34 ± 0.871	<0.001	HS
	B	65.080 ± 6.3498	63.960 ± 6.3018	-1.12 ± 0.961	<0.001	HS
TGH	A	27.200 ± 2.9623	28.360 ± 3.0086	0.9 ± 1.073	<0.001	HS
	B	32.240 ± 3.2423	31.340 ± 3.5145	1 ± 0.765	<0.001	HS
SPL	A	27.120 ± 3.1985	26.100 ± 3.3700	-1.02 ± 0.684	<0.001	HS
	B	25.600 ± 2.5071	24.640 ± 2.5932	-0.96 ± 0.807	<0.001	HS
SPT	A	6.000 ± 1.3401	5.160 ± 1.4758	-0.84 ± 0.865	<0.001	HS
	B	4.920 ± 1.3529	3.900 ± 1.2657	-1.02 ± 0.714	<0.001	HS

Graph 1



Graph 1 Changes in Pharyngeal Airway Dimension in Group A

Graph 2



Graph 2 Changes in Pharyngeal Airway Dimension in Group B

Table 2

Table 2 Comparison Between the Pharyngeal Airway Dimension in Skeletal Class I and Class II Malocclusion Patients Before and After Orthodontic Treatment Following Extraction of Upper First Premolar

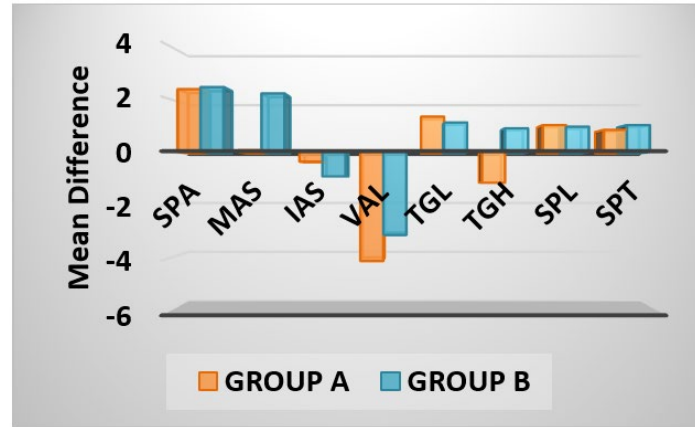
VARIABLES		Pre (Mean ±SD)	Post (Mean ±SD)	Mean Difference pre-post (Mean ±SD)
SPAS	GROUP A	20.6±3.205	18.2±3.042	2.38±1.260
	GROUP B	13.7±1.432	11.3±1.889	2.46±1.216
MAS	GROUP A	13.9±1.921	13.8±1.937	0.08±0.944
	GROUP B	10.8±1.811	8.62±1.894	2.22±1.130
IAS	GROUP A	12.4±3.098	12.8±3.066	2.846
	GROUP B	10.8±1.811	11.7±2.818	2.399
VAL	GROUP A	59.2±3.149	63.3±3.576	-2.848
	GROUP B	58.7±4.235	61.9±4.263	-2.171
TGL	GROUP A	68.9±5.244	67.6±4.972	1.34±0.872
	GROUP B	65±6.349	63.9±6.301	1.12±0.961
TGH	GROUP A	31.3±3.514	32.2±3.242	-0.394
	GROUP B	27.2±2.962	28.3±3.008	0.90±1.074
SPL	GROUP A	27.1±3.198	26.1±3.370	1.02±0.685
	GROUP B	25.6±2.507	24.6±2.593	0.96±0.807
SPT	GROUP A	6±1.340	5.16±1.475	0.84±0.866
	GROUP B	4.92±1.352	3.9±1.265	1.02 ±0.714

p ≤ 0.05 – Significant, CI = 95 %

On **intergroup comparison** between Class I and Class II patients, the mean difference in SPAS (2.42 ± 1.232 , $p = 0.883$) showed **no significant difference**, indicating that the reduction in superior pharyngeal airway space post-treatment was similar between both skeletal patterns. Similarly, no statistically significant difference was observed in IAS (0.64 ± 3.258 , $p = 0.208$), TGL (1.23 ± 0.920 , $p = 0.342$), SPL (0.99 ± 0.745 , $p = 0.825$), and SPT (0.93 ± 0.795 , $p = 0.226$), suggesting comparable changes in inferior airway space, tongue length, and soft palate morphology between the groups.

However, statistically **highly significant intergroup** differences were observed in **MAS** (1.15 ± 1.493 , $p < 0.001$), **VAL** (-3.63 ± 1.228 , $p < 0.001$), and **TGH** (-0.13 ± 1.390 , $p < 0.001$), indicating that Class II patients experienced significantly greater reductions in middle airway space and different patterns of change in vertical airway length and tongue height compared to Class I patients [Table 2](#), [Graph 3](#).

Graph 3



Graph 3 Comparison Between the Pharyngeal Airway Dimension in Skeletal Class I and Class II Malocclusion Patients Before and After Orthodontic Treatment Following Extraction of Upper First Premolar

The primary reasons for seeking orthodontic treatment are functional efficiency, aesthetic harmony, and structural balance. [Yadav et al. \(2024\)](#) Several factors can impact the positioning of the tongue and soft palate, which in turn may influence the size of the airway. Aspects such as breathing habits, body weight, age, sex, tongue enlargement, and genetic predisposition can either widen or narrow the airway. [Paul et al. \(2015\)](#) One of the main considerations is that modifying the anterior tooth alignment and oral musculature through extraction may also alter tongue placement, which could ultimately affect airway size. A study by Patel P et al. [Patel et al. \(2017\)](#) suggested that retracting the anterior teeth backward reduces arch length, causing the anterior boundary of the oral cavity to shift towards the throat. To minimize the influence of growth, the study focused on individuals aged 16 to 25 years, an age range where pharyngeal morphology is typically fully developed. This age selection aimed to provide a more accurate assessment of how extractions affect airway size. The lateral cephalograms were classified into Class I and Class II skeletal patterns based on the ANB angle, as this measurement is widely recognized and frequently utilized to assess the anteroposterior association among maxilla and mandible. [Kim et al. \(2010\)](#), [El and Palomo \(2011\)](#)

Research on individuals with skeletal Class I malocclusion found that orthodontic treatment led to a statistically significant decrease in the superior posterior pharyngeal space (SPAS). This reduction in airway size may be linked to the backward movement of the tongue resulting from the retraction of front teeth. This tongue movement could exert pressure on the soft palate, causing changes in the airway. These results suggest that orthodontic treatment involving tooth retraction can decrease intraoral space, consequently reducing pharyngeal volume. Similar reductions in SPAS following orthodontic treatment were reported in studies by Nasser A et al. [Nasser et al. \(2019\)](#) and Patel P et al. [Patel et al. \(2017\)](#) However, Aldosari MA et al. [Aldosari et al. \(2020\)](#) observed a slight, non-significant increase in SPAS after treatment.

In individuals with skeletal Class I malocclusion, research indicated a significant increase in vertical airway length (VAL) following different orthodontic management approaches. Aldosari MA et al. [Aldosari et al. \(2020\)](#) also reported a similar increase in VAL. However, these findings contrast with those of AlMaaitah et al. [Al Maaitah et al. \(2012\)](#), who found no significant changes in airway dimensions, including vertical airway length, after orthodontic treatment. A significant reduction was observed in TGL, SPL, and SPT, while TGH showed a notable increase in skeletal Class I malocclusion following treatment. Similar results were reported by Nasser A et al. [Nasser et al. \(2019\)](#), who noted a significant rise in TGH along with a significant decline in TGL, SPL, and SPT.

4. OBSERVATIONS

- In patients with skeletal Class I malocclusion, the pharyngeal airway was larger before treatment than after undergoing orthodontic intervention that involved removal of the upper first premolars.
- In patients with skeletal Class II malocclusion, the pharyngeal airway dimension was larger before treatment than after undergoing orthodontic intervention that involved removal of the upper first premolars.
- Before orthodontic treatment, patients with skeletal Class I malocclusion had a larger pharyngeal airway dimension compared to those with skeletal Class II malocclusion.
- The pharyngeal airway dimension was found to be greater in skeletal class I malocclusion patients as compared to the skeletal class II malocclusion patients after orthodontic intervention that involved removal of upper first premolars.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

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