Original Article

Upper Airway Dimensional Changes After Two and Four Premolar Extractions: A Retrospective Analytical Study

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Abstract

Background: Upper airway space (UAS) structures play a significant role in the development of the craniofacial complex and are key parameters in orthodontic diagnosis and treatment planning. Airway space can be influenced by different extraction patterns.

Objective: To compare the effect on upper airway dimensions in orthodontic patients with two and four-premolar extraction patterns.

Methodology: The study was conducted in the Department of Orthodontics, Lahore Medical and Dental College, after approval from the Institutional Review Board and Ethical Committee. Patient's records from January 2020 to December 2023 were assessed. A total of 45 orthodontic patients aged 16–20 years with a dental Class II pattern and no significant medical history were included. All patients were treated with fixed orthodontic appliances. Standardized lateral cephalograms were traced manually on acetate paper, and nasopharyngeal airway dimensions were measured before and after orthodontic treatment. Descriptive statistics and paired t-tests were used to assess changes in pre and post-treatment values.

Results: There was an insignificant change in the values for PPW-PNS (the distance between the posterior pharyngeal wall and the posterior nasal spine) and PPW-S (the distance between the posterior pharyngeal wall and the soft palate) before and after treatment. No significant differences were observed in upper airway dimensions between patients treated with extraction of four premolars and those treated with extraction of two premolars. The average treatment duration was approximately 2.5 years.

Conclusion: Extraction of two or four premolars did not cause significant alterations in upper airway dimensions. Premolar extraction can therefore be considered safe in orthodontic treatment planning with respect to airway space.

Key words: Airway, Nasopharyngeal airway, Premolar extraction, Orthodontic treatment, Lateral cephalogram

Introduction

The structures of the upper airway space (UAS) are important for the development of the craniofacial complex and are crucial for orthodontic diagnosis and treatment planning. Furthermore, obstructive sleep apnoea (OSA) and respiratory problems are somewhat influenced by the UASs craniofacial morphologic, and more especially anatomical features.[1]

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Since Angle's 1907 report describing children with Class II dentofacial deformities as having a constricted upper airway, numerous studies have demonstrated a correlation between specific craniofacial features such as mandibular deficiency and a steep mandibular plane, and a reduced upper airway dimension.[2-5] Treatment options for malocclusions vary depending on the features of the issue, including age, patient co-operation, and antero-posterior disparity. Extra oral appliances, functional appliances, and fixed appliances connected to intermaxillary elastics are among the tech-niques utilised to treat such malocclusions. Extractions may also be part of the therapy regimen. These treatment methods aim to achieve optimal face equilibrium in addition to addressing the dental connection. Dimensional alterations in the airways follow dental arch extension.[6] Although extraction treatments alter the dimensions of the arch, the majority of the space they generate is mostly used for incisor retraction and lip procumbency correction in patients with bimaxillary dental proclination. It is necessary to anticipate that changing the position of the incisors, soft tissues, and arch may have an impact on the position of the tongue and, consequently, the dimensions of the upper airways.[6]

Additionally, the literature has not yet extensively discussed maxillary extraction spaces' ability to be used in a predictable manner. The choice of teeth to be extracted depends on the treatment objectives for the soft tissues as the extraction of upper first premolars only, result in 66.5% of anterior segment retraction, affecting the lip procumbence to a greater extent, in comparison to the extraction of upper 4's and lower 5's where the anterior segment retracts by 56.3%. Moreover, it has been concluded that with moderate anchorage consideration, extraction of all second premolars leads to vertical increase in airway dimensions and lesser anterior retraction.[7] Although the effects of premolar extraction on dental arch dimensions have previously been examined, more research is still needed to determine whether extraction of all four premolars or just the upper premolars may alter the size of the upper and lower airways. The present study aimed to assess the impact of two and four premolar extraction patterns on upper airway dimensions. Orthodontic space closure and incisor retraction may influence airway morphology, potentially affecting breathing and post-treatment quality of life. Specifically, the study sought to determine whether different extraction strategies produce measurable changes in airway space, and to compare the extent and direction of these changes between the two treatment modalities. The findings will aid clinicians in achieving a balance between functional airway health and optimal aesthetic outcomes.

Methodology

This retrospective cross-sectional analytical study was conducted at the Department of Orthodontics, Lahore Medical and Dental College. Patient records from January 2020 to December 2023 were reviewed after obtaining approval from the Ethical Review Board of Lahore Medical and Dental College .

Ethical Consideration: The study was approved by the Ethical Review Board of Lahore Medical & Dental College (Reference No. LMDC/FD/4988/24; dated 15 October 2024). Informed written consent was obtained from all study participants prior to data collection. Participants were assured of the confidentiality of their information, and all data was handled following ethical research guidelines.

A total of 45 patients with dental Class II malocclusion, characterized by a distal relationship of the mandibular teeth relative to the maxillary teeth by more than one-half cusp width as described by Angle, were included. The sample size (n = 45) was selected pragmatically from available records that met the inclusion and exclusion criteria. To confirm that this number is consistent with previously published cephalometric work, we referenced pre and post-extraction airway data published by Sharma et al. in 2014. Using their reported Soft Palate Point to Soft Posterior Pharyngeal Wall (SPP-SPPW) values (pre-treatment mean 15.03±3.73 mm; post-treatment mean 13.80 ± 3.79 mm) and assuming a conservative within-subject correlation (r = 0.69), the calculated standard deviation (SD) of paired differences was approximately 2.95 mm, yielding a standardized effect size (Cohen's d) of about 0.42. Applying the paired-sample t-test formula for $\alpha = 0.05$ and 80% power results in a required sample of 45 paired observations. Thus, the available sample of 45 participants provides adequate power based on comparable published data.[8]

All available records that fulfilled the inclusion and exclusion criteria were selected using non-probability purposive sampling. The patients were between the ages of 16 to 20. Lateral Cephalogram was traced manually on acetate paper and Pre Orthodontic measurement of nasopharyngeal airway was done. Four-unit versus two-unit extraction of teeth was performed in different individuals.

Inclusion Criteria

Patients were included if they were between 16 and 20 years of age, of either gender, and diagnosed with Dental Class II malocclusion, defined according to Angle's classification as a distal relationship of the mandibular teeth relative to the maxillary teeth of more than one-half the width of the cusp. Only those cases with complete pre-treatment and post-treatment lateral cephalograms of adequate diagnostic quality were included in the study.

Exclusion Criteria

Patients with congenital craniofacial anomalies such as cleft lip or palate, nasal obstruction, or any detectable upper airway pathology were excluded. Those with a history of snoring or obstructive sleep apnea, previous orthodontic treatment, or orthognathic/orofacial surgery were also excluded. Records with incomplete or poor-quality radiographs were not considered for analysis.

The following cephalometric measurements were taken to evaluate the nasopharyngeal airway (Fig. I).

PPW–SP represents the distance between the posterior pharyngeal wall and the soft palate, while PPW–PNS denotes the distance between the posterior pharyngeal wall and the posterior nasal spine. Both parameters were measured on pre-treatment and post-treatment lateral cephalograms and compared to assess changes in upper airway dimensions following orthodontic treatment.

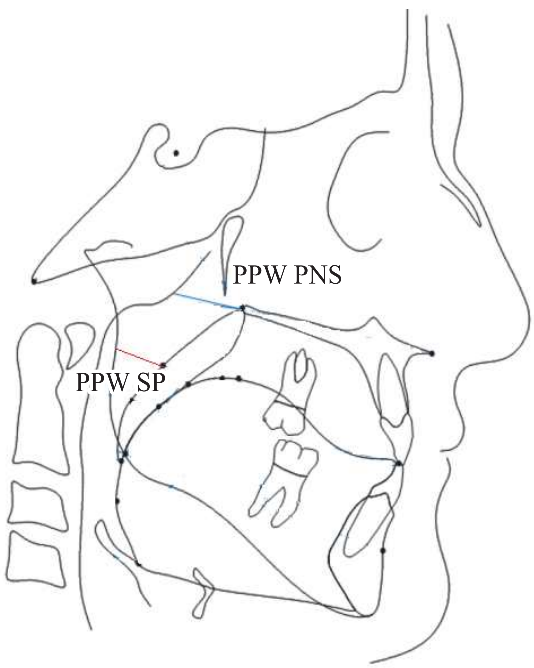

Figure I: *Upper airway dimensions on lateral cephalogram*

Statistical Analysis

Data Analysis was performed using SPSS (Statistical Package for Social Sciences) version 29. Normality of the data was checked by Shapiro-wilk test. Initial analysis included frequency distribution and calculation of descriptive statistics. Descriptive statistics for gender were recorded. Descriptive statistics were used to summarize the distribution of extraction patterns. The study sample comprised 45 patients, with 30 (66.7%) undergoing extraction of four premolars and 15 (33.3%) undergoing extraction of two premolars. Mean and Standard deviation was calculated for quantitative variables like PPW-SP and PPW-PNS etc. A paired sample t-test was used to assess changes in pre and post treatment values (Table II and III) and pearson's correlation coefficient was calculated to evaluate the reliability of observations. The p-value of <0.05 was considered significant.

Results

A total of 45 individuals participated in the study, comprising 7 males (15.6%) and 38 females (84.4%). Descriptive statistics of gender is presented in Table I.

Table I: *Descriptive statistics for Gender*

Gender	Frequency	Percent
Male	07	15.6
Female	38	84.4
Total	45	100.0

Paired sample t-test revealed no statistically significant differences in upper airway measurements, PPW – SP and PPW–PNS before and after extraction of all four premolars ($p = 0.31$ and $p = 0.39$, respectively), as shown in Table II. Similarly, paired sample t-test for the two-premolar extraction group also demonstrated no statistically significant differences in PPW–SP and PPW–PNS measurements before and after extraction ($p = 0.41$ and $p = 0.29$, respectively). Furthermore, the paired sample correlations indicated weak relationships between pre- and post-treatment values for both parameters (PPW-SP: $r = 0.09$, $p = 0.62$; PPW-PNS: $r = 0.10$, $p = 0.56$) as shown in Table II, suggesting that the extrac-tion protocol did not result in consistent or measurable changes in upper airway space.

Pearson's correlation coefficient showed statistically significant correlations in the airway parameters following only upper premolar extractions. (Table III)

The results showed that there was an insignificant change

Table II: *Comparison of pre and post treatment values of upper airway with upper and lower 4s extraction*

Paired Samples Test [a]

	Paired Differences					**t**	**df**	**Sig(2-tailed)**
	Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence interval of the difference**				**p value***
				Lower	Upper			
Pair -1 ppw-sp-pre & ppw-sp-post	0.85	4.57	0.83	-0.85	2.55	1.01	29	0.31
Pair -2 ppw-pns-pre & ppw-pns-post	.093	5.86	1.07	-1.25	3.12	0.87	29	0.39

a. Extraction pattern All 4s

Paired Samples correlations

	N	**Correlation**	**p value****
Pair 1 ppw -sp-pre & ppw -sp-post	30	0.09	0.62
Pair 2 ppw -pns-pre & ppw -pns-post	30	0.10	0.56

** p value calculated by paired t test, ** p value calculated by Pearson's correlation, p value < 0.05 considered significant*

Table II: *Comparison of pre and post treatment values of upper airway with upper and lower 4s extraction*

Paired Samples test [a]

	Paired Differences					**t**	**df**	**Sig(2-tailed)**
	Mean	**Std. Deviation**	**Std.Error Mean**	**95% Confidence interval of the difference**				
				Lower	**Upper**			
Pair 1 ppw -sp-pre & ppw -sp-post	0.80	3.70	0.95	-.1.25	2.85	0.83	14	0.41
Pair 2 ppw -pns-pre & ppw -pns-post	1.13	4.01	1.03	-3.35	1.09	1.09	14	0.29

a. Extraction pattern = upper 4s

Paired samples Correlation

	N	**Correlation**	**Sig.**
Pair 1 ppw -sp-pre & ppw -sp-post	15	0.66	.007
Pair 2 ppw -pns-pre & ppw -pns-post	15	0.49	.058

** p value calculated by paired t test, ** p value calculated by Pearson's correlation, p value < 0.05 considered significant*

in the values for ppw-pns and ppw-s pre and post treatment. There were no changes following either the extraction of four premolars or the extraction of two premolars.

Discussion

An essential component of the craniofacial complex is the upper airway. Literature suggests that Pharyngeal airway width is largely unaffected by malocclusion type.[9-11] Retrognathic patients, on the other hand, had a considerably smaller mean total airway capacity than those with a normal anteroposterior relationship, according to Kim et al.[12] Similarly, Grauer et al. found patients with varying anteroposterior jaw relationships had various airway volumes and shapes.[13] Additionally, Hakan El et al. noted that Class II subjects with a retrusive mandible had the lowest oropharyngeal and nasopharyngeal airway volumes.[14] For more than a century, Orthodontic literature has examined the effects of extraction versus non-extraction treatment on the teeth, skeleton, and soft tissues. As the upper airway's close proximity to the oral structures, different procedures have an impact on its dimensions. While extraction treatment can alleviate crowding and lessen facial convexity, its effect on respiratory function, especially in the upper airway regions of the nasopharynx, oropharynx, and hypopharynx, must be carefully considered. The nasopharynx and hypopharynx are primarily supported by bone and cartilage and are situated farther from the oral cavity, making them less susceptible to changes induced by extraction treatment. Conversely, the oropharynx, which consists of soft tissue and tongue, is directly connected to the oral cavity and may be more influenced by changes resulting from dental extractions. Extraction of teeth also affects the dimensions. The present study aimed to ascertain the impact of extracting two versus four premolars on the upper airway and found no changes following either extraction pattern. This is in line with the Sharma et al. study in which they discovered that the retraction of anterior teeth had no direct effect on the nasopharyngeal dimension.[8]

The evaluation of airway health should be one of the fundamental considerations prior to the commencement of orthodontic treatment that involves the premolars extraction. Earlier research had explored pharyngeal changes dimensions after extraction of premolars in bimaxillary dental proclination patients.[15] Some studies observed discernible constriction following the extraction procedure of the hypopharyngeal space behind the base of the epiglottis, the glossopharyngeal space behind the base of the tongue, and/or the velopharyngeal space behind the soft palate.[16,17] These conflicting results may stem from variations in sample characteristics, such as differences between skeletal Class I Dental Proclination patients with well-developed chins and skeletal Class II Dental Proclination patients with retruded chins. These unique patterns frequently show disparate early pharyngeal morphologies and dimensions, which may have various effects on the approach dentoskeletal therapy is administered.[18] However, following therapy, one research discovered no appreciable alterations in any of the pharyngeal areas.[19] This study aligns with the current research, as it also discovers that upper airway dimensions are unaffected by changes in arch dimensions after extraction therapy. Additionally, Valiathan et al.[20] found no long-term, substantial alterations to the airways. They also concluded that no statistically significant changes in oropharyngeal (OP) airway volume were seen between the four premolar extraction groups and the non-extraction group, even though changes in incisor angulations and positioning were predicted.[20] Consistent with the present hypothesis, a recent retrospective cephalometric study found that extraction orthodontic treatment using maximum anchorage resulted in reductions of upper airway dimensions, whereas moderate anchorage (less anchorage loss) was associated with increases in airway dimensions.[21] The size of the upper airways did not significantly change after extracting two or four premolar teeth, which indicates that, within the studied population, such extractions may not significantly affect airway dimensions. This result is clinically significant for orthodontists and dental practitioners, as it suggests that premolar extractions for orthodontic reasons are unlikely to have a major impact on the airway, potentially easing concerns about airway compromise in patients undergoing these procedures.

Conclusion

In conclusion, the present study found no statistically significant changes in upper airway dimensions following the extraction of either two or four premolars. The comparative analysis between groups confirmed that the extent of premolar extraction did not adversely affect airway space. These results suggest that, within the study's parameters, premolar extractions can be performed without measurable compromise to upper airway dimensions, thereby supporting their continued use in orthodontic treatment planning when clinically indicated.

Limitations & Recommendations

Although the study provides valuable insights, several limitations must be acknowledged. This study's retrospective design presents certain inherent limitations. The data were collected from existing orthodontic records, which may include variability in radiographic quality, treatment timing, and documentation. Because the sample was selected through nonprobability purposive sampling from a single institution, the findings may not be generalizable to broader populations with different demographic or craniofacial characteristics. Another limitation is the reliance on two-dimensional lateral cephalograms instead of three-dimensional imaging such as CBCT, which offers a more accurate volumetric assessment of the airway. Moreover, the timing of post-treatment assessments may also have influenced the outcomes.

Longer follow-up periods and bigger, more diversified sample sizes in future research could offer more definitive conclusions regarding the impact of premolar extractions on airway dimensions. Future studies could investigate the impact of premolar extraction in patients having different vertical and sagittal patterns in addition to anchorage considerations on the dimensions of airways. Furthermore, exploring how extraction patterns affect other aspects of airway function, such as airflow and breathing patterns, could offer a more comprehensive understanding of the connection between orthodontic treatments and overall upper airway health.

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Authors Contribution

All the authors contributed equally in accordance with ICMJE guidelines and are accountable for the integrity of the study. The final version of the manuscript has been revised by all the authors.

MM: study design, acquisition of data, manuscript writing, data analysis, final approval of the manuscript

AS& HMAJ: Contribution to study design, acquisition of data, revision

MM: acquisition of data, analysis of results, revision

FT: literature search, data analysis, review of the manu-script writeup

MJ: Literature search, data analysis and interpretation, revision