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COMPARATIVE ASSESSMENT OF PHARYNGEAL AIRWAY SPACE IN PATIENTS TREATED WITH THERAPEUTIC EXTRACTION OF PREMOLARS AND DISTALIZATION OF MAXILLARY ARCH: A CEPHALOMETRIC STUDY

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ABSTRACT
Introduction: Distalization of the maxillary dentition is alternative treatment modality for Class II and Class I malocclusion with bimaxillary dentoalveolar protrusion patients. Different treatment protocols not only change the size of the oral cavity but also affects the pharyngeal airway dimensions. **Aim**: To evaluate and compare the changes in the pharyngeal airway space in subjects treated with extraction of upper premolars and in subjects treated by distalization of maxillary arch on lateral cephalograms. **Materials and methods**: Present study is retrospective evaluation of the upper respiratory airway between the patients treated either with distalization (Group B) or therapeutic extraction of premolars (Group A). So, as per inclusion criteria, all the required records i.e. pre and post treatment lateral cephalograms for all 30 patients were collected. Evaluation of pharyngeal airway space on pre-treatment(T0) and post-treatment(T1) lateral cephalograms were evaluated and the difference between two was measured. **Results and Conclusion**: No change was found in superior airway space dimensions in both the groups. Middle and inferior airway space was decreased ($P < 0.05$) in both the groups. There was statistically significant narrowing of the airway space in the premolar extraction group (Group A) as well as the distalization group (Group B). Narrowing of airway space was less in distalization group (group B) when compared to premolar extraction group (group A).

INTRODUCTION
Distalization of the maxillary dentition has become an important treatment modality for Class II and Class I malocclusion with bimaxillary dentoalveolar protrusion patients, especially when extraction treatment is not accepted by patients.[1,2] Recently, so many different treatment modalities have been introduced and used to achieve efficient and effective total arch distalization.[3] Its treatment effects, as reported by the same research group, showed significant amounts of distalization and intrusion with minimal distal tipping of the first molar.[4,5] Recently, airway analysis and the effect of different treatment modalities on the airway space have gained increased interest from researchers. In the literature, there are conflicting results regarding the relationship between premolar extraction treatment and airway space.[2,3,4] only one study,[5] have been done to evaluate the effect of distalization of the maxillary dentition and retraction of anterior in nonextraction Class II patients on the airway. Till date only one study,[5] has been done to compare the effect of extraction of premolars and retraction of anterior teeth verses distalization of maxillary arch and retraction of anterior teeth on airway space. Thus, the present retrospective cephalometric study is taken up to evaluate and compare the changes in the pharyngeal airway space in subjects treated with extraction of upper premolars and in subjects treated by distalization of maxillary arch with non-extraction orthodontic treatment using cephalometric radiographs.

MATERIAL AND METHODS
Study Design: Retrospective study

Place of Study
The study will be conducted in Department of Orthodontics and dentofacial orthopedics, K. M. Shah Dental College and Hospital, Piparia, Vadodara.

Source of Samples
The pre-treatment and post-treatment lateral cephalograms of the subjects who have undergone orthodontic treatment with either extraction of upper premolars or distalization of the maxillary arch will be obtained the from current date till the sample size is achieved, from the archieves of the Department of Orthodontics and dentofacial orthopedics, K. M. Shah Dental College and Hospital, Piparia, Vadodara.

Sample Description

Based upon values obtained from the study done by Caken et al[2] the sample size was calculated.

Group sample sizes of 15 and 15 achieve 80% power to detect a difference of 1.7 group standard deviations of 2.4 and with a significance level (alpha) of 0.050 using a two-sided two-sample t-test.

Sample size= 2*(Zalfa/2 +Z1-beta)^2/ (m1-m2/sigma)^2

Where Zalfa/2=1.96

Z1-beta=0.84

m1= mean of group 1= 3.0

m2= mean of group 2= 5.27

sigma= standard deviation=2.20

Minimum sample size for each group is 15. All Pre and post treatment lateral cephalograms from 30th June 2017 till 1st January 2017, fulfilling the inclusion criteria will be included in the study.

Time Scale of Study

The time required for our study would be 3 months from the date of ethical approval.

Inclusion criteria for the selection of sample

1. Presence of permanent dentition at the start of the treatment
2. No missing teeth (excluding third molars) at the start of the treatment.
3. Pre treatment Study models and lateral cephalograms showing dental class I or class II molar relationship which were treated by either extraction of upper premolars or distalization of maxillary arch.

Exclusion criteria for the selection of sample

1. Faulty radiographs
2. Incomplete records
3. Pre and post treatment radiographs not from the same machine

Material / equipment for the study

1. Good quality of Lateral Cephalogram of the patients according to the inclusion criteria (28×35 cm)
2. Dolphin Cephalometric software11.5

Methodology

- ➢ The study will be conducted in the following steps.
- ➢ Pre treatment study models will be evaluated for Class I and Class II molar relationship as per the inclusion criteria
- Pre treatment(T0) and post treatment(T1) cephalograms of the patients who has undergone either extraction of upper premolars or distalization of the maxillary arch for the treatment will be obtained from the archieves of the department of Orthodontics, K. M. Shah Dental College and Hospital, Piparia, Vadodara in from the current date till the sample size is achieved.
- Samples matching the inclusion criteria (Group A: extraction of upper premolars) and Group B: Distalization of maxillary arh) will be included in the study
- **Blinding:** All the Lateral Cephalograms will be coded for blinding by co-investigator. Blinded Lateral Cephalograms will be traced using Dolphin Imaging Cephalometric software 11.5 by primary investigator who is blinded regarding which group the cephalograms belong to.
- ➢ Following landmarks and reference planes will be used for this study (figure 1)

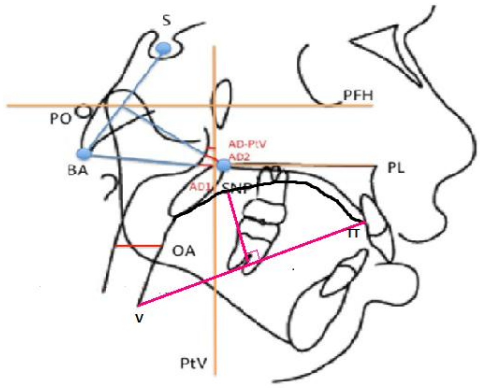

Fig.1: Landmarks and reference planes

Parameters

Maxillary angle SNA: Angle formed by the line SN and NA

Mandibular angle SNB: Angle formed by line SN and NB

Skeletal class ANB: Angles formed by lines AN and NB

Skeletal divergence SN/GoMe: Angle formed by line SN and GoMe

Airway space AD!: Linear distance between the posterior nasal spine and the closet point of adenoidal tissue along the line Ba-PNS

Airway space AD2: Linear distance between the PNS and the nearest point of adenoiud tissue along the line passing through pns and perpandicular to the line joining S and Ba

Airway space AD-PtV: Linear distance between the closest point of adenoid tissue and point on the pterygoid vertical 5 mm above theintersection point between PTV and Ba-PNS

Oropharyngeal Airway space OA: Linear distance of the oropharyngealspace along the palatal plane passing through the gonion

- A horizontal reference (HR) line with 7° angle to SN line and a vertical reference (VR) line perpendicular to horizontal reference line will be constructed.
- The changes in the airway space (T0 to T1) in both the groups will be obtained and compared. The result will be obtained by subtracting pre treatment(T0) value from post treatment(T1) value.
- The parameters will be analyzed using the cephalometric approach used by Woodside, Linder-

Aronson, and Lundstrom for evaluating the upper airway of the nasopharynx.[6,7]

- All the cephalograms will be traced twice, with 14 days gap between each other for method error
- Dahlberg's formula will be used to check the method error
- Lateral cephalograms will be devided into two groups by the co-investigator according to the treatment modality used for the correction of proclination.
- **GROUP A:** Lateral cephalograms of the patients treated with extraction of upper premolars for the correction of proclination at T0 and T1.
- **GROUP B:** Lateral cephalograms of the patients treated by distalization of maxillary arch for the correction of proclination at T0 and T1.

Any method of distalization of molars will be included in the study

- Both groups will be having lateral cephalograms of 20 patients at T0 and T1
- Assessment of the Airway Space The airway measurements of the pre- and postdistalization CBCT images were done by the same researcher using In vivo 5.2 software (Anatomage Inc). The oropharynx was divided into the following two areas: velopharynx and glossopharynx. The velopharynx was defined from the horizontal level of the palatal plane to the horizontal level of the end of the uvula, whereas the glossopharynx was defined from the horizontal level of the end of the uvula to the horizontal level of the C3 (the most anterior and inferior point of the third cervical vertebra).12 The volume of the airway space and the minimum cross-sectional area (MCA) were computed automatically by the software (Figures 3 and 4). The amounts of change between pre- and postdistalization variables were calculated.
- Ten randomly selected cases were reprocessed 4 weeks later to evaluate intraoperator reliability. Intra-Class correlation coefficient using a two-factor, mixedeffects model and type consistency showed that the measurements were reliable (intraClass correlation coefficient for all variables ranged between 0.90 and 0.99). It was not possible to blind the groups and the time point of each CBCT image.

Statistical Analysis

Statistical evaluation was performed using SPSS 16.0 (SPSS Inc, Chicago, Ill). Normal distribution of the parameters was assessed by the Shapiro-Wilk test.

The chi-square test was used to compare the distribution of the severity of Class II between the extraction and nonextraction groups. Changes that occurred from T1 to T2 were evaluated by paired t-test.

Differences between the extraction and Nonextraction groups were assessed by independent sample t-test. Correlations between the amount of distalization and the changes in the total airway volume and the MCA in both groups were evaluated using Pearson correlation.

The statistical significance was determined at <0.05. Bonferroni correction for multiple comparisons was applied.

RESULTS

The amount of change in all variables was obtained by subtracting pre-treatment values from the post-treatment values i.e., "Post treatment- Pre-treatment" formula.

There was no significant difference in the distribution of the severity of Class II relationships between the groups (P=0.601; Table 1). Tables 2 and 3 demonstrate the before and after distalization comparisons between the extraction and Nonextraction groups.

After distalization, in the nonextraction group, the crown of the first molar showed 3.24 mm of distalization (P < 0.001). The palatal root had a nonsignificant 0.84-mm buccal movement, but significant 1.26-mm intrusion and 2.43-mm distalization (P = 0.001). The angulation of the long axis showed a nonsignificant 3.078 of distal tipping. The crown showed no significant rotation in the transverse plane (P =0 .387).

The root of the central incisor showed no significant changes, whereas the crown showed a significant retraction of 1.41 mm (P <0.001), and a lingual inclination of 4.448 (P <0 .001). Also, the root of the canine demonstrated no significant changes, with a significant lingual crown tipping of 5.558 (Table 3).

In the extraction group, the first molar showed 3.41 mm of distalization at the crown level (P=0.001). The root demonstrated 2.00 mm of distalization (P <0 .001), 1.07 mm of intrusion (P <0 .001), and a nonsignificant buccal movement of 0.41 mm. The inclination of the first molar had 3.688 of distal tipping (P <0.001). Also, there was no significant rotation of the crown (P <0.472).

The root of the central incisor in the extraction group showed no significant changes, whereas the crown showed a significant retraction of 3.26 mm (P <0.001), and a lingual inclination of 7.468 (P <0.001). The root of the canine showed a facial movement of 1.25 mm in the transverse plane (P<0 .001), with lingual crown tipping of 6.158. There were no significant differences in the distalization effect between the Nonextraction and extraction groups (Table 4).

Regarding the airway space analysis, the Nonextraction group showed a nonsignificant decrease of 0.92 cm3 in airway volume. Also, the MCA of the was decreased by 7.82 mm2, which was not statistically significant. Similarly, the extraction group demonstrated no significant changes in the airway volume or the MCA. There were no significant differences in the airway variables between the two groups (Table 5).

When the correlation between the amount of distalization and airway space parameters were evaluated, the nonextraction group showed no significant correlation between the amount of distalization and the changes in the total volume or the MCA. However, in the extraction group, there were significant inverse moderate correlations.

Table 1: Age and Gender and molar relationship for IZC and ISP group.

Parameters	Group A(IZC) (n=12)	Group B(ISP) (n=12)	P Value
Sex (M/F)	7/5	6/6	0.809
Age	17.45±1.04	17.27±1.95	0.788
Molar relationship (Full cusp/Half cusp)	7/5	5/7	0.201

Table 2: Changes [mean and standard deviation (SD)] in airway dimensions, and skeletal and dental differences after extraction treatment.

	Pre-treatment (mean ± SD)	Post-treatment (mean ± SD)	Difference (post−pre; mean ± SD)	P value
Upper Airway space measurements				
AD-1	20.6 ± 4	20.3± 3.4	0.3±3.2	0.235
AD-2	15.2±2.8	13.3±3.2	2.2±1.5	**0.011**
AD-PtV	8 ± 3.5	7.2 ± 4.3	0.8±1.7	0.220
SPAS	12.5 ± 3.7	11.8 ± 3.3	1.3±1.9	0.061
Middle airway space	9.7±2.6	7.6 ± 3.2	2.1±1.5	**0.002**
Oropharyngeal airway space	11.9±2.6	8.3±2.4	3.5±2.5	**0.023**
	Pre-treatment (mean ± SD)	**Post-treatment (mean ± SD)**	**Difference (post−pre; mean ± SD)**	**P value**
Skeletal and dental parameters				
SNA	78.5±2.9	79±2.4	0.5±1.6	0.722
SNB	75.7±2.7	76.1±2.2	0.5±1.5	0.221
ANB	3.2±1.0	2.9±0.9	0.3±0.9	0.234
SN-Go-Gn	31.1± 4.8	31.7 ±4.3	0.6 ±2.6	0.280
U1-SN	107.8±3.3	98.3±4.9	16.5±3.9	**0.001**
IMPA	101.6±4.5	89.7±3.9	11.9±3.9	**0.012**

Table 3: Changes [mean and standard deviation (SD)] in airway dimensions, and skeletal and dental differences after distalization treatment.

	Pre-treatment (mean ± SD)	Post-treatment (mean ± SD)	Difference (post−pre; mean ± SD)	P value
Upper Airway space measurements				
AD-1	21.6 ± 4	21.3± 3.4	0.3±1.4	0.235
AD-2	17.2±2.8	16.3±3.2	1.1±1.4	0.170
AD-PtV	8.5 ± 3.5	8.2 ± 4.3	0.3±1.7	0.345
SPAS	12.9 ± 3.7	11.8 ± 3.3	1.3±1.9	0.082
Middle airway space	11.8±2.6	10.6 ± 3.2	1.7±1.5	**0.025**
Oropharyngeal airway space	13.2±2.6	11.3±2.4	2.1±1.2	**0.050**
	Pre-treatment (mean ± SD)	**Post-treatment (mean ± SD)**	**Difference (post−pre; mean ± SD)**	**P value**
Skeletal and dental parameters				
SNA	78.5±2.9	79±2.4	0.5±1.6	0.722
SNB	75.7±2.7	76.1±2.2	0.5±1.5	0.221
ANB	3.2±1.0	2.9±0.9	0.3±0.9	0.234
SN-Go-Gn	31.1± 4.8	31.7 ±4.3	0.6 ±2.6	0.280
U1-SN	117.8±3.3	103.3±4.9	16.5±3.9	**0.001**
IMPA	96.6±4.5	93.7±3.9	11.9±3.9	0.256

DISCUSSION

This study attempted to assess the positional changes in the maxillary dentition and the dimensional alterations in the airway after distalization using lateral cephalograms.

A study recently evaluated the changes in the maxillary tuberosity after distalization in adults. A small amount of increase in the bone size was reported at the distal end of the tuberosity.12 Only a few studies evaluated the transverse changes after distalization. Fuziy et al.13 reported approximately 1.5 mm of buccal movement of the molars after distalization using the pendulum appliance. Varlik and Iscan14 showed an increase of about 1.0 mm in the intercanine width and 1.6 mm in the intermolar width after distalization using cervical headgear. In the current study, the roots of the canine and molar showed nonsignificant displacement (0.4 and 0.8 mm, respectively) in the buccal direction.

Another study evaluating the transverse effect of distalization demonstrated that the Frog appliance resulted in distobuccal rotation of the first molar, whereas ‘‘Karad’s integrated distalizing system’’ resulted in greater rotation but in the distopalatal direction with greater expansion.15. The pendulum appliance also showed mesial-in rotation, whereas the headgear showed distal-in rotation.

Sagitally, a recent study showed 4.2 mm of molar distalization and 3.28 of distal tipping accompanied by 0.3 mm of extrusion using a distal screw appliance placed on the palate.17 Another study reported 3.1 mm of molar distalization with 1.58 of distal tipping and 1.7mm of extrusion using the distalization.4 However, in the current study, the molars were distalized 3.2 mm with 3.18 of distal tipping and 1.3 mm of intrusion. These differences might be because the previous studies were performed on adolescents using a 2D evaluation method.

Regarding the airway analysis, Hsieh et al.18 reported an approximately 3-cm3 decrease in the airway volume after mandibular and maxillary set-back surgery. Wang et al.6 reported a decrease of 1 to 1.5 mm in the oropharyngeal airway anteroposterior width with extraction treatment. However, the decrease in the oropharyngeal airway anteroposterior width was 2.1mm and 3.8 mm in patients treated with extraction and maximum anchorage in the study of Germec-Caken et al.8 Chen et al.7 demonstrated a 21.0% and 25.2% decrease in the cross-sectional areas of the palatopharynx and glossopharynx, respectively, after four first premolar extraction treatments. However, no previous study has evaluated the changes that may occur in the airway space after distalization of the maxillary dentition. In the current study, there was an approximately 0.5 to 1.5 cm3 decrease in the volume and about an 8% to 10% decrease in the MCA of the upper oropharynx; however, these decreases were not statistically significant.

In the extraction group, the amount of distalization had a significant inverse moderate correlation with the changes in airway volume and MCA. This suggests that an increase in distalization would cause some decrease in the airway volume. However, this was not found in the nonextraction group. This might be because the amount of incisor retraction was greater in the extraction group (3.26 mm) than in the nonextraction group (1.41 mm; P ¼ .004), causing some decrease in the tongue space, and in turn decreasing the airway volume to a level that would cause further distalization to have an inverse correlation with the airway volume.

Several studies reported a relationship between the MCA of the oropharynx and the occurrence and severity of OSA.19–21 Lowe et al.21 showed that the mean airway volume in OSA patients was 13.9 cm3. In the current study, the mean airway volume was 16.3 cm3 in the nonextraction group and 14.4 cm3 in the extraction group. After distalization, the volumes decreased to 15.3 cm3 and 13.8 cm3, respectively. However, these changes were not statistically significant.

There were no significant changes in the airway volume or the MCA of the oropharynx. However, because the patients in the current study were adults, the amount of distalization (mean 3.3 mm) might not be large enough to induce changes on the airway space. Therefore, future studies evaluating the airway changes in adolescent patients treated by distalization might be recommended.

In this study, the space of the nasopharynx was not evaluated because the treatment effect was related to the oral cavity and its effect on the airway space would be on the oropharynx and not the nasopharynx. Therefore, adding the nasopharynx space may have resulted in an increase of confounding factors. Therefore, the dimensions of the airway space in this study should be interpreted with caution. Moreover, the body mass index was not reported and the mode of respiration was not controlled. Also, the shape of the palate was not included in the currentstudy; therefore, an assessment of the relationship between palatal dimensions and the changes in root positions might be warranted.

CONCLUSIONS

1. There was statistically significant narrowing of the airway space in the premolar extraction group (Group A) as well as the distalization group(Group B)
2. Narrowing of airway space was less in distalization group (group B) when compared to premolar extraction group(group A).

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