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ORIGINAL ARTICLE

Vertical Facial and Dental Arch Dimensional Changes in Extraction vs. Non-Extraction Orthodontic Treatment

Meena Kumari and Mubassar Fida

ABSTRACT

Objective: To compare the vertical facial and dental arch dimensional changes occurring with extraction and non-extraction orthodontic treatments.

Study Design: Cross-sectional comparative study.

Place and Duration of Study: The Aga Khan University Hospital, Karachi during the period 2003 to 2005.

Methodology: Data were collected using records of patients who visited the study setting during the study period. Pre- and post-treatment lateral cephalographs and study casts of 81 orthodontic patients (41=non-extraction and 40=premolar extractions) were taken. Variables used for evaluating vertical dimension were Frankfort mandibular plane angle (FMA), facial height (N-Me), facial height ratio (N-ANS/ANS-Me), soft tissue facial height (G' to Me'), soft tissue facial height ratio (G'-Sn'/zn'-Me'), upper first molar to palatal plane and lower first molar to mandibular plane distance, posterior facial height to anterior facial height ratio (PFH/AFH) and Y-axis. Intercanine, interpremolar and intermolar widths and arch depths were also measured. To evaluate the pre-treatment and posttreatment comparison within each group, paired t-tests were used. For pre- and posttreatment comparisons between the extraction and non-extraction groups, independent sample t-tests were used.

Results: The mean age was 15.8±1.5 years for non-extraction and 15.4±1.2 years for the extraction group. There was no significant difference in the vertical dimensional changes between extraction and non-extraction treatments as it increased in both groups. When comparing posttreatment arch dimensions, there was an increase in the maxillary intermolar width in the non-extraction group while the intermolar widths and arch depths decreased in the extraction group in both arches.

Conclusion: Vertical dimensional changes showed no significant difference between extraction and non-extraction groups. Intermolar widths and arch depths decreased in both arches in the extraction group while the maxillary intermolar width increased in the non-extraction group.

Key words: *Vertical facial dimension. Inter molar width. Dental arch dimension. Extraction. Non-extraction. Orthodontic treatment.*

INTRODUCTION

Stability following orthodontic treatment continues to be a challenge to all orthodontists.[1] The ability to maintain long-term alignment following orthodontic treatment involving the extraction of premolars, has unfortunately, also been unpredictable. Therefore, the debate over the extraction and non-extraction decision continues to be a contentious issue in orthodontics and numerous studies have compared the fluctuating patterns of the positive and negative perceptions of the effects of extraction and non-extraction orthodontic treatments in recent years.[2,3,4]

Premolars are the most commonly extracted teeth for orthodontic purposes.[5] The two primary reasons for removal of the permanent teeth are to correct a discrepancy between tooth size and arch length, and to reduce bimaxillary protrusion. Premolars are suitably located between the anterior and posterior segments and since there are two premolars per quadrant, premolar extractions would seem to be most appropriate to allow straight forward relief of crowding or the correction of an improper interincisor relationship.[6]

The extraction of premolars as a practical form of orthodontic therapy has been accepted for many years, but there remains a controversy regarding the effect of premolar extraction on the facial vertical dimension and temporomandibular disorders (TMD).[7] According to some authors,[8-10] extraction causes the posterior teeth to move forward which leads to overclosure of the mandible and loss of vertical dimension. According to another proposal, lingual tipping of the anterior teeth occurs during space closure which creates incisal interferences and displaces the condyles posteriorly thus contributing to TMD.[10-12] Though widely investigated, the effect of extractions on facial height remains unclear. However, there are many reports and data to disprove this hypothesis.[13-16]

Another controversial matter in orthodontics has been the stability of an increase in dental arch width

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dimensions. Some claim that arch width is an important factor in obtaining a 'full smile'.[17,18] It has been shown that arch dimensional changes occur with orthodontic treatment both with and without extractions. However, extraction treatment is criticized resulting in narrower dental arches with the formation of dark corners which has a detrimental effect on smile esthetics and also leads to unstable treatment results.[19,20] According to Kahl-Nieke,[3] an intermolar expansion of 4 mm or more and an intercanine arch width increase of 2.5 mm or more after treatment were found to be significantly correlated with the arch width relapse. Arch width, at least in the intercanine zone, is not necessarily narrower after extraction treatment when compared with non-extraction treatment.[21]

It is useful for the clinician to know the effects of different treatment options and what they offer to their patients. The aim of this study was to compare the vertical facial and dental arch dimensional changes occurring in patients treated with non-extraction, with those treated with four first premolar extractions.

METHODOLOGY

The study was carried out at the orthodontic clinic of the Aga Khan University Hospital. Data were collected using pre-treatment and posttreatment lateral cephalographs and study casts of patients visiting during the period 2003 to 2005.

The inclusion criteria adopted were presence of all permanent teeth and the availability of pre-treatment and posttreatment records with fixed mechanotherapy (Roth prescription 0.022 slot) skeletal class I cases. The extraction group consisted of patients with all first premolar extractions. Exclusion criteria were patients with previous orthodontic treatment, patients with functional or removable appliance treatment and patients with craniofacial anomalies.

The lateral cephalographs were traced on an acetate paper under direct observation over an illuminator and cephalometric landmarks were identified. The linear and angular variables taken to evaluate the vertical dimension were Frankfort mandibular plane angle (FMA), facial height (N-Me), facial height ratio (N-ANS/ANS-Me), soft tissue facial height (G' to Me'), soft tissue facial height ratio (G'-Sn'/Sn'-Me'), upper first molar to palatal plane distance and lower first molar to mandibular plane distance, posterior facial height to anterior facial height ratio (PFH/AFH) and the Y-axis. Intercanine, interpremolar and intermolar widths and arch depths were used to evaluate the arch dimensions in both maxillary and mandibular arches. Intercanine width and interpremolar width were measured from the buccal cusp tips of canines and second premolars respectively. Intermolar width was measured from the mesiobuccal cusp tip of the first molar. Arch depth was calculated as the shortest distance from a line connecting the distal surfaces of the 1st molars to the labial surface of the most anterior tooth in the arch.

Data were subjected to statistical analysis on SPSS version 13.0. Descriptive statistics such as mean and standard deviation of all linear and angular measurements were computed. To evaluate the pre-treatment and post-treatment comparison within each group, paired ttests were used. For pre and post-treatment comparisons between the extraction and non extraction groups, independent sample t-tests were used. Results were considered significant at a p-value of 0.05 or less.

RESULTS

Out of the total 81 subjects, 55 were females. Forty one patients were treated with non-extraction and 40 with all first premolar extractions. The mean age was 15.8 ± 1.5 years for the non-extraction group and 15.4 ± 1.2 years for the extraction group.

Table I lists the pre-treatment baseline comparison between the non-extraction and extraction groups. It can be seen that there was no significant difference between the values for vertical and arch dimensions for both groups except that the facial height was greater initially for the patients treated with extractions (p=0.05). This ensures a high compatibility between the studied groups.

Table I: Pre-treatment comparison between non-extraction and extraction groups.

Parameter (vertical and arch dimensions)	Pre-treatment		
	Non-extraction Mean (SD)	Extraction Mean (SD)	p-value
FMA	26.3 (6)	27.8 (6.1)	0.65
Facial Ht	113.3 (6.1)	117.7 (6.4)	0.05*
Facial Ht ratio	56.8 (2.7)	58.5 (3.3)	0.50
Soft tissue facial Ht	126.2 (7.1)	129.1 (10.0)	0.91
Soft tissue facial Ht ratio	86.9 (8.5)	83.9 (8.1)	0.13
U6 to PP	21.4 (2.6)	22.3 (2.0)	0.06
L6 to MP	30.0 (2.4)	31.1 (27)	0.18
PFH/AFH ratio	64.4 (3.8)	63.7 (4.6)	0.35
Y-axis	61.4 (4.1)	61.1 (4.3)	0.49
Max IC width	34.0 (2.9)	34.3 (2.0)	0.30
Max IP width	41.2 (3.4)	41.9 (2.4)	0.65
Max IM width	49.3 (3.4)	51.0 (1.3)	0.28
Max arch depth	42.8 (3.2)	41.7 (3.8)	0.81
Mand IC width	24.5 (2.8)	23.2 (3.1)	0.31
Mand IP width	34.2 (2.4)	33.2 (3.1)	0.55
Mand IM width	44.1 (2.3)	43.0 (1.6)	0.29
Mand arch depth	34.5 (2.0)	34.1 (2.9)	0.79

**Statistically significant at 95% confidence level (p < 0.05).*

SD, standard deviation; FMA, Frankfort horizontal plane; Ht, height; U6, upper 1st molar; PP, palatal plane; L6, lower first molar; MP, Mandibular plane; PFH, posterior facial height; AFH, anterior facial height; Max, maxillary; Mand, Mandibular; IC, intercanine; IP, interpremolar; IM, intermolar.

When comparing the pre-treatment and posttreatment values within the non-extraction group, it was seen that after treatment, there was an increase in the facial height (p=0.001), facial height ratio (p=0.005) and soft tissue facial height (p=0.004). The distance of the upper first molar to the palatal plane and the lower first molar to the mandibular plane increased significantly (p=0.001). The arch dimensional change observed was an increase in maxillary intermolar width after treatment (p=0.05) as seen in Table II.

In the extraction group, the changes observed after treatment were an increase in the facial height (p=0.005), soft tissue facial height (p=0.005), increase in the distance between the maxillary first molar to palatal plane (p=0.006) and lower first molar to the mandibular plane (p=0.005). The arch dimensional changes seen were a decrease in the maxillary and mandibular intermolar widths and also a decrease in the maxillary and mandibular arch depths (Table II).

When comparing the changes between the extraction and non-extraction groups, it was observed that the changes seen in the vertical parameters after treatment were not significantly different from each other (p > 0.05). Changes were however, observed in the arch dimensions as the maxillary intermolar width increased significantly in the non-extraction group, while a decrease in maxillary and mandibular intermolar widths and arch depths was seen in the extraction group (Table III).

Table III: Post-treatment comparison between non-extraction and extraction group.

Parameter (vertical and arch dimensions)	Post-treatment		
	Non-extraction Mean (SD)	Extraction Mean (SD)	p-value
FMA	26.3 (6)	27.8 (6.1)	0.62
Facial height	113.3 (6.1)	117.7 (6.4)	0.63
Facial Ht ratio	56.8 (2.7)	58.5 (3.3)	0.40
Soft tissue facial Ht	126.2 (7.1)	129.1 (10.0)	0.61
Soft tissue facial Ht ratio	86.9 (8.5)	83.9 (8.1)	0.16
U6 to PP	21.4 (2.6)	22.3 (2.0)	0.21
L6 to MP	30.0 (2.4)	31.1 (27)	0.20
PFH/AFH ratio	64.4 (3.8)	63.7 (4.6)	0.78
Y-axis	61.4 (4.1)	61.1 (4.3)	0.15
Max IC width	34.0 (2.9)	34.3 (2.0)	0.14
Max IP width	41.2 (3.4)	41.9 (2.4)	0.10
Max IM width	49.3 (3.4)	51.0 (1.3)	< 0.001***
Max arch depth	42.8 (3.2)	41.7 (3.8)	< 0.001***
Mand IC width	24.5 (2.8)	23.2 (3.1)	0.85
Mand IP width	34.2 (2.4)	33.2 (3.1)	0.41
Mand IM width	44.1 (2.3)	43.0 (1.6)	< 0.001***
Mand arch depth	34.5 (2.0)	34.1 (2.9)	< 0.001***

***Statistically significant at 95% confidence level (P < 0.05)*

NS, not significant; SD, standard deviation; FMA, Frankfort horizontal plane; Ht, height; U6, upper 1st molar; PP, palatal plane; L6, lower first molar; MP, Mandibular plane; PFH, posterior facial height; AFH, anterior facial height; Max, maxillary; Mand, Mandibular; IC, intercanine; IP, interpremolar; IM, intermolar

DISCUSSION

In this study, the pretreatment facial height was greater in the extraction than the non-extraction group, which shows the vertical pattern being one of the factors affecting extraction decision during treatment planning.

Table II: Pre-treatment and posttreatment comparison within non-extraction group and extraction group.

Parameter (vertical and arch dimensions)	Non-extraction			Extraction		
	Pre-tx Mean (SD)	Post-tx Mean (SD)	p-value	Pre-tx Mean (SD)	Post-tx Mean (SD)	p-value
FMA	26.3 (6)	26.9 (6.1)	0.50	27.8 (6.1)	27.6 (5.1)	0.50
Facial height	113.3 (6.1)	118.8 (6.2)	0.001*	117.7 (6.4)	119.2 (7.0)	0.005*
Facial Ht ratio	56.8 (2.7)	57.9 (2.7)	0.005*	58.5 (3.3)	58.5 (3.2)	0.54
Soft tissue facial Ht	126.2 (7.1)	132.3 (7.3)	0.004*	129.1 (10.0)	130.8 (9.5)	0.005*
Soft tissue facial Ht ratio	86.9 (8.5)	88.2 (7.5)	0.765	83.9 (8.1)	85.2 (8.1)	0.72
U6 to PP	21.4 (2.6)	22.8 (1.4)	0.001*	22.3 (2.0)	23.3 (2.2)	0.006*
L6 to MP	30.0 (2.4)	30.8 (1.4)	0.001*	31.1 (27)	31.7 (2.5)	0.005*
PFH/AFH ratio	64.4 (3.8)	65.8 (5.0)	0.16	63.7 (4.6)	66.1 (4.2)	0.97
Y-axis	61.4 (4.1)	61.3 (3.8)	0.21	61.1 (4.3)	62.8 (4.0)	0.01*
Max IC width	34.0 (2.9)	34.5 (1.7)	0.64	34.3 (2.0)	35.1 (1.3)	0.90
Max IP width	41.2 (3.4)	41.2 (2.6)	0.24	41.9 (2.4)	42.3 (1.7)	0.12
Max IM width	49.3 (3.4)	51.4 (2.4)	0.05*	51.0 (1.3)	48.4 (1.6)	< 0.001*
Max arch depth	42.8 (3.2)	41.5 (2.1)	0.57	41.7 (3.8)	36.9 (2.0)	< 0.001*
Mand IC width	24.5 (2.8)	25.4 (2.0)	0.16	23.2 (3.1)	25.1 (2.1)	0.15
Mand IP width	34.2 (2.4)	34.1 (1.7)	0.94	33.2 (3.1)	34.7 (1.4)	0.15
Mand IM width	44.1 (2.3)	43.6 (1.9)	0.30	43.0 (1.6)	40.1 (2.5)	< 0.001*
Mand arch depth	34.5 (2.0)	35.4 (2.5)	0.21	34.1 (2.9)	31.1 (2.3)	0.01*

*** Statistically significant at 95% confidence level (p < 0.05).*

SD, standard deviation; FMA, Frankfort horizontal plane; Ht, height; U6, upper 1st molar; PP, palatal plane; L6, lower first molar; MP, Mandibular plane; PFH, posterior facial height; AFH, anterior facial height; Max, maxillary; Mand, Mandibular; IC, intercanine; IP, interpremolar; IM, intermolar.

More important criteria include soft tissue profile, crowding, overjet, tooth size and status of teeth.

This study showed that the changes in vertical proportions were similar with both treatments producing an increase in the vertical dimension in cephalometric variables measured. Thus, the theory that the extraction of the first premolars produces a loss in the vertical dimension of occlusion, as suggested by several authors,[7-9] was not supported by our study. In a study by Staggers on 45 non-extraction and 38 extraction patients, they showed that the extraction of all first premolars did not result in loss of vertical facial dimensions when compared to non-extraction treatment,[22] corroborating the findings of Kim *et al.*[23] The results of Kocadereli's research on 40 patients in each extraction and non-extraction groups was also in accordance with that of ours as he did not find premolar extraction to be a cause of loss of vertical dimension.[24] Sivakumar and Valiathan showed that linear vertical dimensions increased in both the extraction and the non-extraction groups and the changes were comparatively greater in the extraction group.[25] The increase in vertical dimensions as seen in this study may be attributed to growth, as the patients included were in their growing period which generally results in facial height increase and also to the orthodontic force application i.e. mechanotherapy that tends to favour extrusion of teeth. There is also compensatory eruption of posterior segments that nullifies any bite closing effect from the mesial movement of molars.

It is widely accepted that orthodontic treatment does produce some alterations in arch dimensions.[3,26,27] In this study, there was an increase in the maxillary and mandibular intercanine widths in both the extraction and non-extraction groups but it was not statistically significant. In the lower arch, there was a 0.9 mm increase in the intercanine width in the non-extraction group. However, when posttreatment values were compared between the two groups, it was evident that in the extraction treatment group the increase in intercanine width was higher (1.9 mm). This finding can be explained by the movement of the canines to a more posterior and therefore, wider place in the arch after the removal of the first premolars. In contrast, in a study by Aksu and Kocadereli on 30 extraction and 30 non-extraction patients, they showed a statistically significant increase in the intercanine widths in both treatment approaches.[28] In this study, in the extraction group there was a decrease in the maxillary and mandibular intermolar widths (1.6 mm and 2.9 mm respectively), while an increase was seen in the maxillary intermolar width (2.1 mm) in the non-extraction group. Aksu and Kocadereli, however, showed a decrease only in the mandibular intermolar width with extraction. They also showed that with non-extraction treatment, an increase in the intermolar width occurs as was also seen in this study. In another study by Isik *et al.* they concluded that the upper molar arch widths increase, more in non-extraction when compared with extraction therapies.[29] They also concluded that there is a decrease in lower intermolar distances due to the consolidation of extraction spaces. The present study showed a decrease in arch depths in both upper and lower arches in extraction cases, which is due to elimination of teeth from the arch. Luppanapornlarp and Johnston noted an average arch length reduction of 2-3 mm after treatment, independent of the treatment strategy used.[21] In a study by Kim and Gianelly on 30 extraction and 30 non-extraction cases, they showed that constricted arch widths were not a usual outcome of extraction treatment and neither extraction nor non-extraction treatment had a preferential effect on smile esthetics.[30]

In this study, growth changes were not taken into account and patients in their active growth spurt were not included. Orthodontic treatment is generally completed in adolescents before growth is fully expressed, therefore, any growth changes must be anticipated. In terms of further clinical applications, it is also crucial to judge what is going to change after the orthodontic treatment.

Vertical and arch dimensional changes are affected by the anchorage requirements, and also how much space is utilized for decrowding. It is evident that there is much individual variation in response to growth and treatment created by differences in choice of treatment mechanics and different facial and occlusal objectives, depending on pre-treatment characteristics as well as the extraction sequence itself.

Extractions of specific teeth are required in the various presentations of malocclusion as part of a comprehensive treatment to achieve goals and stability. It is important that all aspects, like soft tissue profile, degree of crowding, overjet, molar relation, status of teeth, growth etc., are taken into account when making a detailed treatment plan.

Neither non-extraction nor extraction treatment should be goals of treatment in themselves, but merely different paths taken to best meet the diagnosed needs of individual patients at the time of presentation. With good case selection, clear objectives and careful management throughout the treatment, any un-toward effects can be avoided.

CONCLUSION

An increase in vertical facial dimensions was seen in both extraction and non-extraction groups after treatment. Vertical dimensional changes showed no significant difference between extraction and non-extraction groups. Regarding the arch dimensions, the extraction group showed a decrease in intermolar widths and arch depths in both arches, while there was an increase only in the maxillary intermolar width in the non-extraction group.

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