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Arch dimensional changes following orthodontic treatment with extraction of four first premolars

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Original Article

Abstract

BACKGROUND AND AIM: Tooth extraction as a part of orthodontic treatment plan to create space for leveling and aligning teeth or causing tooth movement leads to changes in arch width and length. The outcome of these changes is important for the clinicians and affects the treatment and retention plans. Despite some previous studies, data in this regard are still scarce and further investigation is required on this subject. The purpose of this study was to evaluate dental arch dimensional changes following four first premolars extraction orthodontic treatment.

METHODS: In this study, 100 pairs of dental casts and respective patient records that fulfilled the inclusion criteria were randomly selected from the archives of the Department of Orthodontics, School of Dentistry in Shahid Beheshti University of Medical Sciences, Tehran, Iran. Length and width of dental arch were measured on the initial and final casts of patients using a digital caliper with 0.1 mm precision. The mean, standard deviation (SD) and standard error of variables were determined, and the data were analyzed using SPSS software. Paired t-test was applied to compare changes before and after treatment.

RESULTS: The obtained results showed that the maxillary and mandibular inter-canine widths significantly increased as the result of fixed appliance therapy with the extraction of four first premolars. The arch width at the second premolar and molar at mesiobuccal cusp tip and distobuccal cusp tip regions in the maxilla and mandible showed a significant reduction ($P < 0.001$). In this study, arch length at different points was measured. In the maxilla, the incisor-canine distance in both quadrants experienced a significant increase ($P < 0.001$). Furthermore, the canine-molar distance and the incisor-molar distance in both quadrants and the total arch length showed a significant reduction ($P < 0.001$). In the mandible, the incisor-canine distance in the right quadrant significantly increased ($P < 0.050$), but the reduction in the incisor-canine distance in the left quadrant was not statistically significant. Moreover, the canine-molar and the incisor-molar distance in both quadrants and the total arch length all decreased significantly ($P < 0.001$).

CONCLUSION: Orthodontic treatment with extraction of four first premolars significantly increased the inter-canine width and incisor-canine distance in both jaws; but, the inter-premolar and inter-molar widths, canine-molar distance, incisor-molar distance, and total arch length significantly decreased.

KEYWORDS: Dental Arch Length; Dental Arch Width; Extraction Orthodontic Treatment

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Arch dimensional changes following extraction orthodontic treatments are important for orthodontists. A better understanding of these changes is essential for treatment and planning for the retention period.[1] Edward H Angle was a pioneer in describing normal occlusion and was in favor of a full complement of teeth. In 1940, tweed by extraction of first premolars in a group of patients previously treated non-extraction, noticed that their occlusion became much more stable.[2,3] Furthermore, in 1974, Shapiro found that the inter-molar width was

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significantly different in extraction and non-extraction cases.[4] A high number of clinicians believe that tooth extraction narrows the dental arch, decreases the arch width, and increases the buccal corridor display when smiling.[3] Not evaluating arch dimensional changes as the result of tooth extraction leads to inappropriate treatment planning and not meeting patient expectations.[5-7] Thus, it is a research priority to evaluate and measure the maxillary and mandibular arch width and length before and after orthodontic treatment of patients with the extraction of first premolars. The effect of tooth extraction on length and width of dental arch, facial vertical height, soft tissue profile, and prevention of relapse in orthodontic treatments is still a matter of great controversy among researchers and to date; the effect of tooth extraction in this respect has not been well documented.[8-10] The purpose of this study was to evaluate dental arch dimensional changes following four first premolars extraction orthodontic treatment.

Methods

This retrospective, descriptive, analytical study was conducted on dental records of 100 patients with class I angle malocclusion and 200 pairs of casts that met the inclusion criteria and selected from the archives of the Department of Orthodontics, School of Dentistry in Shahid Beheshti University of Medical Sciences, Tehran, Iran, using systematic random sampling. The inclusion criteria were (1) class I malocclusion, (2) presence of a complete permanent dentition, (3) acceptable treatment outcome at the end of treatment, (4) extraction of four first premolars, and (5) availability of pre- and post-treatment orthodontic casts. The exclusion criteria were (1) congenital missing and (2) facial asymmetry.

Measurements were made using a digital caliper (NEIKO/014007A/CHAINA) with 0.1 mm readability and repeated twice for each variable with a 2-day time interval. In cases where the difference between the two measurements was > 0.1 mm, the measurement was repeated for the third time, and the mean of three measurements was calculated and recorded.

Understudy variables were:

1. Intercanine width: defined as the linear distance between the cusp tips of the right and left canines in one arch
2. Inter-second premolar width: defined as the linear distance between the buccal cusp tips of the right and left second premolars in one arch
3. Inter-first molar width at mesiobuccal cusp tip (MBCT): defined as the linear distance between the MBCTs of first molars in one arch
4. Inter-first molar width at distobuccal cusp tip (DBCT): defined as the linear distance between the DBCTs of first molars in one arch
5. Incisor-canine distance: defined as the linear distance between the midpoint of the incisal edge of central incisor and cusp tip of canine tooth in the right and left quadrants
6. Canine-molar distance: defined as the linear distance between the canine cusp tip and DBCT of the first molar in the same quadrants
7. Incisor-molar distance: defined as the linear distance between the midpoint of the incisal edge of the central incisor and the DBCT of the first molar in the right and left quadrants
8. Total arch length: defined as the sum of incisor-canine and canine-molar distances of both quadrants of one jaw.

Data were analyzed using SPSS software (version 18, SPSS Inc., Chicago, IL, USA). Mean and standard deviation (SD) were calculated for each variable. Kolmogorov-Smirnov test was used to determine data distribution. Paired t-test was applied to compare changes before and after treatment.

Results

After the primary evaluation of dental records and pre- and post-treatment casts, the following results were obtained. As observed

in table 1, the inter-canine width significantly increased in the maxilla and mandible. The inter-premolar width after the extraction treatment significantly decreased in both jaws. The inter-molar width at MBCT and DBCT significantly decreased in the maxilla and mandible. As observed in table 1, incisor-canine distance in both maxillary quadrants and right mandibular quadrant significantly increased but experienced a significant reduction in the left mandible. As expected, canine-molar distance in both quadrants of the maxilla and mandible experienced a significant reduction. Incisor-molar distance in both quadrants of the maxilla and mandible significantly decreased. A total arch length in the maxilla and mandible significantly decreased after treatment as well.

In the next step, the pre- and post-treatment images were superimposed, and overall changes in the arch form were evaluated as observed in figure 1 (A and B).

Table 1. Changes in width and length of dental arch following extraction orthodontic treatment in millimeter

Variable	Pre-treatment	Post-treatment	Difference	P
	Mean ± SD	Mean ± SD	Mean ± SD	
Inter-canine width				
Maxilla	33.95 ± 2.69	35.49 ± 1.76	1.54 ± 2.28	0.001***
Mandible	26.43 ± 2.39	27.01 ± 1.75	0.57 ± 2.42	0.019*
Inter-second premolar width				
Maxilla	43.60 ± 3.50	42.58 ± 2.08	-1.02 ± 3.19	0.002**
Mandible	37.28 ± 3.80	34.41 ± 1.97	-2.87 ± 3.69	0.001***
Inter-molar width at MBCT				
Maxilla	49.47 ± 2.20	47.30 ± 2.86	-2.16 ± 3.97	0.001***
Mandible	43.22 ± 3.17	40.36 ± 2.58	-2.86 ± 2.30	0.001***
Inter-molar width at DBCT				
Maxilla	51.86 ± 2.89	50.13 ± 2.75	-1.73 ± 1.94	0.001***
Mandible	46.10 ± 3.19	43.66 ± 2.77	-2.44 ± 2.15	0.001***
Incisor-canine distance				
Maxilla				
R	15.31 ± 1.62	16.24 ± 1.01	0.91 ± 1.49	0.001***
L	15.14 ± 1.49	16.14 ± 1.21	1.00 ± 1.32	0.001***
Mandible				
R	11.51 ± 1.53	12.04 ± 1.26	0.53 ± 1.71	0.003**
L	12.41 ± 1.82	12.08 ± 0.79	-0.32 ± 1.80	0.001**
Canine-molar distance				
Maxilla				
R	26.60 ± 1.71	19.64 ± 1.53	-6.95 ± 1.77	0.001***
L	26.48 ± 1.80	19.53 ± 1.29	-6.94 ± 1.73	0.001***
Mandible				
R	24.95 ± 3.14	19.03 ± 1.29	-5.91 ± 2.82	0.001***
L	25.50 ± 2.32	19.10 ± 1.31	-6.39 ± 1.83	0.001***
Incisor-molar distance				
Maxilla				
R	42.22 ± 2.90	37.56 ± 1.67	-4.66 ± 2.16	0.001***
L	42.21 ± 2.51	37.58 ± 1.81	-4.62 ± 1.95	0.001***
Mandible				
R	36.34 ± 3.17	32.03 ± 1.72	-4.31 ± 2.74	0.001***
L	36.60 ± 2.51	32.19 ± 1.79	-4.41 ± 1.65	0.001***
Arch length				
Maxilla	83.56 ± 4.66	71.57 ± 3.24	-11.99 ± 3.36	0.001***
Mandible	73.52 ± 5.23	62.34 ± 3.24	-11.18 ± 4.00	0.001***

*P ≤ 0.050, **P ≤ 0.010, ***P ≤ 0.001
MBCT: Mesiobuccal cusp tip; DBCT: Distobuccal cusp tip

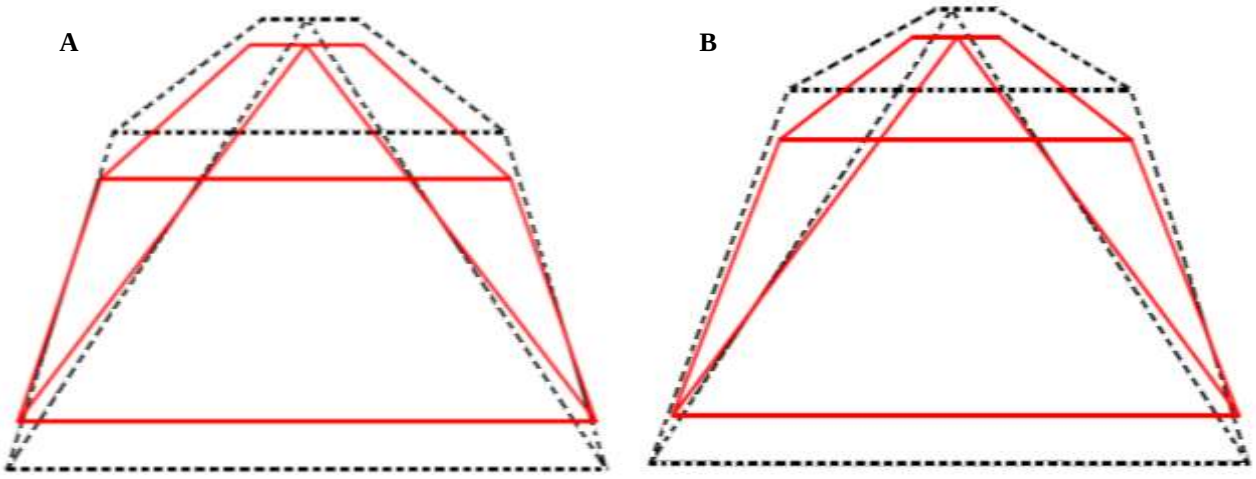

Figure 1. Schematic view of the changes in length and width of dental arch before and after treatment, (A) Maxilla before: Dotted, after: Red line, (B) mandible before Dotted, after: Red line

Discussion

Several studies have discussed changes in arch dimensions as the result of fixed orthodontic treatment along with tooth extraction. This study sought to assess changes in length and width of dental arch following orthodontic treatment with extraction of four first premolars in class I malocclusion patients. This method has been previously used by Kim and Gianelly,[9] Isik et al.,[11] and Al-Sayagh.[12] The obtained results showed that maxillary and mandibular inter-canine width significantly increased following fixed orthodontic treatment with tooth extraction. Inter-second premolar width and inter-molar width at the MBCT and DBCT experienced a significant reduction in both the maxilla and mandible. Similar results were reported by Bishara et al.,[1,8] Gianelly,[13] Kim and Gianelly,[9] Isik et al.,[11] Aksu and Kocadereli,[10] and Al-Sayagh.[12]

Kim and Gianelly[9] compared 30 patients undergoing orthodontic treatment with tooth extraction with 30 patients treated non-extraction treatment plan. Dental arch widths after completion of the treatment significantly changed in both groups with and without extraction except for maxillary inter-canine width that did not change in the non-extraction group compared to the baseline value. After treatment, the inter-canine width in the maxilla and mandible slightly increased in both groups. These changes were statistically non-significant. The inter-molar and inter-premolar widths decreased in both jaws in the extraction group.

The only difference between the two studies is the inter-canine width that although increased in the maxilla and mandible in both studies; this difference in our study was not statistically significant in the mandible. Kim and Gianelly concluded that extraction treatment does not cause narrowing of dental arch and this treatment does not have a negative effect on smile esthetics.[9] In another study, Aksu and Kocadereli,[10] evaluated changes in dental arch width in 30 patients who underwent extraction treatment and 30 patients treated non-extraction and demonstrated a significant increase in inter-canine width in the maxilla and mandible after treatment in both groups. Inter-molar width in the mandible significantly decreased in the extraction group. Reduction in the inter-molar width in the maxilla in the extraction group was not statistically significant;[10] but, this reduction was statistically significant in our study. This difference may be due to the larger sample size in our study. Isik et al. in their study,[11] revealed that the maxillary and mandibular inter-canine width increased in the extraction group. However, this increase only in the maxilla was statistically

significant. Furthermore, similar to our findings, the inter-premolar and inter-molar widths significantly decreased.

In the study by Bishara et al.[1] the inter-canine width increased in the extraction group due to the alignment of crowded anterior teeth. The inter-molar width in their study decreased in the extraction group. Their findings are in agreement with our study results. The only difference is that our study patients had class I malocclusion, whereas Bishara et al.'s understudy subjects had class II division I malocclusion.[1]

Gianelly found that the mandibular inter-canine width significantly increased by 1.39 mm in the extraction group but changes in maxillary inter-canine width and inter-molar width in both jaws were not statistically significant.[13]

The difference between our study and Gianelly's[13] may be attributed to the small sample size in both groups in his study (25 patients) and measurement of inter-second molar dimension instead of inter-first molar width. We evaluated arch length at different areas and found that in the maxilla, the incisor-canine distance in both quadrants significantly increased. Furthermore, the canine-molar distance in the right and left quadrants, incisor-molar distance in both quadrants and total arch length all experienced a significant reduction. In the mandible, the incisor-canine distance in the right quadrant significantly increased but change in incisor-canine distance in the left quadrant was not statistically significant. A statistically significant reduction was also detected in the canine-molar distance in both quadrants, incisor-molar distance in both quadrants and total arch length. Similar results were obtained by Bishara et al.[8] They compared 45 patients treated with tooth extraction and 46 treated non-extraction in the two groups of males and females. In their study, a significant reduction occurred in the posterior arch length in the maxilla and mandible after treatment in the tooth extraction group. The total arch length did not significantly change in all groups post-treatment. The anterior and posterior arch lengths decreased post-treatment in all groups.

In general, their results were similar to our findings. The only difference was that our study subjects had class malocclusion; whereas, Bishara et al.'s patients had class II division I malocclusion and were evaluated in two groups of males and females.[8] Furthermore, Bishara et al. found that changes in width and length of dental arch were similar in the two groups of males and females.[8] In another study by Heiser et al.[7] arch length significantly decreased in both jaws. This finding was similar to our obtained result.

Al-Sayagh[12] conducted a study on 20 patients with tooth extraction (10 males and 10 females) and 20 patients treated non-extraction (10 males and 10 females). Only the maxillary arch was evaluated, and a significant reduction in the following parameters was observed in both maxillary quadrants of males and females in the extraction group: inter-molar width, incisor-molar distance, canine-molar distance, molar vertical distance, and arch length. The inter-canine width significantly increased in females in the extraction group. Moreover, the incisor-canine distance increased in females in the extraction group; but this increase was not statistically significant. In males, this distance decreased but this reduction only in the right maxilla was statistically significant. The difference between findings by Al-Sayagh study[12] and our conclusions could be explained by the small sample size in the aforementioned study especially in the two groups of males and females that decreased the internal consistency of the obtained results.

Conclusion

Orthodontic treatment with extraction of four first premolars:

1. Caused a significant increase in the inter-canine width and incisor-canine distance in both jaws

2. Caused a significant reduction in inter-premolar width, inter-molar width, canine-molar distance, incisor-molar distance, and total arch length

3. Caused forward (mesial) movement of the posterior teeth toward the anterior (narrower) region of the arch.

Conflict of Interests

Authors have no conflict of interest.

Acknowledgments

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