

Original Article

Comparison of Arch Width Changes Following Orthodontic Treatment with and without Extraction Using Three-dimensional Models

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ABSTRACT

Objective: To compare the arch width changes in patients treated fixed orthodontic mechanics without extraction (Group 1), with upper and lower first premolar extractions (Group 2), and with upper first premolar extraction only (Group 3). **Materials and Methods:** The study was conducted with pre- and post-treatment digital models from 240 patients. Anterior, middle, and posterior distances were measured on pre- and post-treatment models. At T1 measurements, the distance among the canine cusp tips, the second premolar buccal cusp tips, and the first molar mesiobuccal cusp tips were measured. In addition, the distance (D) between the intercanine and intermolar lines and the distance (D') between the interpremolar and intermolar lines were defined on the anatomic y-axis, and this distance was maintained in calculating posttreatment measurements (T2). Mandibular and maxillary arch width changes were evaluated within and between groups. **Results:** Anterior, middle, and posterior arch widths increased significantly in Groups 1 and 3. Maxillary anterior and middle arch widths also increased in Group 2, but the increases were not statistically significant. Changes in maxillary anterior and middle arch widths were higher in Groups 1 and 3 when compared to Group 2. However, there was no statistically significant difference in mandibular arch changes between the groups. **Conclusion:** Extraction treatment mechanics did not cause narrow dental arches, but nonextraction treatment increased arch width in all 3 measurements. Treatments with only upper arch extraction showed similar results with nonextraction treatment.

KEYWORDS: Arch width changes, extraction/nonextraction, three-dimensional models

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INTRODUCTION

Effects of arch form and arch width on smile esthetics have long been the subject of discussion in orthodontic publications. Widening dental arches tend to improve smile attractiveness,^[1] as large buccal corridors have a negative effect on smile esthetics. Hence, it is believed that treatments that narrow the dental arches such as premolar extraction can be the result of poor smile esthetics.

Nevertheless, the literature shows no clear connection between premolar extraction and lessening of arch width. Meyer *et al.*, found increases in anterior arch width in patients treated with premolar extraction as well as in patients treated without extraction,

with no significant differences in either pre- or post-treatment buccal corridor dimensions between the groups.^[2] Similarly, Akyalcın *et al.* found no significant differences in maxillary arch width changes in patients treated with and without premolar extraction, with those treated without extraction showing slight increases in pre- and post-treatment intercanine and intermolar measurements,^[3] and both Gianelly^[4] and Kim and Gianelly^[5] reported no constriction of anterior

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or posterior arch width following orthodontic treatment with or without extraction.

It has been widely reported^[6-9] that orthodontic treatment may produce changes in transverse dimension of intercanine and intermolar distance, which may affect the long-term stability of orthodontic treatment. However, it is also widely accepted that intercanine and intermolar widths that have been altered by orthodontic treatment tend to return to their initial sizes. Burke *et al.*'s conclusion that mandibular intercanine width tends to expand with orthodontic treatment, but to return to pretreatment size following the removal of fixed appliances,^[10] is in-line with this notion.

de la Cruz *et al.* suggested that pretreatment arch form is the best predictor of orthodontic treatment success and stability.^[11] Arch forms have been classified differently in different studies. Several studies have used five categories – normal, ovoid, tapered, narrow-ovoid, and narrow-tapered.^[11-13] Another study using three categories – ovoid, square, and tapered – found ratios among the different forms to vary by race.^[14] Felton *et al.* did not identify any predominant arch form, but they found optimal results are achieved when individual arch forms are maintained.^[15]

This retrospective study used digital measurements of orthodontic models (1) to evaluate arch width changes in patients treated with fixed orthodontic appliances whose initial ovoid arch form was maintained following treatment and (2) to compare the changes in arch dimensions in these patients with the changes in patients treated without extraction, with maxillary and mandibular first premolar extractions and in patients maxillary first premolar extraction only.

MATERIALS AND METHODS

This retrospective study was approved by the Regional Ethics Committee (OMU ethics no, OMU KAEK 2015/394). The study was conducted using pretreatment (T1) and posttreatment records (T2) of 240 patients treated with MBT orthodontic mechanics and bracket prescriptions selected from the orthodontic clinic archives of Ondokuz Mayıs University, Faculty of Dentistry, Department of Orthodontics. Patients were included if they were treated without extraction, with maxillary first premolar extraction, or with maxillary and mandibular first premolar extraction. Patients without fully erupted permanent dentition as well as patients with morphological crown anomalies, occlusal wear or dental restorations on the buccal cusps, potential for maxillary and/or mandibular skeletal expansion, and patients with skeletal malocclusion were excluded from the study. All patients had Class I canine relationships

with ideally aligned teeth, normal overjet and overbite, and excellent occlusion with good interdigitated at the end of the treatment. Patients that were selected for this retrospective study treated by the writers or underwent comprehensive orthodontic treatment under the supervision of the writers.

The pre- and post-treatment orthodontic models were scanned and digitized with an orthodontic three-dimensional scanner (3Shape R-700 Desktop Orthodontic Scanner, Copenhagen, Denmark). Maxillary and mandibular arch forms were drawn on the occlusal views of the scanned models using the Orthoanalyzer (3Shape, Copenhagen, Denmark) software program by an orthodontist experienced with the software. The digital images were then compared to the MBT treatment ovoid arch form (OrthoForm™ III 3M Unitek, Monrovia, Calif, USA) [Figure 1], and any patient treated using an arch form that did not match the pretreatment ovoid arch record was excluded from the study.

Patients were grouped according to treatment plan as follows: Group 1 ($n = 80$; 32 boys, 48 girls): Fixed orthodontic treatment appliances without extraction; Group 2 ($n = 80$; 35 boys, 45 girls): Treated fixed orthodontic treatment appliances with upper and lower first premolar extractions; Group 3 ($n = 80$; 30 boys; 50 girls): Treated fixed orthodontic treatment appliances with upper first premolar extraction only. The mean ages at pretreatment were 13.8 ± 2.1 years for Group 1, 14.3 ± 3.4 years for Group 2, and 13.9 ± 1.7 years for Group 3.

Arch width measurements

In total, 480 orthodontic models were used (240 pretreatments [T1] and 240 posttreatments [T2]). Anterior, middle, and posterior arch widths in both maxillary and mandibular arches were measured using the Orthoanalyzer software program. At T1 measurements, anterior arch width was made from the canine cusp tips, middle arch width was made the second premolar buccal cusp, and posterior arch width was made the first molar mesiobuccal cusp tips [Figure 2]. Anterior arch width was made from the canine cusp tips at T2 as T1, in addition, the distance (D) between the intercanine and intermolar lines and the distance (D') between the interpremolar and intermolar lines were defined on the anatomic y-axis between the most labial aspects of the anatomic dental arch of each cast at T1, and this distance was maintained in calculating middle and posterior arch widths measurements at T2 [Figure 3].

Comparisons of the arch widths at T1 between the groups were done by the analysis of variance (ANOVA) to test any arch width difference between the groups

before the orthodontic treatment. Only maxillary posterior arch width was showed significant difference among the three groups [Table 1].

Reliability of measurement was assessed by having the same operator recalculate 20 randomly selected records 1-week after the initial measurements. Random error was calculated using Dahlberg’s formula as follows:

$$SDe = \sqrt{\frac{\sum d^2}{2n}}$$

Where “*d*” is the difference between the repeated measurements and “*n*” is the number of repeated measurements. Mean errors were 0.15 mm for intercanine measurements, 0.18 mm for interpremolar measurements, and 0.21 mm for intermolar measurements.

Statistical analysis

Data were analyzed using SPSS (SPSS Inc., version 15.0, Chicago, IL, USA) for Windows. Means and standard deviations (SDs) and arch width changes (T1-T2) for each parameter (anterior, middle, and posterior) were calculated for all groups. Kolmogorov–Smirnov normality tests showed normal distributions for all three parameters for all groups. Intragroup differences were evaluated using paired samples *t*-tests, and intergroup differences were evaluated using ANOVA with Tukey’s tests. A level of *P* < 0.05 was considered statistically significant.

RESULTS

Table 1 shows the pretreatment comparisons of anterior, middle, and posterior arch width of the groups. Only maxillary posterior and mandibular middle arch widths showed statistically difference between the Groups 1 and 3. Means and SDs of measurements at T1 and T2 are given in Table 2. In both Group 1 (nonextraction) and Group 3 (maxillary extraction), all arch width measurements increased significantly (*P* < 0.05). In Group 2 (maxillary/mandibular extraction), all mandibular arch widths, as well as maxillary posterior arch width, increased significantly following orthodontic

treatment (*P* < 0.05); maxillary anterior and middle arch widths also increased, but the changes were not statistically significant (*P* > 0.05).

Changes in mandibular arch width were similar for all treatment groups; however, maxillary arch widths changes varied by group [Table 3]. Differences in

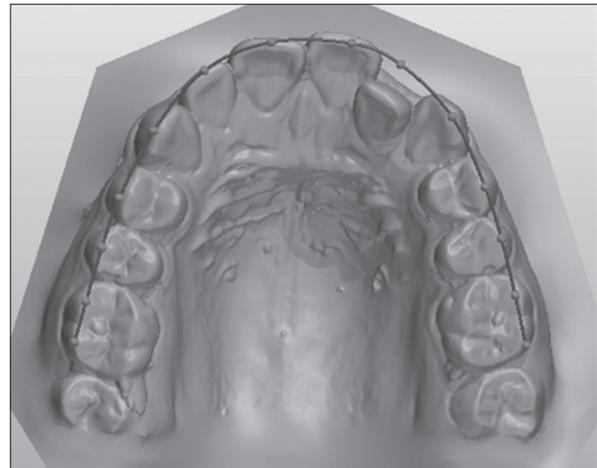


Figure 1: The determination of arch form with software analyze

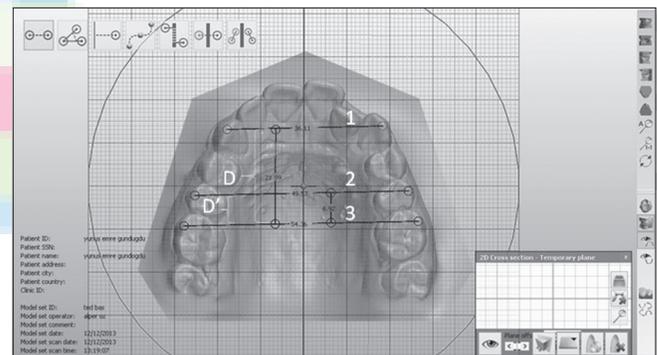


Figure 2: Maxillary arch measurements used at pretreatment models: (1) Maxillary anterior: Distance between the left and right upper canine cusp tips, (2) Maxillary middle: Distance between the upper first left and right first premolar buccal tips, (3) Maxillary posterior: Distance between the upper first left and right first molar mesiobuccal tips, D: The distance between the intercanine and intermolar lines, D’: The distance between the interpremolar and intermolar lines

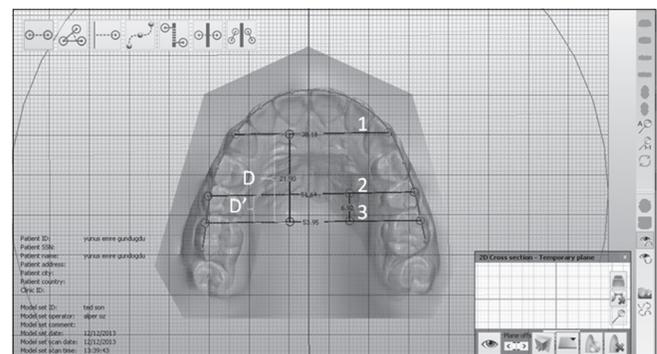


Figure 3: Maxillary arch measurements used at posttreatment model

Table 1: Pretreatment comparison of both maxillary and mandibular arches between the groups

	Group 1-2	Group 2-3	Group 1-3
Maxillary anterior	NS	NS	NS
Maxillary middle	NS	NS	NS
Maxillary posterior	NS	0.013*	0.000*
Mandibular anterior	NS	NS	NS
Mandibular middle	0.010*	0.044	NS
Mandibular posterior	NS	NS	NS

**P*<0.05. NS=Not significant

Table 2: Means and SDs of the arch widths (mm) of the groups at T1 and T2 and differences from pretreatment (T1) and posttreatment (T2) measurements

	Group 1			Group 2			Group 3		
	T1	T2	P	T1	T2	P	T1	T2	P
Maxillary anterior	33.92	35.11	0.000	34.22	34.44	NS	33.64	34.57	0.001
Maxillary middle	44.43	46.18	0.000	43.93	44.24	NS	43.44	45.18	0.003
Maxillary posterior	50.98	51.48	0.032	49.98	50.79	0.000	48.76	50.95	0.000
Mandibular anterior	26.26	26.75	0.011	26.65	27.26	0.007	26.36	26.87	0.006
Mandibular middle	39.23	40.48	0.000	37.88	38.68	0.015	38.99	40.12	0.000
Mandibular posterior	44.50	45.63	0.000	43.62	44.52	0.000	44.34	45.25	0.000

SDs=Standard deviations; NS=Not significant

Table 3: Means and SDs of the arch width changes (mm) of the groups and comparisons between the groups

T2-T1	Group 1		Group 2		Group 3		P		
	Orthodontic	SD	Orthodontic	SD	Orthodontic	SD	Group 1-2	Group 1-3	Group 2-3
Maxillary anterior 2-anterior 1 (mm)	1.19	1.88	0.22	2.27	0.93	2.50	0.018	NS	NS
Maxillary middle 2-middle 1 (mm)	1.75	2.41	0.31	2.67	1.74	2.05	0.001	NS	0.001
Maxillary posterior 2-posterior 1 (mm)	0.50	2.04	0.81	1.35	2.19	1.69	NS	0.000	0.000
Mandibular anterior 2-anterior 1 (mm)	0.49	1.68	0.61	1.97	0.51	1.60	NS	NS	NS
Mandibular middle 2-middle 1 (mm)	1.25	2.26	0.80	3.24	1.13	2.37	NS	NS	NS
Mandibular posterior 2-posterior 1 (mm)	1.14	1.92	0.90	1.61	0.91	1.89	NS	NS	NS

SDs=Standard deviations; NS=Not significant

maxillary anterior and middle arch width changes varied significantly between Groups 1 and 2 ($P < 0.05$), whereas the differences between Groups 1 and 3 were not statistically significance ($P > 0.05$). Changes in maxillary posterior arch width also differed significantly between Groups 1 and 3 and between Groups 2 and 3 but not between Groups 1 and Group 2 ($P > 0.05$).

DISCUSSION

A broad smile may be more attractive than a narrow one.^[16,17] Moore *et al.*, state that most people consider minimal buccal corridors preferable for an esthetic smile,^[1] whereas Roden-Johnson *et al.*^[18] report that buccal corridor space does not affect smile esthetics.

The dimensions of the buccal corridors are closely related to the transverse dimensions of the dental arches.^[16,17] Therefore, several authors investigated the effects of orthodontics treatments on transverse dimensions of the dental arches. In evaluating changes in arch width following orthodontic treatment, most previous studies have used the distance among cusp tips of canines, premolars, and molars,^[19-21] as well as some studies, have used the most labial aspect of the buccal surfaces of canines and molars.^[4,22] Given the

anteroposterior movement of teeth during orthodontic treatment, especially during space closure, it is difficult to obtain a true representation of arch width changes. As Johnsons and Smiths state, the arch form is not a circle that shrinks in radius when teeth are removed.^[23] In orthodontic treatment with extraction, a decrease in the distance between the first molars may occur as the first molars move forward and inward to close the extraction spaces. Various measurement techniques have, thus, been developed to provide more accurate assessments of posttreatment changes.^[2,3] Akyalcın *et al.* measured anterior maxillary arch widths using the points immediately distal to the incisive papilla and middle maxillary arch widths using the third lateral and medial rugae on the midpalatal raphe to measure the same point at the dental arch.^[3] However, these anatomical landmarks are only useful for maxillary measurements. In this study, cusp tips were used for pretreatment measurements (T1). In addition, the distances between the canine cusp tips and molar cusp tips (D) and the distance between the second premolar cusp tips and molar cusp tips (D') at T1 was digitally measured using the software, and this distances (D and D') were maintained in calculating posttreatment (T2) measurements on the

individual dental arches to measure the same points at dental arches.

Although most previous studies have used a digital caliper to measure the arch width, some recent studies have relied on software programs that automatically evaluate the arch form and calculate changes in arch width. In this study, repeatable results were obtained using the Orthoanalyzer software program.

This study also has several limitations. First, although we tried to select similar patients' orthodontic models, the records were retrospective. Second, patients that were selected for investigation treated by the writers or underwent orthodontic treatment under the supervision of the writers because of the difficulty to find similar patients treated with the same clinician.

In view of, the suggested relationship between maxillary arch measurements, buccal corridor ratios and smile esthetics,^[23] most of the studies have evaluated only changes in maxillary arch width following orthodontic treatment; however, this study measured changes in both the maxillary and mandibular arches to better evaluate how the maxillary arch is affected by extraction in both arches as compared to the maxillary arch only. Isik *et al.*, expressed that posttreatment mandibular intercanine distance was wider in the extraction group than in the nonextraction group, mandibular interpremolar and intermolar distances in the extraction group decreased, and the authors concluded that the decreases were due to the consolidation of extraction spaces.^[19] In this present study, mandibular anterior arch with changes results were similar with Işık *et al.* results. However, changes in mandibular arch dimensions did not vary significantly, according to treatment modality.

Changes in anterior maxillary arch dimensions were significantly different between the Group 1 and Group 3. However, the change in maxillary posterior arch widths changes was significantly higher in Group 1 when compared to Group 3 ($P < 0.005$). This difference could be explained with the pretreatment posterior arch difference between these two groups. In Group 3, most of the molar relation was tended Class II at pretreatment due to the mesial drift of upper molars after the early loss of deciduous teeth and molar rotations commonly exist in class II molar relations because upper molars are usually rotated around an axis lingual to their central fossae.^[24] Hence, the pretreatment intermolar distance at Group 3 (maxillary extraction) was less than Group 1 (nonextraction) and Group 2 (maxillary/mandibular extraction) when the mesiobuccal cusp tips were used for posterior arch width. Therefore, the posterior arch change in Group 3 was more than the other groups.

As for our subjects in the nonextraction group, statistically significant differences were recorded for both maxillary and mandibular arch widths changes in all the three measurements. Our results were not different from the other studies that found significant increases for maxillary anterior arch widths^[3] and posterior arch widths^[19,22] for nonextraction treatments. However, in the extraction group, no significant increases in maxillary anterior and middle arch width were recorded. Akyalcin *et al.* reported that all arch measurements stayed actually stable after upper and lower premolar extraction.^[3] Gianelly^[4] evaluated changes in anterior and posterior dental arch width after extraction and nonextraction therapy and concluded that narrow dental arches are not a systematic outcome of extraction therapy. In another study, Isik *et al.*^[19] measured intermolar, interpremolar, and intercanine distances before and after orthodontic treatment with and without extraction. Whereas intercanine maxillary arch width was unaffected by treatment modality, increases in interpremolar and intermolar maxillary arch widths were significantly higher with nonextraction treatment when compared to extraction treatment. In this study, maxillary posterior arch width was showed a significant increase in the extraction group as nonextraction and only maxillary extraction groups. On the other hand, there are no other studies that investigate the arch widths effect of only maxillary first premolar extraction treatments. In this retrospective study, the results showed that nonextraction and only maxillary first premolar extraction cases show significant arch width increases in all the three measurements when there is no skeletal malocclusion.

Zachrisson^[25] has emphasized crown inclination as one of the most important factors in an esthetic smile. Although SWA treatment uses a -9° torque value for maxillary molar brackets, McLaughlin *et al.*^[26] suggest that posterior teeth brackets require additional torque for successful treatment and recommend a value of -14° for maxillary molar brackets. The MBT prescription also recommends buccal crown torques for mandibular molars as well as premolars. Despite differences in bracket prescriptions, this study found posttreatment arch widths and arch width changes to be similar to those reported in the previous studies.^[2-5]

CONCLUSION

Nonextraction treatment and treatment with upper arch extraction only resulted in similar changes in arch width. Extraction treatment with fixed orthodontic mechanics produced no significant changes in either dental arch.

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Conflicts of interest

There are no conflicts of interest.

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