Original Article

Extraction vs Nonextraction: Arch Widths and Smile Esthetics

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Abstract: Dental casts of 30 patients treated with extraction and 30 patients without extraction of four first premolars were randomly selected to determine changes in arch width as a result of treatment. Arch widths were measured from the cusp tips of the canines, premolars, and molars. Posttreatment arch widths were also measured in the midline at a constant arch depth from the most labial surfaces of the incisors. Standardized frontal photographs of the face taken during smiling of 12 extraction- and 12 nonextraction-treated subjects were evaluated. Fifty laypersons judged the esthetics of the smiles. Intercanine width increased less than one mm in both groups, and there was no difference between the two groups. The interpremolar and intermolar distance in both arches decreased significantly from 0.53 to 0.95 mm in the extraction sample, whereas the interpremolar and intermolar widths increased significantly from 0.81 to 2.10 mm in the nonextraction sample. When arch widths of both groups were measured from the most labial surfaces of the teeth at a constant depth, the average arch width of both arches was significantly wider in the extraction sample (1.8 mm wider in the mandible and 1.7 mm wider in the maxilla). The mean esthetic score and the number of teeth displayed during a smile did not differ between the groups. The results indicate that arch width is not decreased at a constant arch depth because of extraction treatment, and smile esthetics are the same in both groups of patients. (*Angle Orthod* 2003;73:354–358.)

Key Words: Smiles; Esthetics; Extraction; Nonextraction; Arch width

The recent criticism concerning the detrimental effects of premolar extraction therapy on smile esthetics[1] has added another dimension to the 100-year-old extraction vs nonextraction debate. Presumably, extraction treatment results in narrower dental arches which, in turn, are associated with a less esthetic smile because the dentition is less full during a smile. In addition, this arch width reduction creates unaesthetic black triangles at the corners of the mouth and 'negative' spaces lateral to the buccal segments.[1,2]

Documentation of the adverse effects of extraction treatment on smiles is scarce. In fact, a Medline search on smiles of extraction and nonextraction patients resulted in only one match, and the data of the cited investigation do not substantiate the assumed unfavorable relationship between extraction treatments and smile esthetics. Johnson and Smith[3] determined that smile esthetics, esthetic scores, and visible dentition during a smile were the same in both extraction and nonextraction patients.

Also, arch width, at least in the intercanine zone, is not necessarily narrower after extraction treatment when compared with nonextraction treatment.[4,5] For example, in comparable groups of patients treated with and without extractions, the posttreatment intercanine widths of the maxillary and mandibular arches were the same in both groups.[5]

Because arch width appears to be a determinant of smile esthetics,[6] the intent of this study is to compare arch width changes in the anterior and posterior parts of the arches as well as smile esthetics in patients treated by extraction and nonextraction procedures.

MATERIALS AND METHODS

Pre- and posttreatment records of 30 randomly selected extraction cases and 30 nonextraction cases were evaluated in this study. In both groups, 18 of the 30 cases were from the archives, and the treatment of the remaining 12 was completed in this study. The only inclusion criteria were that there were no gross dental anomalies or congenitally missing incisors. All patients underwent comprehensive orthodontic therapy with edgewise appliances at a university clinic under the direction of a variety of instructors. In the extraction group, there were 17 boys and 13 girls with a mean age of 14.1 years. Also, there were 18 Class I and 12 Class II, division 1 malocclusions and the average treatment time was 28.1 months. In the nonextraction sample, there were 12 boys and 18 girls with an average age of 14.2 years. In this group, there were 18 Class I and 12 Class

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II, division 1 malocclusions, and the average treatment time was 22.4 months.

Cast evaluation

A black 2H automatic pencil with a 0.5-mm tip was used to mark the mesiobuccal cusps of the first molars, the buccal cusp tips of the second premolars, and the cusp tips of the canines on the maxillary and mandibular arches on the pretreatment (T1) and posttreatment (T2) study models. In cases of wear, estimated cusp tips were used. With a Digit-Cal plus universal digital caliper (Browne and Sharpe Mfg. Co., Kingston, RI), the intermolar, interpremolar, and intercanine widths were measured. A comparison of pretreatment arch widths in the extraction and nonextraction samples was done to establish any arch width differences before treatment. In both groups, changes in arch widths as a result of treatment were recorded as the difference between pretreatment (T1) and posttreatment (T2) measurements

Because the average smile tends to display teeth from incisors to premolars,[7] the arch widths at the region of the premolars is particularly important because it represents the widest part of the arches noted during a smile. For this reason, posttreatment arch widths of both arches were also measured at a constant arch depth representing the premolar-molar junction. The constant arch depth was derived by averaging the arch depths, measured as the distance from a point on the labial aspect between the central incisors to a line connecting the left and right distal contact points of the second premolars of 10 randomly chosen nonextraction posttreatment study models.

The basis for selecting the arch depth of the nonextraction subjects as the standard was that no space closure, which is commonly associated with a decrease in the interpremolar width,[8] was involved. For the maxillary arch, the value was 29.1 + 3.2 mm and for the mandible it was 24.2 ± 2.4 mm. At these specified arch depths, the arch widths, measured from the buccal surface of the most buccal aspect of the tooth, were recorded for all 60 cases. If extraction treatment were to lead to a constriction of the arches, then arch widths in the nonextraction subjects should be larger than the corresponding arch widths of the extraction sample at these arch depths.

Smile evaluation

Close up smile photographs were taken 18 inches from the faces of the 24 individuals who completed treatment during the time period of this study. Twelve subjects were from the extraction group and 12 were from the nonextraction group. Photographs were taken within one month of the completion date. Patients were asked to give a ''pleasing, very natural'' smile. Using a Sony Mavica digital camera at a 1024 × 768 resolution with a standard built-in flash, a black and white, standardized frontal view photograph of the smile was taken. The photos were cropped to display only the immediate perioral area. They were then printed using a Cannon S900 inkjet printer onto glossy photo quality paper and mounted on a black panel. (Because a close-up of the smile is not a standard photograph taken during a records appointment, smile photographs of the other 40 subjects were not available.)

Fifty laypersons were asked to assess and rate the various smile photographs. The raters were first allowed to view all the photographs without being asked to give an evaluation. Then each photograph was presented again, one at a time, to the rater. They were then asked to give each photograph a whole number score between 1 and 10, where 1 is least esthetic and 10 is most esthetic. They were allowed to view all the photographs again and revise their scores if they chose to do so. After the evaluation of the photographs, each rater was asked which characteristics in the photographs led to a high or low score. The photographs were also analyzed to determine the number of teeth displayed in the smile.

Statistical analysis

Standard descriptive statistical calculations were computed for each of the two sample groups. Maxillary and mandibular arch widths were analyzed separately within each sample. Comparisons within the sample group were assessed by Student's paired *t*-tests. Differences between sample groups were tested with the two-sample *t* test. Statistical significance level was established at $P < .05$.

Examiner reliability was evaluated by remeasuring 20 randomly selected cases from the entire sample group. Dahlberg's formula, $SDe = \sqrt{\Sigma D2/2N}$, where D is the difference between double determinations, was then used to calculate the error standard deviations for the arch width measurements.[9] Arch width measurements had an SDe of 0.21 mm. The results of this error study indicate that the measurements are sufficiently reliable to permit the resolution of between treatment differences.

RESULTS

There were no statistically significant differences in the pretreatment arch widths between the extraction and nonextraction groups (Table 1). The average arch widths of the patients in both the extraction and nonextraction groups before and after treatment are listed in Table 2. The arch widths at the end of treatment were significantly changed in both the extraction group and the nonextraction group for all measures, except one. The maxillary intercanine width at the end of treatment in the nonextraction group was not significantly different from the initial measurement.

Table 3 lists the descriptive and comparative statistics of the changes in arch width in both groups when arch widths were measured from the cusp tips of the canines, premolars, and molars. After treatment, there were slight increases in maxillary and mandibular intercanine widths in both

TABLE 1. Pretreatment Descriptive and Comparative Statistics of the Extraction and Nonextraction Groups

	Extraction		Nonextraction		
	Mean	SD	Mean	SD	*t*-test
Intercanine width					
Maxillary	34.84	3.38	34.27	2.43	ns[a]
Mandibular	27.14	2.25	26.44	1.99	ns
Interpremolar width					
Maxillary	44.31	3.78	45.53	3.31	ns
Mandibular	36.89	3.41	38.45	2.50	ns
Intermolar width					
Maxillary	49.71	4.21	50.49	3.37	ns
Mandibular	42.59	3.60	43.79	2.63	ns

[a] ns indicates not significant.

groups, and these changes were not significantly different. In the extraction sample, the increase in intercanine width in the maxillary arch was 0.84 mm, and in the mandibular arch, the increase was 0.51 mm. The intercanine width increase in the nonextraction sample was 0.55 mm in the maxillary arch and 0.43 mm in the lower arch.

The interpremolar and intermolar treatment changes were significantly different between the groups. There was a decrease in interpremolar and intermolar widths in both arches in the extraction sample, whereas these dimensions increased in the nonextraction subjects. In the extraction patients, the maxillary interpremolar width decreased 0.76 mm and the intermolar width 0.53 mm. The decreases in the mandibular interpremolar and intermolar distances were 0.95 and 0.94 mm, respectively. In contrast, the maxillary interpremolar and intermolar widths increased 2.10 and 1.53 mm, respectively, in the nonextraction subjects. The interpremolar and intermolar width increases in the mandibular arch were 1.62 and 0.81 mm, respectively.

The arch width measures at a specified arch depth are listed in Table 4. The widths between the extraction and the nonextraction groups were statistically different for both the mandible and the maxilla. On average, the arch widths were 1.7–1.8 mm greater in the extraction group than in the nonextraction group.

Table 5 lists the mean esthetic scores for the extraction and nonextraction groups. There was no significant difference in the mean esthetic score between the two groups. The number of teeth displayed in the smile was also recorded. Most subjects (50%) displayed 10 teeth and these

TABLE 2. Pretreatment and Posttreatment Arch Width Averages and Standard Deviations for Extraction and Nonextraction Patients

	Extraction					Nonextraction				
	T1		T2			T1		T2		
	Mean	SD	Mean	SD	Significance	Mean	SD	Mean	SD	Significance
Intercanine width										
Maxillary	34.84	3.38	35.69	2.62	**	34.27	2.43	34.83	2.34	ns
Mandibular	27.14	2.25	27.65	1.94	**	26.44	1.99	26.87	1.88	**
Interpremolar width										
Maxillary	44.31	3.78	43.55	2.63	**	45.53	3.31	47.63	2.62	**
Mandibular	36.89	3.41	35.94	2.41	**	38.45	2.50	40.07	1.91	**
Intermolar width										
Maxillary	49.71	4.21	49.17	3.23	**	50.49	3.37	52.02	2.96	**
Mandibular	42.59	3.60	41.65	3.15	**	43.79	2.63	44.59	2.24	**

** $P < .01$; ns indicates not significant.

TABLE 3. Descriptive and Comparative Statistics of the Changes in the Dental Arch Dimension from Posttreatment to Pretreatment (T2-T1)

	Extraction			Nonextraction			
Measure	Mean	SD	Range	Mean	SD	Range	Significance
Intercanine width (T2-T1)							
Maxillary	0.84	1.16	−2.00–2.88	0.55	1.78	−2.60–4.85	ns
Mandibular	0.51	1.12	−1.66–2.67	0.43	0.79	−1.20–2.87	ns
Interpremolar width (T2-T1)							
Maxillary	−0.76	1.86	−3.90–3.79	2.10	1.90	−1.79–6.03	**
Mandibular	−0.95	1.79	−4.48–2.63	1.62	1.31	−0.72–5.04	**
Intermolar width (T2-T1)							
Maxillary	−0.53	1.39	−3.85–2.28	1.53	1.75	−2.47–5.16	**
Mandibular	−0.94	1.38	−3.84–3.05	0.81	1.02	−0.83–3.29	**

** $P < .01$; ns indicates not significant.

TABLE 4. Average Arch Width at a Given Arch Depth

	Extraction		Nonextraction			
	Mean	SD	Mean	SD	Difference	Significance
Mandible arch depth of 24.2 mm	49.2	2.1	47.4	2.2	1.8	*
Maxilla arch depth of 29.1 mm	54.0	2.9	52.3	2.4	1.7	*

* $P < .05$.

TABLE 5. Descriptive Statistics for Smile Esthetics and Differences Between Extraction and Nonextraction Patients

	Nonextraction			Extraction			
	Mean	SD	Range	Mean	SD	Range	Significance
Esthetic score	7.02	1.19	5.3–9.7	6.46	1.09	4.8–9.0	ns

were equally distributed between both the extraction and nonextraction groups. Thirty-three percent of the subjects displayed eight teeth and 17% displayed 12 teeth. Interestingly, the two groups had identical distributions.

DISCUSSION

The stimulus for this investigation was the assertion that extraction treatment is tantamount to constriction of the dental arches, and this decreased arch width has deleterious effects on smile esthetics, particularly when compared with nonextraction treatment.[1] The implication is that nonextraction treatment will result in broader dental arches and more attractive smiles. The data of the present study indicate that this belief may be grossly exaggerated.

There are two issues that require examination. One is that arch widths after extraction treatment are narrower than arch widths after nonextraction treatment. The second is that the smiles of patients treated by extraction procedures are less esthetic than smiles of individuals treated without extractions.

In this study, conventional arch width measurements between the canines, second premolars, and molars were supplemented with a measurement of posterior arch width at a standardized arch depth extending from the incisors to the second premolar area of nonextraction-treated individuals. This measurement was made because a focal point of the present investigation is the interrelationship between arch width and smile esthetics, and the average smile in untreated individuals displays teeth from incisors to premolars.[7] In this context, the arch depth of the nonextraction subjects was selected as the standard because closure of extraction sites often results in mesial movement of the premolars and molars to a narrower part of the arch.[4,5,8] Because premolar and molar A-P position changes during extraction treatment, posterior arch width is best represented by the arch width at a specified location rather than the more customarily cited interpremolar and intermolar widths.

The anterior segments of both arches represented by the intercanine widths were the same before treatment and increased less than one mm as a result of treatment. These increases were not significantly different between the groups. These results are similar to the 0.9- to 1.4-mm increases in intercanine dimensions recorded as a result of treatment of ''clear cut'' extraction and nonextraction patients.[5] They are smaller than the 3 mm increases in maxillary intercanine widths noted in extraction-treated subjects.[8]

In contrast, at the standardized arch depth, the widths of both arches of the extraction subjects were 1–2 mm larger when compared with the arch widths of the nonextraction group. Although the small increase in posterior arch width is of no practical consequence, it reinforces the view that arch constriction after extraction therapy is not a usual and customary result. It also supports the belief expressed by Johnson and Smith that ''typically, transverse arch width at any particular location in the buccal segments is maintained or slightly enlarged after extraction.''[3] They further suggested that those who believe that premolar extraction results in a reduction of the radius of the curve of the dental arch are incorrect because the dental arch is not a circle and does not behave as a circle.

When arch widths were measured from the cusp tips of molars and second premolars, there were the anticipated increases (0.81–2.1 mm) in the buccal segments of the nonextraction-treated patients and decreases (less than one mm) in the extraction group. The largest increases were noted in the second premolar widths. These are expected results because nonextraction treatment should be expansionary to avoid creating crossbites in the buccal segments of the maxillary arch,[10] and molar and second premolar widths, after extraction treatment, are generally smaller, reflecting mesial movement of the posterior teeth into narrower parts of the arch.[5,8] Comparable increases in the interpremolar and intermolar widths in nonextraction groups and slight decreases in both measurements in extraction-treated individuals have been noted by others.[8] For example, in girls, after nonextraction treatment, the maxillary arch interpremolar distance increased 3.3 mm and the intermolar width in-

creased 1.8 mm. In the mandibular arch after extraction treatment, the width between the second premolars decreased −0.2 mm and the intermolar width decreased −1.0 mm.[8]

The supposition that smiles of extraction-treated patients are less esthetic was not corroborated because there was no difference in smile esthetic scores between the two groups. At the risk of being simplistic, this is a logical expectation because the arch widths of both groups were, for practical purposes, equal, and arch width is an important determinant of smile esthetics.[6] The inability to correlate smile esthetics with treatment modality was also noted by other investigators who found no difference in smile esthetic scores of extraction and nonextraction patients.[3] Similarly, when assessing facial photographs, experienced orthodontists and general dentists could not identify whether the treatment was extraction or nonextraction.[11] At present, there are no studies that have determined that smile esthetics differs according to the type of treatment.

However, in judging smile esthetics, many variables are present and some are beyond conventional control. The raters were asked to define the characteristics that led to higher or lower scores. Most comments concerned the proportion of teeth in relation to each other. Additional factors included the appearance of the teeth, the height of the teeth shown, and the symmetry of the smile. Others have related these features to smile esthetics. For example, Janzen observed an improvement in smile esthetics after intrusion of the maxillary incisors coupled with appropriate root torque.[12] Also, the symmetry of the smile was positively associated with a ''good smile'' and no smiles that were asymmetric were given high smile scores.[13]

In the present investigation, only one of the 50 raters pointed to the presence of dark triangles at corners of the mouth as a reason for judging the smiles as less attractive. This observation supports Husley's[13] conclusion that the buccal corridor ratio, defined as the ratio of the intercanine width and the width of the smile, ''appeared to be of no significance to an attractive smile.'' In addition, Rigsbee et al[14] determined that there is no difference in the ratios of orthodontically treated subjects and untreated individuals.

Another important consideration in smile esthetics is the smile arc, which relates the curvature of the incisal edges of the maxillary incisors to the curvature of the lower lip in a posed smile. Ideally, the curvature of the maxillary incisors should be parallel to the curvature of the lower lip.[15] Smile arc flattening, exemplified by a maxillary incisor arc line that is flatter than the curvature of the lower lip in a posed smile, can occur during orthodontic treatment,[16] and the resultant smile is considered to be less attractive when compared with smiles with ideal smile arcs.[15]

The subjects evaluated in the present study were treated with conventional fixed appliances, and there were no attempts to expand the arches because arch width expansion, particularly in the anterior part of the arch, is not stable.[17] For this reason, the data of this investigation may not apply to individuals whose treatment included purposeful arch expansion. Yet, the recorded arch width measurements, as noted, are similar to those documented in other reports,[4,5,8] indicating that the data apply to a large percentage of patients.

CONCLUSIONS

The results of this study indicate that constricted arch widths are not a usual outcome of extraction treatment and that neither extraction nor nonextraction treatment has a preferential effect on smile esthetics.

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