European Journal of Orthodontics 27 (2005) 585–589
doi:10.1093/ejo/cji057
Advance Access publication 28 October 2005

A comparative study of dental arch widths: extraction and non-extraction treatment

Fulya Işık, Korkmaz Sayınsu, Didem Nalbantgil and Tülin Arun
Faculty of Dentistry, Yeditepe University, Istanbul, Turkey

SUMMARY The aim of this study was to determine the pre- and post-treatment width changes in the canine, premolar and molar regions in subjects treated with extraction of four first premolars, non-extraction, and non-extraction with rapid maxillary expansion (RME).

Pre- and post-treatment orthodontic study models of 60 females (13.83 ± 2.77 years) and 24 males (14.33 ± 2.67 years) who underwent comprehensive orthodontic therapy were evaluated. Forty-two were treated non-extraction with fixed appliance therapy, 15 non-extraction with RME, and 27 with extraction of the first premolars. In addition to standard descriptive statistical calculations, one way ANOVA was used for comparison of the groups, and the *post hoc* Tukey multiple comparison test for comparison of the subgroups.

The results revealed that the distance between the upper canines was not affected by the treatment modality. Upper premolar and molar arch widths increased more in the non-extraction subjects when compared with those with extractions, with the greatest increase in patients with RME. In the lower canine area the extraction group showed the widest arch width at the end of treatment. There was also a 0.60 mm decrease in the lower canine width in the non-extraction group. A decrease was found in lower inter-premolar and molar distances due to consolidation of the extraction spaces.

When making a decision between non-extraction with maxillary expansion and extraction treatment modalities in borderline cases where there is constriction in the upper inter-premolar distance, apart from taking profile values into consideration, it should be borne in mind that expansion treatment can be helpful in achieving a wider arch form.

Introduction

In line with modern orthodontic techniques, a specific treatment plan is designed for each patient, with treatment techniques chosen to meet the patient's specific needs. A narrow upper arch requires rapid maxillary expansion (RME), whereas an extremely protrusive profile necessitates the extraction of permanent teeth. In cases where there is a misjudgement in indications, treatments that entail extractions may affect not only the aesthetics of the smile but the whole face, resulting in patients with 'dished-in' profiles. Particularly in the decision-making process regarding borderline patients, choosing a treatment plan that suits the profile characteristics of the patient is essential.

The aesthetics of the smile involve all factors related to the face such as the motion of the jaw and alterations in the nose and eyelids (Rigsbee *et al*., 1988), as well as the teeth, namely the parallelism of the lower lip contour to incisal line, the presence of no asymmetry (Hulsey, 1970) and the amount of maxillary gingival display (Peck *et al.*, 1992a,b).

The theory claiming the contraction of the dental arch in extraction treatment has again become a point of discussion. Some authors claim that arch width is an important factor in obtaining a 'full smile' (McNamara, 2000) and that extraction treatments constrict arch form (Dierkes, 1987; Spahl and Witzig, 1987), while others report that smile aesthetics are not dependent only on arch width (Zachrisson, 2001; 2002) and that extraction treatments do not constrict arch form (Gianelly, 2003; Kim and Gianelly, 2003).

Patients with an apparent narrowness in the upper arch and dark buccal corridors in their smiles, have the indication for expansion of the maxillary arch through RME. It is known that RME increases the width and even the length of the arch (Adkins *et al.*, 1990). Yet in investigations regarding the change of width resulting from extraction or non-extraction treatments in dental arches, patients treated with RME are either not mentioned or are excluded (Gianelly, 2003; Kim and Gianelly, 2003). As for studies investigating relapse following RME, they do not include any comparisons with extraction or non-extraction patients without expansion (Moussa *et al*., 1995; McNamara *et al.,* 2003).

The objective of this study was to assess changes in width in the canine, premolar and molar sections of dental arches before and after treatment of the following three types of patients: those who had their lower and upper first premolars extracted, patients without any extractions and non-extraction patients treated with RME.

Materials and methods

Materials

Pre- and post-treatment orthodontic models of 84 patients comprised the subject matter of this retrospective study (Table 1). The inclusion criteria were based on there being no dental anomalies, congenitally missing teeth or extracted teeth prior to orthodontic planning. Patients underwent comprehensive orthodontic therapy in a university clinic under the supervision of three faculty members. Of these 84 patients, 42 were treated non-extraction with fixed appliance therapy, 15 non-extraction with RME and fixed appliance therapy, and the remaining 27 patients with the extraction of the first premolars and fixed appliances.

Data collection

A universal digital calliper was used to measure the inter-molar, inter-premolar and inter-canine widths on the upper and lower dental casts. The distance between the mesio-buccal cusp tips of the molars, buccal cusp tips of the first and second premolars and cusp tips of the canines were measured in order to determine the inter-molar, inter-premolar and inter-canine distances.

Statistical methods

Statistical calculations were performed with the GraphPad Prisma© Software Version 3.0 for Windows (San Diego, California, USA). In addition to standard descriptive statistical calculations (mean and standard deviation), one way ANOVA was used for comparison of the groups, and the *post hoc* Tukey multiple comparison test for comparison of the subgroups. A paired *t*-test was employed in the assessment of pre- and post-treatment values, and the Chi square test for evaluation of the qualitative data. The results were evaluated within a 95 per cent confidence interval. The statistical significance level was established at $P < 0.05$.

To evaluate measurement error, the records of 20 patients (40 sets of study casts) were selected at random and the experimental procedure repeated. The minimum correlation coefficient (r = 0.92) was found in the lower canine measurements, with a mean correlation coefficient of 0.96 and an absolute mean value of 0.34 mm.

Table 1 Means and standard deviations of the study groups.

	Non-extraction ($n = 42$)	Expansion ($n = 15$)	Extraction ($n = 27$)	*P*
Age	14.21 ± 2.79	14.03 ± 2.87	13.57 ± 2.58	> 0.05
Gender				
Male	13 (31%)	4 (26.7%)	7 (25.9%)	> 0.05
Female	29 (69%)	11 (73.3%)	20 (74.1%)	

Results

Comparison of pre-treatment models

In the upper arch all teeth except the canines, and in the lower arch only the second premolars, showed differences between the groups (Tables 2 and 3).

Evaluation of the upper arch. The differences between the groups are shown in Table 4. The difference in the upper inter-first premolar width between the groups originates from the high values recorded in the non-extraction group.

Table 2 Pre- and post-treatment means and standard deviations for upper teeth.

	Non-extraction ($n = 42$)	Expansion ($n = 15$)	Extraction ($n = 27$)	*P*
Upper canine				
Pre	34.02 ± 2.93	33.07 ± 1.94	34.33 ± 3.57	ns
Post	35.44 ± 1.58	35.92 ± 1.72	36.05 ± 1.74	ns
P	***	***	*	
Upper first premolar				
Pre	40.67 ± 2.61	38.36 ± 2.56	38.97 ± 2.05	**
Post	42.82 ± 1.80	43.42 ± 1.64		ns
P	***	***		
Upper second premolar				
Pre	45.81 ± 2.95	43.77 ± 2.71	43.28 ± 3.77	**
Post	47.92 ± 2.10	48.94 ± 2.01	43.31 ± 2.22	***
P	***	***	ns	
Upper first molar				
Pre	50.79 ± 2.83	48.87 ± 2.16	49.40 ± 2.88	*
Post	52.37 ± 2.23	53.08 ± 2.53	48.52 ± 2.40	***
P	***	***	*	

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$; ns, not significant.

Table 3 Pre- and post-treatment means and standard deviations for lower teeth.

	Non-extraction ($n = 42$)	Expansion ($n = 15$)	Extraction ($n = 27$)	*P*
Upper canine				
Pre	26.88 ± 1.75	26.33 ± 1.79	26.75 ± 2.34	ns
Post	26.29 ± 1.22	26.20 ± 1.07	27.36 ± 1.31	***
P	*	ns	ns	
Upper first premolar				
Pre	34.43 ± 2.25	33.47 ± 2.29	33.64 ± 2.32	ns
Post	35.19 ± 1.33	35.52 ± 1.25		ns
P	*	***		
Upper second premolar				
Pre	40.29 ± 2.58	39.51 ± 2.78	38.50 ± 3.29	*
Post	40.97 ± 1.70	41.49 ± 1.93	35.86 ± 1.70	***
P	*	**	***	
Upper first molar				
Pre	44.90 ± 2.98	44.74 ± 3.63	43.50 ± 2.64	ns
Post	46.02 ± 2.52	46.37 ± 2.92	42.08 ± 2.13	***
P	***	*	**	

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$; ns, not significant.

When the inter-second premolar and inter-molar distances were evaluated, a significant difference was observed between the extraction and non-extraction groups.

Evaluation of the lower arch. The only marked difference was for the inter-second premolar width between the extraction and non-extraction groups (Table 4).

Comparison of pre- and post-treatment values

Evaluation of the upper arch. With all three treatment modalities, the upper inter-canine distance increased by the end of treatment (Table 2). This increase was 2.85 mm in the non-extraction expansion group, 1.42 mm in the non-extraction group, and 1.72 mm in the extraction group (Table 5). The non-extraction groups showed a considerable increase in arch width in the premolar and molar regions. The mean inter-first premolar distance increase was 5.06 mm in the non-extraction expansion group, yet the matching value for the extraction group was 2.15 mm. The mean inter-second premolar width increases were 2.11 and 5.17 mm for the non-extraction and non-extraction expansion groups, respectively. In the molar area, there was a 1.58 mm increase for the non-extraction, a 4.21 mm increase for the non-extraction expansion, and a 0.88 mm decrease for the extraction group.

Table 4 Pre- and post-treatment statistical significance of intra-group differences in the upper and lower arches: Tukey multiple comparison test.

	Non-extraction/ expansion	Non-extraction/ extraction	Expansion/ extraction
Upper canine			
Pre			
Post			
Upper first premolar			
Pre	**	*	ns
Post			
Upper second premolar			
Pre	ns	**	ns
Post	ns	***	***
Upper first molar			
Pre	ns	*	ns
Post	ns	***	***
Lower canine			
Pre			
Post	ns	**	*
Lower first premolar			
Pre			
Post			
Lower second premolar			
Pre	ns	*	ns
Post	ns	***	***
Lower first molar			
Pre			
Post	ns	***	***

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$; ns, not significant.

Table 5 Statistical significance of pre- and post-treatment differences.

	Non-extraction ($n = 42$)	Expansion ($n = 15$)	Extraction ($n = 27$)	P
Upper canine	1.42 ± 2.74	2.85 ± 1.96	1.72 ± 3.95	ns
Upper first premolar	2.15 ± 1.86	5.06 ± 2.85		***
Upper second premolar	2.11 ± 1.69	5.17 ± 1.93	0.03 ± 3.31	***
Upper first molar	1.58 ± 1.62	4.21 ± 2.29	−0.88 ± 1.66	***
Lower canine	−0.60 ± 1.71	−0.13 ± 1.22	0.61 ± 1.99	*
Lower first premolar	0.75 ± 2.02	2.05 ± 1.84		*
Lower second premolar	0.68 ± 1.90	1.99 ± 2.02	−2.64 ± 3.10	***
Lower first molar	1.12 ± 1.68	1.63 ± 2.54	−1.42 ± 2.08	***

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$; ns, not significant.

Evaluation of the lower arch. The non-extraction group showed a statistically significant decrease of 0.6 mm in the lower inter-canine distance (Table 5).

For the inter-first premolar width there was a notable increase of 0.75 mm in the non-extraction and 2.05 mm in the non-extraction expansion group. The considerable amount of change in the values for the lower inter-second premolar and inter-molar distances demonstrated an increase in the non-extraction groups and a decrease in the extraction group.

Comparison of treatment subgroups

Evaluation of the upper arch. The only parameter that did not show any statistically significant difference in the pre- and post-treatment values between subgroups was the upper inter-canine width (Table 5). Assessment of the values for the upper first premolar region showed a substantial difference between the non-extraction groups (Table 5). The upper second premolar and molar regions showed a significant difference among the subgroups.

Evaluation of the lower arch. The significant difference in inter-canine widths was apparent between the non-extraction and extraction groups (Table 6). For the second premolar and molar regions, there was an evident difference between the extraction group and the other groups.

Discussion

This investigation incorporated the issue of maxillary expansion into the extraction versus non-extraction debate. However, it should be borne in mind that this study only relates to the treatment findings and that the long-term stability of the treatment approaches may lead to differences between the groups in terms of relapse and post-treatment changes.

Table 6 Statistical significance of inter-group differences: Tukey multiple comparison test.

	Upper canine	Upper second premolar	Upper first molar	Lower canine	Lower second premolar	Lower first molar
Non-extraction/ expansion		***	***	ns	ns	ns
Non-extraction/ extraction		**	***	*	***	***
Expansion/ extraction		***	***	ns	***	***

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$; ns, not significant.

Since the mean age for the study group was 14 years, the effects of growth and development were not of concern (Lee, 1999).

The arch widths in this investigation were measured from the buccal cusp tips. Studies measuring the arch widths from the most buccal points on the teeth have disregarded the bucco-lingual inclinations of the related teeth (Gianelly, 2003). If teeth are palatally inclined in a wide alveolar arch, measurements carried out on the most buccal aspects of the teeth present the dental arch as a wide one, whereas measurements carried out on the cusp tips reflect the arch as it is during smiling. When the crown inclination is taken into consideration as the key factor for a full and radiant smile (Zachrisson, 2001; 2002), the location of the measurement registration is of importance.

The assessment of the data for the upper inter-canine distance reveals an increase in all treatment groups. This increase in inter-canine width in the upper arch after orthodontic treatment with fixed appliances is in agreement with previous findings (Sadowsky *et al.*, 1994; Moussa *et al*., 1995; Elms *et al.*, 1996; Bishara *et al*., 1997).

The difference among the groups in the pre-treatment values for the upper inter-first premolar width arises from the larger distance in the non-extraction group compared with the other two groups. Such data indicate a specific arch form in the patients with indication for extraction or non-extraction with RME, where there is a constriction in the premolar region. In these cases, the treatment plan is established mostly by taking the profile values of the patient into consideration.

The 2.15 mm increase in the upper inter-first premolar distance in the non-extraction group is in agreement with the 2.7 mm increase reported by Sadowsky *et al.* (1994). It was found in the present study that the inter-premolar distance for the upper arch increased more in the non-extraction group with RME than in the extraction group. The greater increase in the expansion group is a result of constriction in the premolar area. Thus, as reported previously, this may be the most crucial parameter for smile aesthetics (Tjan *et al*., 1984; Zachrisson, 2001; 2002).

Regarding the increase in the upper inter-premolar distance, the expansion group exhibited a two-fold increase in comparison with the non-extraction group. In a study by Adkins *et al*. (1990), a 6.1 mm increase was reported for the inter-premolar arch width just after RME. This finding is also in agreement with the 5 mm increase obtained in the expansion group.

A comparison of pre- and post-treatment values in the upper arch showed an increase in all measurements except those for the second premolars and molars (Table 5). These results may be due to the mesial movement of these teeth towards the narrower anterior part of the arch form (Paquette *et al*., 1992; Luppanapornlarp and Johnston, 1993; Bishara *et al*., 1997). This finding is in agreement with the 1.53 mm increase found by Kim and Gianelly (2003) for the upper inter-molar distance in non-extraction cases, and the 0.53 mm decrease for the extraction cases. It is also in agreement with the 4.5 and 3 mm increases in inter-molar distance reported by Sadowsky *et al.* (1994) and Elms *et al.* (1996). The data for the upper inter-molar distance show that the 4.21 mm increase in the RME group is in conformity with the 5.6 mm increase post-retention reported by Moussa *et al*. (1995).

In the lower arch, there was a 0.6 mm decrease in inter-canine width in the non-extraction group. However, when the post-treatment values are compared, it is evident that the extraction treatment group values are significantly higher. This finding can be explained by the movement of the canines to a more posterior and therefore wider place in the arch. In studies where lower relapse has been investigated, the results of model analysis show that non-extraction treatment increases the inter-canine distance by approximately 0.5 mm (Glenn *et al*., 1987; Paquette *et al*., 1992; Moussa *et al*., 1995; Azizi *et al*., 1999; Yavari *et al*., 2000). BeGole *et al*. (1998) found that with non-extraction therapy, lower inter-canine distance increased by 0.95 mm. Though not statistically significant, Gianelly (2003) mentioned a 0.69 mm increase in lower inter-canine distance in an investigation of arch widths in extraction and non-extraction treatments, and in another related study a 0.43 mm increase in lower inter-canine distance (Kim and Gianelly, 2003). In the present investigation, the decrease in lower inter-canine distance in the non-extraction group may be due to the arch forms being shaped so as to retain the inter-canine distance at the start of the treatment. Some space may also be obtained through stripping when necessary.

The values for lower inter-second premolar and molar widths indicate an increase in the non-extraction groups and a decrease in the extraction group which may be the result of movement of the posterior teeth to a narrower anterior part of the arch similar to the upper arch (Paquette *et al*., 1992; Luppanapornlarp and Johnston, 1993; Bishara *et al*., 1997).

The results of this study for the lower inter-premolar distance are parallel to the 1.62 mm increase in non-extraction

and 0.95 mm decrease in extraction treatments reported by Kim and Gianelly (2003) as well as to the 1.24 mm increase in non-extraction and 2.95 mm decrease in extraction treatments in the study of Gardner and Chaconnas (1976). Similarly, the findings for lower inter-molar distance are in line with those of Kim and Gianelly (2003) who reported an increase of 0.81 mm in non-extraction and a decrease of 0.94 mm with extraction therapy, and with the findings of Gardner and Chaconnas (1976) of a 1.98 mm increase in non-extraction and a 1.49 mm decrease in extraction treatments.

Conclusions

1. There is no difference between the effects of extraction, non-extraction and non-extraction expansion treatment modalities on the distance between the upper canines.
2. Upper premolar and molar arch widths increase more in non-extraction when compared with extraction therapies, with the largest increase in patients with RME.
3. In the lower canine area the extraction group presented the widest arch width at the end of the treatment. In addition, a 0.6 mm decrease was found in the lower inter-canine width in the non-extraction group.
4. There is a decrease in lower inter-premolar and molar distances due to consolidation of extraction spaces.
5. When making a decision between non-extraction with RME and extraction treatment in borderline cases where there is constriction in the upper inter-premolar distance, apart from taking profile values into consideration, it should be borne in mind that expansion treatment can be of help in achieving a wider arch form.

Address for correspondence

Dr Fulya Işık
Yeditepe University
Faculty of Dentistry
Bagdat cad. No 238
Göztepe
İstanbul 81006
Turkey
E-mail: tarun@yeditepe.edu.tr

References

Adkins M D, Nanda R S, Currier G F 1990 Arch perimeter changes on rapid palatal expansion. American Journal of Orthodontics and Dentofacial Orthopedics 97: 194–199

Azizi M, Shrout M K, Haas A J, Russell C M, Hamilton Jr E H 1999 A retrospective study of Angle Class I malocclusions treated orthodontically without extractions using two maxillary expansion methods. American Journal of Orthodontics and Dentofacial Orthopedics 116: 101–107

BeGole E A, Fox D L, Sadowsky C 1998 Analysis of change in arch form with premolar expansion. American Journal of Orthodontics and Dentofacial Orthopedics 113: 307–315

Bishara S E, Cummins D M, Zaher A R 1997 Treatment and post treatment changes in patients with Class II division 1 malocclusion after extraction and nonextraction treatment. American Journal of Orthodontics and Dentofacial Orthopedics 111: 18–27

Dierkes J M 1987 The beauty of the face: an orthopedic perspective. Journal of the American Dental Association (Special Issue): 89E–95E

Elms T N, Buschang P H, Alexander R G 1996 Long-term stability of Class II, division 1, nonextraction cervical face-bow therapy: I. Model analysis. American Journal of Orthodontics and Dentofacial Orthopedics 109: 271–276

Gardner S D, Chaconas S J 1976 Posttreatment and postretention changes following orthodontic therapy. Angle Orthodontist 46: 151–161

Gianelly A A 2003 Arch width after extraction and nonextraction treatment. American Journal of Orthodontics and Dentofacial Orthopedics 123: 25–28

Glenn G, Sinclair P M, Alexander R G 1987 Nonextraction orthodontic therapy: posttreatment dental and skeletal stability. American Journal of Orthodontics and Dentofacial Orthopedics 92:321–328

Hulsey C M 1970 An esthetic evaluation of lip–teeth relationships present in the smile. American Journal of Orthodontics 57: 132–144

Kim E, Gianelly A A 2003 Extraction vs nonextraction: arch widths and smile esthetics. Angle Orthodontist 73: 354–358

Lee R T 1999 Arch width and form: a review. American Journal of Orthodontics and Dentofacial Orthopedics 115: 305–313

Luppanapornlarp S, Johnston Jr L E 1993 The effects of premolar extraction: a long term comparison of outcomes in 'clear-cut' extraction and nonextraction Class II patients. Angle Orthodontist 64: 257–272

McNamara Jr J A 2000 Maxillary transverse deficiency. American Journal of Orthodontics and Dentofacial Orthopedics 117: 567–570

McNamara Jr J A, Baccetti T, Franchi L, Herberger T A 2003 Rapid maxillary expansion followed by fixed appliances: a long term evaluation of changes in arch dimensions. Angle Orthodontist 73: 344–353

Moussa R, O' Reilly M T, Close J M 1995 Long-term stability of rapid palatal expander treatment and edgewise mechanotherapy. American Journal of Orthodontics and Dentofacial Orthopedics 108: 478–488

Paquette D E, Beattie J R, Johnston Jr L E 1992 A long-term comparison of nonextraction and premolar extraction edgewise therapy in 'borderline' Class II patients. American Journal of Orthodontics and Dentofacial Orthopedics 102: 1–14

Peck S, Peck L, Kataja M 1992a Some vertical lineaments of lip position. American Journal of Orthodontics and Dentofacial Orthopedics 101: 519–524

Peck S, Peck L, Kataja M 1992b The gingival smile line. Angle Orthodontist 62: 91–100; discussion 101–103

Rigsbee III O H, Sperry T P, BeGole E A 1988 The influence of facial animation on smile characteristics. International Journal of Adult Orthodontics and Orthognathic Surgery 3: 233–239

Sadowsky C, Schneider B J, BeGole E A, Tahir E 1994 Long-term stability after orthodontic treatment: nonextraction with prolonged retention. American Journal of Orthodontics and Dentofacial Orthopedics 106: 243–249

Spahl T J, Witzig J W 1987 The clinical management of basic maxillofacial orthopedic appliances. Vol.1. Mechanics. PSG Publishing Co., Littleton, Massachusetts

Tjan A H L, Miller G D, The J G P 1984 Some esthetic factors in a smile. Journal of Prosthetic Dentistry 51: 24–28

Yavari J, Shrout M K, Russell C M, Haas A J, Hamilton E H 2000 Relapse in Angle Class II division 1 malocclusion treated by tandem mechanics without extraction of permanent teeth: a retrospective analysis. American Journal of Orthodontics and Dentofacial Orthopedics 118: 34–42

Zachrisson B U 2001 Maxillary expansion, long-term stability and smile esthetics. World Journal of Orthodontics 2: 266–272

Zachrisson B U 2002 Making the premolar extraction smile full and radiant. World Journal of Orthodontics 3: 260–265