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Correspondence address
Yazışma adresi

Esra BOLAT GUMUS
Department of Orthodontics,
Faculty of Dentistry,
Akdeniz University
Antalya, Turkiye
dtesrabolat@gmail.com

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Eylul POLATCAN KILIC
Orthodontist, Privite Practice,
Antalya, Turkiye
ORCID ID: 0000-0003-1047-080X

Esra BOLAT GUMUS
Department of Orthodontics,
Faculty of Dentistry,
Akdeniz University,
Antalya, Turkiye
ORCID ID: 0000-0002-6156-3515

Evaluation of the Effects of Asymmetric Premolar Extraction Treatment on Arch Form and Symmetry

Asimetrik Premolar Çekimli Ortodontik Tedavilerin Ark Formu ve Simetrisi Üzerine Etkilerinin Değerlendirilmesi

ABSTRACT

Objectives:

The study aimed to evaluate the effects of different extraction protocols on arch form and symmetry.

Material and Methods:

In this retrospective dental cast study, participants included 86 patients with a mean age of 14.6 (± 2.3) years. Our study groups were: asymmetric extraction (first premolar on one side and second premolar on the opposite side); unilateral extraction (one-sided first premolar); bilateral extraction (first premolar on both sides).Upper and lower dental casts were evaluated separately, based on previously noted extraction protocols. Consequently, 115 upper and lower dental casts were selected among the 172 dental casts of 86 patients. All measurements were performed digitally. The median palatal suture and the anterior reference plane were used as the primary planes for digital model analysis. Cephalometric analyses of dental measurements were also performed.

Results:

The bilateral extraction protocol resulted in a statistically significant decrease in transverse-direction asymmetry in the anterior region of the lower jaw. Due to unilateral extraction, an increase in anteroposterior asymmetry was observed in the posterior region of the upper jaw, whereas in the lower jaw, asymmetry was decreased for the same parameter ($P < 0.05$).

Conclusion:

Asymmetric and bilateral extraction protocols reduced the asymmetry of the arch length in the upper jaw. The effects of asymmetric and bilateral extraction protocols on arch asymmetry were found to be similar. While these extraction protocols do not generally cause a significant change in arch asymmetry, in some cases, they had a positive effect on reducing asymmetry. The unilateral extraction protocol had an increased effect on arch length asymmetry.

Key Words:

Dental arch, Asymmetry, Tooth extraction, Orthodontic treatment

ÖZ

Amaç:

Bu çalışmanın amacı farklı çekim protokollerinin ark formu ve simetrisi üzerine etkilerinin değerlendirilmesidir.

Gereç ve Yöntemler:

Bu retrospektif model çalışmasında, katılımcılar yaş ortalaması 14.6 (± 2.3) yıl olan 86 hasta idi. Çalışma gruplarımız: asimetrik çekim (bir tarafta birinci premolar ve karşı tarafta ikinci premolar); tek taraflı çekim (tek taraflı birinci premolar); çift taraflı çekim (her iki tarafta birinci premolar) şeklindeydi. Üst ve alt dental modeller; önceden belirlenmiş çekim protokollerine dayanarak ayrı ayrı değerlendirildi. Sonuç olarak, 86 hastaya ait 172 dental modelden 115 üst ve alt model seçildi. Tüm ölçümler dijital olarak yapıldı. Median palatal sutur ve anterior referans düzlemi, dijital model analizi için temel düzlemler olarak kullanıldı. Dişsel ölçümlerin sefalometrik analizleri de yapıldı.

Bulgular:

İki taraflı çekim protokolü, alt çenenin ön bölgesinde transversal yönde asimetrinin istatistiksel olarak azalmasına neden oldu. Tek taraflı çekim sonucunda ise üst çenenin arka bölgesinde anteroposterior asimetrinin arttığı gözlendi, bu arada alt çenede aynı parametre için asimetrinin azaldığı belirlendi ($P < 0.05$).

Sonuç:

Asimetrik ve çift taraflı çekim protokolleri üst çenenin ark uzunluğundaki asimetrinin azalmasına neden olurken; ark asimetrisi üzerindeki etkilerinin benzer olduğu bulundu. Bu çekim protokolleri genellikle ark asimetrisinde önemli bir değişikliğe neden olmasa da, bazı durumlarda asimetrinin azalmasında olumlu etkileri olduğu izlendi. Tek taraflı çekim protokolünün ise ark uzunluğu asimetrisi üzerinde arttırıcı bir etkisi bulunmaktadır

Anahtar Sözcükler:

Dental ark, Asimetri, Diş çekimi, Ortodontik tedavi

INTRODUCTION

Since the initiation of orthodontics as a medical field, clinicians have recognized that orthodontic treatment can affect patients' physical profile and facial aesthetics. However, there remains a lack of agreement on whether to effect tooth extraction as a means for achieving a good profile with pleasing facial aesthetics (1-3). The decision to extract thus remains a critical (4-6) factor when planning orthodontic treatment. Many studies indicate that premolars are the most commonly extracted teeth for orthodontic purposes. Located between the anterior and posterior segments of the dental arches, premolar extraction facilitates the elimination of crowding and the correction of incisor relationships (6). Various authors (4-8) have proposed a variety of extraction protocols, e.g., extraction of maxillary and mandibular first and/or second premolars. In some cases (9-11) unilateral premolar and asymmetric premolar (the first premolar on one side of the arch and the second premolar on the opposite side) may be preferred. Unilateral extractions are generally preferred when occlusal asymmetries are severe, to the degree that they cannot be corrected only by asymmetric mechanics, or when they are not severe enough to require surgical intervention. They also aid in applying normal treatment mechanics symmetrically and pose fewer side-effects. Other advantages of unilateral extraction include preserving the molar relationship, reducing treatment time, and allowing midline correction without causing inclination of the occlusal plane (12). Asymmetric premolar extractions are generally preferred; this is the case even when 2 first premolar extractions are an acceptable treatment plan, but there is a condition requiring second premolar extraction on one side of the arch (adjustment of molar anchorage, second premolar tooth with large decay, canal treatment, etc.) (13).

It is reasonable to assume that unilateral and asymmetric premolar extractions may effect different results on the arch form between the 2 sides of the arch since the impact of extraction on the arch form and width have been indicated (14-16). Studies (15-17) have been published that evaluated arch symmetry following unilateral extraction treatments. However, to our knowledge, no published study has evaluated the effects of unilateral and asymmetric extraction protocols on arch symmetry. Our study aimed to evaluate the effects of asymmetric, unilateral, and bilateral extraction protocols on arch form and symmetry.

MATERIALS and METHODS

This study was approved by the Antalya Training and Research Hospital Ethics Committee. In this single-centered retrospective study, the records of patients whose treatments had been completed at Akdeniz University Faculty of Dentistry Department of Orthodontics, by the same orthodontist (E.P.K.) between the years 2016-2018, were examined. Subsequently, 86 patients (63 females, 23 males) with asymmetric, unilateral and bilateral extractions who met the criteria of the study were included. Upper and lower dental casts were evaluated separately. Consequently, 115 upper and lower dental casts were selected among the 172 dental casts of 86 patients. Digital dental cast analyses were performed on these selected 115 upper and lower jaw dental casts from the patients. The mean age of the patients in the study was 14.6 (± 2.3) years.

The inclusion criteria were as follows: completion of permanent dentition at the start of treatment (excluding third molars); the absence of missing or impacted teeth (except for three molars); the absence of large cavities or restorations; the absence of teeth with significant size anomalies; patients who had received no orthodontic treatment prior to fixed appliance orthodontic treatment (expansion or functional treatments, etc.); fixed treatment that had been completed with acceptable occlusion and the absence of conditions causing skeletal asymmetry (such as lip and palate clefts, craniofacial deformities, etc.). Patients with missing dental records (cephalometric x-rays, dental casts) were excluded from the study. Research groups were structured as follows:

1. UAEG: Sixteen maxillar upper jaw models with first premolar extraction on one side and second premolar extraction on the opposite side (asymmetric extraction).

2. LAEG: Nineteen lower jaw models with first premolar extraction on one side and second premolar extraction on the opposite side (asymmetric extraction).

3. UUEG: Twenty upper jaw models with unilateral first premolar extraction.

4. LUEG: Twenty lower jaw models with unilateral first premolar extraction.

5. UBEG: Twenty upper jaw models with bilateral first premolar extraction.

6. LBEG: Twenty upper jaw models with bilateral first premolar extraction.

Since the upper and lower dental casts of the patients were evaluated separately; only intramaxillary dental measurements and soft tissue measurements were examined on cephalometric radiographs. Upper jaw-related dental measurements were used only in the upper-jaw groups, and lower jaw-related dental measurements were used only in the lower-jaw groups (Fig. 1a-b).

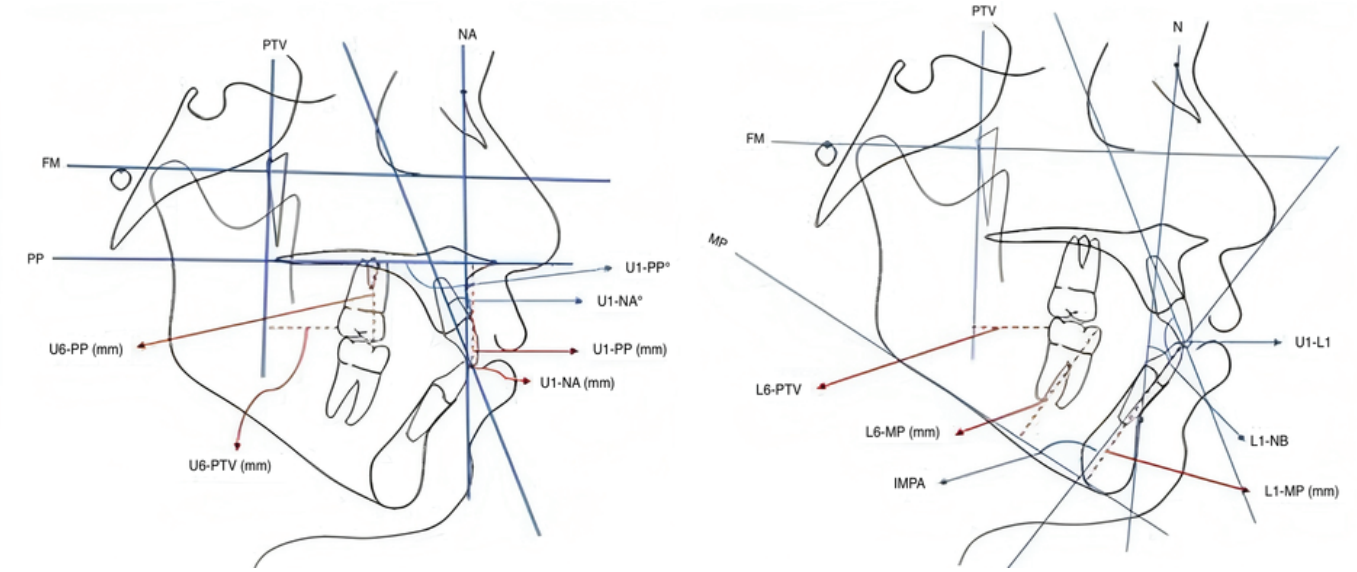

Figure 1. Some of the cephalometric measurements related to upper and lower jaws; Fig. 1a, Upper jaw Fig. 1b, Lower jaw.

Measurements related to both jaws were not included in the study to prevent errors. Cephalometric measurements were performed using the Dolphin (v. 11.95.08.50 Premium, Dolphin Imaging & Management Solutions, Patterson Dental Supply, Chatsworth, CL, USA) digital cephalometric analysis program. The parameters used in cephalometric analyses are shown in Tables 1 and 2.

Pre-treatment (T0) and Post-treatment (T1) dental casts of the patients included in our study were scanned using the 3Shape R700 (3Shape, Copenhagen, Denmark) device to generate digital models. Measurements on 3D digital models were performed by 1 investigator E.P. using Ortho-analyzer (v. 1.5, 3Shape, Copenhagen, Denmark) computer software. The measurements were performed separately on the upper and lower jaws. The median palatal suture and the anterior reference plane were used as the primary planes in the digital model analysis. Planes used in the model analysis were the median palatal suture and the anterior reference plane. The median palatal suture line was created by combining the anterior points of the incisive papillae and the visible part of the suture, at the most posterior point on the patient's dental casts (18-20).

The median raphe was transferred to the mandibular model as follows. The top view in the inspection section of the program was selected, the maxillary model was hidden, and the mandible subsequently became visible. During this adjustment, the horizontal default position with grids was kept stable (Fig. 2).

The anterior reference line was constructed perpendicular to the median raphe through the midpoint between the central incisors, using the horizontal default position of the software with grids (Fig. 3) (19-21).

Table 1. Comparison of cephalometric radiography analysis measurements of upper and lower jaw groups.

	Parameters	Asymmetrical Ext. T0 X±s.s	Asymmetrical Ext. T1 X±s.s	p	Unilateral Ext. T0 X±s.s	Unilateral Ext. T1 X±s.s	p	Bilateral Ext. T0 X±s.s	Bilateral Ext. T1 X±s.s	p
UPPER DENTAL CASTS (n=56)	U1-NA°	23,86±6,38	20,04±5,49	**0,02***	24,06±4,34	25,17±4,54	0,33	23,85±5,77	21,45±3,6	0,13
	U1-NA (mm)	1,57±1,94	4,11±2,87	**0,01***	3,91±1,77	4,24±2,09	0,41	2,62±1,62	4,64±2,22	**0,01***
	U1-PP°	113,35±6,13	110,08±5,41	0,05	113,95±6,17	115,38±5,38	0,22	113,07±5,85	111,31±4,49	0,24
	U1-PP (mm)	27,75±2,11	28,61±2,38	**0,01***	26,22±2,89	26,42±3,24	0,48	25,97±2,68	26,6±2,86	**0,04***
	U6-PTV (mm)	17,44±2,8	21,43±3,38	**0,01***	17,24±3,43	16,82±3,41	0,51	16,23±1,72	18,49±2,22	**0,01***
	U6-PP (mm)	21,64±2,22	22,98±2,29	**0,01***	21,09±2,29	21,51±2,93	0,25	20,94±2,29	22,01±2,29	**0,01***
	UL-U1 (mm)	10,95±1,92	12,28±1,67	**0,01***	10,59±1,93	11,59±1,67	**0,01***	10,71±1,93	12,52±2,4	**0,01***
	UL- S line (mm)	0,28±1,9	-0,37±2,47	**0,02***	-1,34±2,07	-1,02±1,63	0,34	0,11±2,39	-0,32±2,27	0,12
	Nasolabial °	108,64±15,03	110,7±17,62	0,51	105,24±11,52	106,24±11,49	0,66	109,76±7,76	106,5±5,74	0,11
LOWER DENTAL CASTS (n=59)	L1-NB°	26,09±6,88	23,55±7,53	**0,01***	26,04±7,22	23,88±5,24	**0,02***	28,09±6,58	26,17±7,07	**0,01***
	L1-NB (mm)	5,78±2,70	4,29±2,55	**0,01***	5,16±2,41	4,55±1,60	**0,01***	6,09±2,08	4,97±2,61	**0,01***
	IMPA°	92,57±7,95	90,15±8,34	**0,01***	92,84±8,31	90,59±7,03	**0,01***	94,23±6,94	91,83±8,77	**0,01***
	L1-MP (mm)	37,98±3,58	38,17±3,21	**0,01***	36,82±3,15	37,93±2,98	**0,01***	37,72±2,51	38,21±3,09	0,44
	L6-PTV (mm)	15,59±3,24	19,39±3,66	**0,02***	17,74±5,32	20,18±5,58	**0,01***	14,88±2,76	19,49±2,8	**0,01***
	L6-MP (mm)	27,59±2,93	29,63±2,97	**0,01***	28,1±2,76	29,28±2,58	**0,01***	28,11±2	30,38±2,5	**0,01***
	LL-U1 (mm)	10,59±1,45	11,32±1,36	0,15	10,53±1,75	11,58±1,48	**0,01***	10,41±1,66	11,89±1,77	0,39
	LL -S line (mm)	0,95±2,60	0,06±1,93	**0,01***	0,57±2,8	0,63±2,36	**0,01***	1,56±2,21	0,48±2,24	**0,01***

Sidak's inequality test was performed. *$P < 0.05$.

Table 2. Comparison of cephalometric radiography analysis between groups in upper and lower jaw groups.

	Parameters	Asymmetrical Ext. TΔ X±s.s	Unilateral Ext. TΔ X±s.s	Bilateral Ext. TΔ X±s.s	p
UPPER DENTAL CASTS (n=56)	U1-NA°	-3,82±1,52^{a}	1,11±1,12^{b}	-2,4±1,52^{a}	**0,04***
	U1-NA (mm)	2,54±0,61^{a}	0,33±0,38^{b}	2,02±0,46^{a}	**0,01***
	U1-PP°	-3,28±1,55	1,43±1,14	-1,77±1,47	0,06
	U1-PP (mm)	0,86±0,29	0,21±0,29	0,63±0,28	0,28
	U6-PTV (mm)	3,99±0,73^{a}	-0,42±0,61^{b}	2,26±0,54^{a}	**0,01***
	U6-PP (mm)	0,21±0,99^{a}	4,27±0,9^{b}	2,45±0,69^{c}	**0,01***
	UL-U1 (mm)	1,33±0,41	1,01±0,37	1,81±0,34	0,29
	UL- S line (mm)	-0,64±0,26	0,32±0,32	-0,43±0,26	0,05
	Nasolabial °	2,06±3,05	1±2,22	-3,27±1,96	0,25
LOWER DENTAL CASTS (n=59)	L1-NB°	-2,54±3,95	-2,16±6,46	-1,92±6,48	0,94
	L1-NB (mm)	-1,49±1,19	-0,61±1,74	-1,12±1,65	0,21
	IMPA°	-2,42±5,18	-2,25±6,22	-2,4±6,52	0,99
	L1-MP (mm)	0,19±2,08	0,11±1,83	0,49±1,5	0,79
	L6-PTV (mm)	3,8±3,16	2,44±3,04	4,61±3,55	0,11
	L6-MP (mm)	2,04±1,31^{a}	1,18±1,05^{ab}	2,27±1,77^{b}	**0,04***
	LL-U1 (mm)	0,73±1,61	1,05±1,22	1,48±2,17	0,40
	LL -S line (mm)	-0,89±1,28^{a}	0,07±1,56^{b}	-1,09±1,48^{a}	**0,03***

Sidak's inequality test was performed. *$P < 0.05$.

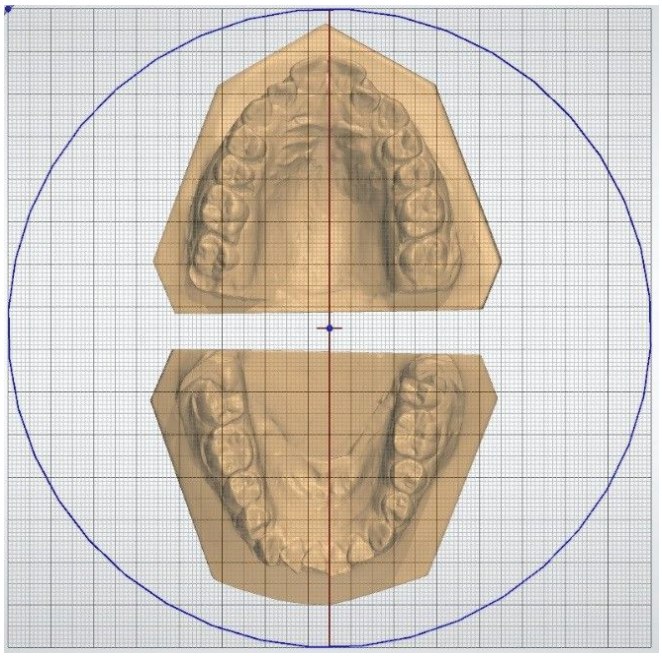

Figure 2. Determination of the median palatal suture and midline of the lower jaw.

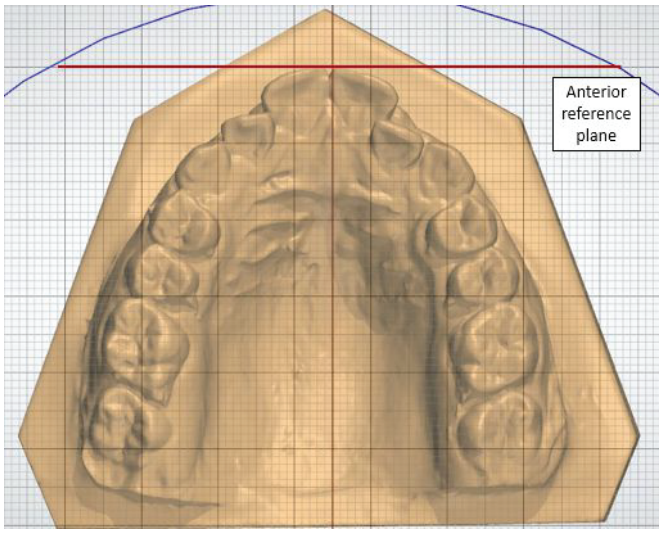

Figure 3. Determination of anterior reference plane in upper jaw models.

The distances from the reference points marked on teeth (incisors, canines, premolars, and first molar) to the determined planes were measured on the lower and upper digital jaw models. The distance of these reference points to the median palatal suture referred to the asymmetry of the transverse direction, while the distance to the anterior reference plane referred to asymmetry in the anteroposterior direction (Fig. 4 and 5).

Measurements of transverse asymmetry for the incisors and canines were combined to produce an index of transverse anterior segment asymmetry. An index of buccal segment asymmetry was formed as a combination of measurements from premolar and molar points. The same procedure was followed to compute the anteroposterior indices of anterior and buccal segment asymmetries (Fig. 4 and 5) (20).

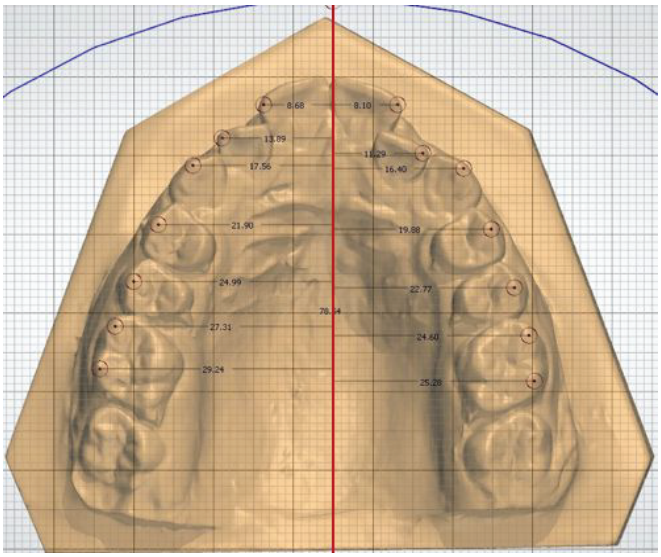

Figure 4. Linear measurements from bilateral tooth landmarks to the median raphe.

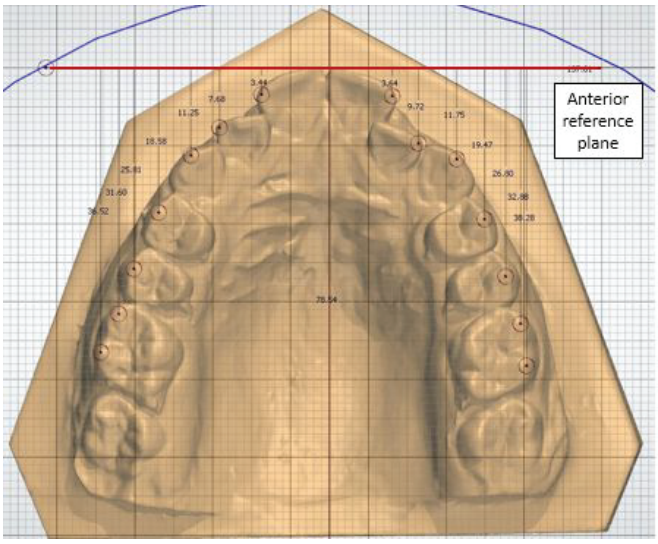

Figure 5. Linear measurements from bilateral tooth landmarks to the anterior reference plane.

Arch lengths (the distance between the midpoint of the central incisor teeth and the mesial of the first molars) and arch angles (the angle created by the median palatal suture, with the plane connecting the median palatal suture to the anterior reference plane in the upper jaw and the mesial point of the first molar) were also measured (Fig. 6 and 7).

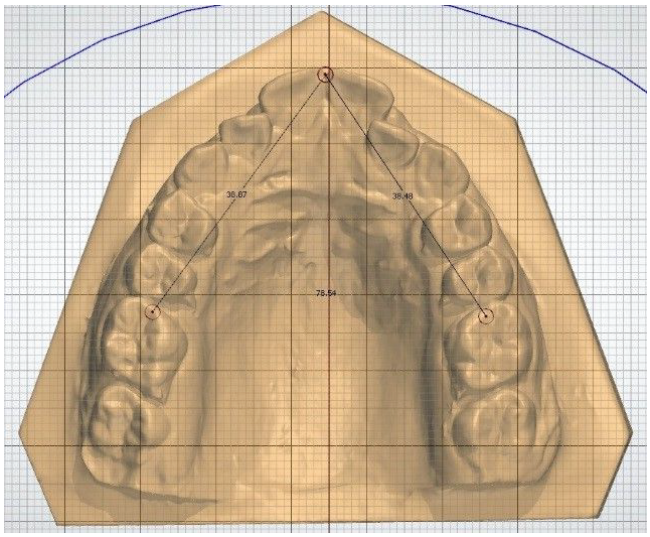

Figure 6. Measurement of bilateral arch lengths.

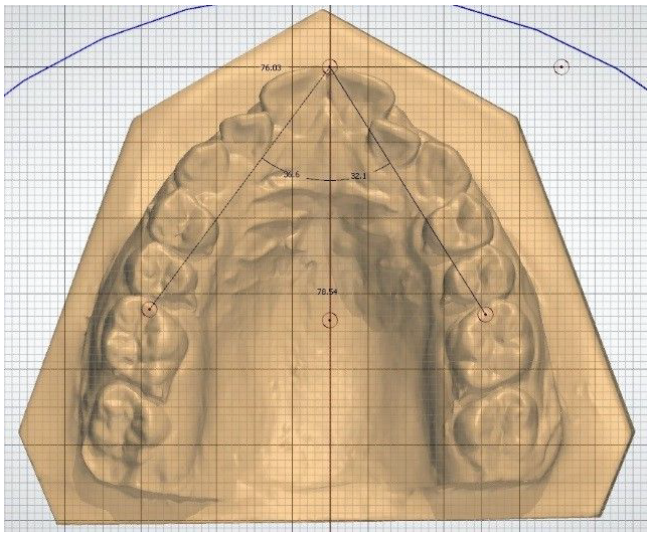

Figure 7. Measurement of bilateral arch angles.

Asymmetries were calculated by determining the absolute difference between opposing measurements, as it related to the reference lines. The same procedure was followed to compute the anterior and buccal segment anteroposterior asymmetries (20,21).

Intercanine (distance between the cusp tips of canines) and intermolar widths (distance between the mesiobuccal cusp tips of the first permanent molars) were also measured.

Statistical Analysis

The SPSS software package (SPSS for Windows v. 22.0; SPSS Inc., Chicago, Ill, USA) was used for statistical analysis in our study. The Sidak dual comparison test was used to identify different groups. Correlation analysis was performed to determine the method error. A chi-square (X^2) test was used to examine differences among measurements. A paired t-test was applied to determine whether the T0 and T1 measurements were different. A multivariate analysis of variance (MANOVA) test was applied to examine T0 and T1–T0 measurements. All values were considered significant at $P < 0.05$.

RESULTS

Two weeks after the first set of recordings, 35 randomly selected digital models were re-measured by the same investigator (E.P.K.) to calculate the method error. No significant differences were found between the 2 sets of measurements.

Cephalometric Radiography Analysis

Means and standard deviations for cephalometric radiogrphy analysis are listed in Tables 1 and 2. Retraction of the central and lateral incisors was observed in all lower jaw groups. Significant incisor retraction was noted only in the asymmetric extraction group, in the upper jaw. Asymmetric and bilateral extractions of the upper jaw were found to be both protruding and extruding. Lower incisors were found to be retracted by all extraction protocols and extruded by asymmetric and unilateral extraction protocols. Significant mesialization and extrusion was observed for the molars in all groups of the lower jaw, and also in asymmetric and bilateral extraction groups in the upper jaw.

Dental Cast Analysis

Means and standard deviations for dental cast analysis are listed in Tables 3 and 4. No statistically significant intra-arch asymmetry changes were observed for the maxillary and mandibular dental arches involving the transverse and anteroposterior asymmetry parameters. The unilateral extraction group of the lower jaw showed a statistically significant decrease in asymmetry in the anteroposterior direction, whereas the unilateral extraction group of the upper jaw showed a statistically significant increase in asymmetry, as was anticipated. Both asymmetric and bilateral extractions had a positive effect on arch-length symmetry in both jaws, but unilateral extraction negatively affected arch-length symmetry.

DISCUSSION

Clinicians may need to decide on unilateral or asymmetric premolar extraction for orthodontic purposes. In such patients, it is generally of concern that the arch symmetry will be disrupted in the transverse or posteroanterior direction. Several studies (18-23) have evaluated arch symmetry in individuals with normal occlusion and/or different malocclusions without orthodontic treatment. The current study aimed to evaluate the effects of asymmetric, unilateral, and bilateral extraction protocols on arch form and symmetry. In addition, the aim of comparing the cephalometric X-ray analyses of patients at the start and the end of treatment was to determine the effects of these treatment protocols on dental and soft tissue measurements. In lateral cephalometric X-ray analysis, parameters related to dental and soft tissues, which were believed to be affected by these extraction protocols, were evaluated. There exists some disagreement in the literature as to whether the median palatal suture is an ideal reference plane for comparing the symmetry between the 2 sides of the arch in the upper jaw. Selected studies (17-22) have reported that in some patients, this suture has a curvature and therefore presents difficulty for establishing a straight reference line along the suture line.

Table 3. Comparison of 3D model analysis measurements of upper and lower jaw groups.

	Parameters	Asymmetrical Ext. T0 X±s.s	Asymmetrical Ext. T1 X±s.s	p	Unilateral Ext. T0 X±s.s	Unilateral Ext. T1 X±s.s	p	Bilateral Ext. T0 X±s.s	Bilateral Ext. T1 X±s.s	p
UPPER DENTAL CASTS (n=56)	T. Anterior Segment	0,74±0,83	0,53±0,31	0,33	0,74±0,56	0,7±0,61	0,80	0,74±0,56	0,53±0,35	0,09
	T. Posterior Segment	1,73±1,54	1,54±1,11	0,73	1,4±1,12	1,54±1,02	0,54	1,61±1,27	1,07±0,83	0,16
	AP Anterior Segment	1,19±1,12	1,04±0,79	0,58	1,32±1,13	1,97±1,82	0,20	1,19±1,12	0,95±1	0,55
	AP Posterior Segment	1,73±1	1,81±1,51	0,87	1,37±1,12	2,4±1,53	**0,01***	1,45±0,99	1,69±1,73	0,64
	Arch Length	2,98±2,53	0,71±0,59	**0,01***	1,88±1,11	5,77±0,92	**0,01***	1,87±1,54	0,69±0,49	**0,01***
	Arch Angle	2,79±1,83	4,75±3,19	0,09	3,66±6,27	3,91±2,9	0,87	2,09±1,86	3,21±2,84	0,21
	3-3 (mm)	34,92±2,98	35,25±2,21	0,52	35,26±3,04	35,5±2,03	0,64	35,96±3,33	35,57±1,65	0,52
	6-6 (mm)	49,36±2,87	47,67±2,44	**0,01***	50,28±2,88	50,31±2,73	0,95	50,8±3,45	48,64±2,08	**0,01***
LOWER DENTAL CASTS (n=59)	T. Anterior Segment	1,62±1,61	0,79±0,71	0,25	3,34±2,49	1,01±0,94	0,65	2,05±1,67	0,85±0,89	**0,04***
	T. Posterior Segment	1,53±1,13	1,05±0,78	0,65	2,22±1,63	2,03±1,66	0,34	1,48±1,12	1,27±0,91	0,26
	AP Anterior Segment	1,36±0,97	0,67±0,5	0,09	1,54±0,90	1,25±0,99	0,41	0,93±0,64	0,59±0,47	0,87
	AP Posterior Segment	2,01±1,11	1,35±1,03	0,22	2,98±2,39	2,4±1,66	**0,02***	1,06±1,04	1,03±0,7	0,35
	Arch Length	1,65±1,51	1,09±1,36	0,17	1,33±1,17	5,82±0,75	**0,01***	1,52±1,16	0,32±0,24	0,44
	Arch Angle	3,77±2,85	3,3±3,01	0,57	4,37±4,6	4,14±2,57	0,06	2,46±1,87	2,96±1,69	0,96
	3-3 (mm)	26,72±2,58	27,45±1,42	0,12	25,76±1,98	26,65±1,09	0,21	27,24±2,58	27,43±1,83	**0,01***
	6-6 (mm)	41,97±3,58	40,84±2,82	**0,01***	43,46±1,93	42,11±1,42	**0,01***	44,51±3,11	41,00±2,09	**0,01***

Sidak's inequality test was performed. *$P < 0.05$.

Table 4. Comparison of 3D model analysis between groups in upper and lower jaw groups.

	Parameters	Asymmetrical Ext. TΔ X±s.s	Unilateral Ext. TΔ X±s.s	Bilateral Ext. TΔ X±s.s	p
UPPER DENTAL CASTS (n=56)	T. Anterior Segment	-0,22±0,21	-0,04±0,16	-0,22±0,12	0,68
	T. Posterior Segment	-0,18±0,51	0,14±0,23	-0,54±0,37	0,41
	AP Anterior Segment	-0,15±0,27	0,66±0,49	-0,24±0,39	0,23
	AP Posterior Segment	0,08±0,49	1,04±0,34	0,24±0,5	0,27
	Arch Length	-2,27±0,58[a]	3,89±0,24[b]	-1,18±0,36[a]	**0,01***
	Arch Angle	1,96±1,07	0,25±1,53	1,12±0,87	0,62
	3-3 (mm)	0,34±0,51	0,24±0,5	-0,39±0,59	0,59
	6-6 (mm)	-1,68±0,3[a]	0,03±0,48[b]	-2,16±0,44[a]	**0,01***
LOWER DENTAL CASTS (n=59)	T. Anterior Segment	-0,83±1,93	-2,33±2,57	-1,2±1,48	0,06
	T. Posterior Segment	-0,49±1,3	-0,19±2,05	-0,21±1,62	0,83
	AP Anterior Segment	-0,69±1,25	-0,29±1,46	-0,34±0,81	0,53
	AP Posterior Segment	-0,66±1,27	-0,58±1,98	-0,03±1,37	0,40
	Arch Length	-0,57±2,34[a]	4,5±1,34[b]	-1,19±1,14[a]	**0,01***
	Arch Angle	-0,47±4,43[a]	-0,24±4,2[a]	0,5±2,51[b]	**0,01***
	3-3 (mm)	0,73±2,45	0,9±1,96	0,19±1,78	0,54
	6-6 (mm)	-1,13±1,61[a]	-1,35±1,56[a]	-3,51±1,82[b]	**0,01***

Sidak's inequality test was performed. *$P < 0.05$.

However, in other studies (19-21,23), the median palatal suture was used as the standard reference plane. In the present study, the median palatal suture was used as the reference plane on upper dental casts; this suture line was transferred to the lower dental casts, as described by Veli et al. (21). Three extraction protocols were observed as not having had a significant effect on the transverse arch asymmetry on the anterior region of the upper jaw (Table 3). In the anterior region of the lower jaw, bilateral extraction reduced asymmetry in the transversal direction ($P < 0.05$; Table 3). Dahiya et al. (15) reported a narrower and more posteriorly displaced arch on the extraction side as a result of unilateral maxillary extraction. Researchers also reported that unilateral collapse of the arch form can lead to poor intertubercular relations, premature contact, asymmetric lateral overjet, and non-aesthetic appearance when smiling. In Struhs (17) it was reported that the lateral incisors and canines were positioned more palatably on the unilateral extraction side. The three extraction protocols showed no significant effect on anteroposterior anterior arch asymmetry in the anterior region of the upper and lower jaws. Asymmetry in the anteroposterior direction in the posterior region increased in the upper jaw and decreased in the lower jaw, as a result of unilateral extraction. The reason for this increase in asymmetry in the posterior region of the upper jaw was believed to be the result of asymmetric mesialization of the molars. The decrease in asymmetry in the posterior region of the lower jaw, however, was believed to be due to the different pretreatment malocclusion types among patients.

Asymmetric and bilateral extractions in the upper jaw had a similar positive effect in terms of arch-length asymmetry. It is believed that the upper jaw arches, which were initially asymmetric, were rendered more symmetric as a result of the extractions on both sides. Unilateral extraction increased the arch-length asymmetry in both upper and lower jaws, as was anticipated. The molar on the extraction side was more mesialized, resulting in a greater decrease in the arch length on this side, leading to a more asymmetric arch length. Intercanine distance was not significantly affected in the upper jaw by the three extraction protocols but was increased as a result of bilateral extraction in the lower jaw. Some researchers have reported an increase in maxillary intercanine distance following extractions (24,25). Strang (26) attributed this increase to the distalization of canine teeth to a larger portion of the arch. Begole et al.14, Isik et al. (27) Luppanappornlap and Johnston (28), and Rübendüz & Altunay (29) among others, reported no significant change in the maxillary intercanine distance with extraction treatment. Rübendüz & Altunay (29) reported that in cases with increased crowding, the area where the canine teeth were located in the vestibule was larger than the area where they should be located, on the dental arches. Several studies (16,24,27-29) have shown that maxillary and mandibular intermolar distances were reduced by extraction treatment. In accordance with the literature, in the present study, decreases in intermolar distances were observed in all groups for the lower jaw and in asymmetric and bilateral extraction groups in the upper jaw. This decrease in intermolar distances in dental cast analyses corresponded with the mesialization found in the cephalometric analyses in the present study. Although researchers have reported retraction of incisors after premolar extraction (30-32), others have reported protrusion (33). In the present study, significant incisor retrusion was observed only in the asymmetric extraction group, between the upper jaw groups ($P < 0.05$; Table 1). It is known that increasing the labial crown torque reduces the degree of incisor retraction (33). Statistically, significant retrusion was detected in all groups for the lower incisors ($P < 0.05$; Table 1). This retrusion was believed to have been the result of space-closing mechanics. There was no clinically significant difference in lower incisor retraction between the lower jaw groups ($P > 0.05$; Table 2). Due to the retrospective design of our study, the study materials were selected using archived records. Due to disorganization and deficiencies in such records, many cases were not included in our study. Had this study included more patients with specific types of malocclusions and variable instances of crowding, we believe that the results would have been clinically more meaningful, particularly regarding the cephalometric findings. In addition, the lack of knowledge regarding the treatment mechanics applied to patients was also a problem in terms of interpreting the study results. The effects of the different extraction protocols on the dental midlines could not be evaluated in our study since no materials (photographs or posteroanterior X-rays) were available to evaluate the midlines. Studies have reported that asymmetry in any arch increases the likelihood of asymmetry of the opposite arch (17,18,23). Accordingly, the recommendation is made that opposing arches be included in future studies.

CONCLUSION

This study suggests that there is no difference between the asymmetric and bilateral extraction protocols as it relates to arch symmetry. The unilateral extraction protocol had an increased effect on arch-length asymmetry, as was expected. The unilateral extraction protocol also increased the anteroposterior asymmetry in the posterior region of the maxilla; however, its effect in the lower jaw was the opposite.

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REFERENCES

1. Angle EH Treatment of Malocclusion of the Teeth: Angle's System. Greatly Enl. and Entirely Rewritten, with Six Hundred and Forty-one Illustrations. SS White dental manufacturing Company, 1907.

2. Case CS. The question of extraction in orthodontia. Am J Orthod. 1964;50:660-91.

3. Hahn GW. Orthodontics: its objectives, past and present. Am J Orthod Oral Surg. 1944;3:401-4.

4. Brandt S, Safirstein GR. Different extractions for different malocclusions. Am J Orthod. 1975; 68:15-41.

5. Proffit WR. Forty-year review of extraction frequencies at a university orthodontic clinic. Angle Orthod. 1994;64:407-14.

6. Crossman I, Reed R. Long term results of premolar extractions in orthodontic treatment. Br J Orthod. 1978;5:61-6.

7. De Castro N. Second-premolar extraction in clinical practice. Am J Orthod. 1974;65:115-37.

8. Steyn C, Du Preez R, Harris A. Differential premolar extractions. Am J Orthod Dentofac Orthop. 1997;112:480-6.

9. Burstone CJ. Diagnosis and treatment planning ofpatients with asymmetries. Semin Orthod. 1998;4:153-64.

10. Rebellato J Asymmetric extractions used in the t reatment of patients with asymmetries. Semin Orthod. 1998;4:180-8.

11. Lindauer SJ. Asymmetries: diagnosis and treatment. Semin Orthod. 1998;4:133.

12. Turpin DL. Correcting the Class II subdivision malocclusion. Am J Orthod Dentofacial Orthop. 2005;128:555-6.

13. Tayer BH. The asymmetric extraction decision. Angle Orthod. 1992;62:291-97.

14. BeGole EA, Fox DL, Sadowsky C. Analysis of change in arch form with premolar expansion. Am J Orthod Dentofacial Orthop. 1998;113:307-15.

15. Dahiya G, Masoud AI, Viana G, Obrez A, Kusnoto B, Evans CA. Effects of unilateral premolar extraction treatment on the dental arch forms of Class II subdivision malocclusions. Am J Orthod Dentofacial Orthop. 2017;152:232-41.

16. Kim E, Gianelly AA. Extraction vs nonextraction: arch widths and smile esthetics. Angle Orthod. 2003;73:354-58.

17. Struhs TW. Effects of unilateral extraction treatment on arch symmetry and occlusion. Thesis, 2005.

18. Maurice TJ, Kula K. Dental arch asymmetry in the mixed dentition. Angle Orthod. 1998; 68:37-44.

19. Scanavini PE, Paranhos LR, Torres FC, Vasconcelos MHF, Jóias RP, Scanavini MA. Evaluation of the dental arch asymmetry in natural normal occlusion and Class II malocclusion individuals. Dental Press J Orthod. 2012;17:125-37.

20. Alavi DG, BeGole EA, Schneider BJ. Facial and dental arch asymmetries in Class II subdivision malocclusion. Am J Orthod. Dentofacial Orthop. 1988;93:38-46.

21. Veli I, Yuksel B, Uysal T. Longitudinal evaluation of dental arch asymmetry in Class II subdivision malocclusion with 3-dimensional digital models. Am J Orthod Dentofacial Orthop. 2014;145:763-70.

22. Lundström A. Some asymmetries of the dental arches, jaws, and skull, and their etiological significance. Am J Orthod. 1961;47:81-106

23. Uysal T, Kurt G, Ramoglu SI. Dental and alveolar arch asymmetries in normal occlusion and Class II Division 1 and Class II subdivision malocclusions. World J Orthod. 2009;10:7-15.

24. Bishara SE, Bayati P, Zaher AR, Jakobsen JR. Comparisons of the dental arch changes in patients with Class II, division 1 malocclusions: extraction vs nonextraction treatments. Angle Orthod. 1994;64:351-58.

25. Sampson P, Little RM, Årtun J, Shapiro PA. Long-term changes in arch form after orthodontic treatment and retention. Am J Orthod Dentofacial Orthop. 1995;107:518-30.

26. Strang RH. The fallacy of denture expansion as a treatment procedure. Angle Orthod. 1949;19:12-22.

27. Işık F, Sayınsu K, Nalbantgil D, Arun T. A comparative study of dental arch widths: extraction and non-extraction treatment. Eur J Orthod. 2005;27:585-89.

28. Luppanapornlarp S, Johnston Jr LE. The effects of premolar-extraction: a long-term comparison of outcomes in “clear-cut” extraction and nonextraction Class II patients. Angle Orthod. 1993;63:257-72.

29. Rübendüz M, Altunay AS. Çekimli ve çekimsiz tedavilerde dental ark değişiklikleri. Turk J Orthod. 2001;14:132-7.

30. Bravo LA, Canut JA, Pascual A, Bravo B. Comparison of the changes in facial profile after orthodontic treatment, with and without extractions. Br J Orthod. 1997;24:25-34.

31. Saelens NA, De Smit AA. Therapeutic changes in extraction versus non-extraction orthodontic treatment. Eur J Orthod. 1998;20:225-36.

32. Chen K, Han X, Huang L, Bai D. Tooth movement after orthodontic treatment with 4 second premolar extractions. Am J Orthod Dentofacial Orthop. 2010;138:770-77.

33. Al-Nimri KS. Vertical changes in class II division 1 malocclusion after premolar extractions. Angle Orthod 2006;76:52-8.