DOI: 10.4274/TurkJOrthod.2022.2022.59

TURKISH JOURNAL of ORTHODONTICS

Original Article

Evaluation of First Molar Buccolingual Angulations and Dental Arch Parameters in Adolescents with Bilateral Posterior Crossbite

Taner Öztürk[1], Ahmet Yağcı[1], Sabri İlhan Ramoğlu[2]

[1]Erciyes University Faculty of Dentistry, Department of Orthodontics, Kayseri, Turkey
[2]Altınbaş University Faculty of Dentistry, Department of Orthodontics, İstanbul, Turkey

Cite this article as: Öztürk T, Yağcı A, Ramoğlu Sİ. Evaluation of First Molar Buccolingual Angulations and Dental Arch Parameters in Adolescents with Bilateral Posterior Crossbite. *Turk J Orthod.* 2023; 36(3): 165-172.

Main Points
- The dental arch parameters differ between the sexes regardless of the presence of a posterior crossbite.
- The difference in the molar angulation between individuals with and without the posterior crossbite increases with age during adolescence.
- The dental parameters and molar angulation of individuals with bilateral posterior crossbite do not significantly differ between the different age groups.

ABSTRACT

Objective: This study aimed to compare the maxillary and mandibular transverse dental arch widths and buccolingual inclinations of the molar teeth in patients with and without bilateral posterior crossbite (BPC) divided into different age groups.

Methods: The study included dental models from 120 patients (age: 12-18 years), including 60 with BPC (32 boys and 28 girls) and 60 without BPC (controls; 30 boys and 30 girls), who were divided into three age groups (12-14, 14-16, and 16-18 years). The centroid and lingual transverse arch widths, dental arch perimeters, dental arch depths, and buccolingual angulation of the molar teeth in the maxillary and mandibular regions were evaluated using scanned three-dimensional dental models.

Results: Dental arch parameters and buccolingual molar angulation did not significantly differ between the different age groups in either the patients with BPC or the controls ($p>0.05$). However, several dental arch width parameters differed significantly between sexes in both groups, with higher values in boys than in girls ($p<0.05$). The difference in the upper and lower molar buccolingual angulation between patients with BPC and controls was greater at the age of 16-18 years than the age of 12-14 years ($p<0.05$).

Conclusion: Patients with BPC have smaller maxillary dental arch widths and larger mandibular intermolar widths than those without BPC. The difference in the molar buccolingual angulation between them increases with advancing age.

Keywords: Posterior crossbite, dental model analysis, buccolingual angulation

INTRODUCTION

Posterior crossbite is defined as unilateral or bilateral positioning of the lower molars more lingually in relation to the buccolingual position and angle of the upper molars. While the unilateral crossbite may be of a dental or skeletal origin, bilateral crossbite typically the result of a narrow maxilla.[1] However, while the skeletal structure is in the normal position, the buccolingual angulation of the upper molars may be inclined lingually.[1] The prevalence of posterior crossbite ranges from 8% to 23%[2] and and it tends to increase with age.[2,3] Additionally, the prevalence of bilateral crossbite is higher than that of unilateral crossbite, and it is more commonly seen in the permanent dentition than in the primary dentition.[4,5] Various treatment options are available for correcting

Corresponding author: Taner Öztürk, e-mail: tanertr35@gmail.com

Received: April 11, 2022
Accepted: September 27, 2022
Epub: April 26, 2023
Publication Date: September 29, 2023

posterior crossbite, including expansion and grinding. However, spontaneous correction can also occur in some cases, although it occurs at a relatively low rate.[6]

Most studies have focused indiscriminately on crossbite or unilateral crossbite; resulting in a lack of research on bilateral crossbite.[7-13] These mostly include radiographic analysis methods that result in radiation exposure.[7,9,14,15] Although radiographic analysis can provide more detailed information, dental model analysis maintains its importance for basic orthodontic diagnoses.[1] Dental arch parameters, such as arch width, arch length, and tooth angulation, are frequently evaluated in dental model analyses to assess transverse problems and relationships.[8,10-12,16] Andrews[17] identified key features of an ideal occlusal relationship, including an ideal buccolingual angulation relationship. Similarly, a compensation curve viewed from the frontal plane defined by Wilson has been used to define the buccolingual relationship of the molar teeth.[16] Studies have reported that posterior crossbite is caused by the difference in the buccolingual angulations.[7-13,15,18] Additionally, these studies have examined the changes in the buccolingual angulation during correction of the anomaly.[8,10,12]

Notably, Sayania et al.[19] reported that the maxillary molars erupted with buccal crown torque and lingual inclination over time; while mandibular molars erupted with lingual crown torque, and buccal inclination. However, to our knowledge, no study has investigated the dental characteristics of different age groups and the differences in posterior crossbite among these groups. Thus, this study aims to evaluate and compare the angulation of the permanent first molar teeth and the maxillary and mandibular dental arch parameters to interpret the transverse anomaly in individuals with bilateral posterior crossbite (BPC) at different age groups during adolescence. Our null hypothesis is that there are no differences in permanent first molar angulation and maxillary and mandibular dental arch parameters between individuals with and without bilateral crossbite in different age groups during adolescence.

METHODS

This study was approved by the Erciyes University Clinical Research Ethics Committee (approval number: 2020/44, date: 15.01.2020) and was registered at the US National Institutes of Health Ongoing Trials Register (ClinicalTrials.gov) [registration number-(ID): NCT04955860]. A power analysis was conducted to determine the sample size of the study, indicating that a minimum of 18 samples in each group was needed for an alpha value of 0.05, a d value of 1.12, and a power of 90%.[10] Accordingly, this study included radiographic and dental model records from 120 patients, including 60 with BPC (32 boys and 28 girls) and 60 without BPC (controls; 30 boys and 30 girls). Patients were randomly selected from those who sought orthodontic treatment at the Erciyes University Department of Orthodontics.

The inclusion criteria for the study were: (1) no history of orthodontic treatment, (2) presence of bilateral posterior crossbite (for the study group), (3) no restoration or permanent tooth loss, (4) permanent dentition, and (5) absence of a syndrome or systemic disease affecting the craniofacial region.

The dental cast models were obtained using a three-dimensional model scanning device (3Shape R700 3D Scanner, 3Shape A/S, Copenhagen, Denmark) and analyzed using the 3Shape Orthoanalyzer software (3Shape A/S). For each tooth, points were placed on the distal, facial, mesial, and lingual surfaces, from the right first permanent molar to the left first permanent molar within the same arch, thus eliminating the effect of dental rotations (Figure 1A).[10,20] Transverse dental arch measurements were obtained between the following teeth: permanent canines, first premolars, second premolars, and permanent first molars. The dental arch width, defined as the distance between these teeth, was evaluated on the basis of two sets of measurements: the distance from the lingual point of the selected tooth to the same point on its antimere and between the centroid and the antimere of the tooth (Figure 1A and B). The arch depth was determined by measuring the distance between the midpoint between the facial surfaces of the central incisors and the tangent drawn between the mesial surfaces of the right and left permanent first molars (Figure 1C). The arch perimeter was calculated by drawing a line between the mesial and distal contact points of the teeth between the mesial surface of the permanent first molar and the contact point between the permanent first molar on the other side of the arch (Figure 1D).[10] To evaluate the molar tooth angulation the buccal and lingual cusp tips of the maxillary (Figure 1E) and mandibular (Figure 1F) permanent first molars were selected. An angulation below 180° indicated that the molar teeth were inclined buccally, while that above 180° indicated that these teeth were inclined lingually.[10]

Statistical Analysis

The obtained data were statistically analyzed using the SPSS software (version 24.0, IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test was used to assess data normality and the Levene test to analyze homogeneity. It was determined that all the data are normally and homogeneously distributed. One-way ANOVA (post-hoc Tukey's test) was used for comparisons between the age groups and the independent samples t-test between the study groups and sexes. For method errors, 10% of the sample was randomly selected for re-evaluation by the same investigator 1 month after the first measurements. The intra-class correlation coefficient was found to be between 0.897 and 0.915, indicating a high reproducibility of the measurements.

RESULTS

The dental arch parameters did not show significant differences between the age groups in individuals with BPC ($p>0.05$; Table 1). However, the mandibular arch perimeter (MdAP) and maxillary molar angulation (MxMAg) and mandibular MAg (MdMAg) showed significant differences between the sexes ($p<0.05$). While the MdAP and MxMAg were significantly larger in the boys than in the girls, the MdMAg was found to be smaller

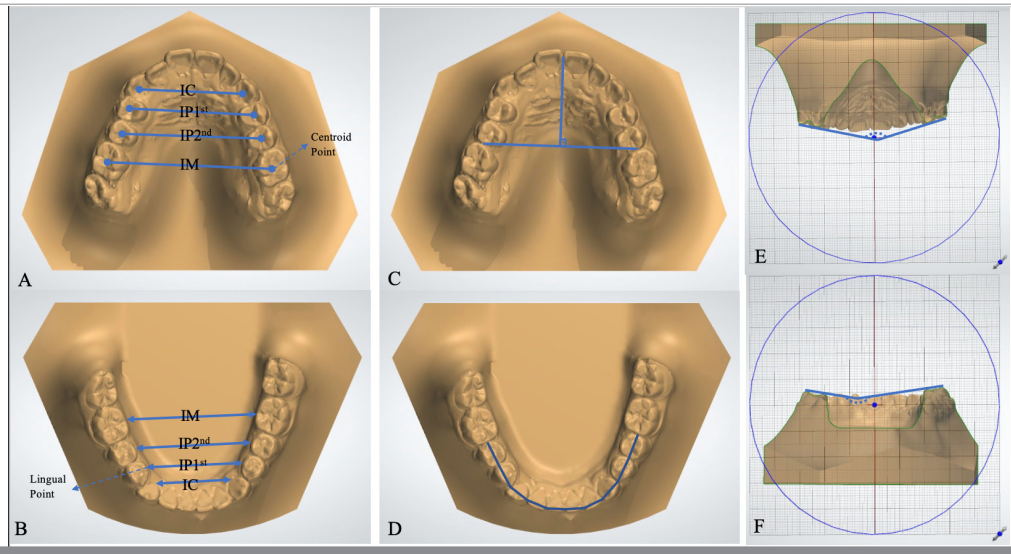

Figure 1. A- Intermolar (IM), interpremolar (IP1st and IP2nd) and intercanine (IC) distances from the centroid points of posterior teeth were measured in the transversal dimension. B- Intermolar (IM), interpremolar (IP1st and IP2nd) and intercanine (IC) from the lingual points where lingual grooves of posterior teeth meet with palatal and lingual mucosa were measured in transversal dimension. C- Arch depth parameter was measured as the length of the perpendicular line connecting the mesial contact point of right and left first molars from the mesial contact point of central incisors. D- Arch perimeter parameter was calculated as the length of lines from the mesial contact point of the first molar on one side to the mesial contact point of the first molar on the other side and passing through the mesial and distal contact points of teeth in between. E and F- Angulation of maxillary and mandibular first molars was calculated as the intersection angle of lines passing through the buccal and lingual cups of these teeth[10]

Table 1. Comparison of dental arch characteristics according to age groups and genders of individuals with bilateral posterior crossbite

Bilateral posterior crossbite		12-14 Age group (N=20)	14-16 Age group (N=20)	16-18 Age group (N=20)	p values[OWA]	Males (N=32)	Females (N=28)	p values[Is]
		Mean±SD	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
Age		13.14[a]±0.62	15.29[b]±1.11	17.30[c]±0.66	<0.001***	15.53±2.10	14.99±1.69	0.145
Maxillary arch width (Centroid)	IM	43.80±3.04	43.41±3.20	43.12±4.12	0.826	43.20±4.09	43.66±2.79	0.612
	IP (2nd)	37.71±2.32	37.02±3.40	36.94±3.79	0.711	36.90±3.99	37.51±2.31	0.465
	IP (1st)	32.91±2.39	31.98±3.49	32.21±3.04	0.594	31.97±3.49	32.71±2.46	0.341
	IC	29.07±2.79	29.73±2.64	28.78±2.43	0.503	29.29±2.70	29.10±2.57	0.782
Maxillary arch width (Lingual)	IM	32.45±3.32	31.38±3.24	30.55±4.08	0.249	30.86±4.34	31.99±2.75	0.225
	IP (2nd)	28.95±2.60	27.86±3.41	27.70±3.59	0.421	27.81±3.96	28.48±2.43	0.425
	IP (1st)	24.25±2.56	23.49±3.57	23.27±3.10	0.586	23.34±3.55	23.96±2.63	0.440
	IC	24.62±2.74	24.44±2.61	23.71±2.17	0.485	24.28±2.29	24.24±2.72	0.949
Mandibular arch width (Centroid)	IM	44.46±2.49	44.95±4.08	44.04±3.68	0.712	44.90±3.59	44.12±3.32	0.391
	IP (2nd)	36.89±3.37	37.73±3.55	37.40±3.91	0.764	37.28±3.97	37.39±3.25	0.910
	IP (1st)	31.25±2.19	30.33±3.70	30.27±3.40	0.549	30.43±3.68	30.78±2.63	0.664
	IC	23.99±1.88	23.68±1.71	23.19±1.70	0.366	23.91±1.90	23.37±1.63	0.239
Mandibular arch width (Lingual)	IM	36.01±2.59	36.43±3.85	35.60±3.27	0.728	36.09±3.41	35.94±3.13	0.859
	IP (2nd)	31.90±2.89	31.81±4.00	32.32±3.56	0.889	32.22±3.75	31.83±3.24	0.665
	IP (1st)	26.50±2.04	26.54±2.90	26.62±3.08	0.990	26.72±3.21	26.41±2.13	0.653
	IC	20.17±1.78	19.73±1.61	19.84±1.81	0.709	20.29±1.97	19.59±1.41	0.115
Arch depth	Mx	25.79±1.89	25.61±2.54	25.82±2.04	0.945	25.81±1.97	25.67±2.31	0.798
	Md	21.69±2.31	21.44±1.71	20.48±1.52	0.110	21.41±1.85	21.03±1.99	0.452
Arch perimeter	Mx	81.47±5.19	78.98±7.07	77.92±5.36	0.160	80.03±6.13	78.95±5.98	0.147
	Md	77.63±6.62	75.45±7.27	73.26±7.32	0.286	77.35±7.09	73.71±6.93	0.006**
Molar angulation	Mx	157.56±10.17	156.24±9.38	156.80±6.27	0.893	159.77±7.12	154.33±9.14	0.014*
	Md	202.81±10.75	204.16±14.13	206.12±9.20	0.662	202.12±10.03	206.32±12.35	0.036*

IM, Intermolar; IP, Interpremolar; IC, Intercanine; Mx, Maxillary; Md, Mandibular; SD, Standard deviation, [OWA]p values based on One-Way ANOVA results. [Is]p values based on the Independent samples t-test results. *p<0.05; **p<0.01; ***p<0.001
Different letters (a, b, c) in the age variable indicate that there is a significant difference between the groups

in boys than in girls (p<0.05). There was no significant difference in dental arch parameters between the age groups among the controls (p>0.05; Table 2). Meanwhile, the maxillary IM and IP (first and second) arch widths were significantly larger in boys than in girls (p<0.05). Mandibular IM and IP second arch widths and MdAP were also significantly larger in boys than in girls (p<0.05). In contrast, the MdMAg was significantly larger in girls than in boys (p<0.05). In all age groups, maxillary IM and IP arch widths were significantly smaller in individuals with BPC than in controls (p<0.05; Table 3). While maxillary IC arch width differed between patients with BPC and controls in the 12-14-year age group (p<0.05), it did not differ in the other age groups (p>0.05). Mandibular IM arch width of the patients with BPC was significantly larger than that of the controls in all age groups (p<0.05). Similarly, maxillary arch perimeter (MxAP) and MdAP were found to be significantly larger in individuals with BPC than in controls in all age groups (p<0.05). While the MxMAg was significantly smaller in individuals with BPC than in controls in all age groups, the MdMAg was larger (p<0.05). When sexes were evaluated separately, maxillary arch width at both centroid and lingual levels was found to be smaller, and the mandibular arch width was found to be larger in individuals with BPC than in controls in both sexes (p<0.05; Table 4). MxAP and MdAP were also e larger in the individuals with BPC than in controls in both sexes (p<0.05).

DISCUSSION

In this cross-sectional study, the dental arch dimensions and molar angulation were compared among individuals of different age groups and between those with and without bilateral crossbite. Based on our findings, the null hypothesis was partially rejected. The variables did not differ significantly between patients with BPC and controls across all age groups. However, significant differences in several parameters were observed between patients with BPC and controls when separately analyzing different age groups.

Table 2. Comparison of dental arch characteristics according to age groups and genders of control individuals without posterior crossbite

Control		12-14 Age group (N=20)	14-16 Age group (N=20)	16-18 Age group (N=20)	p values[OWA]	Males (N=30)	Females (N=30)	p values[Is]
		Mean±SD	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
Age		13.22[a]±0.53	14.99[b]±0.56	16.61[c]±0.44	<0.001***	15.01±1.54	14.88±1.45	0.208
Maxillary arch width (Centroid)	IM	47.40±2.14	46.20±2.10	47.43±3.44	0.250	47.97±2.76	46.05±2.19	0.004**
	IP (2nd)	41.52±2.17	40.12±1.96	41.26±2.98	0.158	41.74±2.50	40.18±2.17	0.012*
	IP (1st)	36.91±2.38	35.37±1.90	35.75±2.59	0.097	36.66±2.40	35.36±2.17	0.031*
	IC	30.84±2.18	29.83±3.08	29.79±2.15	0.335	30.42±2.11	29.89±2.87	0.420
Maxillary arch width (Lingual)	IM	34.19±2.79	33.18±2.36	34.31±3.27	0.385	34.88±2.86	32.91±2.47	0.006**
	IP (2nd)	32.07±2.29	31.07±2.01	32.04±2.77	0.328	32.49±2.45	30.97±2.09	0.012*
	IP (1st)	27.47±2.00	26.21±1.97	26.92±2.40	0.179	27.49±2.01	26.25±2.15	0.025*
	IC	25.43±1.85	24.05±1.92	24.17±2.15	0.058	24.88±1.95	24.22±2.11	0.209
Mandibular arch width (Centroid)	IM	42.38±2.47	41.16±2.65	42.45±3.45	0.290	43.06±2.64	40.93±2.79	0.004**
	IP (2nd)	36.22±2.38	35.04±2.18	36.69±2.85	0.105	36.75±2.23	35.22±2.63	0.018*
	IP (1st)	31.58±1.76	29.65±1.71	31.23±2.21	0.063	31.30±2.00	30.34±2.04	0.163
	IC	24.10±1.57	23.06±1.64	23.70±1.47	0.112	23.94±1.70	23.30±1.44	0.123
Mandibular arch width (Lingual)	IM	33.17±2.34	32.04±2.52	33.13±3.04	0.322	33.85±2.20	31.71±2.67	0.001**
	IP (2nd)	30.20±2.16	28.72±3.01	30.82±2.62	0.066	30.57±2.85	29.26±2.46	0.022*
	IP (1st)	27.17±3.40	25.67±2.21	26.86±1.96	0.166	27.17±2.80	25.96±2.37	0.077
	IC	20.35±1.45	19.30±1.33	19.89±1.73	0.099	20.22±1.58	19.48±1.45	0.064
Arch depth	Mx	26.86±1.64	26.21±1.41	25.95±1.84	0.201	26.29±1.82	26.38±1.51	0.839
	Md	22.40±1.71	21.63±1.16	21.72±1.40	0.190	21.99±1.51	21.85±1.43	0.713
Arch perimeter	Mx	72.89±3.15	71.26±2.67	71.74±2.81	0.056	73.24±3.36	72.01±3.10	0.147
	Md	64.18±2.75	64.27±2.56	64.23±3.68	0.250	65.37±3.13	64.08±3.09	0.006**
Molar angulation	Mx	162.03±6.07	168.36±5.58	165.19±7.35	0.134	166.52±6.26	163.86±7.14	0.332
	Md	198.45±6.22	195.03±7.91	195.10±10.00	0.328	194.00±8.42	198.39±7.51	0.038*

IM, Intermolar; IP, Interpremolar; IC, Intercanine; Mx, Maxillary; Md, Mandibular; SD, Standard deviation. [OWA]p values based on One-way ANOVA results. [Is]p values based on the Independent samples t-test results. *p<0.05; **p<0.01; ***p<0.001
Different letters (a, b, c) in the age variable indicate that there is a significant difference between the groups

Table 3. Comparison of dental arch characteristics of individuals with and without bilateral posterior crossbite according to age groups (Independent Samples t-test)

		12-14 Age group			14-16 Age group			16-18 Age group			Totally		
		BLC	C	p value	BLC	C	p value	BLC	C	p value	BLC	C	p value
		Mean±SD	Mean±SD		Mean±SD	Mean±SD		Mean±SD	Mean±SD		Mean±SD	Mean±SD	
Maxillary arch width (Centroid)	IM	43.80±3.04	47.40±2.14	<0.001***	43.41±3.20	46.20±2.10	0.002**	43.12±4.12	47.43±3.44	0.001**	43.45±3.44	47.01±2.65	<0.001***
	IP (2nd)	37.71±2.32	41.52±2.17	<0.001***	37.02±3.40	40.12±1.96	0.001**	36.94±3.79	41.26±2.98	<0.001***	37.22±3.19	40.96±2.45	<0.001***
	IP (1st)	32.91±2.39	36.91±2.38	<0.001***	31.98±3.49	35.37±1.90	<0.001***	32.21±3.04	35.75±2.59	<0.001***	32.37±2.98	36.01±2.36	0.042*
	IC	29.07±2.79	30.84±2.18	0.032*	29.73±2.64	29.83±3.08	0.911	28.78±2.43	29.79±2.15	0.171	29.19±2.61	30.15±2.51	<0.001***
Maxillary arch width (Lingual)	IM	32.45±3.32	34.19±2.79	0.048*	31.38±3.24	33.18±2.36	0.042*	30.55±4.08	34.31±3.27	0.003**	31.46±3.59	33.89±2.83	<0.001***
	IP (2nd)	28.95±2.60	32.07±2.29	<0.001***	27.86±3.41	31.07±2.01	0.001**	27.70±3.59	32.04±2.77	<0.001***	28.17±3.22	31.73±2.38	<0.001***
	IP (1st)	24.25±2.56	27.47±2.00	<0.001***	23.49±3.57	26.21±1.97	0.005**	23.27±3.10	26.92±2.40	<0.001***	23.67±3.08	26.87±2.16	<0.001***
	IC	24.62±2.74	25.43±1.85	<0.001***	24.44±2.61	24.05±1.92	0.599	23.71±2.17	24.17±2.15	0.508	24.26±2.51	24.55±2.04	0.483
Mandibular arch width (Centroid)	IM	44.46±2.49	42.38±2.47	0.012*	44.95±4.08	41.16±2.65	0.001**	44.04±3.68	42.45±3.45	0.165	44.48±3.44	42.00±2.90	<0.001***
	IP (2nd)	36.89±3.37	36.22±2.38	0.470	37.73±3.55	35.04±2.18	0.006**	37.40±3.91	36.69±2.85	0.518	37.34±3.57	35.98±2.54	0.018*
	IP (1st)	31.25±2.19	31.58±1.76	0.584	30.33±3.70	29.65±1.71	0.758	30.27±3.40	31.23±2.21	0.296	30.62±3.14	30.82±2.06	0.779
	IC	23.99±1.88	24.10±1.57	0.831	23.68±1.71	23.06±1.64	0.252	23.19±1.70	23.70±1.47	0.321	23.62±1.77	23.62±1.60	0.995
Mandibular arch width (Lingual)	IM	36.01±2.59	33.17±2.34	0.001**	36.43±3.85	32.04±2.52	<0.001***	35.60±3.27	33.13±3.04	0.018*	36.01±3.24	32.78±2.66	<0.001***
	IP (2nd)	31.90±2.89	30.20±2.16	0.052	31.81±4.00	28.72±3.01	0.011*	32.32±3.56	30.82±2.62	0.138	32.01±3.46	29.91±2.72	<0.001***
	IP (1st)	26.50±2.04	27.17±3.40	0.456	26.54±2.90	25.67±2.21	0.292	26.62±3.08	26.86±1.96	0.769	26.55±2.66	26.57±2.64	0.980
	IC	20.17±1.78	20.35±1.45	0.723	19.73±1.61	19.30±1.33	0.365	19.84±1.81	19.89±1.73	0.931	19.91±1.71	19.85±1.55	0.828
Arch depth (First molar)	Mx	25.79±1.89	26.86±1.64	0.052	25.61±2.54	26.21±1.41	0.362	25.82±2.04	25.95±1.84	0.838	25.74±2.14	26.34±1.66	0.088
	Md	21.69±2.31	22.40±1.71	0.273	21.44±1.71	21.63±1.16	0.694	20.48±1.52	21.72±1.40	0.011*	21.20±1.92	21.92±1.46	<0.001***
Arch perimeter	Mx	81.47±5.19	74.89±3.15	<0.001***	78.98±7.07	71.26±2.67	<0.001***	77.92±5.36	71.74±2.81	<0.001***	79.46±6.02	72.63±3.27	<0.001***
	Md	77.63±6.62	67.18±2.75	<0.001***	75.45±7.27	64.27±2.56	<0.001***	73.26±7.32	64.23±3.68	<0.001***	75.41±7.18	65.23±3.29	<0.001***
Molar angulation	Mx	157.56±10.17	162.03±6.07	0.003**	156.24±9.38	168.36±5.58	<0.001***	156.80±6.27	165.19±7.35	<0.001***	156.87±8.64	165.19±6.79	<0.001***
	Md	202.81±10.75	198.45±6.22	0.048*	204.16±14.13	195.03±7.91	<0.001***	206.12±9.20	195.11±10.00	0.001**	204.36±11.43	196.20±8.21	<0.001***

IM, Intermolar; IP, Interpremolar; IC, Intercanine; Mx, Maxillary; Md, Mandibular; SD, Standard deviation, BLC: Bilateral crossbite, C: Control. *p<0.05; **p<0.01; ***p<0.001

Table 4. Comparison of dental arch characteristics of individuals with and without bilateral posterior crossbite according to gender between groups (Independent Samples t-test)

		Females			Males		
		BLC	C	p value	BLC	C	p value
		Mean±SD	Mean±SD		Mean±SD	Mean±SD	
Maxillary arch width (Centroid)	IM	43.66±2.79	46.05±2.19	<0.001***	43.20±4.09	47.97±2.76	<0.001***
	IP (2nd)	37.51±2.31	40.18±2.17	<0.001***	36.90±3.99	41.74±2.50	<0.001***
	IP (1st)	32.71±2.46	35.36±2.17	<0.001***	31.97±3.49	36.66±2.40	<0.001***
	IC	29.10±2.57	29.89±2.87	0.261	29.29±2.70	30.42±2.11	0.085
Maxillary arch width (Lingual)	IM	31.99±2.75	32.91±2.47	0.173	30.86±4.34	34.88±2.86	<0.001***
	IP (2nd)	28.48±2.43	30.97±2.09	<0.001***	27.81±3.96	32.49±2.45	<0.001***
	IP (1st)	23.96±2.63	26.25±2.15	<0.001***	23.34±3.55	27.49±2.01	<0.001***
	IC	24.24±2.72	24.22±2.11	0.975	24.28±2.29	24.88±1.95	0.283
Mandibular arch width (Centroid)	IM	44.12±3.32	40.93±2.79	<0.001***	44.90±3.59	43.06±2.64	0.030*
	IP (2nd)	37.39±3.25	35.22±2.63	0.006**	37.28±3.97	36.75±2.23	0.529
	IP (1st)	30.78±2.63	30.34±2.04	0.550	30.43±3.68	31.30±2.00	0.403
	IC	23.37±1.63	23.30±1.44	0.870	23.91±1.90	23.94±1.70	0.946
Mandibular arch width (Lingual)	IM	35.94±3.13	31.71±2.67	<0.001***	36.09±3.41	33.85±2.20	0.004**
	IP (2nd)	31.83±3.24	29.26±2.46	0.001**	32.22±3.75	30.57±2.85	0.074
	IP (1st)	26.41±2.13	25.96±2.37	0.439	26.72±3.21	27.17±2.80	0.572
	IC	19.59±1.41	19.48±1.45	0.768	20.29±1.97	20.22±1.58	0.883
Arch depth (First molar)	Mx	25.67±2.31	26.38±1.51	0.159	25.81±1.97	26.29±1.82	0.399
	Md	21.03±1.99	21.85±1.43	0.069	21.41±1.85	21.99±1.51	0.193
Arch perimeter	Mx	78.95±5.98	72.01±3.10	<0.001***	80.03±6.13	73.24±3.36	<0.001***
	Md	73.71±6.93	64.08±3.09	<0.001***	77.35±7.09	66.37±3.13	<0.001***
Molar angulation	Mx	154.33±9.14	163.86±7.14	<0.001****	159.77±7.12	166.52±6.26	<0.001***
	Md	206.32±12.35	198.39±7.51	0.004**	202.12±10.03	194.00±8.42	0.001**

BLC, Bilateral posterior crossbite; C, Control; IM, Intermolar; IP, Interpremolar; IC, Intercanine; Mx, Maxillary; Md, Mandibular; SD, Standard deviation.
*p<0.05; **p<0.01; ***p<0.001

Although previous studies have evaluated unilateral posterior crossbite[8,12,13,21] to our knowledge, there is a lack of research focusing on bilateral posterior crossbite. Therefore, this study can be considered as the first to address this gap in the literature. Additionally, research on dimensional differences across age groups is limited, with many studies focusing on a particular age group while overlooking differences across other age groups. In the study by Yang and Chung[18] in 2019, the buccolingual relationship of the molars was examined on tomography images, and some differences were found. However, the age range of participants in their study was broad (6-35 years), and they only included individuals with normal occlusion. Additionally, only the buccolingual angulation of molars was evaluated in their study. It is worth noting that, treatment for posterior crossbite is typically recommended during the early stages of development, particularly during adolescence.[4,8,22] The fact that a wide age range was included in the above study makes it difficult to comment specifically on the adolescence period, when the treatments for this problem are concentrated. In the study by Liu et al.,[23] the age in which rapid maxillary expansion was applied ranged between 5 and 20 years. Therefore, this study examined the dental arch dimensions of individuals aged 12-18 years with permanent dentition, as orthodontic treatment is more frequently performed in such individuals. The fact that the age range in which the posterior crossbite is frequently treated also supports the inclusion of these individuals in this study.[24]

The measurements used in this study were based on those used by McNamara et al.[10], which have been preferred in several previous studies[12,20] and provide comprehensive information about dental arch dimensions. Transverse measurements were performed from both the centroid and lingual regions, and a two-way evaluation was used to obtain a more accurate result. To avoid incomplete interpretation due to tooth rotation and the differences in the buccolingual angulation, measurements were also taken from the lingual region. This study found that transverse widths and buccolingual angulation did not differ between the age groups in either controls or patients with BPC. However, a study by Nanda et al.[25] showed that transverse growth of the maxilla and mandible continued until the age of 18 years, and transverse dimensions at the age of 6 years made up a significant portion of the dimensions at the age of 18 years; with less growth observed after that age.[25] This finding supports the lack of difference in maxillary and mandibular transverse

widths in individuals aged 12-18 years in this study. However, in contrast to the study by Nanda et al.[25], this study found that the same was true for patients with BPC. These findings suggest that, since the upper molars in individuals with BPC are more palatally inclined than those in individuals without BPC, and the lower molars may limit the spontaneous recovery of the upper molars, similar treatments in different age groups will reveal the necessity of correcting the molar angulation. This study found differences in transverse dimensions between males and females in both controls and individuals with BPC. Similar findings in previous studies were thought to be attributed to differences in growth periods and rates between boys and girls,[26] as well as the fact that the face of boys is larger than that of girls.[27]

When the controls and individuals with BPC were compared, the maxillary intermolar width was found to be larger in the controls, whereas the mandibular intermolar width was found to be larger in the individuals with BPC, regardless of age or sex. However, larger maxillary and mandibular anterior-posterior widths were obtained in the individuals with BPC compared to controls. These findings are consistent with those of previous studies[10,20,28] and show that these values are different between individuals with and without BPC regardless of age or sex. Many studies[8,10,12,20,23] on posterior crossbite have focused on treatment-related procedures, and the number of cross-sectional studies remains insufficient. Therefore, this study makes an important contribution to the literature. Although cone-beam computed tomography (CBCT) is considered more effective for examining the buccolingual angulation of the molars,[7,14,15,18] the potential harm of radiation exposure cannot be ignored, and it is recommended to follow the ALARA principle.[29] For this reason, dental models are still used for primary treatment planning and diagnosis instead of CBCT.[1,30] Although the use of dental models may be considered a limitation of the study, their analyses is safer (and thus more ethical) and does not cause any harm to individuals. This study found that the angulation of the molars was greater for the mandible and lower maxilla in individuals with BPC, consistent with the results of McNamara et al.[10] and Geran et al.[20] However, the difference in the angulation between the individuals with BPC and controls was calculated for both younger (12-14 years) and older individuals (16-18 years) in this study. The findings suggest that the molar teeth are upright in both age groups, which is in line with the results by Marshall et al.[31] However, we determined that the difference between the individuals with BPC and controls in the 16-18-year age group was greater than that observed in the 12-14-year age group.

Andrews[32] previously reported a wide range of buccolingual angulation of the first permanent molars in untreated individuals. Although this study showed similar results for both groups, individuals with BPC had a greater variation in this interval. This finding can serve as a reference for recommending posterior crossbite treatment clinically. If the aim of the treatment is to correct molar angulation, different treatment methods may need to be reviewed for individuals with BPC. Because when the existing variation increases, the correction of the molar angulation to their normal positions may become more difficult with treatment. Further clinical studies with different methods should investigate individuals with BPC, and treatment results should be examined based on the analyses performed in this study.

CONCLUSION

The transverse dimension and buccolingual angulation of the molar teeth did not show significant differences between the age groups in both the controls or individuals with BPC. However, the transverse dental arch width and buccolingual angulation of the molars differed between the sexes, regardless of the presence of a posterior crossbite. The difference in molar angulation between individuals with BPC and controls was found to be greater in the older age groups, suggesting that posterior crossbite may affect molar uprighting, with age. Further studies are needed to examine other factors affecting this anomaly, including analyses of different parameters related to BPC, and to identify appropriate treatment methods.

Ethics

Ethics Committee Approval: This study was approved by the Erciyes University Clinical Research Ethics Committee (approval number: 2020/44, date: 15.01.2020).

Informed Consent: Informed consent forms were obtained from all patients included in the study and their parents.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - T.Ö., S.İ.R.; Design - T.Ö., A.Y., S.İ.R.; Supervision - A.Y., S.İ.R.; Funding - T.Ö.; Materials - T.Ö.; Data Collection and/or Processing - T.Ö.; Analysis and/or Interpretation - T.Ö., A.Y., S.İ.R.; Literature Review - T.Ö.; Writing - T.Ö., A.Y.; Critical Review - A.Y., S.İ.R.

Declaration of Interests: The authors have no conflicts of interest to declare.

Funding: The authors declared that this study has received no financial support.

REFERENCES

1. Proffit W, Sarver D, Ackerman J. Orthodontic diagnosis: The problem-oriented approach. Contemporary Orthodontics 5th ed. St Louis: Mosby; 013:150-219. [CrossRef]
2. Lombardo G, Vena F, Negri P, et al. Worldwide prevalence of malocclusion in the different stages of dentition: A systematic review and meta-analysis. *Eur J Paediatr Dent.* 2020;21(2):115-122. [CrossRef]
3. Alhammadi MS, Halboub E, Fayed MS, Labib A, El-Saaidi C. Global distribution of malocclusion traits: A systematic review. *Dental Press J Orthod.* 2018;23(6):40. [CrossRef]
4. Gungor K, Taner L, Kaygisiz E. Prevalence of Posterior Crossbite for Orthodontic Treatment Timing. *J Clin Pediatr Dent.* 2016;40(5):422-424. [CrossRef]

5. Uematsu S, Yoshida C, Takada K. Proportions of malocclusions in Japanese female adolescents over the last 40 years. *Oral Health Prev Dent.* 2012;10(4):373-377. [CrossRef]
6. Petrén S, Bondemark L, Söderfeldt B. A systematic review concerning early orthodontic treatment of unilateral posterior crossbite. *Angle Orthod.* 2003;73(5):588-596. [CrossRef]
7. Alkhatib R, Chung CH. Buccolingual inclination of first molars in untreated adults: A CBCT study. *Angle Orthod.* 2017;87(4):598-602. [CrossRef]
8. Bukhari A, Kennedy D, Hannam A, Aleksejuniene J, Yen E. Dimensional changes in the palate associated with slow maxillary expansion for early treatment of posterior crossbite. *Angle Orthod.* 2018;88(4):390-396. [CrossRef]
9. Eraydin F, Cakan DG, Tozlu M, Ozdemir F. Evaluation of buccolingual molar inclinations among different vertical facial types. *Korean J Orthod.* 2018;48(5):333-338. [CrossRef]
10. McNamara JA Jr, Baccetti T, Franchi L, Herberger TA. Rapid maxillary expansion followed by fixed appliances: a long-term evaluation of changes in arch dimensions. *Angle Orthod.* 2003;73(4):344-353. [CrossRef]
11. Shu R, Han X, Wang Y, et al. Comparison of arch width, alveolar width and buccolingual inclination of teeth between Class II division 1 malocclusion and Class I occlusion. *Angle Orthod.* 2013;83(2):246-252. [CrossRef]
12. Wong CA, Sinclair PM, Keim RG, Kennedy DB. Arch dimension changes from successful slow maxillary expansion of unilateral posterior crossbite. *Angle Orthod.* 2011;81(4):616-623. [CrossRef]
13. Leonardi R, Lo Giudice A, Rugeri M, Muraglie S, Cordasco G, Barbato E. Three-dimensional evaluation on digital casts of maxillary palatal size and morphology in patients with functional posterior crossbite. *Eur J Orthod.* 2018;40(5):556-562. [CrossRef]
14. Almaqrami BS, Alhammadi MS, Tang B, ALyafrusee ES, Hua F, He H. Three-dimensional morphological and positional analysis of the temporomandibular joint in adults with posterior crossbite: A cross-sectional comparative study. *J Oral Rehabil.* 2021;48(6):666-677. [CrossRef]
15. Choi JY, Chaudhry K, Parks E, Ahn JH. Prevalence of posterior alveolar bony dehiscence and fenestration in adults with posterior crossbite: a CBCT study. *Prog Orthod.* 2020;21(1):8. [CrossRef]
16. Dindaroğlu F, Duran GS, Tekeli A, Görgülü S, Doğan S. Evaluation of the Relationship between Curve of Spee, WALA-FA Distance and Curve of Wilson in Normal Occlusion. *Turk J Orthod.* 2016;29(4):91-97. [CrossRef]
17. Andrews LF. The six keys to normal occlusion. *Am J Orthod.* 1972;62(3):296-309. [CrossRef]
18. Yang B, Chung CH. Buccolingual inclination of molars in untreated children and adults: a cone beam computed tomography study. *Angle Orthod.* 2019;89(1):87-92. [CrossRef]
19. Sayania B, Merchant M, Josephs P, Chung CH. Changes in the buccolingual inclination of first molars with growth in untreated subjects: A longitudinal study. *Angle Orthod.* 2017;87(5):681-687. [CrossRef]
20. Geran RG, McNamara JA Jr, Baccetti T, Franchi L, Shapiro LM. A prospective long-term study on the effects of rapid maxillary expansion in the early mixed dentition. *Am J Orthod Dentofacial Orthop.* 2006;129(5):631-640. [CrossRef]
21. Ferro F, Spinella P, Lama N. Transverse maxillary arch form and mandibular asymmetry in patients with posterior unilateral crossbite. *Am J Orthod Dentofacial Orthop*. 2011;140(6):828-838. [CrossRef]
22. Pietilä I, Pietilä T, Pirttiniemi P, Varrela J, Alanen P. Orthodontists' views on indications for and timing of orthodontic treatment in Finnish public oral health care. *Eur J Orthod.* 2007;30(1):46-51. [CrossRef]
23. Liu S, Xu T, Zou W. Effects of rapid maxillary expansion on the midpalatal suture: a systematic review. *Eur J Orthod.* 2015;37(6):651-655. [CrossRef]
24. Celikoglu M, Akpinar S, Yavuz I. The pattern of malocclusion in a sample of orthodontic patients from Turkey. *Med Oral Patol Oral Cir Bucal.* 2010;15(5):791-796. [CrossRef]
25. Nanda R, Snodell SF, Bollu P. Transverse Growth of Maxilla and Mandible. *Semin Orthod.* 2012;18(2):100-117. [CrossRef]
26. Lux CJ, Conradt C, Burden D, Komposch G. Transverse development of the craniofacial skeleton and dentition between 7 and 15 years of age--a longitudinal postero-anterior cephalometric study. *Eur J Orthod.* 2004;26(1):31-42. [CrossRef]
27. DeKock WH. Dental arch depth and width studied longitudinally from 12 years of age to adulthood. *Am J Orthod.* 1972;62(1):56-66. [CrossRef]
28. Allen D, Rebellato J, Sheats R, Ceron AM. Skeletal and dental contributions to posterior crossbites. *Angle Orthod.* 2003;73(5):515-524. [CrossRef]
29. Yeung AWK. The "As Low As Reasonably Achievable" (ALARA) principle: a brief historical overview and a bibliometric analysis of the most cited publications. *Radioprotection.* 2019;54(2):103-109. [CrossRef]
30. Rheude B, Sadowsky PL, Ferriera A, Jacobson A. An evaluation of the use of digital study models in orthodontic diagnosis and treatment planning. *Angle Orthod.* 2005;75(3):300-304. [CrossRef]
31. Marshall S, Dawson D, Southard KA, Lee AN, Casko JS, Southard TE. Transverse molar movements during growth. *Am J Orthod Dentofacial Orthop.* 2003;124(6):615-624. [CrossRef]
32. Andrews LF. Straight Wire: The Concept and the Appliance. San Diego: L.A. Wells; 1989. [CrossRef]