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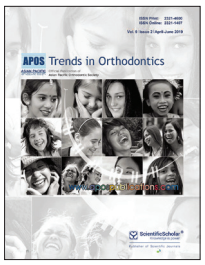

Original Article

Evaluation of mandibular indices and cephalometric parameters in adolescents with impacted maxillary canines

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ABSTRACT

Objectives: Maxillary impacted canines have an important place in orthodontics for the reason of being a common anomaly and its treatment is time consuming and difficult. The aim of this study was to investigate the mandibular indexes and cephalometric parameters in adolescents with impacted maxillary canines.

Materials and Methods: The radiographs of 4026 patients aged 12–19 years old were scanned and a total of 155 patients were included in the study. Subjects were divided into three groups according to the permanent maxillary canines: Bilateral impacted canine (BIC) (52 subjects; mean age 15.02 ± 1.74 years), unilaterally impacted canine (UIC) (51 subjects; mean age 14.89 ± 1.39 years), and the control (52 subjects; mean age 14.84 ± 1.65 years) groups. Skeletal, soft tissue and dental measurements were performed on cephalometric radiographs. Mandibular index analyzes including the panoramic mandibular index (PMI), mental index (MI), antegonial index (AI), and gonial index (GI) measurements and also angular measurements of impacted maxillary canines were performed on panoramic radiographs. Data were analyzed statistically and $P < 0.05$ was considered significant.

Results: Maxillary skeletal and dental measurements showed retrusive positioned maxillary dental arch in the sagittal direction in the impacted canine groups ($P < 0.05$). PMI and MI values were greater in the BIC and UIC groups than in control group ($P < 0.05$). There was no statistically significant difference in AI value among groups ($P < 0.05$). GI value of BIC group was found statistically lower than other groups ($P < 0.05$).

Conclusion: Individuals with impacted maxillary canines have more retrusive maxillary dental arch and soft-tissue components. Furthermore, mandibular cortex was thicker in subjects with impacted maxillary canine than individuals with not and clinicians should keep in mind this when examine the panoramic radiographs in terms of early diagnosis of impacted maxillary canine teeth.

Keywords: Impacted maxillary canine, Mandibular cortex, Mental index, Lateral cephalometric radiography, Panoramic radiography

INTRODUCTION

Maxillary impacted canines have an important place in orthodontics for the reason of being a common anomaly with a time consuming and difficult treatments. Maxillary canines are very important in terms of aesthetics and development of occlusion. Various complications such as decreased dental arch length, follicular cyst formation, canine tooth ankylosis, recurrent infections, pain, and internal or external resorption of canine and adjacent teeth can be observed when impacted canines are left untreated.[1,2]

Maxillary canines are the second most frequently impacted teeth after the third molars. Although the prevalence of impacted maxillary canines varies by ethnicity and region, it ranges between 0.92and 6.04%, where the impaction is more frequently palatal than buccal, and affects women twice as often as men.[3-5] Although the etiology of impacted maxillary canines is not fully known, there are studies showing that multifactorial and complex mechanisms play a role in their formation. In recent years, there have been remarkable genetic studies investigating the gene expression profile and transcription factors in dental follicles of impacted canines.[6-8]

Bone remodeling is a life-long complex process. Radiological assessment of bone quality can be performed using conventional radiographs, quantitative ultrasound (QUS), quantitative computed tomography (QCT), and dual-energy X-ray absorptiometry (DEXA). However, panoramic radiographs commonly used in oral and maxillofacial regions can also be used to obtain quantitative information about cortical and trabecular bones.[9] Several methods including mental index (MI), panoramic mandibular index (PMI), mandibular cortical index (MCI), gonial index (GI), antegonial index (AI), and fractal dimension analysis (FDA) are often used to measure bone quality and density in panoramic radiographs.

Wical and Swoope[10] have introduced mandibular bone measurements of mental foramen region to the literature and stated that the bone distance from the foramen to the inferior border of the mandible remains relatively constant throughout life despite the alveolar bone resorption above the mental foramen. There are five mandibular radiomorphometric indices which are frequently used to measure bone quality and density. These indices are MCI, MI, PMI, AI, and GI. MCI is a qualitative index that classifies the porosity of cortical bone distally to the mental foramen in the different three categories (C1-C3). MI is a linear measurement of the mandibular cortex thickness at mental foramen region.[11] PMI, which is calculated according to the technique described by Benson *et al.*,[12] refers to the ratio of mandibular cortical thickness and varies by race, gender, and age. AI and GI, which were introduced by Ledgerton *et al.*,[11] are the linear measurements of the cortical thickness in the mentioned regions. Most of the studies in the literature focused on the relationship between these indexes and osteoporosis, dental condition, or metabolic diseases.[13-15]

Panoramic radiographs are routinely used in dentistry for diagnosis and treatment and available for almost every patient and these indexes are easy to analyze. This study aims to evaluate the mandibular indices and lateral cephalometric parameters in adolescents with bilateral and unilateral impacted maxillary canines and aims to offer a different option to clinicians to early diagnosis of impacted maxillary canine teeth.

MATERIALS AND METHODS

The study was approved by the Local Ethics Committee of the Ordu University (#2018/261) and performed on panoramic and lateral cephalometric radiographs taken from adolescents with bilateral or unilateral impacted maxillary canines who applied for orthodontic treatment in Turkey.

The inclusion criteria

The following criteria were included in the study:
- Individuals with bilateral or unilateral impacted maxillary canine teeth
- Ages 12–19 years
- The absence of decidious teeth other than decidious canine or persistent teeth
- Canine root development is at Stages 4 or 5.

The exclusion criteria

The following criteria were excluded from the study:
- The craniofacial syndrome or cleft lip and palate
- Radiographs with artifacts and poor resolution
- Radiographs where mental foramen cannot be clearly observed.

Individuals were divided into three groups homogenous in terms of age and gender according to the state of the maxillary permanent canines: Bilateral impacted canine (BIC), unilateral impacted canine (UIC), and control groups. The sample size was calculated based on a power analysis using G*Power Software version 3.1.9.2 (Universität Düsseldorf, Germany) for a Fasial angle at α error probability of 0.05 and a power of 90%.[16] The power analysis showed that a total of 136 samples was required. It was calculated that at least 46 individuals would be required per group in the study performed on three groups.

A total of 155 patients, 51 for BIC and control groups and 52 for UIC group, were included in the study. In addition, the numbers of individuals with bilateral and unilateral impacted maxillary canines were determined and their percentages in the Turkish orthodontic patient population were calculated.

Measurements

Panoramic and lateral cephalometric radiographs were obtained using the same device (Kodak 8000C, Rochester NY, USA). After calibration settings, all radiographic measurements were performed by a single operator (E.G.) using FACAD software (trial version 3.8.4.2- Ilexis AB, Linkoping, Sweden) program. For intraobserver reliability, 20% of the measurements were repeated after 1 month.

Parameters measured in lateral cephalometric film analysis are shown in [Table 1].

After 27% magnification correction, mandibular index measurements were performed as right and left two measurements on the panoramic radiography of each individual and the mean index values were calculated by taking the arithmetic averages.[17-19]

Table 1: The lateral cephalometric measurements and definitions.

Parameter	Definition
SNA (°)	The angle between SN and NA planes
SNB (°)	The angle between SN and NB planes
ANB (°)	The angle between NA and NB planes
Wits (mm)	The distance between projections of points A and B on the occlusal plane.
NPerp-Pog (mm)	The distance between Pogonion point and N-perpendicular plane
NPerp-A (mm)	The distance between A point and N-perpendicular plane
Convexity (°)	The angle between NA and A-Pog planes
Face Angle (°)	The angle between Frankfurt plane and N-Pog plane
SNGoMe (°)	The angle between mandibular plane and SN plane
PP/SN (°)	The angle between palatal plane and SN plane
Y-axis/SN (°)	The angle between Y axis and SN plane
Ant. Face (mm)	The distance between Nasion and Menton points
OccP/SN (°)	The angle between Occlusal plane and SN plane
U1/SN (°)	The angle between long axis of the maxillary incisor and SN plane
U1/PP (°)	The angle between long axis of the maxillary incisor and palatal plane
IMPA (°)	The angle between long axis of the mandibular incisor tooth and mandibular plane
Interincisal (°)	The angle between long axis of mandibular incisor and maxillary incisor teeth.
U1-NPog (mm)	The distance between upper incisor tooth and NPog line
U1/NA (°)	The angle between long axis of the maxillary incisor and NA plane
U1-NPog (°)	The angle between long axis of the maxillary incisor and N-Pog plane
L1-NPog (°)	The angle between long axis of the mandibular incisor and N-Pog plane
Nasolabial Angle (°)	The angle between Columella, Subnasale, and Labrale Superior points
LabSup-SLine (mm)	The distance between Labrale superior point and S line
LabInf-SLine (mm)	The distance between Labrale inferior point and S line
H-Angle (°)	The angle between Nasion-B line and Labrale Superior-soft tissue Pogonion line
Z-Angle (°)	The angle between Frankfort plane and the soft tissue Pogonion and the tangent line between the upper / lower lips.

The MI, the cortical bone thickness on the line that passes through the middle point of the mental foramen perpendicular to the lower border of the mandible was measured.[11,12] PMI index was performed as PMI superior which was the ratio of the mandibular cortical width to the distance between the upper margin of the mental foramen and the lower margin of the mandible.[11,12] The AI is calculated as the mandibular cortical width at the point where the tangent passing through the anterior border of the ramus intersects the lower border of the mandible.[11] GI, the mandibular cortical width was measured at the point where the bisector of the angle formed by the line passing through the lower border of the mandible and the tangent line from the posterior border of the ramus[11] [Figure 1].

Angular measurements were also made to determine the impaction features. The measurements of the impacted maxillary canine teeth are summarized in [Table 2 and Figure 2]. The root development completion of maxillary canines is around 15 years old.[20] Then, the individuals around the age of 15 were in majority in the study, the root development stages were calculated. The canine tooth root development stage was evaluated in 6 stages based on Sajnani and King;[21] Stage 0: Root formation not yet begun, Stage 1: Root formation less than a quarter complete, Stage 2: Root formation between a quarter and a half complete, Stage 3: Root formation between a half and three quarters complete, Stage 4: Root formation more than three quarters complete, and Stage 5: Root formation complete.

Statistical analysis

All measurements were analyzed statistically using the SPSS Statistics 26.0 software (IBM SPSS Inc, Chicago, ILL, USA).

Table 2: The angular measurements of impacted maxillary canine teeth in the study.

Measurements	Definition
Canine-Midline Angle (1)	The angle between long axis of the canine tooth and midline plane determined by considering anterior nasal spine, intermaxillary suture and prosthion points
Canine-Lateral Angle (2)	The angle between long axis of canine and lateral teeth on the same side
Lateral- Midline Angle (3)	The angle between long axis of lateral tooth and midline plane
Canine-Occlusal Plane Angle (4)	The angle between long axis of canine tooth and the tangent passing through the mesial tubercle of the maxillary permanent first molar tooth and the middle point of the incisal edge of the permanent central incisor on the same side
Canine-Bicondylar Plane Angle (5)	The angle between long axis of canine tooth and the condylar plane passing through the upper point of the right and left condyles

One-way analysis of variance and Kruskal–Wallis tests were used in comparisons among groups. LSD and Mann–Whitney U-test were used in *post hoc* analysis of paired comparisons between groups. Cohens' Kappa statistics was performed to evaluate intra-observer reliability. For all tests, results with $P < 0.05$ were considered statistically significant.

RESULTS

There was no statistical difference between groups in terms of gender and age ($P > 0.05$) [Table 3]. The measurements repetition coefficients were found between 0.852 and 0.910 for cephalometric measurements, 0.807–0.954 for mandibular index measurements, and 0.956–0.997 for canine measurements. BIC and UIC group angular measurements are given in [Table 4] and there was a statistically significant difference in all measurements ($P < 0.05$).

A total of 208 impacted maxillary canine patients were detected in 4026 orthodontic patients and prevalence of impacted maxillary canine in Turkish orthodontic patient population was 5.16%. The prevalence of BIC and UIC was 1.39% and 3.77%, respectively, and the number of UIC was 2.71 times higher than BIC. Female individuals were 2.40 times more affected than males.

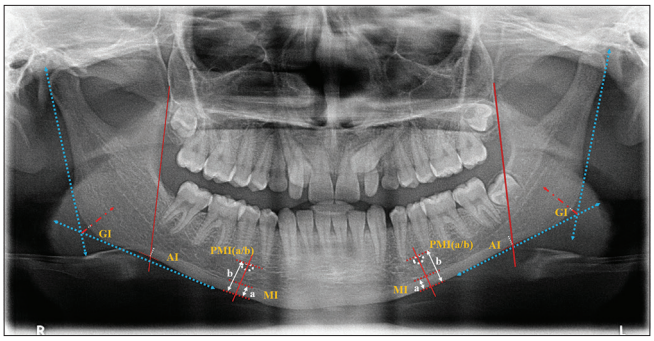

Figure 1: The mandibular indices measurements of the right and left sides of mandible. MI: Mental index; PMI: Panoramic mandibular index; AI: Antegonial index; GI: Gonial index.

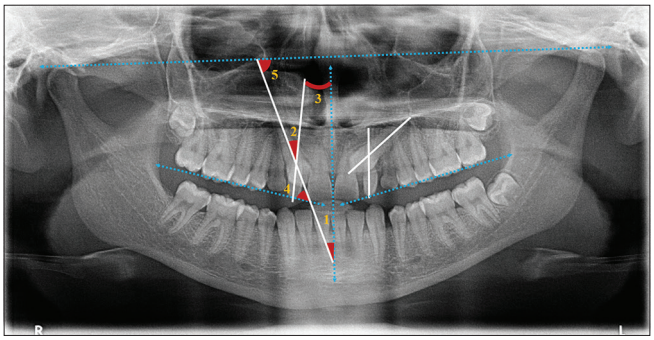

Figure 2: The angular measurements of impacted maxillary canine teeth. (1) Canine-midline angle; (2) Canine-lateral angle; (3) Lateral- midline angle; (4) Canine-occlusal plane angle; (5) Canine-bicondylar plane angle.

The mandibular index mean values are shown in [Table 5]. There was a statistically significant difference in MI values between the groups ($P = 0.005$), and MI value in UIC group was higher than BIC and control groups ($P < 0.05$). There was also a statistically significant difference between groups in the mean PMI superior value ($P = 0.025$), and PMI superior value of the UIC group was higher than control group ($P < 0.05$). In AI analysis, it was seen that the mean values were close to each other and there was no statistically significant difference between the groups ($P > 0.05$). In the GI analysis, there was a statistically significant difference between groups ($P = 0.043$) and the BIC group GI value was lower than UIC and control groups ($P < 0.05$).

In cephalometric hard tissue values, there was no statistically significant difference between the groups in most of parameters ($P > 0.05$). However, BIC group ANB and Convexity values were lower than the control group ($P < 0.05$); whereas SN/Occ angle of control group was lower than BIC and UIC groups ($P < 0.05$). Moreover, BIC group Wits value was lower than control group ($P < 0.05$) [Table 6]. In dental measurement, there was a statistically significant difference in all parameters except IMPA ($P < 0.05$). U1/SN, U1/PP, U1-NPog, U1-NA, U1-NPog, and L1-NPog values were smaller in the BIC and UIC groups compared to the control group ($P < 0.05$). The interinsical angle value was higher in BIC and UIC groups compared to the control group ($P > 0.05$) [Table 7]. In soft-tissue values, there was no statistically significant difference between the groups in Nasolabial angle and LabSup-S line ($P > 0.05$); however, UIC group LabInf-S line and BIC group H angle values were lower than control group ($P < 0.05$) and BIC group Z angle value was higher than the control group ($P < 0.05$) [Table 7].

The development stage of both sides' maxillary canines of all individuals was found same. While canine tooth root development was the most advanced in the UIC group, it was found significantly backward in the BIC group compared to both groups.

DISCUSSION

In this study, the reliability coefficients of MI, PMI, AI, and GI were found as 0.948, 0.807, 0.955, and 0.885, respectively;

Table 3: The age and gender distribution of the experimental and control groups.

Groups	Female/Male	Age	Total
BIC	38/14	15.02 (1.74)	52
UIC	37/14	14.89 (1.39)	51
Control	37/15	14.84 (1.65)	52
P	0.975[b]	0.835[a]	155

P[a]: *P*-value of One-Way ANOVA parametric test, P[b]: *P*-value of Pearson Chi-square non-parametric test, BIC: Bilateral impacted canine, UIC: Unilateral impacted canine

Table 4: The mean value and standard deviations of angular values in impacted and erupted maxillary canine regions.

Parameter	BIC-Left	Control-Left	*P*	BIC-Right	Control-Right	*P*	UIC-Impacted	UIC-Erupted	*P*
	Mean(SD)			Mean(SD)			Mean(SD)		
Canine-Midline Angle	33.55 (20.50)	4.73 (3.40)	0.000**	32.21 (20.21)	3.97 (3.47)	0.000**	32.25 (17.07)	4.77 (4.15)	0.000**
Canine-Lateral Angle	42.77 (22.77)	5.52 (5.65)	0.000**	39.37 (22.38)	4.30 (3.99)	0.000**	43.62 (16.00)	5.61 (6.00)	0.000**
Lateral- Midline Angle	57.18 (21.29)	91.53 (5.59)	0.000**	57.67 (20.20)	90.94 (5.01)	0.000**	60.61 (20.95)	90.69 (5.99)	0.000**
Canine-Occlusal Plane Angle	11.18 (8.17)	6.04 (4.03)	0.001*	9.26 (5.82)	4.53 (3.36)	0.000**	13.22 (7.89)	6.58 (4.96)	0.000**
Canine-Bicondylar Plane Angle	45.89 (20.79)	82.27 (5.29)	0.000**	46.75 (18.73)	81.73 (4.62)	0.000**	48.16 (18.45)	80.55 (5.94)	0.000**

*P=0.001, ** P=0.0001, BIC: Bilateral impacted canine, UIC: Unilateral impacted canine

Table 5: The mean values and standard deviation of MI, PMI, AI, and GI parameters and comparisons between groups.

Parameter	BIC		UIC		Control		*P*	Post-Hoc		
	Mean	SD	Mean	SD	Mean	SD		BIC-UIC	BIC-C	UIC-C
MI	4.66	0.83	5.05	0.74	4.54	0.89	0.005**	0.015*	0.471	0.002**
PMI	0.29	0.05	0.31	0.05	0.28	0.05	0.025*	0.109	0.293	0.006**
AI	3.45	0.65	3.58	0.50	3.67	0.59	0.214	0.222	0.085	0.704
GI	1.39	0.28	1.50	0.22	1.52	0.21	0.043*	0.039*	0.025*	0.786

*P=0.05; **P=0.01, BIC: Bilateral impacted canine, UIC: Unilateral impacted canine, MI: Mental index, PMI: Panoramic mandibular index, AI: Antegonial index, GI: Gonial index

and the values of $\alpha > 0.800$ indicated that the measurements had high reliability. The lower age limit for individuals whose radiographs would be used in the study was accepted as 12 years. Sajnani and King[22] observed significant differences between the mean distances from canine tubercle to occlusal plane at the age of 5 years and beyond. They found a statistically significant difference between the mean angles made with the midline at the age of 9 years and beyond. In addition, the root development of the canine tooth at the age of 12 years and above was found close to the completion with an average root growth stage at the age of 4.5 years and beyond.

Panoramic radiographs can be affected by factors such as technical equipment and patient position and have limitations such as distortion and magnification. Therefore, there are studies suggesting that using linear measurements in panoramic radiographs do not produce accurate information. However, several studies have reported that accurate linear, proportional, and angular measurements can be obtained with magnification correction in favorable conditions.[23,24] The PMI measurement methods differ in the literature. The PMI superior, one of the PMI measurements, was used in this present study. In addition, the MCI analysis was not performed due to the low age range and the presence of high number of factors affecting MCI evaluation.[25]

There are many studies examining the relationship between impacted canine and craniofacial skeletal structures. They have examined the relationship between impacted canine and various structures including maxillary arch width, palatal depth, nasal cavity width, sinus volume, ocular asymmetry, sella turcica, and vertebral morphologies.[26-28] Studies of the radiographic evaluation of bone quality mostly deals with osteoporosis. In addition, there are studies investigating the relationship between dental condition and metabolic diseases such as diabetes, scleroderma, and chronic kidney failure. This present study was conducted to evaluate the mandibular indices and cephalometric parameters in young adults with impacted maxillary canine teeth, which is the first study performed to examine the relationship between impacted canine and mandibular indices.

There are also studies showing the relationship between these indexes and systemic conditions. Yalcin *et al.*[19] found that individuals with scleroderma had significantly higher PMI and MI values than those in the control group, where there was no significant difference between their GI and AI measurements. David *et al.*[17] have reported that measuring MI, AI, and GI could be an important method for evaluating bone quality changes in diabetic patients. Yasa *et al.*[29] have investigated the relationship between body mass index and

Table 6: The mean values and standard deviation of cephalometric hard tissue measurements and comparisons between groups.

Parameter	Groups	Mean	SD	*P*	LSD Test		
					BIC-UIC	BIC-Control	UIC-Control
SNA (°)	BIC	80.63	3.53	0.131	0.573	0.160	0.051
	UIC	80.20	4.35				
	Control	81.70	3.69				
SNB (°)	BIC	78.19	3.30	0.230	0.161	0.874	0.119
	UIC	77.11	4.20				
	Control	78.31	4.07				
ANB (°)	BIC	2.43	1.80	0.119	0.163	0.044*	0.539
	UIC	3.09	2.28				
	Control	3.38	2.92				
NPerp-A (mm)	BIC	−2.10	3.21	0.604	0.458	0.829	0.339
	UIC	−2.60	3.82				
	Control	−1.96	3.12				
NPerp–Pog (mm)	BIC	−5.92	5.72	0.202	0.098	0.158	0.800
	UIC	−8.00	5.96				
	Control	−7.68	7.22				
Convexity (°)	BIC	2.46	4.66	0.101	0.200	0.034*	0.400
	UIC	3.92	5.64				
	Control	4.87	6.75				
SNGoMe (°)	BIC	32.21	7.32	0.729	0.477	0.510	0.955
	UIC	33.08	5.86				
	Control	33.01	5.26				
Occ/SN (°)	BIC	17.36	4.72	0.008**	0.320	0.036*	0.002**
	UIC	18.27	5.09				
	Control	15.45	3.94				
Yaxis/SN (°)	BIC	67.76	3.70	0.303	0.148	0.801	0.231
	UIC	68.84	4.20				
	Control	67.95	3.34				
Ant. Face (mm)	BIC	109.87	7.75	0.967	0.809	0.965	0.843
	UIC	110.19	5.67				
	Control	109.93	6.33				
Parameter	**Groups**	**Mean**	**SD**	***P***	**Mann-Whitney U Test**		
					BIC-UIC	**BIC-Control**	**UIC-Control**
Wits (mm)	BIC	−1.22	3.66	0.020*	0.203	0.030*	0.363
	UIC	−0.30	3.39				
	Control	0.82	3.97				
Face Angle (°)	BIC	86.69	3.18	0.209	0.063	0.133	0.971
	UIC	85.57	3.33				
	Control	85.70	3.97				
PP/SN (°)	BIC	8.27	3.46	0.781	0.069	0.907	0.054
	UIC	8.80	6.20				
	Control	8.25	3.24				

*P=0.05; **P=0.01, BIC: Bilateral impacted canine, UIC: Unilateral impacted canine

mandibular indices, and found that the obese and overweight group had higher PMI and MI values than the normal weight group. They also found that the obese and overweight group had thicker mandibular cortical bone, suggesting that this situation should be considered in orthodontic treatment planning.

There are several studies which have revealed the relationship between bone density measurements and mandibular radiomorphometric index. Shakeel *et al.*[30] have reported that MI and PMI values had a positive correlation with T-score in both males and females. Bollen *et al.*[31] have suggested that if cortical bone thickness in the gonial region decreases below 1 mm, this an important sign of metabolic disease. They have also argued that a MI value equal to or <3 mm and a PMI value <0.30 is associated with high risk of osteoporosis.[6,32,33] Servais *et al.*[6] reported that trabecular

Table 7: The mean values and standard deviation of cephalometric dental and soft tissue measurements and comparisons between groups.

Parameter	Groups	Mean	SD	*P*	LSD Test		
					BIC-UIC	BIC-Control	UIC-Control
U1/SN (°)	BIC	98.45	7.03	0.000***	0.734	0.000***	0.000***
	UIC	97.93	8.90				
	Control	105.26	7.36				
U1/PP (°)	BIC	106.72	6.93	0.000***	0.993	0.000***	0.000***
	UIC	106.73	9.95				
	Control	113.51	6.85				
IMPA (°)	BIC	91.40	8.46	0.168	0.912	0.114	0.093
	UIC	91.21	8.09				
	Control	94.13	9.64				
İnterincisal (°)	BIC	137.95	12.15	0.000***	0.937	0.000***	0.000***
	UIC	137.76	11.62				
	Control	127.60	11.71				
U1-NPog (mm)	BIC	4.10	3.26	0.000***	0.291	0.000***	0.002**
	UIC	4.85	3.37				
	Control	7.07	4.15				
U1-NA (°)	BIC	17.82	6.89	0.000***	0.956	0.000***	0.000***
	UIC	17.74	8.05				
	Control	23.56	8.21				
U1-NPog (°)	BIC	4.10	3.26	0.000***	0.291	0.000***	0.002**
	UIC	4.85	3.37				
	Control	7.08	4.14				
L1-NPog (°)	BIC	1.70	3.50	0.044*	0.986	0.031*	0.030*
	UIC	1.69	2.86				
	Control	3.14	3.67				
Nasolabial Angle (°)	BIC	109.90	8.29	0.403	0.179	0.539	0.462
	UIC	112.58	11.07				
	Control	111.12	10.69				
LabSup-S Line (mm)	BIC	−4.08	1.87	0.177	0.659	0.074	0.180
	UIC	−3.90	1.81				
	Control	−3.37	2.36				
LabInf-S Line (mm)	BIC	−2.11	2.53	0.058	0.690	0.064	0.028*
	UIC	−2.32	2.32				
	Control	−1.16	2.96				
H Angle (°)	BIC	7.85	4.68	0.098	0.601	0.038*	0.122
	UIC	8.34	4.45				
	Control	9.80	5.11				
Z Angle (°)	BIC	87.00	7.52	0.006**	0.060	0.001**	0.180
	UIC	84.22	6.33				
	Control	82.24	8.35				

*P=0.05; **P=0.01; *** P=0.0001, BIC: Bilateral impacted canine, UIC: Unilateral impacted canine

bone was more intense in the impacted canine region; and Rothe *et al.*[13] stated that patients with thinner mandibular cortices were at increased risk for dental relapse. All these studies have shown that when mandibular indices are low, bone density may also be low.

This study found that mandibular cortical thickness was higher in the impacted canine groups. The higher MI values in this present study than those in many other studies may be because of the low average age of the individuals in the sample. The reason why the data were lower than 0.30 which is accepted as the limit for the risk of osteoporosis may be because of the difference in PMI measurement methods used; PMI superior is lower than PMI inferior. This study found no significant difference between the groups' AI values, whereas David *et al.*[17] found that AI values significantly differed in the groups. In this present study, the GI analysis revealed that the control group had the thickest gonial cortex and that the BIC group had a significantly lower GI value than the other groups.

This study also found that ANB, convexity and Wits values were supportive for each other, where the BIC group had the lowest values, followed by the UIC group, and the control

group had the highest values. This may be because of the low arch perimeter due to the maxillary canines missing in the arch and lying behind in the sagittal direction. Amini *et al*.[16] found that facial angle was more obtuse in patients with palatally-displaced impacted maxillary canine than those with erupted canine; however, they did not find any significant difference between the groups in terms of SN/Go-Gn and gonial angles. Like our study, Arboleda-Ariza *et al*.[34] did not find any significant difference between the groups in terms of SNA and ANB angles. They found that NSAr angle was statistically significantly larger in the group with unilateral impacted maxillary canine than in both the group with bilateral impacted maxillary canine and the control group. Mercuri *et al*.[35] stated that individuals with erupted maxillary canine were characterized by increased values of ANB and by a retro-positioned or smaller lower jaw.

In this present study, the dental evaluation revealed that U1/SN, U1-NPog, and U1-NA values were supportive for each other. The maxillary canines were more retroclined and retruded in the BIC and UIC groups. Regarding the mandibular incisor positions, the incisors were more retroclined and retruded in the BIC and UIC groups compared to the control group. This may be because of the compensatory movement of mandibular incisors with maxillary incisors.

The soft-tissue parameters were also supportive for both the hard tissue and dental data. The upper and lower lips were positioned ahead in the control group however were more retrosive in the BIC and UIC groups. Mercuri *et al*.[3] have classified the facial types as normofacial, dolicofacial, and brachiofacial, and the facial profile as straight, convex and concave, and found that most groups with palatally and buccally impacted canines had normal facial type and profile.

CONCLUSION

- The prevalence of impacted maxillary canines was 5.16% in the Turkish orthodontic patient population
- In individuals with bilateral impacted maxillary canine, there was a retarded development in maxillary canine root compared to those with UIC or erupted canine
- The cephalometric dental measurements revealed that maxillary incisors were more retroclined and retruded in individuals with impacted canine and soft tissue was compatible with this situation
- The PMI values were consistent with MI values and higher in individuals with impacted maxillary canine
- The mandibular cortex was thicker in individuals with impacted maxillary canine therefore clinicians should keep in mind this when examine the panoramic radiographs in terms of early diagnosis of impacted maxillary canine teeth.

Human rights statements

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Authors' contributions

EG: Conceived the ideas and methodology, interpreted the data, led the writing and editing and final approval of manuscript, collected the data.

SKB: Conceived the ideas and methodology, interpreted the data, led the writing and editing and final approval of manuscript, data and statistical analysis.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Conflicts of interest

There are no conflicts of interest.

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