ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

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Comparison of Dentoalveolar Arch Symmetry in Individuals with Unilateral Maxillary Palatal Impacted Canine

Tek Taraflı Maksiller Palatal Gömülü Kanine Sahip Bireylerde Dentoalveolar Ark Simetrisinin Karşılaştırılması

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ABSTRACT Objective: To compare the dentoalveolar measurements of the subjects with unilateral palatally impacted canines versus non-impacted contralateral side on cone-beam computed tomography. **Material and Methods:** This retrospective study comprised 27 patients (16 female, 11 male; mean age: 15.34±1.95 years) with unilateral palatally impacted canine. Dolphin imaging software was used to reconstruct coronal, sagittal, and axial images. Coronal images were used for the evaluation of the angulation of the canine and lateral teeth, dentoalveolar height from the central and lateral incisors. On sagittal images, canine, lateral, first premolar angulation, and the distance of the canine cusp tip to the occlusal plane, on axial images; the lateral incisor rotation and arch width from premolar to mid-palatine raphe were evaluated. The paired samples t-test and Pearson correlation analysis were used for the statistical evaluation. **Results:** Lateral incisors on the impacted side showed significantly higher coronal angulation and lower sagittal angulation, compared to the non-impacted side ($p<0.05$). On impacted side, axial width from the first premolar to the mid-palatine raphe and lateral incisor rotation was significantly lower than on the non-impacted side ($p\leq0.001$). Canine cusp tip-occlusal plane was negatively correlated with the dentoalveolar height of the central ($r=-0.400$; $p=0.039$) and lateral incisors ($r=-0.373$; $p=0.055$). **Conclusion:** The results of the study implicate that unilateral palatally impacted maxillary canines can provide asymmetric dentoalveolar measurements. The deviation of the lateral incisors from normal angulation should be taken into consideration during orthodontic examination.

Keywords: Tooth impacted; cuspid; cone-beam computed tomography

ÖZET Amaç: Çalışmanın amacı, konik ışınlı bilgisayarlı tomografi kullanılarak tek taraflı palatal gömülü kanine sahip bireylerin dentoalveolar ölçümlerinin, gömülü kanin olmayan karşı taraf ile karşılaştırılmasıdır. **Gereç ve Yöntemler:** Retrospektif dizaynlı çalışmamız, tek taraflı maksiller palatal gömülü kanine sahip 27 bireyi (16 kadın, 11 erkek; ortalama yaş: 15,34±1,95 yıl) içermektedir. Dolphin yazılım programı kullanılarak koronal, sagital ve aksiyel kesitler elde edilmiştir. Koronal görüntülerde; lateral ve kanin dişlerin açılanmaları, santral ve lateral dişlerin dentoalveolar yükseklikleri ölçülmüştür. Lateral, kanin ve 1. premolar dişlerin sagital açılanmaları ve kanin tüberkülünün okluzal düzleme olan mesafesinin ölçümü sagital görüntüler kullanılarak yapılmıştır. Lateral diş rotasyonu ve pre-molar-midpalatal sütur arası genişlik ölçümleri aksiyel görüntüler üzerinde yapılmıştır. Eşleştirilmiş örneklem-t-testi ve Pearson korelasyon analizi istatistiksel değerlendirmede kullanılmıştır. **Bulgular:** Gömülü taraftaki lateral kesiciler, gömülü olmayan tarafa göre daha yüksek koronal açılanma ve daha düşük sagital açılanma değeri göstermiştir ($p<0,05$). Gömülü segmentte 1. premolar diş ile midpalatal sütur arası aksiyel genişlik ve lateral dişin rotasyonu karşı tarafa kıyasla daha düşük bulunmuştur ($p\leq0,001$). Kanin tüberkülünün okluzal düzleme olan dikey mesafesi ile santral ($r=-0,400$; $p=0,039$) ve lateral kesicilerin ($r=-0,373$; $p=0,055$) dentoalveolar yükseklikleri arasında negatif korelasyon saptanmıştır. **Sonuç:** Bu çalışmanın sonuçları tek taraflı palatal maksiller gömülü kaninlerin asimetrik dentoalveolar ölçümlere neden olabileceğini vurgulamaktadır. Lateral kesici dişlerin normal açılanmadan sapma göstermesi ortodontik muayene sırasında dikkate alınmalıdır.

Anahtar Kelimeler: Gömülü diş; kuspid; konik ışınlı bilgisayarlı tomografi

Impacted canine is seen 2 to 3 times more often on the palatal side than on the buccal side, and the etiology is mainly related to the guidance and/or the genetic theory.[1-5] Palatally impacted canines can change the inclination of the root and/or crown of the lateral incisor teeth because of a pushing effect.[6]

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It has also been implied that lateral incisors can show tipping and rotational movements due to palatally impacted canines.[7]

Kanavakis et al. indicated that lateral incisors' root near to the palatal impacted canines showed more angulation than the lateral incisors on the non-impacted side.[8] In a retrospective split-mouth study, it was shown that unilateral palatally impacted canine caused significant arch perimeter and alveolar bone dimension decrease, compared to the contralateral side.[9] In short, it is thought that impacted canines may decrease bucco-palatal bone width, and cause changes in the dental angulations of the adjacent teeth.[8,9]

It has been emphasized that the precise localization of the impacted canines has an important influence on the prognosis of the neighboring teeth.[10] With the use of cone-beam computed tomography (CBCT) images, impacted canine localization in different planes of the space can be determined clearly, and angular, linear and volumetric measurements can be provided.[11,12]

In the literature, a limited number of studies compared the unilateral impacted canine side with the non-impacted contralateral side in the same subjects.[8,9,13] None of these studies evaluated the sagittal angulations of the premolar teeth on the impacted side. It has been emphasized that unilateral palatally impacted canines may cause asymmetric dentoalveolar and bone structures between the right and left segments of the maxilla.[14] In this context, the aim of the present retrospective study was to compare the unilateral palatally impacted canines with the opposing erupted maxillary segment in relation to the coronal and sagittal angulations of the lateral and canine teeth, sagittal angulations of the first premolar teeth, dentoalveolar heights of the central and lateral incisor teeth, rotations of the lateral teeth, and interpremolar arch width.

The null hypothesis of this study was that there is no significant difference in lateral coronal angulation, lateral rotation, sagittal angulation of the lateral and first premolar teeth, dentoalveolar height of the central and lateral incisors, and interpremolar arch width between the sides of impacted canine and non-impacted canine.

MATERIAL AND METHODS

This retrospective trial reviewed totally 115 CBCT images of the patients with impacted canines, who were referred to Hacettepe University, Faculty of Dentistry, Department of Orthodontics. Sixty patients presented bilateral, while 55 patients presented unilateral maxillary canine impaction. Out of 55 CBCT scans; 27 scans were selected according to the inclusion criteria. The ethical approval was granted from Research Ethics Committee of Hacettepe University with a number of GO 18/560-26 and date of 12/06/2018 in accordance with the Declaration of Helsinki. Informed consent was obtained from the patients to use the CBCT images.

The inclusion criteria were as follows: 1-) CBCT images presenting unilateral palatally impacted canine, 2-) eruption of the contralateral canine, 3-) images of the patients older than 12 years old. The exclusion criteria were as follows: 1-) history of a previous orthodontic treatment, 2-) images with congenital missing teeth in the maxillary arch, 3-) images including supernumerary teeth, cystic follicles, or other pathologies around the impacted tooth.

MEASUREMENTS

CBCT images were acquired with I-CAT Imaging System (Imaging Sciences International, Hatfield, Pa) at maximum intercuspation. The scanning settings were as follows: 23x17 cm field of view (voxel size, 0.30 mm), 120-kVp tube voltage, tube current of 2 mA, and 17.8 seconds scan time. Dolphin Imaging Software (version 11.8, Dolphin Imaging & Management Solutions, California, USA) was used for importing CBCT image files (DICOM). The images were repositioned with the facial sagittal plane vertical to the occlusal plane; and occlusal plane transient to the maxillary central incisors' tips and maxillary first molars' mesio-buccal cusp tips (Figure 1).[13,15]

The sagittal scans reconstructed from the volumetric images were created for each side (impacted and non-impacted) separately, and used for the following measurements (Figure 2-A):

- The sagittal angulation of the lateral, canine and first premolar teeth: These were measured as the

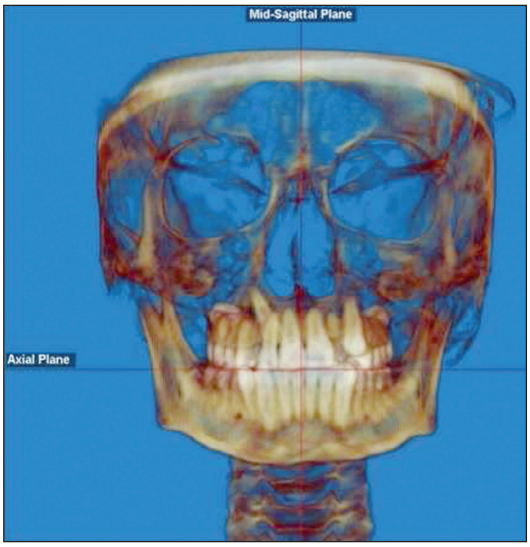

FIGURE 1: The orientation of the volumetric image.

angle between the axis of the lateral, canine and first premolar teeth and the vertical line.

■ Canine cusp-occlusal plane distance: This was measured as the distance between the tip of canine cusp and the occlusal plane.

The anteroposterior images derived from the volumetric images were used for the following measurements (Figure 2-B):

■ The coronal angulation of the lateral and canine teeth: These were measured as the angle between the axis of the lateral and canine teeth and the vertical facial line. Angle was recorded as positive when the crown tipped buccally, or negative when tipped palatally.

■ Dentoalveolar heights of the central and lateral incisors: These were measured as the distance between the incisal edge of the upper incisors and the plane passing through the floor of nostrils perpendicular to the midsagittal plane.

The axial 3D reconstructions were used to measure the following variables (Figure 3-A and 3-B):

■ Lateral rotation angle: This was measured as the angle between the line that was tangent to the buccal side of the lateral incisor and the midsagittal palatal midline. When the crown rotated disto-buccally the value was increasing, and when the crown rotated mesio-buccally the value was decreasing.

■ Premolar-median raphe width: This was measured as the distance between the palatal midline and the alveolar ridge between the canine and first premolar teeth.

All measurements were made by one calibrated operator (E.A.). Intra-observer reliability was assessed with repeating the analysis of randomly selected CBCT images of 14 patients after a 1-month interval. The operator regenerated the images, and repeated the measurements, all from the beginning. Intra-class correlation coefficients (ICC) for all variables were between 0.931 and 0.999.

A priori sample size analysis was carried out using G* Power 3.1.9.2 software taking into account a previous study, with alpha significance of 0.05 and a power of 80% considering a mean difference of 6±8.58° in the lateral incisor angulation.[13] Minimum 26 sides were required, and the study comprised 27

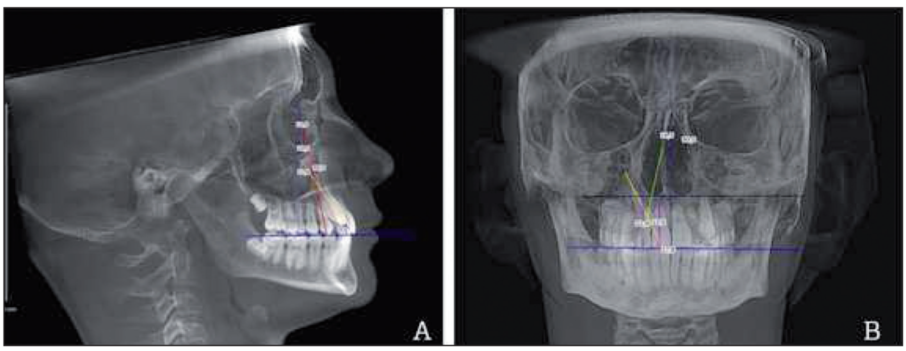

FIGURE 2: A) Angulation of the lateral incisor, canine and first premolar (relative to the vertical line perpendicular to occlusal plane), and the distance of the canine cusp tip to the occlusal plane in the sagittal view; **B)** Angulation of the lateral incisor and canine (relative to the midline) in the coronal view, and the distance of the incisal edges of upper incisors to the horizontal plane in coronal view.

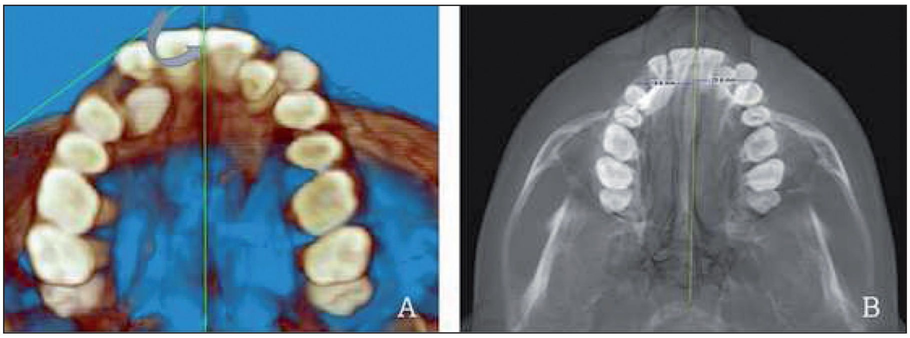

FIGURE 3: A) Rotation of the lateral incisor (the line that was tangent to the buccal crown side of the lateral incisor) relative to the midline; **B)** Premolar-median raphe width (from the proximal alveolar ridge between the canine and first premolar teeth to the palatal midline) in the occlusal view.

sides with and without palatal maxillary canine impaction with a total sample size of 54.

STATISTICAL ANALYSIS

Statistical analyses were applied using IBM-SPSS version 22.0 (SPSS Inc., Chicago, IL, USA). The Shapiro-Wilk test was applied to determine the distribution of the variables. The distribution of the differences for dependent variables between the two related groups showed almost normal pattern. Therefore, paired samples t-test was used for the comparison of the variables between the impacted and non-impacted sides. Mean and standard deviation (SD) were used for descriptive statistics. Pearson correlation analysis was applied to determine the correlations between the variables. The significance level was set at p<0.05 for all the tests.

RESULTS

The demographic variables of the study are shown in Table 1.

The measurements for the canine teeth showed a significant difference between the impacted and non-impacted sides (for coronal angulation, p<0.001; for sagittal angulation, p=0.019; for canine cusp tip-occlusal plane, p<0.001). The coronal angulation of the lateral teeth on the impacted side (17.09±8.33°) was significantly higher than on the non-impacted side (11.41±4.23°) (p=0.004). The average sagittal angulation of the lateral incisors were 20.62±11.80° for the impacted side, and 28.43±8.66° for the non-impacted side with a significant difference (p=0.001). Sagittal angulation of the first premolar teeth did not show a significant difference comparing the impacted and non-impacted sides (Table 2).

TABLE 1: Demographic and clinical characteristics of the sample.

Variables	Study group
Number of subjects	27
	(16 female, 11 male)
Age (year)	15.34 ±1.95
Impacted side	Right (9)%33.3
	Left (18)% 66.7

Dentoalveolar height of the central and lateral incisors did not show a significant difference comparing the impacted and non-impacted sides (Table 2).

Comparison of the axial measurements showed a significant difference between the impacted and non-impacted sides related to the lateral rotation and premolar-median raphe width (p<0.05) (Table 2). Maxillary premolar-median raphe width on the impacted side (17.64±1.89 mm) was significantly lower than the non-impacted side (19.90±1.42 mm) (p<0.001). The mean value of the lateral rotation measurement was significantly lower on the impacted side (46.20±17.76°) compared to the non-impacted side (56.36±12.16°) (p=0.001).

According to the Pearson correlation analysis, the distance of the canine cusp tip to the occlusal plane was negatively correlated with the dentoalveolar height of the central (r=-0.400; p=0.039) and lateral (r=-0.373; p=0.050) incisors (Table 3).

TABLE 2: Comparison of coronal, sagittal, and axial measurements between the impacted and non-impacted sides.

Variables	Canine Impacted/ Non-impacted	Mean± Standard Deviation	95% Confidence Interval Lower	Upper	p-value
Coronal angulation canine (°)	Impacted	-28.46 ±17.29	-35.30	-21.62	
	Non-impacted	11.13 ± 5.06	9.12	13.13	<0.001*
	Difference	-39.59 ±16.87	-46.26	-32.91	
Coronal angulation lateral incisor (°)	Impacted	17.09 ±8.33	13.79	20.39	
	Non-impacted	11.41 ±4.23	9.73	13.08	0.004*
	Difference	5.68 ±9.25	2.02	9.34	
Dentoalveolar height central incisor (mm)	Impacted	24.99 ±3.58	23.57	26.41	
	Non-impacted	25.00 ±3.45	23.64	26.36	0.969
	Difference	-0.01 ±0.98	-0.40	0.38	
Dentoalveolar height lateral incisor (mm)	Impacted	23.87 ±3.41	22.52	25.21	
	Non-impacted	24.01 ±3.50	22.62	25.40	0.620
	Difference	-0.14 ±1.50	-0.74	0.45	
Sagittal angulation canine (°)	Impacted	31.37 ±11.13	26.97	35.77	
	Non-impacted	24.61 ±6.09	22.20	27.02	0.019*
	Difference	6.76±14.05	1.20	12.32	
Sagittal angulation lateral incisor (°)	Impacted	20.62 ±11.80	15.95	25.28	
	Non-impacted	28.43 ±8.66	25.01	31.86	0.001*
	Difference	-7.81±10.41	-11.93	-3.70	
Canine cusp-occlusal plane (mm)	Impacted	-9.48 ±2.71	-10.55	-8.41	
	Non-impacted	-1.88 ±3.46	-3.25	-0.51	<0.001*
	Difference	-7.60±3.37	-8.93	-6.26	
Sagittal angulation first premolar (°)	Impacted	13.39 ±7.74	10.33	16.46	
	Non-impacted	13.03 ±6.67	10.39	15.67	0.829
	Difference	0.36±8.54	-3.02	3.74	
Lateral incisor rotation (°)	Impacted	46.20 ±17.76	39.17	53.22	
	Non-impacted	56.36 ±12.16	51.55	61.17	0.001*
	Difference	-10.16±13.40	-15.46	-4.86	
Premolar-median raphe width (mm)	Impacted	17.64 ±1.89	16.89	18.38	
	Non-impacted	19.90 ±1.42	19.34	20.46	<0.001*
	Difference	-2.26±2.11	-3.09	-1.42	

Paired samples- t-test, comparison of alveolar bone measurements between the groups, the significance level was p<0.05. *Statistically significant.

TABLE 3: Correlation between the canine variables and other measurements.

Variables	N	Coronal angulation lateral incisor (°) R (P)	Dentoalveolar height central incisor (mm) R (P)	Dentoalveolar height lateral incisor (mm) R (P)	Sagittal angulation lateral incisor (°) R (P)	Sagittal angulation premolar (°) R (P)	Lateral incisor rotation (°) R (P)	Premolar -median raphe width (mm) R (P)
Coronal angulation canine (°)	27	0.090 (0.654)	-0.226 (0.256)	-0.120 (0.552)	0.171 (0.395)	-0.088 (0.662)	0.112 (0.579)	0.045 (0.825)
Sagittal angulation canine (°)	27	-0.178 (0.375)	-0.101 (0.616)	-0.192 (0.338)	-0.001 (0.996)	0.106 (0.599)	0.086 (0.669)	0.248 (0.212)
Canine cusp tip-occlusal plane (mm)	27	-0.055 (0.784)	-0.400 (0.039)*	-0.373 (0.050)*	-0.062 (0.759)	0.099 (0.625)	0.132 (0.513)	-0.041 (0.839)

Pearson correlation coefficient analysis. Values are presented as R (p) value.

DISCUSSION

It is known that the adjacent lateral incisors display an important role in relation to the palatally impacted canines, because common genes control their eruption and dimensions, and because lateral incisor position in the dental arch effects the pathway of the canine eruption.[16-19] Therefore, the present study aimed to search if the maxillary lateral incisor angulation differed between the impacted and non-impacted sides in individuals with unilateral palatally impacted canine. It was also aimed to investigate the other parameters, since unilateral palatal impaction could lead to asymmetric dentoalveolar dimensions between the right and left segments of the maxilla.

The null hypothesis of the study was mostly rejected. The coronal angulation of the lateral incisor was significantly different by 5.68°, which was greater on the impacted side compared to non-impacted side. This result presented coronal disto-angulation of the lateral incisors on the impacted canine side. Likewise, D´Oleo-Aracena et al. presented more disto-angulated incisors in the impacted group on the coronal section measurements using CBCT images.[13] In contrast to the finding of these studies, in another study, it was found that the maxillary lateral incisors in the palatally impacted canine side were more upright in the coronal plane.[15] This altered result might arise from the different angulation of the impacted maxillary canine. From a clinical perspective, these findings can suggest that mesio-distal angulation of the lateral incisors might have a prognostic significance during a clinical decision in relation to the possible palatal displacement and impaction of the adjacent canine teeth.

The results of the present study showed that the sagittal angulation of the lateral incisors on the impacted side were significantly lower by 7.81° than on the non-impacted side. It was reported that incisor inclinations in Angle Class II Division 2 patients had been found as risk factors for palatal impaction of the canine teeth.[20,21] The lower sagittal inclination degrees of the lateral incisors on the impacted side can be related to the force on the root of the lateral incisor pushing the root buccally while the crown palatally resulting from the impacted canine.[6] Differently from the studies in the literature, the present study also evaluated the inclination of the first premolar teeth in sagittal constructions.[13,15] However, the results did not show any significant difference in relation to the premolar inclination between the impacted and non-impacted sides.

The maxillary lateral incisors on the impacted side presented more mesio-labially rotation by 10.16°, compared with those on the non-impacted side in the present study. In accordance with our results, previous studies also reported more mesio-labially rotation degree of the lateral incisors adjacent to the impacted palatal canines.[15,22]

The premolar-median raphe width measurement was significantly lower on the impacted side compared to the non-impacted side. This result may have arisen from the insufficient development of the impacted side, as the absence of a tooth might comprise a deficiency of arch development. Also similar findings were presented by other studies reporting the decrease of the arch width and arch length on the affected sides with split-mouth study designs.[9,13] According to the results of a recent retrospective CBCT study, subjects with unilateral or bilateral maxillary canine impaction showed reduced maxillary transverse widths than did subjects without impaction.[23] In contrast to these findings, several studies demonstrated no skeletal or dentoalveolar transverse width differences between the palatally impacted canine and non-impacted group.[24-26] However differently from our study, these studies compared the impacted canine cases and control groups. We evaluated and compared the arch symmetry in relation to the arch width with a split-mouth study design.

In the present study, no correlation was found between the vertical position of the impacted canine teeth, and the sagittal and coronal angulations of the lateral teeth on the impacted side. Conversely, Liuk et al. indicated that the vertical displacement of the palatally impacted canines was greater at what time the lateral incisor displayed reduced inclination in the sagittal and coronal plane.[15] In contrast to this finding, a recent study stated a positive correlation between the canine cusp tip to occlusal plane distance, and the coronal angulation of the lateral incisor in normal mixed dentition children.[15,27] The different results between the studies may arise from the difference of the sample groups and study designs.

According to the results of the present study, anterior dentoalveolar height was not different when impacted and non-impacted sides were compared, and was in similar to the finding of a recent cross-sectional study.[13] Yet a significant correlation was found in the present study, which was as the vertical position of the impacted canine teeth increased, dentoalveolar height of the central and lateral incisors decreased. Thus, clinically, this result could imply that the dentoalveolar height of the central and lateral incisor teeth could be affected by the vertical position of the impacted canine. However, because of the great variability related to the crown size among the patients, this result should be taken with caution. Besides any variation existing between the heights of the two nostrils can result in a non-stable reference plane, which can be considered as one of the limitations of the present study.

As suggested by different studies, early diagnosis can provide prevention of future palatal impaction of the canines.[14,28] From this perspective, the inclination, rotation or dentoalveolar height of the lateral incisors may warn the clinicians for the possibility of canine impaction. Also, the finding in relation to the arch width asymmetry in the present study can reveal a clinical significance that the clinician should imply a greater consideration to correct the transverse asymmetries on the impacted canine side before starting orthodontic treatment. Maxillary expansion can be applied to both correct the transverse deficiency and decrease the possibility of the canine impaction.

Since palatal canine impaction is a genetically controlled clinical presentation, we cannot be sure that the contralateral side is developed in the same way as individuals without canine impaction. This may be considered as one of the limitations of the study. It would be better to include a control group in order to clarify how much of the difference is physiological. On the other hand, it was impossible for the present study to select a Class I non-impacted control group from the perspective of ethical reasons in taking CBCT images. Besides, the sample size was carried out and minimum sample size was taken into consideration. According to our strict inclusion criteria, only 27 samples were taken and evaluated. However it might be better to provide larger sample size in order to make firm and sufficient conclusions. Also increasing the sample size might cover the wide spectrum of variations in the position of impacted canines. Since the total number of the sample used in this study was not sufficient to evaluate the effect of gender, the gender factor was not considered.

Due to the retrospective design of the study, possible bias should be kept in mind while deducing the results of the present study.

CONCLUSION

1- The maxillary lateral incisors on the impacted side showed more upright position in the sagittal plane, more disto-angulated position in the coronal plane and more mesio-labially rotation in the axial plane compared to the non-impacted side.

2- Interpremolar arch width was significantly reduced on the impacted side.

3- There was a negative correlation between the distance of canine cusp tip to the occlusal plane and dentoalveolar height of central and lateral incisors.

4- The deviation of lateral incisors from normal angulation should be taken into consideration during orthodontic examination. The positional changes of lateral incisor teeth may be related to impacted canine teeth.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Ezgi Atik, Hande Görücü Coşkuner;* ***Design:*** *Ezgi Atik, Hande Görücü Coşkuner, Bengisu Akarsu Güven;* ***Control/Supervision:*** *Bengisu Akarsu Güven;* ***Data Collection and/or Processing:*** *Ezgi Atik, Hande Görücü Coşkuner, Bengisu Akarsu Güven;* ***Analysis and/or Interpretation:*** *Ezgi Atik, Hande Görücü Coşkuner, Bengisu Akarsu Güven;* ***Literature Review:*** *Ezgi Atik;* ***Writing the Article:*** *Ezgi Atik;* ***Critical Review:*** *Ezgi Atik, Hande Görücü Coşkuner, Bengisu Akarsu Güven;* ***References and Fundings:*** *Ezgi Atik, Hande Görücü Coşkuner;* ***Materials:*** *Ezgi Atik, Hande Görücü Coşkuner, Bengisu Akarsu Güven.*

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