

Skeletal and dentoalveolar dimensions in unilateral impacted canines: a cone beam computed tomography study

Purpose

To compare skeletal and dentoalveolar measurements of subjects with unilateral impacted canine versus the non-impacted contralateral side using cone beam computed tomography (CBCT).

Materials and Methods

30 CBCTs with unilaterally impacted maxillary canines (Buccal=15, Palatal=15) were selected. Skeletal and dentoalveolar variables (alveolar ridge height of incisors, dentoalveolar height, angulations of incisors and canines, basal lateral width and premolar width) were compared between the impacted and the contralateral sides. Independent t-test was used to compare the variables.

Results

There was a significant difference in the mean basal lateral width between the impacted (28.25 ± 1.83 mm) and non-impacted (31.64 ± 2.18 mm) sides. Premolar width was significantly lower on the impacted side ($p < 0.05$). The canines exhibited significantly greater angulations on the impacted side compared to the non-impacted side. The basal lateral width was significantly higher in the buccal subgroup (29.03 ± 1.65 mm) compared to palatal (27.48 ± 1.70 mm) on the impacted side. The intra-operator reliability was found to be high (0.99%).

Conclusion

Significant differences were seen in canine angulation, premolar width and basal lateral width between impacted vs. non impacted sides. Basal lateral width was higher in buccal impacted cases compared to palatal.

Keywords: Impacted canine, CBCT, skeletal dimensions, diagnosis, orthodontic treatment

Introduction

An impacted tooth is one that is stopped from erupting into place due to malposition, lack of space, or other obstructions, according to Mead in early 1954. Later, Peterson defined impacted teeth as teeth that do not erupt into the dental arch in the expected period. Farman defined impacted teeth as teeth that are stopped from erupting due to a physical impediment in the eruption route (1, 2). Maxillary canines, after third molars, are the second most common teeth that are impacted, with prevalence varying from 1.80% to 3.29%, depending on the demographic studied (3). According to D'Oleo-Aracena *et al.* (4), incidence of impacted canine is more prevalent in females with a ratio of 2:1, and the frequency in the maxilla is more than double that of the mandible.

The maxillary canine has the longest eruption route of all the teeth, beginning right below the orbit's floor. It then takes a circuitous route into the oral cavity, guided by lateral incisor's root. The causative factors of impacted maxillary canines include maxillary lateral incisor's aberrant

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morphology, disturbance in the dental lamina of developing canines, premature development of the canine, and microform of the cleft lip and palate (5).

Palatally impacted canines are two or three times more common than buccally impacted canines (6). Palatal impactions of canines are frequently associated with the presence of enough space in the dental arch, whereas most labial impactions of canines are associated with crowding. Dental arch space insufficiency was seen in 83% of arches with labial displacement of maxillary canines, according to Jacoby (7). Guidance hypothesis and genetic theory are the two main explanations for the development of an impacted palatal canine. From a regulatory point of view, local conditions such as the primary canine retention and / or absence, malformations, or abnormalities of the maxillary lateral incisor contribute to canine eruption (5). Genetic theory, on the other hand, states that the conflict is caused by genetic predisposition, and is supported by evidence showing a link between affected canines and other phenotypic dental variants of genetic origin, such as the small size of the lateral incisor crown, lateral incisor agenesis, aplasia of premolars and third molars, distal dislocation of mandibular second premolars (8).

The impaction might cause changes in the alveolar bone's dimensions or disrupt the dental angulations of surrounding teeth. Subjects with maxillary canine impactions showed a transverse maxillary deficit in the anterior section of the dental arch, according to McConnell *et al.* (9).

The effect of canine impaction on alveolar maxillary dimensions has been evaluated in several studies (4,8,10). Compared with the unaffected side, Tadinada *et al.* (10) found that buccal-palatal width, height of floor of nasal cavity to alveolar ridge, and dental arch perimeter were significantly reduced towards the affected side. Lateral incisor roots near the affected palatal canines are more angulated than those of the lateral incisors near canines that erupt normally, according to Kanavakis *et al.* (8). On the affected side, D'Oleo-Aracena *et al.* (4) found reduced arch width in the area of the primary premolars and increased distal angulation of lateral incisors.

Cone beam computed tomography (CBCT) imaging is a precise and reliable method of detecting the exact position of an impacted tooth as well as measuring alveolar bone dimensions. In cases of palatally impacted canines of one side alone, previous investigations examined alveolar bone widths and heights on the impacted and non-impacted sides (4, 10). However, none of the investigations have taken into account canines that have been impacted buccally.

Therefore, this study aims to compare the skeletal and dento-alveolar dimensions in subjects with maxillary unilateral impacted canines, buccal or palatal versus the unaffected contralateral side using CBCT. The null hypothesis of the study was there is no difference in skeletal and dento-alveolar dimensions between impacted vs. nonimpacted side and buccal vs. palatal sides.

Materials and methods

Study design and sample size estimation

This cross-sectional and retrospective study with a split

mouth design was a multi-centre study. The sample consisted of CBCT's of subjects with unilateral maxillary impacted canines sourced from the archives of dental diagnostic centres specialising in CBCT imaging. Sample size calculation considered a mean difference of 2 mm in premolar width as clinically significant. A level of significance of 0.05 and 80% power required a sample of 28 sides with impacted and non-impacted canines each. Therefore, a sample of 30 CBCT's with unilateral canine impaction was taken for the study.

Ethical statement

The institutional ethics committee granted the ethical clearance to this study (IIEC/RP/2019/002).

Study participants

The inclusion criteria for the CBCTs were patient's age older than 15 years of both sexes, canines fully calcified, unilateral maxillary canine impaction, fully erupted contralateral canine and no history of any previous orthodontic treatment. Points for exclusion included poor image quality, tooth agenesis evident in CBCT scan, pathologies associated with the follicle like enlargement or cystic changes, CBCT scans demonstrating mesial migration of 1st premolar or distal migration of lateral incisor in impacted canine position, or any other pathology, dento-alveolar traumas, maxillary canine transpositions, craniofacial malformations, bilateral impacted maxillary canines, and patients with multiple impacted teeth.

30 CBCT scans that fulfilled the selection criteria were distributed into two separate groups: Group I (Non impacted) and Group II (Impacted) among which 15 had palatally impacted maxillary canine (subgroup A) and 15 had buccal impaction of maxillary canine (subgroup B). Evaluating the CBCT scans in axial section with lateral incisor and first premolar as reference teeth, position of impacted canine was determined, that is, buccal or palatal.

Image acquisition and analysis

Imaging was performed with 6 mA and 90 Kv settings using a Newtom 3D scanner (Newtom Giano, Cefla s.c., Italy). The image volume of all patients' CBCT scans was acquired using an 11 x 08 cm field of view with 0.15 mm isotropic voxel sizes and a 25-second exposure time. The DICOM pictures were analysed using NNT (New Net Technologies Ltd, Naples, Florida) software, which contained multiplanar reconstructions as well as 3D reconstructions in volume rendering mode and anteroposterior radiographs generated from CBCTs. All measurements were taken by a single calibrated radiologist and given in millimeters (mm) and degrees (°). An experienced Oral and Maxillofacial Radiology specialist performed the calibration. Anteroposterior radiographs produced from CBCTs in MIP coronal views were used to assess the skeletal and dentoalveolar variable heights, as well as the angulations of incisors and canines (Figure 1 A,B,C,D), and the widths of dentoalveolar variables (Figure 2 A,B,C) were measured in axial sections. The mid-sagittal plane was used as a reference plane for measuring alveolar

ridge height, dentoalveolar height, incisor and canine angulations, and basal lateral width, whereas the middle palatine raphe was used as a reference plane for measuring premolar width. The impacted and contralateral sides, as well as buccal and palatal impacted canines, were compared in terms of the assessed characteristics. All of the measurements were redone by the same examiner after a week.

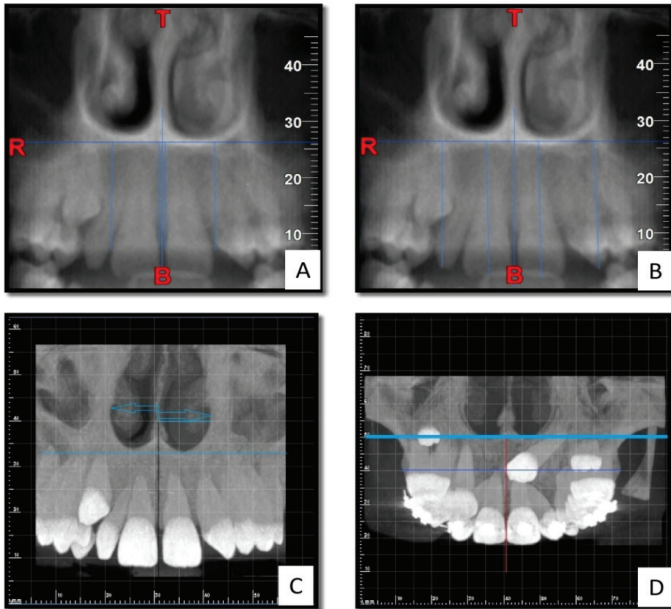


Figure 1. A- Anterior alveolar ridge height, B- Anterior dentoalveolar height, C- Nasal cavity width and D- Basal lateral width.

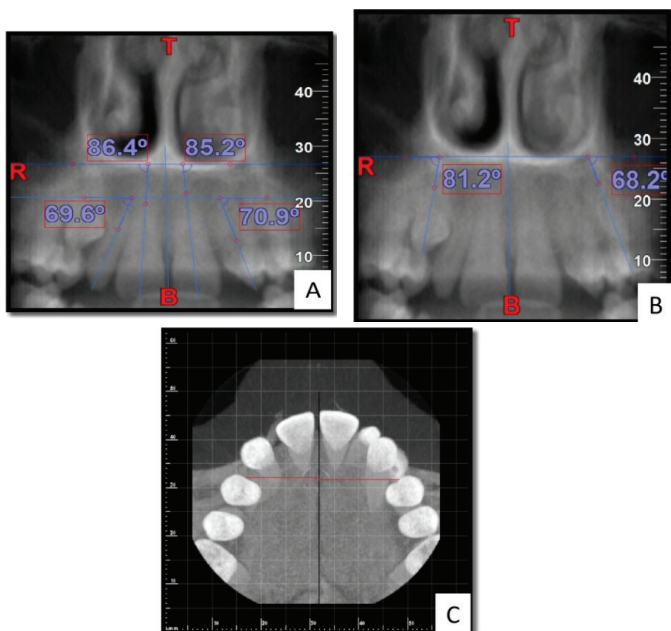


Figure 2. A- Lateral angulation of long axis of the incisors with respect to the nasal horizontal plane, B- Lateral angulation of long axis of canines with respect to the nasal horizontal plane, C- Premolar width.

Variables measured on CBCT images and their definitions

1. Anterior alveolar ridge height (AARH-CI and AARH-LI)- distance from the bone ridge of upper central incisors (CI) and lateral incisors (LI) to the floor of the nostrils

towards the side of impacted canine and on the side without impaction by drawing a straight line parallel to the mid-sagittal plane.

2. Anterior dentoalveolar height (ADH) is distance from the upper incisor edge to the floor of the nostrils on the side of the impacted canine and the side without impaction by drawing a straight line parallel to the midsagittal plane.
3. Nasal cavity width(NCW)- The distance between the anterior nasal spine and the lateral wall of the nasal base on the side of the impacted canine and the canine without impaction is measured in mm.
4. Basal lateral width (BLW)- The distance between the anterior nasal spine and the outermost dentoalveolar rim on the side of the impacted canine and the side of the canine without impaction is measured in millimetres.
5. Lateral angulation of the incisors' long axis with respect to the nasal horizontal plane (ACI and ALI)- Value of the external angle of the central incisors' (CI) and lateral incisors' (LI) longitudinal axes with respect to the tangent of the nostril floor in both quadrants.
6. Lateral angulation of the long axis of canines with respect to the nasal horizontal plane (AC) - Value of the external angle of the impacted canine's longitudinal axis with regard to the tangent of the nostril floor that has no impaction.
7. Premolar width (PW) - The distance in millimetres between the canine (deciduous or permanent) and first premolar on each side, measured in the axial cut at bone crest level, from the middle palatine raphe to the proximal alveolar bone crest.

Statistical analysis

SPSS version 16.0 (Chicago, IL, USA) was used for the statistical analysis. The study groups were subjected to descriptive statistics. To see if the data was regularly distributed, the Shapiro-Wilk test was used. An independent t-test was used to compare the results. For all tests, statistical significance was determined at a level of $p < 0.05$.

Results

13 males (mean age 20.3 ± 3.0 years) and 17 females (mean age 19.4 ± 3.6 years) were included in the present study. The method of acquiring measures was performed by the second examiner, and the measurements were compared to the first examiner's measurements using the intraclass correlation coefficient for inter-examiner reproducibility (ICC). The ICC values were found to be statistically insignificant, indicating high reliability, with a mean of 0.91 (ICC 0.88-0.94). A strong correlation was found in intra-examiner reliability analysis (ICC 0.99). In terms of the acquired results, the post hoc Power (1-err prob) was 0.8878047, indicating that the sample size was appropriate.

Table 1 shows the comparison of measured variables between the impacted vs the non-impacted sides. The basal lateral width was significantly greater on the non-impacted side compared to the impacted side whereas the angulation of canine was significantly greater on the impacted sides,

in both the buccal and palatal impaction cases. In the palatal impaction cases, a significant difference was also seen in the premolar width ($p=0.03$) whereas a significant difference was observed in the angulation of the central incisor ($p=0.002$) in the buccal impaction cases.

Table 2 shows the comparison of the buccal vs the palatal canine impaction subgroups. In the non-impacted side, the angulation of central incisors ($p=0.03$) was greater in the buccal compared to the palatal cases by 2.45° . On the impacted side, the basal lateral width in the buccal impaction cases was significantly higher (29.03 ± 1.65 mm) than in the palatal impaction cases (27.47 ± 1.70 mm).

Discussion

CBCT was used to assess skeletal and dentoalveolar variables in the maxillary arch in instances with unilaterally (buccal or palatal) impacted canines to the contra-lateral unaffected site. The accuracy of CBCT in measuring alveolar dimensions has previously been documented (4,8,10). The number of females ($n=17$) in the sample was higher than the number of males ($n=13$). This is consistent with prior research that found a higher prevalence of impacted canines in females (4,11,12).

The study found that the side with impacted tooth and the normal sides had substantial differences in basal lateral width, premolar width, and canine angulation. However, there was

no significant difference between the impacted and non-impacted groups in anterior alveolar ridge height, anterior dento-alveolar height of incisors, nasal cavity width, or incisor angulation. Because the alveolar process develops in response to tooth eruption, it's plausible to assume that the canine tooth's non-eruption/impaction resulted in changed alveolar dimensions on the impacted side (13,14). In cases of unilateral palatal canine impactions, certain earlier investigations have found a variation in maxillary alveolar dimensions and tooth angulations (4,10,15,16). When compared to the non-impacted side, Tadinada *et al.* (10) found that the impacted side had considerably smaller bucco-palatal width (BP), nasal floor to alveolar crest length, and arch perimeter. The bucco-palatal breadth was reduced at a level of 2mm above the alveolar crest in their study, but not at 6 or 10mm apically. The presence of impacted canine higher in the alveolar crest was the main reason for this. They claimed that bone loss was greater in the horizontal than in the vertical dimension. This is supported by our findings, which show that there were substantial changes in width measurements (basal lateral width and premolar width), but not in dento-alveolar heights. The measurement from the mid-palatal raphe to the first premolar on the afflicted side was substantially lower than the side that was normal, according to D' Oleo-Aracena *et al.* (4). They also suggested that canine impaction would have little effect on alveolar heights in the incisor region since the incisors erupt before the canines. Impaction of the maxillary canine has been linked to

Table 1: Descriptive statistics and comparison of impacted vs. non impacted sides.

Variables	Groups	N	Palatal impacted canine			Buccal impacted canine		
			Mean \pm SD	Mean Difference	p Value	Mean \pm SD	Mean Difference	p Value
AARH-CI	Group I	15	17.11 \pm 2.72	0.27	0.78	17.81 \pm 2.58	-0.19	0.85
	Group II	15	16.84 \pm 2.45			17.99 \pm 2.87		
AARH-LI	Group I	15	16.83 \pm 2.64	0.11	0.92	18.67 \pm 3.67	0.64	0.62
	Group II	15	16.72 \pm 3.16			18.03 \pm 3.23		
ADH-CI	Group I	15	25.17 \pm 3.48	0.49	0.7	26.89 \pm 2.59	0.57	0.53
	Group II	15	24.68 \pm 3.41			26.32 \pm 2.39		
ADH-LI	Group I	15	23.63 \pm 4.16	-0.37	0.79	25.54 \pm 3.07	0.47	0.68
	Group II	15	23.99 \pm 3.21			25.07 \pm 3.16		
NCW	Group I	15	12.28 \pm 1.007	0.34	0.44	11.81 \pm 1.41	-0.33	0.52
	Group II	15	11.94 \pm 1.33			12.14 \pm 1.34		
BLW	Group I	15	30.89 \pm 1.41	3.43	0.00*	32.39 \pm 2.57	3.37	0.00*
	Group II	15	27.47 \pm 1.7			29.03 \pm 1.66		
ACI	Group I	15	87.25 \pm 2.74	-0.09	0.96	89.71 \pm 3.31	4.19	0.002*
	Group II	15	87.34 \pm 5.76			85.51 \pm 3.59		
ALI	Group I	15	77.1 \pm 7.62	-1.42	0.65	77.14 \pm 6.42	0.95	0.78
	Group II	15	78.52 \pm 9.22			76.19 \pm 11.46		
AC	Group I	15	83.59 \pm 9.44	-30.83	0.00*	75.39 \pm 13.09	-25.18	0.00*
	Group II	15	114.42 \pm 20.86			100.57 \pm 20.87		
PW	Group I	15	18.5 \pm 2.44	2.03	0.03*	19.48 \pm 3.08	1.6	0.14
	Group II	15	16.47 \pm 2.43			17.88 \pm 2.63		

Independent t-test, Significant, $p\leq 0.05$ SD standard deviation, AARH-CI and AARH-LI: Anterior alveolar ridge height of central incisor (CI) and lateral incisor (LI), ADH: Anterior dentoalveolar height, NCW: Nasal cavity width, BLW: Basal lateral width, ACI and ALI: Lateral angulation of long axis of incisors with respect to the nasal horizontal plane, AC: Lateral angulation of long axis of canines with respect to the nasal horizontal plane, PW: Premolar width

Table 2: Descriptive statistics and comparison of buccal vs. palatal impacted canine groups.

Variables	Groups	N	Non impacted side			Impacted side		
			Mean \pm SD	Mean Difference	p Value	Mean \pm SD	Mean Difference	p Value
AARH-CI	Group A	15	17.11 \pm 2.72	-0.7	0.48	16.84 \pm 2.44	-1.15	0.25
	Group B	15	17.81 \pm 2.58			17.99 \pm 2.86		
AARH-LI	Group A	15	16.83 \pm 2.64	-1.84	0.13	16.72 \pm 3.16	-1.31	0.27
	Group B	15	18.67 \pm 3.67			18.03 \pm 3.23		
ADH-CI	Group A	15	25.17 \pm 3.48	-1.72	0.13	24.68 \pm 3.40	-1.64	0.14
	Group B	15	26.89 \pm 2.59			26.32 \pm 2.39		
ADH-LI	Group A	15	23.63 \pm 4.16	-1.91	0.16	23.99 \pm 3.20	-1.07	0.36
	Group B	15	25.54 \pm 3.07			25.07 \pm 3.16		
NCW	Group A	15	12.28 \pm 1.007	0.46	0.3	11.94 \pm 1.32	-0.2	0.68
	Group B	15	11.81 \pm 1.41			12.14 \pm 1.34		
BLW	Group A	15	30.89 \pm 1.41	-1.5	0.06	27.47 \pm 1.70	-1.56	0.01*
	Group B	15	32.39 \pm 2.57			29.03 \pm 1.65		
ACI	Group A	15	87.25 \pm 2.74	-2.45	0.03*	87.34 \pm 5.76	1.82	0.31
	Group B	15	89.71 \pm 3.31			85.51 \pm 3.58		
ALI	Group A	15	77.1 \pm 7.62	-0.04	0.99	78.52 \pm 9.22	2.32	0.54
	Group B	15	77.14 \pm 6.42			76.19 \pm 11.45		
AC	Group A	15	83.59 \pm 9.44	8.20	0.06	114.42 \pm 20.86	13.85	0.08
	Group B	15	75.39 \pm 13.09			100.57 \pm 20.87		
PW	Group A	15	18.5 \pm 2.44	-0.98	0.34	16.47 \pm 2.42	-1.40	0.14
	Group B	15	19.48 \pm 3.08			17.88 \pm 2.62		

Independent t-test, Significant, $p \leq 0.05$ SD standard deviation, AARH-CI and AARH-LI: Anterior alveolar ridge height of central incisor (CI) and lateral incisor (LI), ADH: Anterior dentoalveolar height, NCW: Nasal cavity width, BLW: Basal lateral width, ACI and ALI: Lateral angulation of long axis of incisors with respect to the nasal horizontal plane, AC: Lateral angulation of long axis of canines with respect to the nasal horizontal plane, PW: Premolar width

a lack of transverse growth in the front section of the dental arch in studies by McConnell *et al.*(9) and Schindel and Duffy (17). The findings of these investigations suggest that when a transverse maxillary deficit is noted clinically, the possibility of maxillary canine impaction should be considered. At this point, expanding the arch could be termed an interceptive technique. The clinical importance of our findings in terms of treatment suggests that more attention should be paid to correcting asymmetries in transverse dimension, particularly at the level of the first premolar on the side with an impacted canine. Only dental alignment should be used to correct the severity of this asymmetry (about 2 mm between both sides); however, in cases of more severe asymmetry, such as unilateral cross bite, asymmetric expansion could be considered.

The angulations of the impacted canine were substantially bigger than those of the non-impacted canine, and the impacted canine displayed mesial tilting. Hanke *et al.* (3) and D'Oleo-Aracena *et al.* (4) observed similar findings in their previous studies. The average difference in canine angulation between the impacted and non-impacted sides ranged from 25 to 30 degrees. The angulation of the canine is very important in deciding its prognosis. The incisor angulations on the affected and non-impacted sides, however, were not significantly different. D'Oleo-Aracena *et al.* (4) showed a substantial difference in incisor angulation between the affected and non-impacted sides, with greater distal crown angulation on the impacted sides, whereas Kanavakis *et al.*

(8) found a 2.5 degree mesial angulation of lateral incisors close to impacted canines.

However, according to D'Oleo-Aracena *et al.* (4), orthodontic treatment in unilateral impacted canines necessitates prior traction; aligning the incisors without distancing the impacted canine could expose the incisor roots to the impacted canine due to their distal angulation with respect to the opposite side without impaction. In addition, orthodontists should place a greater emphasis on rectifying transverse asymmetries, particularly at the level of the breadth between the median raphe and the first premolar on the affected side with an impacted canine.

We discovered no significant variations in the other characteristics between the buccal and palatal impacted canines, except for the basal lateral width, which was substantially greater in the buccal subgroup (29.03 \pm 1.65mm) compared to the palatal subgroup (27.48 \pm 1.70mm) on the impacted side. The distance between the mid palatine raphe and the proximal alveolar bone crest between the canine and first premolar on the impacted side was significantly shorter than the non-impacted side ($p < 0.05$) in palatal impacted canine cases. On the other hand, there was no significant change in premolar width on the impacted side of buccally impacted canines.

The drawbacks of study include a small sample size. Moreover the study did not differentiate the impacted canines according to the severity of impaction. The extent of

displacement of the canines from their normal positions in the arch may have affected the variables studied. The study excluded cases of canine impaction with presence of other dental anomalies such as peg-shaped or diminutive lateral incisors, agenesis of teeth and other anomalies to minimize confounding factors but in actuality, the impaction of canines, especially palatal ones has shown to be associated with such anomalies. Another drawback of this study is the small number of observers.

Conclusion

Within limitations, the following conclusions may be drawn from the study: Significant differences were observed in the canine angulation, premolar width and basal lateral width between the impacted vs. contra-lateral sides. Basal lateral width and premolar width were more on the non- impacted sides than impacted sides. Canine angulation on the side with impaction was substantially higher than on the contra-lateral side. On the buccal impacted sides, the basal lateral width was much bigger than on the palatal impacted sides.

Türkçe Özet: Tek taraflı gömülü köpek dişleri olan olgularda iskeletsel ve dentoalveolar boyutların konik ışınli bilgisayarlı tomografi kullanılarak karşılaştırılması. Amaç: Konik ışınli bilgisayarlı tomografi (KIBT) kullanarak tek taraflı gömülü köpek dişleri olan hastalarda dişin olduğu taraf ile olmayan tarafın iskeletsel ve dentoalveolar ölçümlerini karşılaştırmak amaçlanmıştır. Gereç ve Yöntem: Tek taraflı gömük maksiller kaninlere (Bukkal=15, Palatal=15) sahip 30 KIBT görüntüsü seçilmiştir. İskeletsel ve dentoalveolar değişkenler (kesici dişlerin alveolar kret yüksekliği, dentoalveolar yüksekliği, kesici dişlerin ve köpek dişlerinin açıları, bazal lateral genişlik ve premolar genişlik) gömülü dişin olduğu taraf ve olmayan karşı taraf arasında karşılaştırıldı. Değişkenleri karşılaştırmak için bağımsız t testi kullanıldı. Bulgular: Gömülü (28.25 ± 1.83 mm) ve etkilenmemiş (31.64 ± 2.18 mm) taraflar arasında ortalama bazal lateral genişlik açısından anlamlı bir fark vardı. Gömülü tarafta premolar genişliği anlamlı olarak daha düşüktü ($p < 0.05$). Köpek dişleri, etkilenmemiş tarafa kıyasla, etkilenen tarafta önemli ölçüde daha büyük açılar sergiledi. Bukkal alt grupta (29.03 ± 1.65 mm) gömük tarafta palatal (27.48 ± 1.70 mm) ile karşılaştırıldığında bazal lateral genişlik anlamlı olarak daha yüksekti. Ölçümcü içi güvenilirlik yüksek (%0.99) bulundu. Sonuç: Gömülü ve gömülü olmayan taraflar arasında köpek dişinin açılanması, premolar genişlik ve bazal lateral genişlikte önemli farklılıklar görüldü. Bukkal pozisyonunda gömülü diş olan olgularda bazal lateral genişlik palatal ile karşılaştırıldığında daha yüksekti.

Ethics Committee Approval: Ethical clearance was obtained from the institutional ethics committee (IIEC/RP/2019/002).

Informed Consent: Participants provided informed consent.

Peer-review: Externally peer-reviewed.

Author contributions: SKS, MS, PS participated in designing the study. SKS, MS, AS, PS, MR participated in generating the data for the study. SKS, MS, AS participated in gathering the data for the study. SKS, MS, AS participated in the analysis of the data. SKS wrote the majority of the original draft of the paper. SKS, MS, AS, PS, MR participated in writing the paper. SKS, MS, AS, PS, MR have had access to all of the raw data of the study. SKS, MS, PS have reviewed the

pertinent raw data on which the results and conclusions of this study are based. SKS, MS, AS, PS, MR have approved the final version of this paper. MR guarantees that all individuals who meet the Journal's authorship criteria are included as authors of this paper.

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