Original Article

Crown Size Comparisons in Patients with Unilateral Palatally Impacted Canine by Cone-Beam Computed Tomography

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Abstract

Objective: Impacted canine is a frequently encountered clinical problem. The goal of this study is to compare canines' dimensions and the adjacent lateral incisors to investigate the impact of tooth size on canine impaction as it could help the orthodontists to prepare a scientific treatment plan which proportionally aligns the teeth on both sides.

Methods: In this retrospective study, the cone-beam computed tomography of 40 patients with unilateral palatally impacted canines from the Kurdish population was assessed. Individual linear measurements were obtained from multiple axial slices of cone-beam computed tomography to assess mesiodistal width, gingivoincisal height, and labio-palatal thickness of the upper maxillary canines and lateral incisors crowns. The achieved data were compared between the impacted and non-impacted sides and a ratio of lateral incisor/canine for each dimension was calculated.

Results: The crowns of maxillary impacted canines were significantly larger labio-palatally and mesiodistally than the canine on the normally erupted side. While lateral incisor crowns adjacent to the impacted canines were shorter gingivoincisally than those adjacent to non-impacted canines. There was a significant association between the erupted lateral incisor and higher gingivoincisal meanwhile no significant difference was observed in labio-palatal and mesiodistal dimensions.

Conclusions: Palatally impacted canines were significantly larger in labio-palatal and mesiodistal dimensions than the normally erupted canines. The maxillary lateral incisors in the impacted canine side were slightly shorter than those on the non-impacted side and this difference has an effect on the orthodontic treatment planning.

Keywords: *Crown size, Palatally impacted canine, Cone-beam computed tomography.*

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Introduction

According to the position of the canine intraorally, it is regarded as an important tooth in functional occlusion, occlusion protection, and aesthetics. So, the proper knowledge about the permanent canine impaction and its position is essential before ortho-surgical procedures[1]. Maxillary canine is the second-most frequently impacted tooth in the dental arch after the third molars with prevalence from 1 to 3%. Most of the canine impactions are palatal 85%, whereas 15% are labial[2]. A tooth is considered as impacted if it's unable to erupt after root completion, or its contralateral side erupted with complete root formation[3]. The impacted permanent canine should be assessed both clinically and radiographically. It was suggested that canine impaction is more in females 3.6 times more than in males, and mostly diagnosed as unilateral impaction[1].

Surgical exposure and a guided orthodontic eruption is the preferred approach that can be followed for the treatment of impacted canines among the other approaches[4]. The exact position of palatally impacted canines (PIC) can be determined by cone-beam computerized tomography (CBCT) because its linear and angular measurements are very accurate and precise[5]. In a general sense, the risks of CBCT in orthodontics are outweighed by the benefits that CBCT scans provide in special cases in which conventional radiographs cannot provide the information necessary for diagnosis and treatment planning[6,7]. The CBCT offers a three-dimensional image that aid in the orthodontic diagnosis, and treatment planning and as soon will change the method in taking the needed orthodontic records [8]. Also with advancements in the technology and the CBCT devices, the in vivo evaluations of teeth and surrounding tissue become more dependable and can be applied in orthodontic diagnosis and treatment planning[9].

Three-dimensional models construction from the CBCT allowed a novel and accurate approach to the quantification of canine displacement[10,11]. There were no clinical differences between the measurements obtained by CBCT and digitalized plaster models[12], so the CBCT was applied in numerous branches of dentistry in the orthodontic field[13].

The dimension of the maxillary dentition in PIC cases among the Kurdish population has not been studied in detail by experts in the field. Besides, there are insufficient articles on this subject in our community. Therefore, by conducting this study, we may add a valuable resource.

Patients and methods

The present study was done in the Kurdistan region specifically Erbil city. The ethical committee, College of Dentistry/University of Sulaimani agreed to give the approval to perform the study with an ethical number (21/32). It's a retrospective study based on the diagnostic records of 2400 cases who attended the radiology department of Denta Center in Erbil city from early 2014 till the end of 2016. After sample size calculation from the collected cases, only 40 patients (27 Females, 13 Male) were selected as they were all from the Kurdish population and met the selective criteria of the study. The mean age of the sample was 26.8±7.7 years according to the presented data as it's a retrospective study and to ensure the erupted contralateral canine for the comparison. All the CBCT were from the same device (New Tom GiANO, CBCT unit, NNT version 6.1, software for reconstruction) with the settings exposure as 90 KV, 3.00 mA, and 9.0 second exposure time with the patient in maximum intercuspation and the Frankfort horizontal plane parallel to the floor as common CBCT imaging protocols.[14]

Selective Criteria:

1. No limitation of dental or skeletal classification.
2. No deformation of erupted canine and lateral incisor crowns due to attrition or trauma and no prosthetic crown.
3. No dental restoration or root canal treatment for both erupted canine and lateral incisor
4. Two-thirds of canine root appear with cusp tip located behind the root of the lateral incisor (as the palatally impacted canine was selected) in the horizontal plane of CBCT scan.
5. No previous root restoration.
6. No previous orthodontic treatment
7. No cleft palate.
8. All the radiographic images for the patients are of good quality from the Kurdish population in origin (all the three grandparents of both parents were Kurdish from Iraq).
9. No congenital anomaly of hard tissue like amylogenesis imperfecta.
10. Patient without missing of lateral incisors.

Measurements

Individual linear measurements can be obtained from the CBCT by using multiple axial slices with 0.150 mm voxel size including coronal and sagittal reformatted images and then selecting maximum dimensions in each slice to assess mesiodistal (MD) width, gingiva-incisal (GI) height, and labio-palatal (LP) thickness of each crown for maxillary canines and lateral incisors.[15]

Axial images were used to determine grayscale threshold values in HU that could be used to separate the various tissues of the teeth and periodontium. For the maxillary canine, the (MD can be measured from the greatest mesial to distal anatomic contact points, (GI) from the cusp tip of the canines on the incisal edge to the deepest curvatures on the cementoenamel junction while (LP) from buccal or labial surface of the maxillary canines[15], which indicate anatomically the labial ridge to a point on the palatal side which indicates lingual ridge of maxillary canine on cingulum as in figure 1. A. The same measurements should also be done for the maxillary lateral incisors except instead of the cusp tip of the canine the incisal edge was used for the lateral as in Figure 1. B. The points were chosen regarding clinical and radiographic dental anatomy[16,17].

Each of the measurements that were taken for the canine and lateral incisors on the impacted side was compared to the same measurements on the non-impacted side. Canine measurements and measurements from the ipsilateral incisor were combined to create a lateral incisor/canine ratio for each dimension. This ratio should be compared between the impacted and non-impacted sides to further illustrate whether canine crown size alone affects the rate of impaction, or if also there may have been a combined effect from the size of lateral incisors. This was done by orienting each tooth parallel to the long axis for gingiva-incisal height and perpendicular to the long axis for the mesiodistal width and labiolingual thickness[15].

The reliability of the observer was tested by repeating the linear measurements for 20 randomly selected subjects after a 10- week washout period and calculating the intra-class correlation coefficients. The result was excellent, with r=0.81 for the GI, r=0.72 for the LP and r=0.8 for the MD as shown in Table 1.

Statistical analysis

The patients' data were calculated by Statistical Package for Social Sciences (SPSS) version 21 was used. Descriptive statistics are presented as (mean ± standard deviation) and frequencies as percentages. Kolmogorov Smirnov analysis verified the normality of the data set. Multiple contingency tables were conducted and appropriate statistical tests were performed, independent sample t-test was used to compare between two means. The level of significance (*p-value*) was set at ≤ 0.05 and the result was presented as tables.

Results

The descriptive statistics for the variable included in the study were summarized in Table 2. The mean MD of impacted canine was significantly higher than the mean MD of erupted canine and the mean GI of lateral incisor at the impaction side was significantly lower than the mean GI of lateral incisor at the eruption side. All the compared canine means according to impaction and eruption sides were determined in Table 3. The mean MD and GI ratio at the impaction side was significantly lower than the eruption side with a highly significant difference. No significant differences in LP ratio between impaction and eruption sides as in Table 4.

The mean MD of canines in the impacted side was significantly higher than erupted side for both males and females. Also. the mean MD of canines in the impacted side was significantly higher than the erupted side as shown in Table 5. For both male and female patients, erupted lateral incisors and higher GI mean showed a significant result. For right and left impaction sides, there was a significant difference between erupted lateral incisor and higher GI mean. No significant difference was observed in the other measurements of lateral incisors between impacted and erupted sides as in Table 6.

Table 1: Intra-examiner reliability in measuring canines and lateral incisors.

Variable	Intraclass correlation	95% PIC	*p-value*
GI 1st measurement & 2nd measurement	0.81	0.74-0.85	≤ 0.05**
LP 1st measurement & 2nd measurement	0.72	0.63-0.91	≤ 0.05**
MD 1st measurement & 2nd measurement	0.8	0.57-0.93	≤ 0.05**

Table 2: Demographic characteristics of palatally impacted canine patients.

Variable	No.	%
(Age mean± SD 2.6±7.7)		
<20 years	8	20.0
20-29 years	20	50.0
30-39 years	9	22.5
40 years	3	7.5
Total	40	100.0
Gender		
Male	13	32.5
Female	27	67.5
Total	40	100.0
Impaction side		
Right	20	50.0
Left	20	50.0
Total	40	100.0

Table 3: Comparison of measurements mean of the variables in mm between impacted and non-impacted sides.

Variable	Impaction	Eruption	t-test	*p-value*
	Mean±SD (mm)	**Mean±SD (mm)**		
GI of canine	9.76±0.9	9.45±1.02	1.4	0.1
LP of canine	7.93±0.61	6.53±0.58	10.4	≤ 0.05**
MD of canine	7.87±0.84	6.06±0.54	11.4	≤ 0.05**
GI of lateral incisor	9.76±0.9	9.45±1.02	1.4	0.1
LP of lateral incisor	7.93±0.61	6.53±0.58	10.4	≤ 0.05**
MD of lateral incisor	7.87±0.84	6.06±0.54	11.4	≤ 0.05**

*Independent sample t-test

Table 4: Distribution of lateral incisor/canine ratio means according to impaction and eruption sides.

Variable	Impaction	Eruption	t-test	*p-value*
	Mean±SD	**Mean±SD**		
GI of lateral incisor/ GI of canine ratio	0.9±0.07	1.17±0.23	7.1	≤ 0.05**
LP of lateral incisor/ LP of canine ratio	0.78±0.09	0.8±0.05	1.2	0.2
MD of lateral incisor / MD of canine ratio	0.77±0.1	0.86±0.06	4.1	≤ 0.05**

*Independent sample t-test

Table 5: Distribution of canines' characteristic means according to impaction and eruption sides for male and female patients.

Variable	Impaction	Eruption	t-test	*p-value*
	Mean±SD (mm)	Mean±SD (mm)		
Male				
GI of canine	10.2±0.7	9.85±0.78	1.2	0.2
LP of canine	8.3±0.68	6.46±0.53	7.6	≤ 0.05**
MD of canine	7.7±0.89	5.96±0.56	5.8	≤ 0.05**
Female				
GI of canine	9.54±0.91	9.25±1.08	1.05	0.2
LP of canine	7.75±0.49	6.55±0.61	7.8	≤ 0.05**
MD of canine	7.96±0.82	6.11±0.53	9.7	≤ 0.05**
Right				
GI of canine	9.64±1.03	9.35±1.19	0.8	0.4
LP of canine	7.63±0.46	6.45±0.52	7.5	≤ 0.05**
MD of canine	8.04±0.81	6.07±0.54	9.04	≤ 0.05**
Left				
GI of canine	9.88±0.75	9.55±0.84	1.2	0.2
LP of canine	8.23±0.61	6.61±0.64	8.2	≤ 0.05**
MD of canine	7.71±0.86	6.06±0.55	7.1	≤ 0.05**

*Independent sample t-test

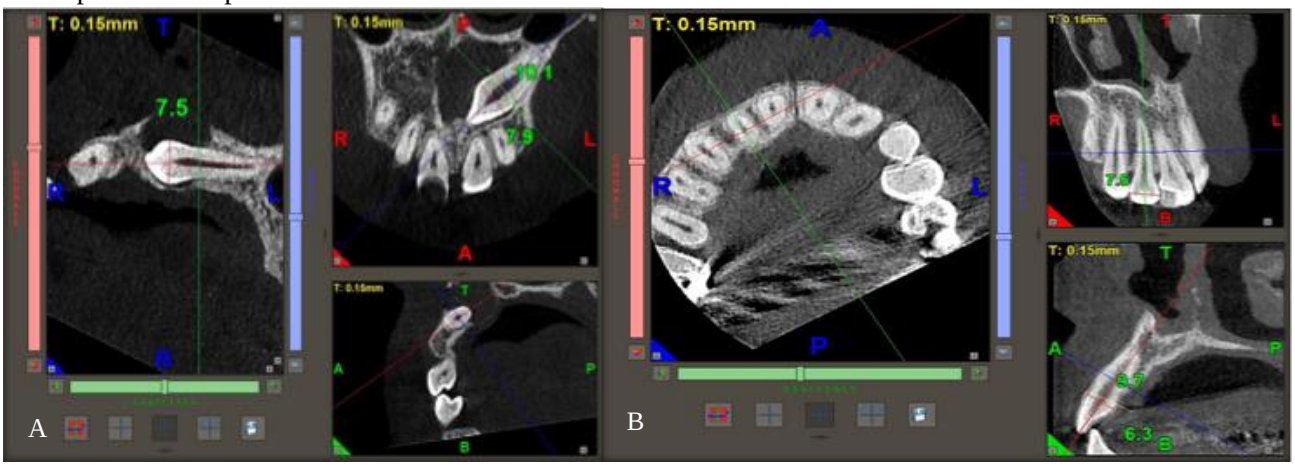

Figure 1: A: A. Measurement of mesiodistal width of impacted canine on axial section. B. Measurement of inciso-gingival and bucco palatal dimensions of impacted canine on coronal section. C. Impacted canine on sagittal view. B: A. Orienting the axes on the maxillary lateral incisors on axial section. B Measuring the maximum mesiodistal dimension on coronal section. C. Measuring the bucco palatal and gingivoincisal dimensions on sagittal section.

Table 6: Distribution of lateral incisor characteristic means according to impaction and eruption sides for male and female patients.

Variable	Impaction	Eruption	t-test	*p-value*
	Mean±SD (mm)	Mean±SD (mm)		
Male				
GI of lateral incisor	8.41±1.07	9.43±0.58	2.6	0.006**
LP of lateral incisor	6.6±0.47	6.47±0.32	0.7	0.4
MD of lateral incisor	6.29±0.47	6.16±0.53	0.6	0.5
Female				
GI of lateral incisor	8.2±1.04	9.52±1.12	4.4	≤ 0.05**
LP of lateral incisor	6.2±0.5	6.25±0.49	0.3	0.7
MD of lateral incisor	6.25±0.58	6.15±0.61	0.6	0.5
Right				
GI of lateral incisor	8.25±0.93	9.7±1.03	4.6	≤ 0.05**
LP of lateral incisor	6.23±0.51	6.36±0.45	0.8	0.3
MD of lateral incisor	6.29±0.52	6.16±0.6	0.7	0.4
Left				
GI of lateral incisor	8.3±1.16	9.28±0.88	1.2	≤ 0.05**
LP of lateral incisor	6.43±0.53	6.29±0.46	8.2	0.3
MD of lateral incisor	6.24±0.58	6.15±0.57	7.1	0.6

Discussion

The use of CBCT improved the diagnostic capabilities and increased the chances of success in the more difficult cases[18]. CBCT produced a three-dimensional evaluation of impacted maxillary canines which helps in selecting specific treatment procedures[19]. Currence of impacted canines, due to the chance of combined dental anomalies[20]. The current study mainly depended on the records that were taken from CBCTs which were considered one of the most reliable and accurate tools, to assess teeth dimension[20,21].

Differences in palatally impacted canine dimensions

The PIC in the present study was larger by 1.40±0.03 mm and wider by 1.81±0.30 mm when compared to normally erupted canine. It was observed a statistically significant difference in the LP and MD mean values (P≤ 0.05) of the canines between the impacted and normally erupted sides which agreed with Eliason and Lindauer[15]. This study disagreed with Yan et al.[22] who found non-significant differences in the MD width and LP dimensions. However, when conducting the study among the unilateral PIC subjects alone, the mesiodistal widths on the impaction side were significantly greater than those on the normal side, whereas the LP width was similar between the impaction and normally erupted side. Contrary to our findings, a study was done in Germany which showed that the maxillary canine on the affected side is smaller in size than the contralateral side[23].

Three-dimensional evaluation done by Kim et al in 2017 on the morphology of the impacted maxillary canine and adjacent teeth with the aid of CBCT, suggested that the impacted canine has a greater size compared to the canine on the normally erupted side, which may be an influential factor for maxillary canine impaction[24].

The difference in maxillary lateral incisors dimensions

In this study, the GI of the lateral incisor adjacent to the impacted canine was smaller than that of the contralateral side with no statistically significant difference in the MD and LP mean values. Many studies have concluded that smaller lateral incisors are less likely to work as a navigator for the developing maxillary canine during their eruption, and this supports the guidance theory of canine eruption described by Becker et al.[25] The results of this study are supported by Liuk et al.[26], who found that the lateral incisors in the impacted side were shorter than the that in the control group.

The current study results also agreed with Dubovska et al.[27] who evaluated the morphology of the lateral incisor adjacent to the PIC using CBCT. They stated that the size of the lateral incisor on the side of impaction is shorter. Also, a study performed by Kim et al.[24], concluded that the root of the lateral incisor had a significantly shorter length and smaller size on the impaction side compared with the normal eruption side. Also, another study done by Yan et al.[22] comparing CBCT of patients with PICs and a control group, found that there was statistically significant difference in the MD dimensions of the lateral incisors between the two groups. Also, two other studies that

used dental casts have found that the lateral incisor was narrower (MD dimension was smaller) than the lateral incisor of the unaffected side[28].

The lateral incisor adjacent to the PIC may act as an investigator to the impaction of the canine, either because its eruption and size are related to the same genes that control the eruption of the canine (genetic theory) or due to its position in the arch which influences the eruption path of the canine[29].

Maxillary canine/lateral incisor dimensions ratio

Eliason and Lindauer[15] created a ratio for the dimensions of the lateral incisor adjacent to the canine on both impacted and non-impacted sides, and then compared both ratios. Their purpose was to determine whether a larger canine with a normal size lateral incisor produces the same size difference when compared to a normal size canine with an adjacent small lateral incisor. In both conditions, the size of the lateral incisor may not be adequate relative to the adjacent canine to work as a guide during the eruption process of the maxillary canine. In this manner, we tried to develop the same ratio and make a comparison between the impacted and normally erupted sides. In our findings, we observed statistical differences in the lateral incisor over the canine ratios for both mesiodistal and incisogingival dimensions but such statistical difference was not found in the buccolingual dimension.

The results of the current study coincide with Eliason and Lindauer, who stated in their study that the only significant differences were in the mesiodistal and incisogingival ratios[15]. Regarding the sex difference the current study, compared the male and female unilateral PIC cases separately. In the results, the difference in the dimensions of the impacted canine and its adjacent lateral incisor compared to the contralateral side were the same in males and females. Chaushu et al made a study in 2002, which used dental casts to make the comparison of the maxillary dentition size between PIC cases and the control group. They observed in their results that the size of the lateral incisors was significantly smaller in the PIC cases than in the control group for both males and females with no difference, which is in agreement with the findings of this study. This may be due to the fact they used dental casts and not radiographic methods in measuring the size of the impacted maxillary canine[30]. In this study, there was an only a significant difference in the MD and LP of the maxillary canine and GI of the lateral incisors.

Conclusions

The LP and MD dimensions of the palatally impacted canines were significantly larger than the normally erupted canines. The maxillary lateral incisors adjacent to PICs were slightly shorter than those adjacent to the non-impacted canines. There is no gender difference regarding the dimensions of the impacted canine and adjacent lateral incisors in comparison to the contralateral side. The side of the impaction has no influence on the crown size when the comparison is made between the impacted and non-impacted sides. Each difference in the size between the examined teeth has an effect on orthodontic treatment planning.

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