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THREE-DIMENSIONAL EVALUATION OF MORPHOLOGIC DIFFERENCES OF MAXILLARY LATERAL INCISOR AND CANINE IN PALATAL VERSUS BUCCAL IMPACTED CANINE

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CBCT, Impacted canine, Morphology.

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ABSTRACT

Introduction: The morphological differences between buccally and palatally impacted maxillary canines and their adjacent lateral incisors have always been thought to be an indicating factor for the impaction site. **Aim:** The present study was conducted to compare the morphological differences of maxillary canine and adjacent lateral incisor in buccally versus palatally impacted canine cases using Cone Beam Computed Tomography (CBCT). **Material and Methods:** Forty -two CBCT scans of patients having unilateral impacted maxillary canine were collected from the archives of the Oral Radiology department, Faculty of Dentistry, Suez Canal University. The scans were divided into two buccal and palatal impaction study groups, each comprising 21 scans. The contra-lateral normally erupted canine side was used as control for comparison with each study group. The following parameters were evaluated using OnDemand3DApp software for both the canine and the adjacent lateral incisor in the study and control groups: Mesiodistal width of the crown, Anatomic height of the crown, Length of the root, Volume of the crown, Volume of the root and Density of the bone surrounding the maxillary canine. **Results:** Buccally impacted canines and their adjacent lateral incisors showed increase in morphological parameters compared to their control side. Palatally impacted canines showed no statistically significant differences compared to the control side, while their adjacent lateral incisor showed a decrease in size compared to the control side. **Conclusion:** Buccally impacted canines and the adjacent lateral incisors are larger in size compared to normal erupted corresponding canines in unilateral impacted canine cases. Palatally impacted canines are of equal size as their unimpacted canines, while their adjacent lateral incisors are smaller in size than their counterparts.

INTRODUCTION

Maxillary permanent canines are the second most frequently impacted tooth after the third molars (1). To avoid confusion, the term impacted canine is used to refer to the canine in an anomalous intraosseous position after the expected time of eruption, while the term ectopically erupting canine refers to the canine in an anomalous intraosseous position before the expected time of eruption (2). Interceptive treatment strategies have been suggested for the ectopically erupting canines, whereas a surgical – orthodontic approach is required in the impacted canines. Interceptive treatment of ectopically erupting canines is important as treatment of the impacted canines is longer, expensive and more complex orthodontic mechanics are needed. Moreover, ectopically erupting canines can cause the root resorption of adjacent teeth [3].

Impacted teeth have been a serious problem for orthodontists, the decision whether to extract them or to drag them into occlusion depends on several factors and require accurate diagnosis and treatment planning and coordination between a team consisting of general dentist, orthodontist, periodontist, and surgeon. Maxillary canine impactions diverge from the normal eruptive site in either the buccal or the palatal direction. According to the studies thus far, the etiologies of these two phenomena appear to differ. Palatally impacted canines are related to excessive space in the dental arch, some studies showed that the majority of impactions have sufficient space for eruption while on the contrary, it has been reported that buccally impacted canines are closely related to crowding [4]. The relevance between the anomalies of lateral incisors and impacted canines has also been a well-known fact for a long time[5]. Differences in the overall size of the lateral incisor and canine in cases of palatally and buccally impacted canine cases show a strong relation between the morphology of these teeth and the impaction site [6]. The aim of the present study is to compare the morphological characteristics of lateral incisor and canine in cases of buccal impacted canine versus cases of palatal impacted canine to stand on the relation between these characteristics and the impaction side.

MATERIALS AND METHODS

Study settings and design:

In the present retrospective study, 42 CBCT scans of patients having unilateral maxillary impacted canine were collected from the archives of the Oral Radiology Department, Faculty of Dentistry, Suez Canal University after the approval of the Research Ethics Committee of the faculty – REC (80/2018). The CBCT records were scanned using Scanora 3Dx-Cone Beam CT installed in the Oral Radiology Department at the Faculty of Dentistry, Suez Canal University.

Inclusion and exclusion criteria:

The CBCT scans were selected to fulfil the following inclusion criteria:

1. Patients with age range of 14-24 years of both genders.
2. CBCT records with good quality.
3. Patients with no dental anomalies (missing teeth – peg shaped lateral incisors – cleft lip or palate)

While CBCT scans with the following criteria were excluded:

1. Congenitally missing or malformed lateral incisors
2. Transposed maxillary canines and premolars or transposed maxillary canines and lateral incisor
3. The canine is distally impacted toward the first premolar or with definitive obstructions (e.g., odontoma or supernumerary teeth)
4. Craniofacial anomalies (e.g., cleft lip or palate), several impacted or congenitally missing teeth.

Sample grouping:

The 42 CBCT records were divided into 2 groups:

Group (A): 21 scans of patients with unilateral buccally impacted canine.

Group (B): 21 scans of patients with unilateral palatally impacted canine.

The contra-lateral side having a normally erupted canine (control group) of each patient was used for comparison between assessed parameters. The evaluated parameters in each study group were compared to the other study group.

Measurements:

All CBCT images were saved as DICOM format (Digital Imaging and Communication in Medicine). The CBCT images were imported into OnDemand-3DApp 1.0.9.3223 imaging software, and module [M] DVR was used for tissue segmentation, 3D reconstruction, and volumetric measurement.

Measurements were made on 3D reconstructed images of the maxillary dentition. Using OnDemand3DApp, preparation of the CBCT images was first done to facilitate visualization and measuring. Draw Mask Segmentation tool was used for segmentation.

A method described by Hoffman [7] in a previous study for measurements of impacted canine was used in the present study. In each of the two groups and their control sides, the following morphologic parameters were evaluated for both the canine and the adjacent lateral incisor:

1. Mesiodistal width of the crown: After viewing each tooth from the occlusal view, using the 3D ruler for standardized measurements, this was measured from the mesial anatomic contact point to the distal anatomic contact point (**Figure 1**).
2. Anatomic height of the crown: From the frontal view, the height of the crown was measured by drawing a line extending from the incisal edge perpendicular to the cementoenamel junction (**Figure 2).**
3. Length of the root: From the frontal view, the length of the root was measured by drawing a line extending from the root apex perpendicular to the cementoenamel junction (**Figure 3**).
4. Volume of the crown: After segmentation of the tooth and removing any overlying soft and hard tissue using the 3D tool, the root was separated from the crown through the cementoenamel junction, and the three-dimensional space occupied by the crown of the tooth was measured in mm^3 (**Figure 4**).
5. Volume of the root: The three-dimensional space occupied by the root of the tooth was measured in mm^3 (**Figure 5**).
6. Density of the bone surrounding maxillary canine: According to a previous study by Servais,[8] the bone density surrounding maxillary canine was measured. Images were cropped to a 64 x 64-pixel region of interest. Regions of interest were selected from areas that did not contain dental structures, cortical bone, or vascular canals. The regions from which bone density was measured were standardized in all scans for both groups. The maxillary alveolar process interproximal to the canines and first premolars was selected as the region of interest because of the availability of trabecular bone.

The radiographs were given numbers before being assessed by the principal researcher to ensure obtaining unbiased results. All measurements on CBCT were repeated by the same examiner with one-week interval between the two measurements.

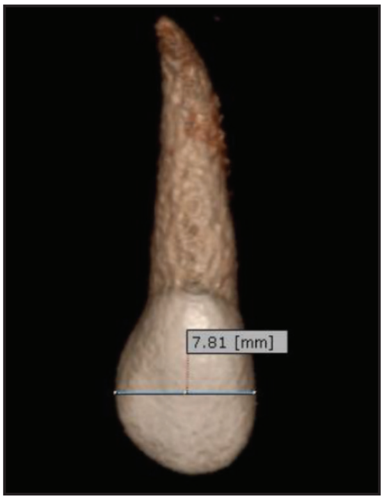

Fig. (1) Mesiodistal width of the crown

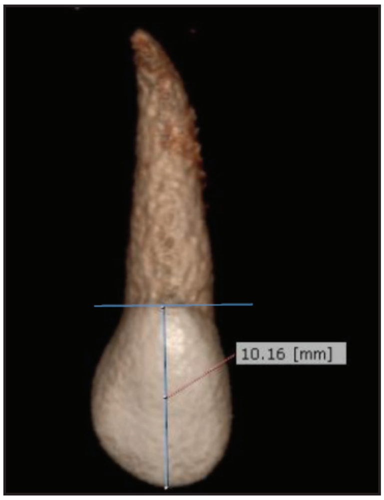

Fig. (2) Anatomic height of the crown

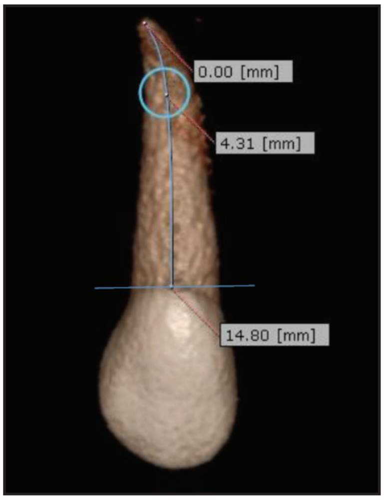

Fig. (3) Length of the root

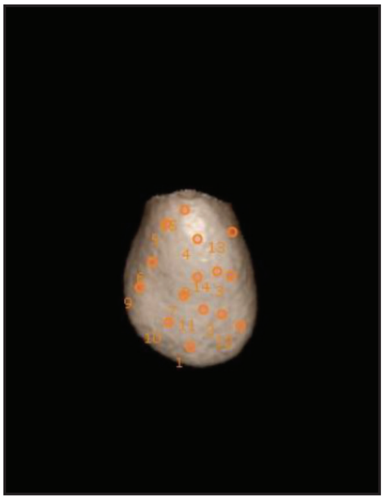

Fig. (4) Volume of crown

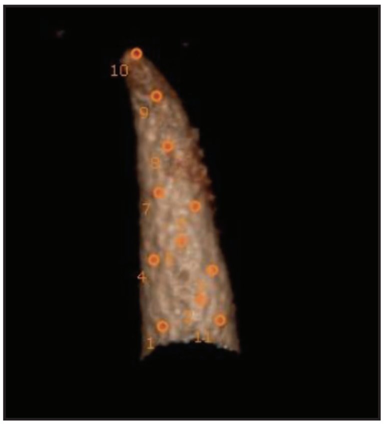

Fig. (5)Volume of Root

RESULTS

Results of the current study are presented as the morphologic parameters for the canine and adjacent lateral incisor separately.

Measurements of Canine:

Table (1) shows results of the comparison between canine measurements in the impaction side and the normal side in both buccally and palatally impacted canine cases.

Table (1) *Comparison between canine measurements in impaction side and normal side (control) in buccally and palatally impacted canine cases.*

Canine measurements		Study Group	Control Group	p-value
Mesiodistal Dimension of Crown	**Buccal**	7.66 ±0.50	7.44 ±0.48	0.008*
	Palatal	7.56 ±0.52	7.50 ±0.33	0.583ns
	Mean Diff	0.095 (p=0.548)		
Anatomic Height of Crown	**Buccal**	9.78 ±0.62	9.87 ±0.87	0.639ns
	Palatal	9.71 ±1.21	10.05 ±1.07	0.133ns
	Mean Diff	0.071 (p=0.811)		
Length of Root	**Buccal**	14.86±0.93	13.96 ±0.99	0.003*
	Palatal	14.90 ±1.97	14.90 ±1.87	0.981ns
	Mean Diff	0.038 (p=0.937)		
Volume of Crown	**Buccal**	321.67±57.42	290.95±50.24	0.030*
	Palatal	279.30± 58.70	266.45 ±65.64	0.153ns
	Mean Diff	42.367(p=0.023)		
Volume of Root	**Buccal**	291.95 ±54.73	223.57 ±28.76	<0.001*
	Palatal	282.50 ±70.20	283.00 ±79.26	0.970ns
	Mean Diff	9.457 (p=0.629)		
Bone Density	**Buccal**	1429.57±176.11	1189.48±178.50	<0.001*
	Palatal	1506.14±182.64	1322.33±194.59	<0.001*
	Mean Diff	76.571(p=0.174)		

P- value for comparisons between each study and control group, statistical significance was set at P ≤ 0.05.
**Means significant difference. Ns means non-significant difference.*

The results for buccal canine impaction cases showed statistically significant higher values in the impaction side in comparison to the normal erupting side regarding the mesio-distal dimension of the crown, volume of the root, length of the root, bone density and volume of the crown while there was no statistically significant difference in height of the crown.

While in palatal impaction cases, the results showed statistically significant higher bone density values surrounding the canine in the impaction side in comparison to the control, while there was no statistically significant difference in all other assessed parameters.

Upon comparing the canine in buccal impaction cases and palatal impaction cases, the results showed statistically significant difference with an increased volume of crown of buccal one. On the other hand, there were no statistically significant differences in the other parameters.

Measurements of Lateral Incisor:

Table (2) shows results of the comparison between the lateral incisor measurements in the impaction side and the normal side in both buccally and palatally impacted canine cases.

Table (2) *Comparison between lateral incisor measurements in impaction side and normal side (control) in buccally and palatally impacted canine cases.*

Lateral Incisor measurements		Study Group	Control Group	p-value
Mesiodistal Dimension of Crown	**Buccal**	6.67 ±0.59	6.45 ±0.42	0.033*
	Palatal	6.35 ±0.81	6.34 ±0.70	0.929ns
	Mean diff	0.312 (p=0.016)		
Anatomic Height of Crown	**Buccal**	9.25 ±0.98	9.44±1.08	0.118ns
	Palatal	8.46 ±0.87	9.22 ±1.06	0.009*
	Mean diff	0.795 (p=0.008)		
Length of Root	**Buccal**	11.66 ±0.88	11.15 ±0.99	0.009*
	Palatal	11.80 ±2.26	12.10 ±1.50	0.369ns
	Mean diff	0.146 (p=0.078)		
Volume of Crown	**Buccal**	213.19 ±59.55	198.62 ±36.87	0.071ns
	Palatal	149.43± 40.56	165.46 ±41.73	0.020*
	Mean diff	63.762(p=0.002)		
Volume of Root	**Buccal**	164.19± 24.85	153.81 ±31.73	0.227ns
	Palatal	154.05±53.70	151.17 ±59.80	0.822ns
	Mean diff	10.133(p=0.043)		
Bone Density	**Buccal**	1429.57±176.11	1189.48±178.50	<0.001*
	Palatal	1506.14±182.64	1322.33±194.59	<0.001*
	Mean diff	76.571(p=0.174)		

P- value for comparisons between each study and control group, statistical significance was set at P ≤ 0.05.
**Means significant difference. Ns means non-significant difference.*

Results for lateral incisor in buccal impacted canine cases showed statistically significant higher values in the impaction side in comparison to the control regarding only the mesio-distal dimension of the crown, length of the root and bone density.

While upon comparing lateral incisor in palatal impaction cases, the results showed statistically significant lower values regarding anatomic height of crown and volume of crown in the impaction side in comparison to the control side. On the other hand, there was statistically significant higher value of bone density in comparison to the control group. The other values showed statistically insignificant differences.

The comparison between lateral incisor in buccal impaction cases and palatal impaction cases showed statistically significant differences with an increase in buccal impaction group in anatomic height of crown, volume of crown and volume of root. The rest of the parameters showed no significant difference.

DISCUSSION

The proper alignment of canines has always been a key factor in a successful orthodontic treatment. A class I canine relation is the utmost goal for every clinician to achieve, giving the canine a unique importance in the field of orthodontics. Therefore, failure of the canine to erupt has always been a concern for orthodontists to study and evaluate the different etiologies leading to canine impaction to allow for proper interpretations [2].

Two main theories of canine impaction were suggested in the literature: the genetic theory which assigns genetic factors as the primary origin of the eruption anomaly of maxillary permanent canines and, the guidance theory which suggests that the canine depends on the root of the adjacent lateral incisor as a guide while eruption, hence, any alteration in the shape or morphology of the lateral incisor may lead to the failure of the canine to erupt[4].

Nevertheless, the reason that decides the side of the impaction, whether buccal or palatal, remains with no clear theory or explanation, however, studies showed that there might be a relation to the morphological characteristics of both the canine and adjacent lateral incisor [5].

The present study was designed as a split mouth retrospective study conducted using cone beam radiographs to compare the morphological differences of maxillary canine and adjacent lateral incisor in buccally and palatally impacted canine cases using Cone Beam Computed Tomography. According to a previous study by Kim et al, [9] a number of 42 cone beam radiographs were calculated as a sufficient sample size for obtaining reliable results. The scans were divided into 2 groups: Group (A) consisted of 21 radiographs of patients with buccally impacted canine and Group (B) of 21 radiographs of patients with palatally impacted canine. The contra-lateral side in every radiographic record with normally erupting canine was used as the control side for comparison.

CBCT scans were selected to be of patients having unilateral impacted canine only and ranging in age from 14-24. Age 14 was the minimum age included in the study to make sure that the canine passed its time to erupt. Our inclusion criteria required CBCT records of good quality to facilitate measurements and patients to have normal dentition to ensure no other factors influenced the normal eruption of the teeth. We excluded every radiographic record with congenitally missing or malformed lateral incisor, transposed maxillary canines and premolars, impacted canine due to definitive obstructions or craniofacial anomalies. These exclusions were to make sure no anomaly played a role in the failure of the canine to erupt.

Our measurements were directed to analyze the differences in morphological characteristics between the studied teeth and their normal counterparts in both buccally and palatally canine groups. We chose the method described by *Hofmann* [7] in his previous study to evaluate the morphological characters of each tooth. Our measured parameters included the mesiodistal width of the crown, anatomic height of the crown, length of root, volume of crown, volume of root and density of bone surrounding the maxillary canine. These measurements aimed to answer the question if the differences in the morphologic characters of the lateral incisor and canine could be suggested to play a role in the failure of the canine to erupt according to the guidance theory or not.

All measurements on CBCT were made twice by the same examiner with one-week interval between the two measurements to ensure accurate results.

Upon comparing canine morphology in buccal impacted canine cases with their normal erupted counterparts, there was statistically significant higher values of the impacted canine in each of the mesiodistal dimension, length of the root, volume of crown, volume of root and bone density while we found no difference in the anatomic height of crown. Our results came in line with *Kim et al* [9] who stated that width and volume of the canine's crown were significantly greater on the impaction side compared with the normal eruption side. Additionally, *Chausho*[10] stated that buccally impacted canines have larger-than-average teeth when compared to the opposing normally erupted canines. *Cernochova et al* [11] also found that, in impacted maxillary canines, the deflection of a root apex develops in close contact with compact bone which justifies our results regarding the significantly higher bone density values surrounding the impacted canine.

While upon comparing the canine morphology in palatal impacted canine cases with the normal erupted canines, there was no statistically significant difference in any of the evaluated values except the bone density surrounding the canine which was greater on the impaction side.

Our results came in line with those of *Al-Nimri & Gharaibeh* [12] who stated that the mesiodistal widths of the maxillary teeth were not significantly different in the impaction and control side groups. Additionally, when *Chaushu et al* [10] compared palatally impacted canine with their normal erupting counterpart, they found no significant differences regarding the size or the shape.

However, *Leonardi et al* [13] disagreed with our results. They found a statistically significant difference between the palatally impacted canines and the normally erupting counterpart. Additionally, *Hettiarachchi et al* [14] disagree with the results of our study as they found that palatally impacted canines have the tendency to develop shorter roots when compared to the normally erupted canines.

The comparison between buccal impacted canine and palatally impacted canine showed a statistically significant difference with higher value of volume of crown in favor of buccal impacted canine, while there was no significant difference in the mesiodistal dimension, anatomic height of crown, length of the root, volume of the root or bone density surrounding the canine.

Chaushu et al [10] disagree with our results in their study where they compared the morphologic characteristics of buccal and palatal impacted canines. Their results were partly contrary to ours regarding the size of the tooth. They found that buccally impacted canines were generally larger in size than palatally impacted canines, which lines in part with our findings regarding the increase in crown volume.

Upon comparing the lateral incisor adjacent to buccally impacted canine with its counterpart on the normally erupted side, we found statistically significant higher values regarding mesiodistal dimension of the crown, length of the root and bone density. These results come in line with *Chaushu et al* [10] who found a generalized increase in size of the dentition generally associated with buccal canine impaction.

While regarding the comparison between lateral incisor adjacent to palatally impacted canine and its counterpart on the normally erupted canine side, the lateral incisor on the impaction side was found to be smaller in most of the assessed parameters.

The guidance theory of canine impaction[4] mainly depends on the size of the adjacent lateral incisor. The theory has always suggested that a smaller in size lateral incisor is a main contributor in the failure of the canine to erupt, therefore, it has always been believed that a smaller in size lateral incisor is frequently associated with palatal impacted canines.

Our results comparing lateral incisor adjacent to palatally impacted canine with its counterpart adjacent to normally erupting canine show typical outcomes that come in line with the guidance theory suggesting a generally smaller in size lateral incisor on the palatal impaction side.

Our results are additionally supported by *Kim et al*[9], *Dubovska and Urbanova* [16], *Bertl et al* [17], *Oliver et al*[18], *Leonardi* [13] and *De Carvelho* [19] who all approved our results.

The comparison between the lateral incisor adjacent to buccally impacted canine with the lateral incisor adjacent to palatally impacted canine showed the former having higher values in all the assessed measurements except the bone density which showed no difference between both groups. Again, our results come in line with the former discussed literature suggesting an overall increase in size in cases of buccal canine impaction and a decrease in size in palatal canine impaction.

CONCLUSION

The failure of canine to erupt may be influenced by the morphologic factors of the canine itself and the adjacent teeth. A greater in size canine and lateral incisor may be an influential factor for the canine to get impacted buccally, while on the other hand, a smaller in size lateral incisor, especially regarding the root length and volume may fail in guiding the canine to erupt resulting in a palatal impaction.

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