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Comparative Analysis of Lateral Incisor Morphology in Patients with Unilateral Palatally Impacted Canines: A CBCT Study

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Abstract

Background and objectives:
This study aimed to evaluate the morphology of maxillary lateral incisors in patients with unilateral palatally impacted canines compared to the contralateral side using cone beam computed tomography (CBCT) technique.

Materials and Methods:
A cross-sectional study analyzed CBCT images of 70 patients (35 males and 35 females; mean age, 25.83 ± 9.27 years) with unilateral palatally impacted canines. The lateral incisor length, crown width, and colum angle were evaluated on both the impacted and non-impacted sides. Paired and independent t-tests were used for comparisons, and intraclass correlation coefficients (ICCs) were used to assess intra- and inter-examiner reliability. Statistical significance was set at $P < 0.05$.

Results:
The results revealed a statistically significant difference in lateral incisor length between the impacted side (21.81 ± 2.28 mm) and the non-impacted side (22.12 ± 2.03 mm). In contrast, crown width and collum angle did not show any significant differences. In the gender-based comparison, the lateral incisor length was significantly reduced in female participants ($p = 0.006$). All ICC values indicated excellent agreement (ICC > 0.9).

Conclusion:
The lateral incisor was significantly shorter on the impacted side than on the non-impacted side, supporting its potential role as a clinical predictor of palatal canine impaction. In contrast, there were no significant differences in the crown width or colum angle of the lateral incisors.

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1. INTRODUCTION

Maxillary canines are the cornerstone of the oral cavity. Their strategic location over the canine eminences supports the upper lip and alar base, achieving good facial and smile aesthetics. In terms of functionality, canines have a crucial role in supporting the dentition as a whole and in assisting in posterior disocclusion during lateral excursions [1]. Even though, maxillary canine is the most impacted tooth following the maxillary and mandibular third molars with a prevalence rate ranging from 1% to 5%, depending on the population [2, 3]. 83–92% of canine impactions occur unilaterally [4], with more affected females by 2:1 ratio [5].

Studies have reported a multifactorial etiology of canine impaction. Baccetti et al. suggested two opposing theories regarding the cause of palatally impacted canines: the genetic theory and the guidance theory.

Genetic theory proposes that genetic factors, such as transcription factors MSX1 and PAX9, are linked to lateral incisor agenesis and malformations. Therefore, these factors are indirectly implicated in the genetic regulation of maxillary canine malposition and impaction [6]. Meanwhile, the guidance theory hypothesizes that the lateral incisors serve as a guide for canine eruption. If the root of the lateral incisor is missing or deformed, the canine will not erupt [7, 8]. Collectively, these theories highlight the importance of the presence and morphology of the lateral incisor in the normal eruption of the maxillary canine. Rajendran and Sundharam reported some potential sequelae of canine impaction, such as adjacent tooth migration, decreased arch length, internal resorption, periodontal bone loss, dentigerous cyst formation, infection, referred pain, and combinations of the previous sequelae [9]. One well-known effect of impacted canines is incisor root resorption, particularly in the lateral incisors [10].

The dental morphology of patients with unilateral palatally impacted canines has been evaluated using different diagnostic modalities, such as dental casts and panoramic radiographs. However, the advent of cone beam computed tomography (CBCT) has facilitated a more precise evaluation of the position and orientation of the impacted canine, as well as the detailed dimensions of adjacent skeletal and dental structures for successful surgical procedures and orthodontic diagnosis and traction [11, 12]. Previous studies have reported that palatal canine impaction is associated with significant differences in lateral incisor morphology compared with the control groups [13, 14]. Notably, the lateral incisor has a greater mesially angulated root on the impacted side [14, 15]. However, Shahabi et al. demonstrated that unilateral palatal canine impaction was not associated with a reduced lateral incisor size [16]. In contrast, Topsakal et al. reported in the same year that lateral incisors adjacent to unilaterally palatally impacted canines exhibited shorter roots and narrower crowns than contralateral teeth [17]. These contradictory results highlight the need for more studies among different ethnicities to obtain more conclusive results. Therefore, this study aimed to evaluate the lateral incisor morphology in patients with unilateral palatally impacted canines compared to the contralateral side using CBCT.

2. METHODOLOGY

2.1. Study design

This retrospective cross-sectional study with a split-mouth design was conducted using CBCT images of 70 patients with unilateral palatally impacted canines. Ethical approval was obtained from the Ethical Committee of the Faculty of Dentistry, Sana'a University, Yemen (NO. OR:03/01/2025). CBCT images were selected from the records of patients who attended a private oral and maxillofacial radiology center in Sana'a, Yemen, between 2020 and 2024, according to the following inclusion criteria: clear CBCT images of patients aged > 15 years with unilateral palatally impacted maxillary canine, fully erupted contralateral canine, and absence of any developmental anomalies. The exclusion criteria included a history of orthodontic treatment, existence of any odontomas, supernumerary teeth, lateral incisor agenesis or restorations, evident root resorption, maxillary canine transpositions, dentomaxillary trauma, craniofacial malformations, and bilateral or buccally impacted canines. The minimum sample size required was 47 patients, calculated using G*Power software with an effect size of 0.6 for lateral incisor length based on a previous study [2], a significance level of 0.05, and a statistical power of 95%.

2.2. Data collection and assessment

All CBCT scans were obtained using an X-MIND TRIUM unit (Acteon, Italy) with an 80 × 80 mm field of view (FOV) to capture the full maxillary arch. The total exposure time was 9 s, with a kilovoltage of 85–90 kV and a milliamperage of 6–10 mA. The voxel size was 0.15 mm. During exposure, the patient's posture was adjusted so that the Frankfurt plane was parallel to the ground. All datasets were exported in DICOM format and analyzed using CS 3D Imaging version 3.10.38, created by Carestream Health. Images were displayed in multiplanar reformation (MPR) mode with adjustments to contrast, sharpness, and brightness to improve the visualization of the anatomical structures. All measurements were performed by a single well-trained operator using the axial, coronal, and sagittal sections of the CBCT scans. For image analysis, measurement tools such as a ruler and an angular measurement tool were used, with results recorded in millimeters (mm) and degrees (°). Each image was reoriented to align the long axis of the lateral incisor with the sagittal and coronal planes (Figure 1). Lateral incisor crown width (LICW) was measured as the greatest mesiodistal width of the crown of the lateral incisor measured in the axial slice, which was also confirmed in the coronal view (Figure 2). The lateral incisor length (LIL) was assessed as the anatomical length in millimeters from the incisal tip to the root apex in the sagittal slice (Figure 2). The lateral incisor collum angle (LICA) was calculated by subtracting the crown root angle (CRA) from 180°. CRA was defined as the angle formed between the long axis of the crown and the long axis of the root, determined by two reference lines: the line connecting the incisal tip to the mid-point of the cemento-enamel junction (CEJ) and another line drawn between the CEJ and root apex in the sagittal view (Figure 3). The colum angle was considered positive when the crown was lingually inclined relative to the root axis and negative when the crown was labially inclined. The

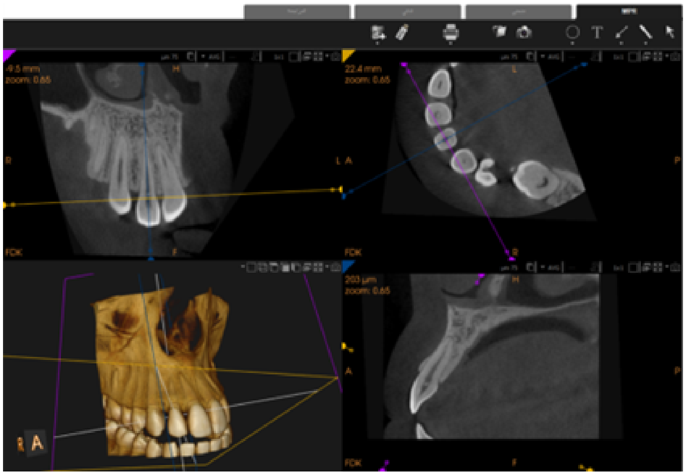

Figure 1. Standardization of CBCT views along the long axis of lateral incisor.

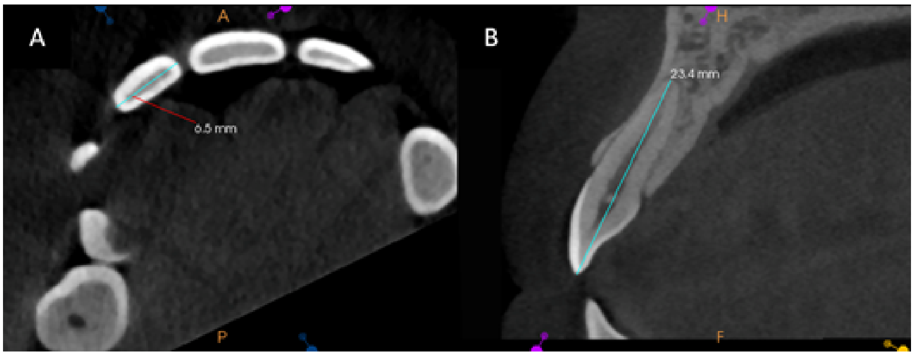

Figure 2. : A) Lateral incisor crown width; and B) Lateral incisor length

collum angle was considered zero in the straight tooth (Figure 3). These variables were evaluated on both the impacted and non-impacted sides.

2.3. Statistical analysis

Statistical Package for Social Sciences (SPSS) software (version 27.0; Chicago, IL, USA) was used for statistical analysis, with a significance level set at $p<0.05$. The normality of the data distribution was confirmed using the Shapiro-Wilk test. Therefore, a paired t-test was used to compare the measurements between the impacted and non-impacted sides. In contrast, independent samples t-tests were used to assess differences between independent groups. To assess measurement reliability, 20% of the sample was randomly selected and remeasured by the same operator and by a second well-trained examiner two weeks after the first measurement. Intra- and inter-examiner reliability were evaluated using intraclass correlation coefficients (ICCs).

3. RESULTS

The sample included 70 patients (35 men and 35 women) with a mean age of 25.83 ± 9.27 years. The ICC values ranged between 0.95 and 0.99, indicating excellent agreement for both intra- and inter-examiner reliability, as shown in Table 1. The comparison of LICW, LIL, and LICA between the impacted and non-impacted sides showed a significant difference in LIL between the impacted side (21.81 ± 2.28 mm) and non-impacted side (22.12 ± 2.03 mm). In contrast, LICW and LICA showed no significant differences (Table 2). In the gender-based comparison, LIL was significantly lower in female participants ($p < 0.05$). No significant difference was found in LICW and LICA between men and women (Table 3).

4. DISCUSSION

Maxillary canine impaction is a common finding among orthodontic patients worldwide [4], with palatally impacted canines occurring 2–3 times more frequently than buccally displaced ones [18]. Early diagnosis of canine impaction facilitates appropriate interceptive management and improves treatment outcomes. Lateral incisor morphology may serve as a potential predictor of subsequent canine impaction [16]. Therefore, this study aimed to evaluate the dimensions of lateral incisors in patients with unilateral palatally impacted canines using a split-mouth study design, in which the impacted sides served as the study group and the non-impacted sides as the control group. The comparison of the two maxillary halves ensured comparable genetic and environmental

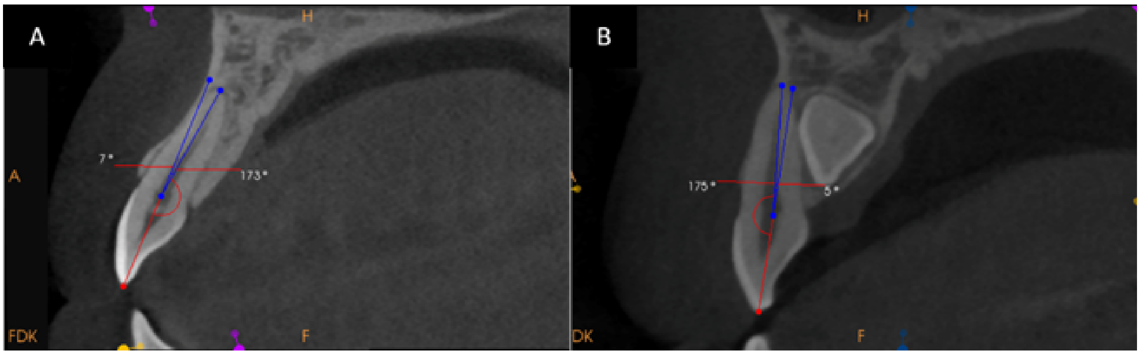

Figure 3. Collum angle A) Positive lateral incisor collum angle (blue); and B) Negative lateral incisor collum angle (blue)

Table 1. Intra-examiner and inter-examiner reliability analysis

Measured Variable	Intra-examiner reliability		Inter-examiner reliability	
	Impacted side	Non-impacted side	Impacted side	Non-impacted side
LICW	0.957	0.962	0.989	0.990
LIL	0.993	0.994	0.998	0.998
LICA	0.988	0.951	0.997	0.988

ICC: intra-class correlation coefficients; LICW: lateral incisor crown width; LIL: lateral incisor length; and LICA: lateral incisor collum angle.

backgrounds and allowed a fair comparison [19]. Furthermore, the CBCT imaging modality has introduced high resolution and accuracy, suggesting it as the most reliable diagnostic method for the assessment of impacted teeth and all related dimensions and orientations [20].

There was no statistically significant difference in the lateral incisor crown width between the impacted and non-impacted sides. This is in accordance with Barros et al.[21], Albayrak, E. and N.E. Senisik [15] reported no significant differences in lateral incisor crown dimensions between the displaced and normally erupted canine groups or between the impacted and erupted sides. In contrast, previous studies have reported significant differences in lateral incisor morphology compared to the contralateral normal side or control group [2, 22]. Yan et al. [23] assessed the potential etiological factors of palatal canine impaction and concluded that a smaller mesiodistal width of the adjacent lateral incisor, in comparison to both buccal canine impaction and control group, may be implicated in palatal impaction. The heterogeneity among these results may be attributed to the differences in the study methodologies and ethnicities of the included samples.

In the present study, a statistically significant difference was found in the lateral incisor length, with a shorter anatomical length on the impacted side than on the contralateral side. This variation may support, but not conclusively prove, the guidance theory, as the difference is statistically significant but perhaps clinically unsubstantial. This result is in agreement with previous studies across different populations, suggesting that lateral incisor root size and volume are possible predictive markers for canine impaction [15, 17, 22, 24, 25]. This could be linked with lateral incisor root resorption caused by the pressure exerted by the adjacent impacted canine. Conversely, other studies revealed no significant difference in lateral incisor root length or root resorption between the impacted and non-impacted sides. They attributed

Table 2. Comparison of the lateral incisor morphology between impacted and non-impacted sides.

Measured Variable	Impacted side (Mean ± SD)	Non-Impacted side (Mean ± SD)	Mean difference	p-value
LICW	6.08 ± 0.83	6.16 ± 0.64	0.074	0.279
LIL	21.81 ± 2.28	22.12 ± 2.03	0.312	0.032*
LICA	3.06 ± 5.04	3.33 ± 5.11	0.186	0.597

Paired t-test; SD standard deviation; * $p < 0.05$, significant; LICW: lateral incisor crown width (mm); LIL: lateral incisor length (mm); and LICA: lateral incisor collum angle (°).

Table 3. Comparison of the lateral incisor morphology between females and males.

Measured Variable	Female (Mean ± SD)	Male (Mean ± SD)	p-value
LICW	5.963 ± .8534	6.203 ± .7954	0.228
LIL	21.083 ± 2.2769	22.540 ± 2.0579	0.006*
LICA	2.57 ± 5.198	3.54 ± 4.901	0.424

Independent t-test; SD standard deviation; * $p < 0.05$, significant; LICW: lateral incisor crown width (mm); LIL: lateral incisor length (mm); and LICA: lateral incisor collum angle (°).

this finding to the low resolution of the CBCT images [15, 26].

Palatal root torque incorporated into the bracket prescription for maxillary incisors may be affected by their colum angles and may compromise the achievement of optimal esthetic outcomes. In addition, any contact between the incisors and palatally impacted canine, either during leveling, alignment, or torquing, may cause resorption [27]. Regarding the lateral incisor's collum angle, the impacted side showed reduced collum angles compared to the non-impacted side, but this difference was not statistically significant (p = 0.597). A similar conclusion was reached by Nazir and Mushtaq [28], but the available literature in this field remains limited, as most studies have evaluated mesiodistal crown-root angulation rather than the colum angle.

The lateral incisor length was significantly shorter in females than in males, which is in accordance with previous studies that revealed a larger size of teeth in males [29, 30]. This sexual dimorphism may be due to a combination of genetic and hormonal factors, different growth patterns, and developmental changes. This finding highlights the importance of personalized treatment planning. In contrast, Montes-Díaz et al. [25] reported no significant differences in lateral incisor length between sexes among Spanish participants. Other measured parameters showed insignificant sex-related differences. The generalizability of these findings might be constrained by the retrospective nature of the study, including the sample from a single radiological center and the reliance on a single observer. A more comprehensive, multicenter longitudinal study evaluating greater dimensions and comparing these dimensions with respect to the horizontal and vertical positions of the impacted canine is recommended.

5. CONCLUSION:

The lateral incisor was significantly shorter on the impacted side. In contrast, no significant differences were observed in the crown width or colum angle. Sexual dimorphism was also observed, with females exhibiting reduced lateral incisor lengths compared to males.

ETHICS APPROVAL

This study protocol was approved by the Ethical Committee of the Faculty of Dentistry, Sana'a University, Yemen, with reference number (OR:03/01/2025) issued on 3/2/2025.

DATA AVAILABILITY

The dataset used and/or analyzed in the current study is available from the corresponding author upon reasonable request.

COMPETING INTERESTS

The authors declare no conflicts of interest.

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