ORIGINAL RESEARCH

Unilateral vs Bilateral Maxillary Canine Impaction: A Cone–Beam Computed Tomography Study of Patterns and Associations

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Abstract

Aim: This retrospective study aimed to compare and evaluate the pattern of maxillary canine impaction and its association with other anomalies using cone–beam computed tomography (CBCT).

Methods: A total of 59 CBCT records of patients (ages 12 and up) were divided into two groups: A total of 35 subjects with unilateral canine impactions and 24 subjects with bilateral canine impactions. The CBCT data were analyzed for the measurement of qualitative and quantitative variables.

Results: In unilateral canine impaction, the mesiodistal (MD) width of the central incisors and the nasal cavity (NC) width were wider ($p < 0.05$). The canine–palatal plane (U3-PP) distance was significantly longer in bilateral canine impaction ($p < 0.05$). The distance of the impacted canines from the palatal and mid-sagittal planes, the anterior dental arch width, and the maxillary skeletal width changed significantly with the position of the impacted canines ($p < 0.05$). Males had 0.185 odds of presenting with a bilateral canine impaction as compared to females ($p = 0.025$). The odds of having bilateral canine impaction with a longer canine-midsagittal plane (U3-MSP) distance was 1.30 ($p = 0.003$).

Conclusion: The findings indicate a gender predilection with females showing a greater prevalence of bilateral canine impaction. Supernumerary teeth were associated with unilateral impacted canines and lower canine impaction with bilaterally impacted canines.

Clinical significance: Anomalies in the form of the maxillary central and lateral incisors, distance from the maxillary canine to the palatal plane and the mid-sagittal plane, NC width, maxillary skeletal width, and gender, are the best discriminating parameters between unilateral and bilateral canine impactions.

Keywords: Bilateral, Canine impaction, Cone–beam computed tomography, Prevalence, Unilateral.

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Introduction

An impacted tooth is a permanent tooth with a root that is more than two-thirds developed but whose spontaneous eruption is not expected in a reasonable time. Maxillary canines are the most frequently impacted tooth, second only to the third molars.[1] Its prevalence varies from 1.7 to 4.7% according to the population examined with a female predilection.[2] The presence of an impacted canine may play a role in the resorption of adjacent teeth.[3] Maxillary impacted canine may result in several complications such as short dental arch, follicular cysts formation, recurrent infections, canine tooth ankylosis, pain, or a combination of these complications.[4]

The canine often referred to as the keystone of the arch, plays a crucial role in developing the dental arch and facial aesthetics.[5] Canine impaction is prevalent due to its long and deep path to erupt into the oral cavity, which can be waylaid.[6,7] It has been reported that impacted maxillary canine is considered the second most common group of impaction after the third molar impaction.[8] There are 8% of the patients with impacted maxillary canines are located bilaterally.[9] The diagnosis and localization of impacted canines are based on clinical and radiographic examinations. Early detection and an interdisciplinary approach can result in positive clinical outcomes. Early diagnosis and management of maxillary canine impaction have a great impact on successful treatment outcomes and preventing other possible associated problems like root resorption of adjacent teeth, cyst formation, ankylosis, etc.[10] Monitoring and interceptive treatment in patients with ectopic canines can prevent impaction in high-risk cases.[11]

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The etiology of canine impaction is multifactorial.[12] Several theories sought to explain the etiology and debate rages as to whether a disturbance in the local environment[13] or genetics[14] plays the greater role. Disturbances or anomalies in the local environment such as the agenesis of lateral incisors or the presence of peg laterals retained deciduous canines and crowding may hamper eruption.[15,16] Malformation of the lateral incisor may lead to the loss of an eruptive guide.[17] Earlier research has shown that canine impaction is linked to genetic anomalies such as microdontia, hypoplasia, and familial occurrence.[9,18]

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Table 1: Qualitative measurements

Qualitative variables	*Definition*
Supernumerary teeth	Presence of 1 or more supernumerary teeth
Maxillary incisor impaction	Presence of 1 or more impacted maxillary incisors
Mandibular canine impaction	Presence of 1 or more impacted mandibular canine
Peg-shaped lateral incisors (U2)	The greatest U2 MD width at the cervical margin was less than 66% of U1 width
Maxillary lateral incisor (U2) agenesis	Congenital absence of 1 or both maxillary lateral incisors
Premolar agenesis	Congenital absence of 1 or more premolars
Third molar agenesis	Congenital absence of 1 or more third molars

Many other factors may play a role in the impaction of the maxillary canine such as odontoma, ankylosis of the upper canine, the age of the patient, location, angulation of the canine, and the small upper arch.[9,19]

The position of the impacted canine can have additional consequences. Root resorption was associated more with palatal canine impaction.[20] In general, the impacted maxillary canine is more often in the palatal position than the buccal position except in the Chinese population where the impacted canine was found more in the buccal position due to some genetic factors.[8]

Two-dimensional radiographs are often used for the diagnosis of impacted teeth. However, they provide limited data and present difficulties evaluating findings in three dimensions. Cone–beam computed tomography allows for three-dimensional localization of the canines without magnification errors. It permits the visualization of the canine around all three axes, permitting rotation and allowing the clinician to see extraneous structures that would otherwise obscure the view. Also, CBCT in combination with digital treatment planning can help visualize the exact surgical movements planned with the precise impacts of these movements on the soft tissue. Thus, using a CBCT is more accurate and reliable for evaluating and determining the localization of the maxillary impacted canine.[21]

There is a scarcity in the orthodontic literature of well-designed studies that evaluate and compare the pattern of maxillary canine impaction by using CBCT. Such data would help clarify the pattern and position of maxillary impacted canines and aid clinicians in predicting canine impaction and developing optimum treatment plans. This study aimed to compare and evaluate the pattern of maxillary canine impaction and its association with other anomalies in a Saudi Arabian population using CBCT.

Materials and Methods

This is a retrospective study comparing the pattern of maxillary canine impaction (unilateral or bilateral) and identifying the etiologic factors associated with each group. The study protocol was approved by the Standing Committee for Research Ethics, Jazan University (Reference No. REC42/1/094). The sample of this study consisted of records of male and female patients aged 12 years and older who were consecutively treated at the College of Dentistry, Jazan University, Saudi Arabia between 2013 and 2020. Informed consent was obtained from all individual participants included in this study. The records were collected from the CBCT machine (3D Accuitomo, J. Morita MFG. Corp. Japan) for patients that required a CBCT for diagnosis. Demographic data of the sample were obtained from the R4 electronic system. Patients with maxillary impacted canines were selected for the study and they were divided into two groups according to the presence of maxillary impacted canines; the unilateral group ($n = 34$) and the bilateral group ($n = 24$). Patients who had a syndrome, cleft lip and palate, and facial deformities, were excluded from this study. All CBCT data were de-identified and coded as Test 1, Test 2, etc. Patient information such as the patient's full name, chart number, and date of birth was recorded on a separate code form where each patient had a unique identifier code. There was no identifying data recorded in the code form and all CBCT findings were recorded on the data collection form with patient codes only to maintain anonymity.

Measurements

At different Hounsfield unit ranges, the CBCT images were segmented and analyzed in the program to exhibit the teeth and skull. The partition ranges were selected based on the default threshold values of dental enamel and bone in the program. Qualitative and quantitative variables were identified as described by previous work.[22,23] Impaction side and qualitative variables were evaluated in the volumetric and three orthogonal views (Table 1). For measuring quantitative variables, the digital landmarks tool of the program was used to identify the landmarks in the volumetric view (Table 2). The landmarks were confirmed in sagittal, coronal, and axial views before it was used to examine the quantitative variables. The linear measurements were calculated by the program to the closest 0.01 mm. Interrater and intrarater reliability for qualitative and quantitative variables were evaluated by repeating the analysis of records after 2 weeks.

Statistical Analysis

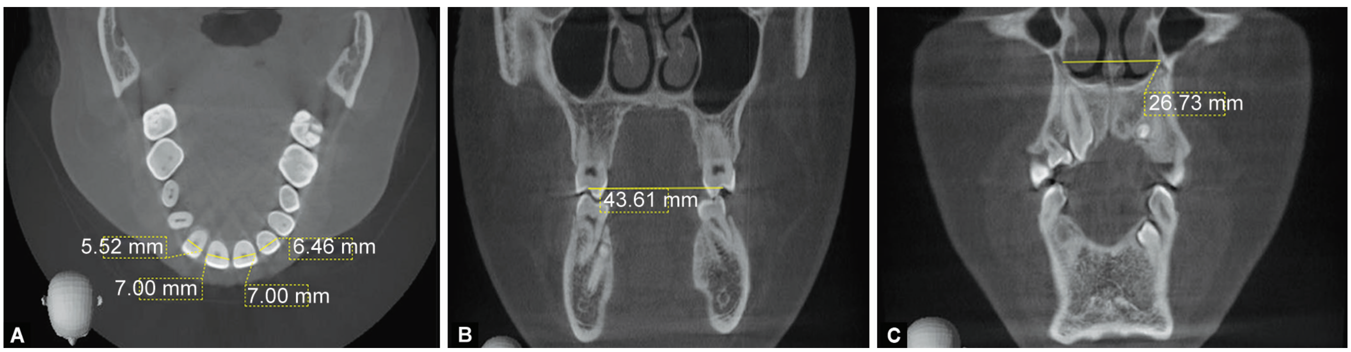
Means and standard deviations for the two groups were calculated for all variables using statistical package for the social science (SPSS), version 21 (IBM Corp., NY, USA). Parametric tests were applied for statistical evaluations, as the sample demonstrated normal distribution. In addition, the Student's *t*-test was applied to investigate the differences between unilateral and bilateral groups. One-way analysis of variance (ANOVA) was the comparison test used between dental and skeletal measurements with the impacted canine occurrence, anomalies, side, and position in the oral cavity. The level of statistical significance was set at 5% ($p < 0.05$). Multinomial regression analysis was done between bilateral and unilateral groups with gender, sides, and dental/skeletal measurements. Fisher's exact test was applied to compare impaction location with dental anomalies. The level of statistical significance was set at a $p < 0.05$. Additionally, intraclass correlation coefficients (ICC) and the 95% confidence interval were used to evaluate the inter- and intrarater reliability.

Results

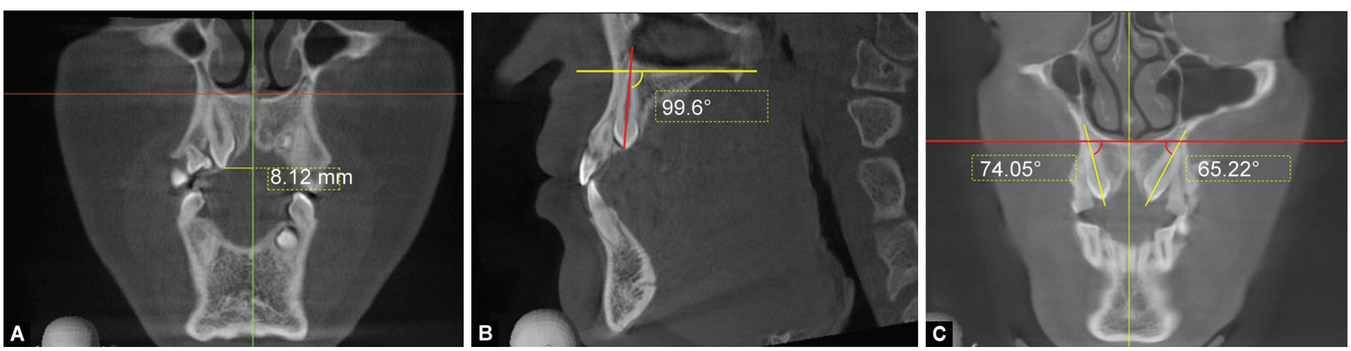
The records of 1,736 patients were initially screened. The CBCT data (DICOM files) of 59 patients with maxillary canine impaction

Table 2: Dental and skeletal measurements

Quantitative variables	*Definition*
Tooth MD width (Fig. 1A)	Maximum mesiodistal crown diameter of maxillary anterior teeth (U1, U2, and U3)
Tooth BL width	Maximum buccolingual crown diameter of maxillary anterior teeth (U1, U2, and U3)
IPI (anterior dental arch width)	Intermaxillary arch width between the deepest points of the central fosse of the maxillary first premolars (U4)
IMI (posterior dental arch width) (Fig. 1B)	Intermaxillary arch width between the deepest points of the central fosse of the first molars
J-J (maxillary skeletal width)	Linear distance between the right and left jugal points (intersection of the outline of the maxillary tuberosity and the zygomatic buttress)
NC-NC width (Fig. 1C)	Linear distance between the right and left lateral walls of the nasal base
U3-MSP distance (Fig. 2A)	Perpendicular distance from U3 cusp tip to the midsagittal plane
U3-PP distance	Perpendicular distance from U3 cusp tip to the palatal plane
Lateral angulation of long axis of impacted canines with respect to the palatal plane (Fig. 2B)	Value of the internal angle of the longitudinal axis of the impacted canine to the tangent of palatal plane
Lateral angulation of long axis of impacted canines with respect to the nasal horizontal plane (Fig. 2C)	Value of the internal angle of the longitudinal axis of the impacted canine with respect to the tangent of the nostril floor



Figs 1A to C: (A) Mesiodistal width of the maxillary anterior teeth; (B) Posterior dental arch width between the central fossa of maxillary first molars (mm); (C) Nasal cavity width from the lateral walls of the nasal base



Figs 2A to C: (A) Distance of impacted canine measured from canine tip to the midsagittal plane (mm); (B) Lateral angulation of long axis of canines with respect to the palatal plane; (C) Lateral angulation of long axis of canines with respect to the nasal horizontal plane

were included in the study. In the present sample, more subjects showed evidence of unilateral maxillary canine impaction. Out of 59 subjects, 35 had unilateral and 24 had bilaterally impacted canines. Demographics and distribution of impactions are summarized in Table 3.

In cases of unilateral canine impaction, the MD width of the central incisors was significantly wider (7.24 ± 1.10) than with bilateral canine impaction (6.96 ± 1.10) ($p < 0.05$). The mean U3-PP distance was significantly longer with bilateral canine impaction (15.84 ± 4.57) compared to unilateral canine impaction (12.70 ± 4.93) ($p < 0.05$). Moreover, the NC was significantly wider in the unilateral canine impaction group (28.79 ± 1.11) than in the bilateral impaction group (26.84 ± 1.16) ($p < 0.05$). Comparisons between unilateral and bilateral canine impactions are presented in Table 4.

Table 5 shows significant dental and skeletal differences concerning the position of the impacted canines. There was a

Table 3: Descriptive statistics demographic

	Unilateral		Bilateral	
Variable	*n = 35*	*%*	*n = 24*	*%*
Gender				
Male	15	42.86	5	20.83
Female	20	57.14	19	79.17
Position				
Palatal	24	68.57	35	72.92
Buccal	8	22.86	13	27.08
Mid alveolar	3	8.57	0	0
Side				
Right	16	45.71	24	50.0
Left	19	54.29	24	50.0
Anomalies				
Supernumerary teeth	4	11.43	0	0
Maxillary incisor impaction	1	2.86	0	0
Peg-shaped U2	2	5.71	1	2.08
U2 agenesis	3	8.57	0	0
Premolars agenesis	2	5.71	3	6.25
Third molar agenesis	6	17.14	9	18.75
Lower canine impaction	0	0	8	16.7
No anomaly	17	48.57	27	56.25

Table 4: Descriptive statistics of dental and skeletal measurements by canine impaction location

	Unilateral	Bilateral
Variable	*Mean ± SD*	*Mean ± SD*
MD width of 3	7.21 ± 0.613	7.36 ± 0.553
MD width of 2	5.35 ± 1.79	5.53 ± 0.795
MD width of 1	7.24 ± 1.10	6.96 ± 1.10*
BL width of 3	7.43 ± 0.760	7.28 ± 0.552
BL width of 2	6.14 ± 2.06	6.53 ± 0.677
BL width of 1	6.97 ± 1.87	7.19 ± 0.508
IPI (anterior dental arch width)	33.84 ± 9.06	34.35 ± 7.98
IMI (posterior dental arch width)	45.37 ± 3.30	44.60 ± 9.60
Lateral angulation of long axis of impacted canines to nasal horizontal plane	56.88 ± 25.29	53.95 ± 16.28
Lateral angulation of long axis of canines to the palatal plane	127.04 ± 17.57	126.62 ± 14.31
U3-PP distance	12.70 ± 4.93	15.84 ± 4.57*
U3-MSP	7.07 ± 4.92	8.62 ± 4.65
Maxillary skeletal width (J-J)	56.08 ± 4.10	55.92 ± 4.37
NC-NC width	28.79 ± 1.11	26.84 ± 1.16*

**t*-test; significant when $p < 0.05$. SD, standard deviation

Table 5: Comparison tests between dental and skeletal measurements with the position of impacted canine

	Side		Position		
	Right	*Left*	*Palatal*	*Buccal*	*Mid alveolar*
MD width of 3: Mean ± SD	7.27 ± 0.615	7.31 ± 0.551	7.28 ± 0.602	7.32 ± 0.519	7.48 ± 0.730
MD width of 2: Mean ± SD	5.81 ± 1.15	5.42 ± 1.02*	5.52 ± 1.31	5.22 ± 1.34	5.90 ± 0.963
MD width of 1: Mean ± SD	7.10 ± 1.10	7.10 ± 1.09	6.94 ± 1.48	7.01 ± 0.688	7.67 ± 0.610
BL width of 3: Mean ± SD	7.32 ± 1.09	7.32 ± 1.10	7.36 ± 0.60	7.17 ± 0.706	8.21 ± 0.373
BL width of 2: median (IQR)	6.54 (5.92–6.95)	6.71 (6.15–7)	6.54 (6.02–6.82)	6.86 (6.02–6.82)	7.39 (6.41–7.82)
BL width of 1: median (IQR)	7.19 (6.70–7.49)	7.38 (7.02–7.8)	7.26 (6.73–7.6)	7.47 (7.1–7.76)	7.49 (7.2–8.13)
Lateral angulation of long axis of impacted canines to nasal horizontal plane Mean ± SD	53.39 ± 22.68	56.85 ± 18.30	56.34 ± 18.89	47.55 ± 21.24	85.89 ± 16.19
Lateral angulation of long axis of canines to the palatal plane Mean ± SD	126.35 ± 14.70	127.21 ± 16.68	124.32 ± 15.58	135.06 ± 13.91	117.53 ± 7.49
U3-PP distance Mean ± SD	14.58 ± 4.07	14.46 ± 5.70	15.16 ± 4.69	12.90 ± 5.66	13.25 ± 1.68[a]
U3-MSP distance Mean ± SD	7.90 ± 4.77	8.02 ± 4.89	6.99 ± 4.04	9.94 ± 5.85	13.33 ± 4.39[a]
IPI (anterior dental arch width) Mean ± SD	35.87 ± 1.11	35.16 ± 1.09	33.55 ± 9.61	35. 49 ± 4.14	36.12 ± 2.92[a]
IMI (posterior dental arch width) Mean ± SD	46.06 ± 1.06	44.70 ± 1.07	45.08 ± 6.56	44.25 ± 10.40	46.67 ± 3.91
J-J (maxillary skeletal width) Mean ± SD	56.34 ± 4.16	55.34 ± 4.30	55.63 ± 4.03	56.93 ± 4.63	56.44 ± 6.01[a]
NC-NC width Mean ± SD	27.66 ± 1.15	28.22 ± 1.11	28.00 ± 3.73	27.41 ± 4.09	26.12 ± 3.33

The following tests are significant when $p < 0.05$: [a]one-way ANOVA teat; **t*-test. IQR, interquartile range; SD, standard deviation

Table 6: Comparison tests between dental and skeletal measurements with different dental anomalies

	Supernumerary teeth	*Maxillary incisor impaction*	*Peg-shaped U2*	*U2 agenesis*	*Premolars agenesis*	*Third molar agenesis*	*Lower canine impaction*
MD width of 3: Mean ± SD	6.52 ± 0.606	7.72	7.54 ± 0.524	7.16 ± 0.148	7.14 ± 0.918	7.28 ± 0.519	7.43 ± 0.324
MD width of 2: Mean ± SD	5.83 ± 0.559	6.35	2.99 ± 2.59	2.23 ± 3.86	5.87 ± 0.461	5.58 ± 0.569	5.39 ± 0.350*
MD width of 1: Mean ± SD	7.52 ± 0.646	0	8.08 ± 0.411	4.42 ± 4.07	6.93 ± 0.596	7.12 ± 0.599	6.73 ± 0.371
BL width of 3: Mean ± SD	7.59 ± 1.27	7.13	7.59 ± 0.937	7.30 ± 0.261	6.89 ± 0.440	7.32 ± 0.468	7.00 ± 0.417
BL width of 2: Median (IQR)	6.03 (5.48–6.18)	6.35	4.35 (0–4.63)	0 (0–6.69)	5.64 (5.64–5.82)	5.72 (5.21–5.96)	5.4 (5.2–5.68)
BL width of 1: Median (IQR)	7.65 (7.07–7.98)	0	7.95 (7.75–8.54)	5.25 (0–8.02)	6.84 (6.84–7.42)	7 (6.73–7.55)	6.66 (6.46–6.84)
IPI (anterior dental arch width) Mean ± SD	35.35 ± 5.41	35.2	36.41 ± 1.36	32.56 ± 2.05	19.54 ± 17.86	34.85 ± 3.69	33.84 ± 5.71
IMI (posterior dental arch width) Mean ± SD	45.80 ± 4.62	47.31	47.46 ± 3.31	43.1 ± 0.550	44.61 ± 4.65	44.97 ± 2.68	34.13± 21.10
Lateral angulation of long axis of impacted canines to nasal horizontal plane Mean ± SD	49.27 ± 34.83	64.49	74.17 ± 15.09	71.44 ± 29.74	48.23 ± 6.96	49.93 ± 20.66	46.81 ± 16.09*
Lateral angulation of long axis of canines to the palatal plane Mean ± SD	132.23 ± 23.66	126.87	119.2 ± 5.42	123.47 ±20.87	130.79 ±14.15	133.84 ±15.00	134.94 ± 8.91
U3-PP distance Mean ± SD	13.09 ± 6.83	3.49	16.75 ± 6.41	12.4 ± 2.19	14.31 ± 1.89	12.20 ± 3.75	13.15 ± 6.48*
U3-MSP distance Mean ± SD	4.84 ± 3.57	7.97	8.22 ± 6.11	9.32 ± 7.27	7.99 ± 7.16	7.00 ± 4.32	11.35 ± 2.84
J-J (maxillary skeletal width) Mean ± SD	56.67 ± 6.72	61.28	58.22 ± 4.56	56.28 ± 2.52	50.74 ± 3.55	55.17 ± 4.52	54.94 ± 4.89
NC-NC width Mean ± SD	28.26 ± 3.36	29.37	30.46 ± 2.01	28.08 ± 2.67	26.29 ± 3.77	26.20 ± 3.35	25.81 ± 5.14

*One-way ANOVA test, significant when $p < 0.05$. IQR, interquartile range; SD, standard deviation

significant difference in the distance of the impacted canines from the palatal and mid-sagittal planes. Moreover, the anterior dental arch width and the maxillary skeletal width changed significantly with the position of impacted canines ($p < 0.05$).

Dental anomalies demonstrated different dental and skeletal measurements as depicted in Table 6. Significant differences across the anomalies were observed in the MD width of the lateral incisor, lateral angulation of the long axis of the impacted canines to the nasal horizontal line, and the U3-PP distance ($p < 0.05$).

Factors Associated with Unilateral vs Bilateral impacted Canines

Table 7 presents the results of the regression analysis. It showed a gender predilection towards canine impaction, males were 0.185 times less likely to have bilateral canine impaction than females ($p = 0.025$). In addition, there was a significant 1.30 odds ($p = 0.003$) of having bilateral canine impaction with a longer U3-MSP distance.

There were differences in the presence of dental anomalies between unilateral and bilateral impacted canine groups. Moreover, a significant association was observed between the presence of supernumerary teeth with unilateral impacted canines and lower canine impaction with bilaterally impacted canines. The overall test of association was significant ($\chi^2 = 17.64$; $p = 0.014$).

In reliability analysis, intraclass correlation coefficients (ICC) were 0.84 for interrater reliability [95% confidence interval (CI): 0.65–0.94] and 0.88 for intrarater reliability (95% CI: 0.67–0.95) indicating moderate to excellent measurement reliability.

Table 7: Multinomial regression analysis between bilateral and unilateral groups with gender, side and dental/skeletal measurements (pseudo-$R^2 = 0.265$, $p = 0.0184$)

Variables		*OR*	*(95% CI)*	*p-value*
Gender, (reference: female)	Males	0.185	(0.042, 0.808)	0.025*
Sides, (reference: left)	Right	1.38	(0.451, 4.24)	0.571
MD width of 3		3.02	(0.890, 10.28)	0.076
MD width of 2		0.884	(0.357, 2.19)	0.790
MD width of 1		0.833	(0.301, 2.31)	0.726
BL width of 3		0.653	(0.195, 2.19)	0.490
BL width of 2		1.72	(0.699, 4.25)	0.237
BL width of 1		0.851	(0.289, 2.51)	0.769
Anterior dental arch width (IPI)		0.988	(0.914, 1.07)	0.756
Posterior dental arch width (IMI)		0.996	(0.904, 1.10)	0.938
Lateral angulation of long axis of impacted canines to nasal horizontal plane		0.977	(0.934, 1.02)	0.314
Lateral angulation of long axis of canines to the palatal plane		1.02	(0.963, 1.08)	0.529
U3-MSP distance		1.30	(1.09, 1.55)	0.003*
U3-PP distance		1.08	(0.920, 1.27)	0.346
Maxillary skeletal width (J-J)		1.08	(0.898, 1.31)	0.402
NC-NC width		0.921	(0.785, 1.08)	0.309

Base group: Unilateral, *Significant when $p < 0.05$

Discussion

Impacted teeth pose several challenges to the orthodontist. They may compromise esthetics, and function, and hinder tooth movement. Furthermore, undetected impacted canines can resorb the roots of the adjacent teeth, making their early detection and prompt treatment vital to dental health. Identification of factors potentially implicated in maxillary canine impaction can help in the prediction of possible impactions and prompt treatment. This study aimed to examine the patterns of maxillary canine impaction, whether unilateral or bilateral and to investigate its association with other developmental anomalies in a Saudi Arabian population using CBCT.

We observed a greater number of unilateral canine impactions than bilateral impactions. This finding is consistent with previous work showing a greater prevalence of unilateral canine impactions by Alassiry[24] and Alyami et al.[25] who examined prevalence in Saudi populations. Our finding is broadly supported by consensus in the literature that unilateral canine impaction is more common in the ratio of 92:8.[26]

We noted a definite gender predilection for maxillary canine impaction. The odds of having bilateral canine impaction, being a male as opposed to a female was 0.185. Several authors have commented on gender differences in the occurrence of impacted canines. Peck et al.[14] and Prskalo et al.,[27] reported that palatal canine impaction tended to be, more than twice as common in females than in males. However, this gender difference could not be confirmed, owing to the small sample size for detectable effects. Peck et al. stressed that gender bias is one of five factors for supporting the genetic origin hypothesis of canine impaction which stated that both genetic mutations and environmental factors seem to play a role in defining canine impaction in affected individuals.[14,27] Syrynska stated that impacted maxillary canine is more often localized palatally and was more often found in women than men.[28] The reason for this gender bias could be explained by the gender differences in the occurrence of palatal canine impaction and the greater detection due to the higher demand for orthodontic treatment among females in Saudi Arabia.[14,29,30] Also, da Silva Santos et al.[8] reported a female predilection in canine impaction. Our results reflect those of Alhammadi et al.[31] and Alassiry[24] who noted a female predilection for maxillary canine impaction in Saudi Arabian population.

The location of impacted canines particularly may be attributed to genetics or geographic differences.[32] This would encompass differences in jawbone structure for different ethnicities, such as the shape of the maxillary arch, the height of the palate, and the NC, which influence the jaw shape and cause variations in the position of the tooth germ in the arch.[8]

Altered or increased MD dimensions could be a possible indicator of impacted canines. In our study, we observed that the MD width of the maxillary anterior teeth affects the pattern of canine impaction. The MD width of the maxillary central incisors was wider with unilateral canine impaction than with bilateral canine impaction. Similarly, the MD width of the maxillary lateral incisors was significant across anomalies. Our finding corroborates the work of Yan et al.[23] who studied the etiological factors for canine impactions. They reported that lateral incisors were considerably smaller in the palatally impacted canine group than in the buccally impacted canine and control groups.[25] Sacerdoti et al. demonstrated that both unilateral and bilateral palatally displaced canines showed significant association with bilateral small-size upper lateral incisors.[33,34] This also accords with observations by Al-Nimri and Gharaibeh who reported that female subjects with unilateral palatally impacted canines tended to have a smaller MD width of the lateral incisors as compared to unaffected orthodontic patients.[30] Our findings also showed that these dimensions were wider on the right side of the oral cavity than on the left ($p < 0.05$). The reduction in the size of the maxillary lateral incisor on the impacted side may indicate a localized dental lamina disturbance as suggested.[35] However, this result is not without its dissenters as Ali Alqerban et al. stated that no difference was found between impacted and nonimpacted canines in lengths or crown widths of the lateral incisors.[36] Similarly, Brenchley and Oliver[34] argued that there was no statistically significant evidence to support the view that palatally impacted maxillary canines are associated with diminutive maxillary lateral incisors.[37]

The position and presence of an impacted canine may be related to the canine's proximity to the midsagittal plane. We noted a correlation of U3-MSP distance and the presence of the impacted canine. Having a longer U3-MSP distance has 1.30 odds of having bilateral canine impaction. Yan et al. found that palatally impacted canines were closer to the midsagittal plane.[23] Our finding is in keeping with a report by Alqerban et al.[36] who sought prediction criteria for maxillary canine impaction in young patients, based on angular and linear measurements. They reported that one of the best-discriminating parameters between impacted and non-impacted canines was canine cusp to mid-sagittal plane distance.[36] Saiar et al. reported that the closer the canine crown is to the midsagittal plane in the frontal head film, the higher the probability of palatal displacement and eventual impaction of the canine on the corresponding side of the dental arch.[39] This may be useful to discriminate canine impaction for early intervention or regular follow-up.

The mean distance from the cuspid to the palatal plane may be etiologically related to canine impaction. We found this distance to be significantly longer with bilateral canine impaction than that with unilateral canine impaction. This data indicates that bilaterally and unilaterally impacted canines appear to have different distances not only to the midsagittal plane but also to the palatal plane. Oz reported that in right-side impactions, the mean distance from the canine tip to its target point on the palatal plane decreased significantly, as opposed to measurements involving the left-side impactions.[39,40] Therefore, they interpreted that the maxillary canines that were impacted on the right side were more superiorly positioned compared to the left impacted canines.

We observed that the NC width, the maxillary skeletal width, and the dental arch width play a significant role in determining the pattern and position of maxillary canine impaction. In our study, the NC width in unilateral canine impaction was significantly wider than that in bilateral canine impaction. This finding was contrary to Yan et al.,[23] who reported that the NC width was similar among the impaction groups.[23] Similarly, Saiar et al. did not find any association between palatally impacted canines and NC width.[39] Among the skeletal width measurements, buccally impacted canines had smaller maxillary widths compared to the other groups.[23]

We found that the lateral angulation of the long axis of impacted canines to the nasal horizontal plane and the palatal plane does not influence the eruption pattern. However, Mohammed *et al* argued that impacted canine localization and the inclination of its long axis have a definite impact on its prognosis, the pattern of eruption, and treatment duration.[37]

We observed that the pattern of canine impaction is not influenced by the buccolingual (BL) dimension of the maxillary anterior teeth. Our results differ from Yan et al. who found that all maxillary anterior teeth in the canine impaction groups were significantly smaller than those in their respective control groups.[23] However, no difference was observed between the palatally impacted canines and the buccally impacted canines.[23]

The prevalence of certain developmental anomalies appeared to predispose to maxillary canine impaction. When comparing dental and skeletal measurements with different dental anomalies, the MD width of the lateral incisor, lateral angulation of the long axis of the impacted canines to the nasal horizontal line, and the U3-PP distance were significantly different across the anomalies. Al-Nimri and Gharaibeh demonstrated a clear association between palatal impaction of the maxillary canine and anomalous lateral incisors.[30] This supports the previous findings of Becker and Peck.[12,13] Their overall test of association was significant (χ^2 = 17.64; $p = 0.014$) between occurrence of supernumerary teeth with unilateral impacted canines and lower canine impaction with bilaterally impacted canines. In contrast to these findings, Sacerdoti et al. posted that unilateral palatally displaced maxillary canines showed a significant association with aplasia of maxillary lateral incisors, whereas bilateral palatally displaced maxillary canines were significantly associated with third molar aplasia.[33] Another study has shown that anomalies such as supernumerary teeth or missing premolars or molars were not significantly frequent in the palatally impacted canines than in the control or buccally impacted canines.[23] Furthermore, it was found in earlier studies that incisor impaction was significantly more prevalent in the buccally impacted canine group.[23,38] However, our results showed that both bilateral and unilateral impaction groups did not demonstrate a significant association with incisor impaction.

Our study was limited by the small sample size, and confounding factors, and heterogeneity in the design of the included studies were a few drawbacks. The results of this research add to our understanding of the risk factors associated with unilateral and bilateral canine impaction. Further research is necessary to confirm and validate these findings.

Conclusion

Our findings indicate that unilateral maxillary canine impaction is more prevalent than bilateral impaction. There appears to be a gender predilection with females showing a greater prevalence of bilateral canine impaction. The evidence suggests that the MD width of the maxillary central and lateral incisors, distance from the maxillary canine to the palatal plane and the mid-sagittal plane, NC width, maxillary skeletal width, and gender, are the best-discriminating parameters between unilateral and bilateral canine impactions. Alterations in these parameters can be predictors of canine impaction. The overall association between the occurrence of supernumerary teeth with unilateral impacted canines and lower canine impaction with bilaterally impacted canines was significant.

References

1. Litsas G, Acar A. A review of early displaced maxillary canines: Etiology, diagnosis, and interceptive treatment. Open Dent J 2011;5:39–47. DOI: 10.2174/1874210601105010039.
2. Lövgren ML, Dahl O, Uribe P, et al. Prevalence of impacted maxillary canines: An epidemiological study in a region with systematically implemented interceptive treatment. Eur J Orthod 2019;41(5): 454–459. DOI: 10.1093/ejo/cjz056.
3. Yan B, Sun Z, Fields H, et al. Maxillary canine impaction increases root resorption risk of adjacent teeth: A problem of physical proximity. Am J Orthod Dentofac Orthop 2012;142(6):750–757.
4. Alqerban A, Jacobs R, Lambrechts P, et al. Root resorption of the maxillary lateral incisor caused by impacted canine: A literature review. Clin Oral Investig 2009;13(3):247–255. DOI: 10.1007/s00784-009-0262-8.
5. Katz MI. Angle classification revisited 2: A modified Angle classification. Am J Orthod Dentofac Orthop 1992;102(3):277–284. DOI: 10.1016/S0889-5406(05)81064-9.
6. Bishara SE, Ortho. D. Impacted maxillary canines: A review. Am J Orthod Dentofac Orthop 1992;101(2):159–171. DOI: 10.1016/0889-5406(92)70008-X.
7. Cooke J, Wang H-L. Canine impactions: incidence and management. Int J Periodontics Restorative Dent 2006;26(5):483–491. PMID: 17073358.
8. da Silva Santos LM, Bastos LC, Oliveira–Santos C, et al. Cone–beam computed tomography findings of impacted upper canines. Imaging Sci Dent 2014;44(4):287–292. DOI: 10.5624/isd.2014.44.4.287.
9. Zilberman Y, Cohen B, Becker A. Familial trends in palatal canines, anomalous lateral incisors, and related phenomena. Eur J Orthod 1990;12(2):135–139. DOI: 10.1093/ejo/12.2.135.
10. Dağsuyu İM, Kahraman F, Okşayan R. Three-dimensional evaluation of angular, linear, and resorption features of maxillary impacted canines on cone–beam computed tomography. Oral Radiol 2018;34(1):66–72. DOI: 10.1007/s11282-017-0289-5.
11. Ericson S, Kurol J. Early treatment of palatally erupting maxillary canines by extraction of the primary canines. Eur J Orthod 1988;10(4):283–295. DOI: 10.1093/ejo/10.4.283.
12. Becker A, Chaushu S. Etiology of maxillary canine impaction: A review. Am J Orthod Dentofac Orthop 2015;148(4):557–567. DOI: 10.1016/j.ajodo.2015.06.013.

13. Becker A, Peck S, Peck L, et al. Palatal canine displacement: Guidance theory or an anomaly of genetic origin? A letter to the editor from Adrian Becker, with a response from Sheldon and Leena Peck, and Matti Kataja. Angle Orthod 1995;65(2):95–102. DOI: 10.1043/0003-3219(1995)065<0095:PCDGTO>2.0.CO;2.
14. Peck S, Peck L, Kataja M. The palatally displaced canine as a dental anomaly of genetic origin. Angle Orthod 1994;64(4):250–256. DOI: 10.1043/0003-3219(1994)064<0249:WNID>2.0.CO;2.
15. Thilander B, Jakobsson SO. Local factors in impaction of maxillary canines. Acta Odontol Scand 1968;26(2):145–168. DOI: 10.3109/00016356809004587.
16. Brin I, Becker A, Shalhav M. Position of the maxillary permanent canine in relation to anomalous or missing lateral incisors: A population study. Eur J Orthod 1986;8(1):12–16. DOI: 10.1093/ejo/8.1.12.
17. Laurenziello M, Montaruli G, Gallo C, et al. Determinants of maxillary canine impaction: Retrospective clinical and radiographic study. J Clin Exp Dent 2017;9(11):e1304. DOI: 10.4317/jced.54095.
18. Rutledge MS, Hartsfield JK Jr. Genetic factors in the Eeiology of palatally displaced canines. Semin Orthod 2010;16:165–171. DOI: 10.1053/j.sodo.2010.05.001.
19. Kumar S, Mehrotra P, Bhagchandani J, et al. Localization of impacted canines. J Clin diagnostic Res JCDR 2015;9(1):ZE11–ZE14. DOI: 10.7860/JCDR/2015/10529.5480.
20. Schroder AGD, Guariza–Filho O, de Araujo CM, et al. To what extent are impacted canines associated with root resorption of the adjacent tooth? A systematic review with meta-analysis. J Am Dent Assoc 2018;149(9):765–777.
21. Grisar K, Piccart F, Al-Rimawi AS, et al. Three-dimensional position of impacted maxillary canines: Prevalence, associated pathology and introduction to a new classification system. Clin Exp Dent Res 2019;5(1):19–25. DOI: 10.1002/cre2.151.
22. D Oleo–Aracena MF, Arriola–Guillén LE, Rodríguez–Cárdenas YA, et al. Skeletal and dentoalveolar bilateral dimensions in unilateral palatally impacted canine using cone–beam computed tomography. Prog Ortho 2017;18(1):7. DOI: 10.1186/s40510-017-0160-6.
23. Yan B, Sun Z, Fields H, et al. Etiologic factors for buccal and palatal maxillary canine impaction: A perspective based on cone–beam computed tomography analyses. Am J Orthod Dentofac Orthop 2013;143(4):527–534. DOI: 10.1016/j.ajodo.2012.11.021.
24. Alassiry A. Radiographic assessment of the prevalence, pattern and position of maxillary canine impaction in Najran (Saudi Arabia) population using orthopantomograms: A cross-sectional, retrospective study. Saudi Dent J 2020;32(3):155–159. DOI: https://doi.org/10.1016/j.sdentj.2019.08.002.
25. Alyami B, Braimah R, Alharieth S. Prevalence and pattern of impacted canines in Najran, South Western Saudi Arabian population. Saudi Dent J 2020;32(6):300–305. DOI: 10.1016/j.sdentj.2019.10.002.
26. McConnell TL, Hoffman DL, Forbes DP, et al. Maxillary canine impaction in patients with transverse maxillary deficiency. ASDC J Dent Child 1996;63(3):190–195. PMID: 8853823.
27. Prskalo K, Zjača K, Škarić–Jurić T, et al. The prevalence of lateral incisor hypodontia and canine impaction in Croatian population. Coll Antropol 2008;32(4):1105–1109. PMID: 19149215.
28. Syryńska M, Budzyńska A. The incidence of uni-and bilateral impacted maxillary canines and their position in dental arch depending on gender and age. Ann Acad Med Stetin 2008;54:132–137. PMID: 19374243.
29. Al-Tawachi A, Alhaija ESA, Al-Jamal GA. Evaluation of maxillary canine root and maxillary bone thickness and density in patients with displaced maxillary canines: A cone–beam tomography study. Am J Orthod Dentofac Orthop 2022;162(3):318–330. DOI: 10.1016/j.ajodo.2021.03.025.
30. Al-Nimri K, Gharaibeh T. Space conditions and dental and occlusal features in patients with palatally impacted maxillary canines: An aetiological study. Eur J Orthod 2005;27(5):461–465. DOI: 10.1093/ejo/cji022.
31. Alhammadi M-S, Asiri H-A, Almashraqi A-A. Incidence, severity and orthodontic treatment difficulty index of impacted canines in Saudi population. J Clin Exp Dent 2018;10(4):e327–e334. DOI: 10.4317/jced.54385. DOI: 10.4317/jced.54385.
32. Walker L, Enciso R, Mah J. Three-dimensional localization of maxillary canines with cone-beam computed tomography. Am J Orthod Dentofac Orthop 2005;128(4):418–423. DOI: 10.1016/j.ajodo.2004.04.033.
33. Sacerdoti R, Baccetti T. Dentoskeletal features associated with unilateral or bilateral palatal displacement of maxillary canines. Angle Orthod. 2004 Dec;74(6):725-32. DOI: 10.1043/0003-3219.
34. Brenchley Z, Oliver RG. Morphology of anterior teeth associated with displaced canines. Br J Orthod 1997;24(1):41–45. DOI: 10.1093/ortho/24.1.41.
35. Oliver RG, Mannion JE, Robinson JM. Morphology of the maxillary lateral incisor in cases of unilateral impaction of the maxillary canine. Br J Orthod 1989;16(1):9–16. DOI: 10.1179/bjo.16.1.9.
36. Alqerban A, Jacobs R, Fieuws S, et al. Radiographic predictors for maxillary canine impaction. Am J Orthod Dentofac Orthop 2015;147(3):345–354. DOI: 10.1016/j.ajodo.2014.11.018.
37. Mohammed AK, Sravani G, Vallappareddy D, et al. Localization of impacted canines: A comparative study of computed tomography and orthopantomography. J Med Life 2020;13(1):56–63. DOI: 10.25122/jml-2020-0001.
38. Chaushu S, Zilberman Y, Becker A. Maxillary incisor impaction and its relationship to canine displacement. Am J Orthod Dentofac Orthop 2003;124(2):144–150. DOI: 10.1016/s0889-5406(03)00344-5.
39. Saiar M, Rebellato J, Sheats RD. Palatal displacement of canines and maxillary skeletal width. Am J Orthod Dentofac Orthop 2006;129(4):511–519. DOI: 10.1016/j.ajodo.2005.03.021.
40. Oz AZ, Oz AA, El H, Palomo JM. Maxillary sinus volume in patients with impacted canines. Angle Orthod. 2017;87(1):25–32.