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Research Article

Patterns, Position and Factors Associated with Maxillary Canine Impactions: A Cone Beam Computed Tomography (CBCT) based Study

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Abstract

Canines are most important teeth in dental arches, resolution of canine's impactions has been one of the toughest challenges posed to orthodontists. Objective of this study was to assess the patterns of maxillary canine impactions, to assess any association between studied variable and factors associated with severe lateral incisor root resorption (SIRR), using CBCT as imaging modality. A total of 102 CBCT scans were performed during study period and included in study. For analysis, the images were saved as digital imaging and communications in medicine (DICOM) software files. The statistical analysis was carried out by using statistical software SPSS (version 25). Descriptive analysis was done on the data. Frequencies and percentages were calculated for age, gender and qualitative variables including buccopalatal position and mesiodistal location of impacted canine, overlap of adjacent incisor by impacted canine. Within the limitation of the study we conclude that females are more prone to canine impaction with a female to male ratio of 2.3:1, Age does not have statistically significant correlation and 9.8% impacted teeth cause root resorption of lateral incisor.

Keywords: *Impacted Canines; Cone Beam Computed Tomography; Root Resorption*

Introduction

An impacted tooth is the one that fails to erupt into the dental arch within the expected developmental window [1]. After third molars the canines are most frequently impacted teeth in oral cavity [2] among which maxillary canines are more commonly seen impactions as compared to mandibular canine impaction. Prevalence of maxillary impacted canines has found to be between 0.8 and 2.8% and prevalence in Pakistan is between 1 - 5% [3,4]. Canines are most important teeth in dental arches, resolution of canine's impactions has been one of the toughest challenges posed to orthodontists. Diagnosis and treatment planning requires precise localization of the un-erupted canine which is usually achieved using a combination of clinical and radiographic examination.

The most recent United Kingdom guidelines on the use of radiographs for orthodontic diagnosis recommend that when a maxillary canine is unerupted and is not palpable, then radiographic examination is indicated [5]. Two dimensional radiography was used routinely as a conventional method of diagnosis, however this led to missed diagnosis of presence and extent of root resorption of incisors. Superimposition of incisor roots and the crown of an impacted canine on intraoral radiographs obscured the root morphology in 43% of cases. Thus, to overcome these limitations three dimensional (3D) imaging techniques have been introduced in modern dentistry practice. Nowadays CBCT (Cone beam computed tomography) is gaining more popularity because of its low radiation dosage, low cost and far better diagnostic accuracy. It shows an undistorted 3D image of dentition, can accurately localize unerupted teeth, analyzes exact orientation of roots and help in identification of anomalous structures [6].

Cone beam computed tomography (CBCT) provided more efficient tools for diagnosing canine impactions and its sequel, which gives the clinician the opportunity to evaluate the relation of impacted teeth to the adjacent teeth [7]. Ericson and Kurol found a high correlation in the diagnosis of root resorption between the CT images and clinical findings of extracted teeth [8].

Accurate localization of maxillary canine is of prime importance for comprehensive treatment planning, many classification systems are available to assess the level and severity of maxillary canine impaction. Sector classification is based on the location of the canine tip in relation to the root of the lateral incisor [9]. Becker classified canine impaction based on the transverse relationship of the canines to the dental arch and the height of the canine in relation to the occlusal plane [10]. Ackerman and Fields classified impacted canines as horizontal in relation to the arch and vertical in relation to the apex [1].

Objective of the Study

Objective of this study was to assess the patterns of maxillary canine impactions, to assess any association between studied variable and factors associated with severe lateral incisor root resorption (SIRR), using CBCT as imaging modality.

Materials and Methods

This descriptive cross-sectional study was conducted in the department of Orthodontics in Hamdard University Dental Hospital Karachi, Pakistan after approval by ethical committee. Data included CBCT scan of patients from March 2018 till March 2020 seeking orthodontic treatment for missing canines in orthodontic department, whose CBCT scan were done to achieve more information regarding impacted maxillary canine's teeth, for diagnostic accuracy beside conventional orthodontic radiographs in order to avoid additional radiation exposure. Patients falling on our inclusion criteria were selected on a non-probability consecutive pattern. A total of 102 CBCT scans were performed during study period and included in study.

CBCT scans of subjects having age between 13 to 40 years biting in centric occlusion, full field of view images focusing maxillary region having impacted canines were included in research. Whereas subjects with history of root resorption secondary to pulp, cyst or any other pathology, previous orthodontic treatment, anomalous lateral incisors like peg shaped teeth or teeth with anomalous root forms, known syndromal conditions, presence of pathology/trauma in craniofacial region and 3D scans having movement artifact were excluded from the study.

It was make sure by two assessors that CBCT scans of the included subjects were done using a same machine, NewTom VGi 3D [QR systems, Verona, Italy], with patients positioned in the upright position and making the Frankfort horizontal (FH) plane parallel to floor in maximum intercuspation. The exposure settings were 110 kV, 4 mA, 0.3-mm voxel size, 60 seconds exposure time. For analysis, the images were saved as digital imaging and communications in medicine (DICOM) software files.

The statistical analysis was carried out by using statistical software SPSS (version 23). Descriptive analysis was done on the data. Frequencies and percentages were calculated for age, gender and qualitative variables including buccopalatal position and mesiodistal

location of impacted canine, overlap of adjacent incisor by impacted canine, vertical crown height of impacted canine with reference to adjacent incisor root and severity of root resorption. Kruskal Wallis test and pair wise comparison between quantitative variable were performed and p-value ≥ 0.05 kept significant.

Results

Out of total sample (n = 102), 45 (44.1%) were males and 57 (59.99%) females. The study sample was divided into 3 age groups, with age range of 13 years to 40 years, 62.7% (total 64) patients fell in age group between 13 - 20 years, and the mean age of study population was of 20.52 ± 8.362. Out of 102 canine impaction 47 (46.1%) were Unilateral (Male 22 Female 25) and 55 (53.9%) were Bilateral (Male 23 Female 32). Distributions of impacted canines in different anatomical locations are summarized in table 1. Mean and standard deviation of the canines with different location in the arch were summarized in table 2. Schematic illustration of impacted canine was shown in figure 1. Root resorption caused by impacted canine was shown in figure 2.

S. No.	Position of impacted canine in oral cavity				
1.	**Bucco lingual Position**	**Frequency (Percentages)**			
	Buccal	52 (51%)			
	Lingual	36 (35.3%)			
	In the line of arch	14 (13.7%)			
2.	**Mesio-distal Location**				
	Sector 1	36 (35.3%)			
	Sector 2	18 (17.6%)			
	Sector 3	33 (32.4%)			
	Sector 4	14 (13.7%)			
	Sector 5	15 (14.7%)			
3.	**Angle of impacted canine to Mid-line**		Minimum 2°	Maximum 113°	Mean 39.27° ± 21.66°
	Group 1	23 (25.5%)			
	Group 2	31 (30.4%)			
	Group 3	33 (32.4%)			
	Group 4	11 (10.8%)			
	Group 5	3 (2.9%)			
	Group 6	1 (1.0%)			
4.	**Overlap of impacted canine to Lateral Incisor root**				
	Grade 1	38 (37.3%)			
	Grade 2	18 (17.6%)			
	Grade 3	18 (17.6%)			
	Grade 4	28 (27.5%)			
5.	**Vertical crown height of impacted canine relative to lateral incisor root**				
	Apical	31 (30.4%)			
	Middle	44 (43.1%)			
	Coronal	27 (26.5%)			
6.	**Width of Dental follicle of impacted canine**		Minimum 6 mm	Maximum 13.5 mm	Mean 9.032 ± 1.5796
	1 - 10 mm	81 (79.4%)			
	11 - 20 mm	21 (20.6%)			
7.	**Severity of Incisor root resorption by impacted canine (SIRR)**				
	Nil	92 (90.2%)			
	Slight	6 (5.9%)			
	Moderate	4 (3.9%)			

Table 1: *Distribution of impacted canines in different locations.*

S. No.	Variable Name	Mean and Standard Deviation	P Value
1.	**Width of dental follicle - gender**		
	Male	9.398 ± 1.733	0.03
	Female	8.744 ± 1.3554	
2.	**Angulation to midline - root resorption**		
	Present	2.8 ± 0.42	0.04
	Absent	2.45 ± 0.75	
3.	**Bucco-lingual position compare Dental follicle**		0.04
4.	**Sectors compare Angulations**		
	1 - 3		0.005
	1 - 4		0.001
	1 - 5		0.001
	2 - 5		0.001
5.	**Angulations compare overlap of lateral incisor**		
	Grade 1 - 3		0.001
	Grade 1 - 4		0.001
	Grade 2 - 3		0.004
	Grade 2 - 4		0.001
6.	**Angulation compare dental follicle**		
	Grade 1 - 3		0.001
	Grade 2 - 3		0.001

Table 2: *Mean and standard deviation of the canines with different location in the arch.*

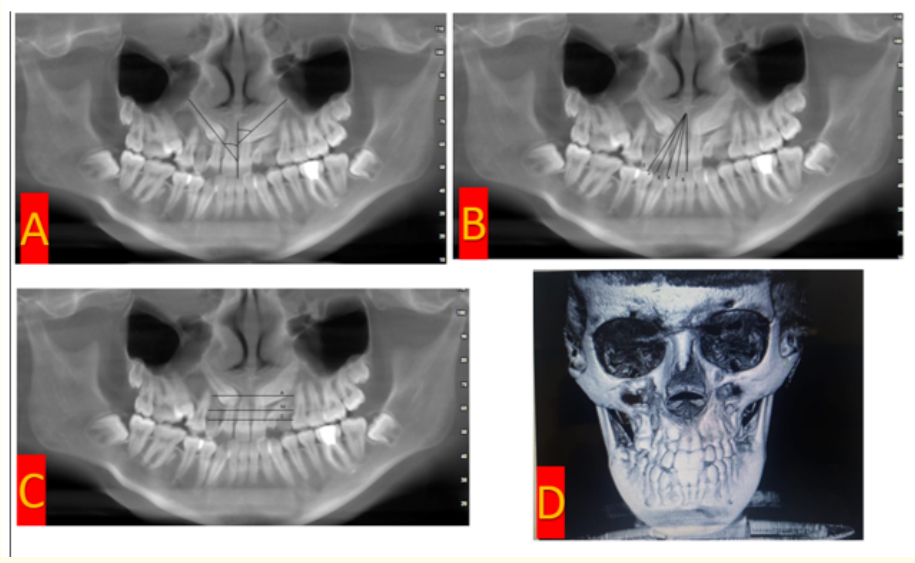

Figure 1: *Schematic illustration of maxillary canines impaction. A: Angulation to mid-line. B: Sectors of canines position. C: Vertical crown height. D: Bucco-palatal position of canines.*

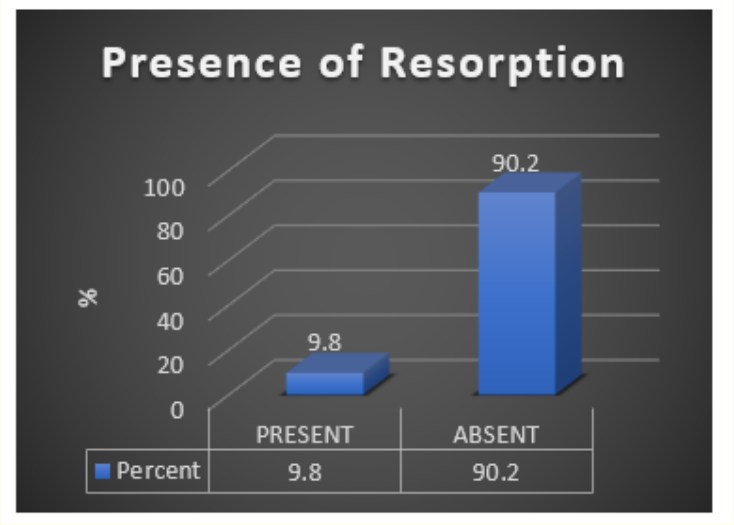

Figure 2: *Root resorption caused by impacted canine.*

Discussion

Resolution of canine's impaction is the most challenging task, the optimal treatment planning depends on the accurate diagnosis and knowledge of associated factors. It is utmost importance to locate the actual position, angulation and orientation of the tooth to achieve occlusion. Early intervention serves to reduce overall treatment time and aesthetic challenges, morbidity associated with longstanding impacted teeth, and prevent loss of canine guided occlusion [11] on the affected side and the deterioration of neighboring dentition.

A radiographic examination is an essential part of the diagnostic process in case of an impacted canine. Until recently, 2D radiological imaging was the standard method of choice due to the relatively low emitted radiation dose [12] and availability of this procedure in the standard dental office. The major divergent towards 3D radiography as in 2D images, many structures overlap as complex 3D structures are projected onto plain film [2].

With the advent of technology, cone-beam computed tomography (CBCT) can be used to visualize the impacted region [6]. In this study 3D radiography was used to predict different parameters for accurate diagnosis, CBCT units will provide more accurate diagnosis with reduced radiation exposure. CBCT has been introduced; it seems to be the most promising advanced method for the precise location of ectopic canines [13] the direct measurement of the transverse (buccolingual) inclinations of the canines, the accurate identification of root resorption areas of the adjacent frontal teeth, and the selection of the less-invasive surgical exposure technique [14]. The use of CBCT in orthodontics improves our understanding of maxillary impacted canines' angular, linear and resorption features.

In contrast to many studies the sample size of our study is 102 that is much bigger than any of reported literature this large sample size makes the results universal and more generalizable and to be taken as reference quite attractively. Canine's impactions were commonly seen in females 59.99% in this study these results are similar to a previous studies based on Pakistani population [3,4,13], consistent with this finding of study by Lai., *et al*. [15], Al-Zoubi [16] and Alassary [2], reported a female-to-male ratio of 2:1 in a maxillary impacted canine study. There possible explanations for these findings might be women may be more vocal than men about situations accompanying impacted canines, there may be differences in dentofacial growth and development between women and men and women tend to have a smaller sized skull and jawbones, which can contribute to this gender difference [3].

Out of total 53.9% bilateral canine impactions were seen, these results are contradictory to the results of similar studies [3,16] in which unilateral canine impaction is more common than bilateral canine impaction in the ratio of 92:8, reason might be this is a single centered study. In our study, the breakdown of the maxillary impacted canine locations was as follows: palatal, 35.3%; central, 3.7% and buccal, 51%, most of studies [8,17], reported palatal impaction more common, 85%. These results were supervising and revealed the importance more researches in our population and we recommend multicenter studies.

Ericson and Kurol [8] reported an incidence of enlarged follicle in 23% of sample. The mean width of dental follicle in our study was 9.032 ± 1.5796, which was much larger reported by Walker., *et al*. [18] found similar average follicle width values (3.6 mm) in their impacted canine study, and they revealed that there was no relationship between follicle size and impaction of the canine. The significant association was seen in width of dental follicle and female population, female has larger width of dental follicle, and when width was compared with angle of canine towards mid-line. There is a significant association between position of impacted canine and size of dental follicle. Bjerklin [19] revealed that there was a large variation in follicle width in same gender groups, but no significant differences between males and females were found for the normally and the ectopically erupting canines. Ericson and Kurol [8] studied intraoral radiographs for assessment of the thickness of the impacted maxillary canine dental follicle, and they found 78% of the cases had a normal follicle thickness and 22% had exceeded a 3 mm follicle thickness. In many studies Ericson and Bjerklin [8,19], there appears to be no association between enlarged canine follicles and resorption of adjacent lateral incisor tooth similar results were seen in this study, we concluded that follicular enlargement was not a factor in the etiology as follicle may prevent direct tooth contact between canine enamel and incisor root cementum.

Neighboring anatomical structures near the follicle can have an influence on the dental follicle size and shape. Further research is needed to compare the follicle width with other variables, such as genetic components, bone quality, hormones, growth factors, and follicle shape (symmetrical or asymmetrical). In our study, most of the impacted canines were observed at the level of mid-level of lateral incisors. Sajnani., *et al*. [20] found the distance of the canine cusp tip to the occlusal plane was the most important predictor of maxillary canine impaction. Ericson., *et al*. [9] stated that the more mesially positioned an impacted canine crown was, the less likely passive eruptions were to occur. Sector position could be used to detect the labiopalatal position of the impacted canines. Sector location will provide greater influence on the prediction of impaction than mesio-distal location. Lindauer., *et al*. [21] reported that most canines destined to become palatally impacted had cusp tips overlapping or mesial to the lateral incisor root. The results show, Sectors 1, 2 and 4 showed more frequent mid-alveolus and labially impacted canines and Sector 5 showed more frequent mid-alveolus and palatally impacted canines. In this study total 52 (51%) canines were found in buccal position. In total, 26 out of 30 labially impacted canines were located in Sectors 1, 2 and 3, while 15 out of total 23 mid-alveolus impacted and 17 out of 20 palatally impacted canines were located mesially to the lateral incisor and were in Sectors 4 and 5. Total 35.3% canines were located in sector 1 in this study. Warford., *et al*. [22] found that sector location provided a greater influence on the prediction of impaction than on angulation, with canine location in the more mesial sectors substantially predictive of impaction. They reported that 48.6% of impacted canines were found in Sectors 3, 4 and 5. Lindauer., *et al*. [21] found that 41.5% of impacted teeth occurred in sectors 3, 4 and 5. Our study suggests that when canine impactions are suspected in Sectors 3, 4 and 5 on panoramic radiography, CBCT should be considered for those with suspected incisor resorption.

In the assessment of Lindauer's sector analysis [21] impacted maxillary canine was located in sector I in 22% [15] of cases, in sector II in 22% [15] of cases, in sector III in 19% [13] of cases and in sector IV in 37% [26] of cases. Sector of impacted canine evaluation revealed that sector 3 canines were most associated with SIRR, 50% of subjects. Literature supports that more horizontally displaced canines prove to be a greater risk factor for SIRR [9,14,19].

Alqerban [14] suggest that impacted canine angulation to the lateral incisor is a relevant predictor of canine impaction. Similar to our results, Yu., *et al*. [7] found that the mesial inclination of impacted canines to the occlusal plane ranged from 53.8° to 68.5°. Meanwhile, Ericson., *et al*. [23] reported a relationship between impacted canine angulation and resorption, finding that resorption increased by 50%

when the impacted canine angulation to the midline exceeded 25° and also increased by 50% when the impacted canine inclination to the long axis of the lateral incisor exceeded [23].

Since CBCT is a 3-D imaging system, the relationship between IMC and neighboring structures, the true location and accurate position of impacted teeth can be determined successfully with CBCT. The angulation method is the most sensitive predicting method for detecting the IMC in palatal position. Briefly, when the IMC is located palatally, angulation of IMC will be smaller than 65° [22]. In the present study, the probability of being in palatal or labial location for an IMC was half.

Sector 5 surrounds an area where IMC crowns are closer to the midline and overlapped with the root of central incisor. Labially located IMCs are less likely to approach to the midline due to insufficient bone thickness in the vestibule, regardless of the vertical level. According to Ericson and Kurol [9] 48% of lateral incisors show root resorption in the presence of an impacted canine. Various clinically applicable scoring methods have been developed to determine the degree or severity of the resorption lesion. In our study root resorption of incisor was present in 9.8% of cases and more common in females 70%. Liu., *et al*. [24] identified a resorption rate of 23.4% for central incisors and 27.2% for lateral incisors. The present study found a comparable incidence between central incisors (23.3%); however, the resorption incidence for lateral incisors was greater (64.2%).

In this CT study, resorption on the roots of the incisors adjacent to the ectopically positioned canine occurred in 34% of cases. This percentage is lower than that found by Ericson and Kurol [9] in the similar CT study (47%), but it is very similar to that found by the recent study of Alqerban [14] (33.8%). However, the highly significant correlation between root resorption and the presence of inclusion (p value = 0.002), in agreement with the literature, demonstrates a real risk of resorption in the case of inclusion of the maxillary canine. According to our sample, SIRR was more common in females. 70% of sample that had SIRR, females have more predilections towards SIRR according to Lai., *et al*. [15] literature shows a non-association between gender and SIRR as well. 4,19. Female to male ratio of SIRR group was 2.3:1 in our study signifying a great affinity of female gender with SIRR. Chaushu., *et al*. [12] confirmed these findings by having a female to male ratio of 5:1. In our sample number of affected persons is inadequate to draw a valid conclusion as SIRR was present in 9.8% of total sample that is statistically insignificant but at the same time a large sample size may be beneficial in establishing the effective correlation of female gender with SIRR.

In regards to bucco-palatal location of impacted canine, more SIRR was present in subjects with palatally impacted canines, with the statistics of 50% palatal impactions produced SIRR. Lai., *et al*. [15] have reported no association between bucco-palatal location of canine and SIRR.

SIRR was most commonly associated with grade 3 (≥ 31°) angulation of impacted canine to midline. Chaushu., *et al*. [12] proposed similar findings as they found SIRR to be highest with more mesially angulated canines. Greater the overlap of canine crown to adjacent incisor greater was the risk of incisor root resorption. Vertical height of impacted canine crown in relation to incisor root showed that canines located in middle third had most SIRR (60%) reported and least in the cervical third. These findings have been confirmed by multiple authors stating a more horizontally displaced (towards midline) canine, having a greater overlap with the incisor root, lying in middle third of incisor root level having a mesial preference of angulation was confidently associated with SIRR [9,25,26].

According to our findings greater the width of impacted canine dental follicle was associated with greater risk of SIRR. Conflicting data is available in literature is regarding the size of dental follicle and its impact on root resorption.

Although sample size of our study was comparatively much larger than previously reported studies, incidence of incisor root resorption was present in a number that is statistically insignificant. Therefore, the sample population to assess the etiological factors of SIRR was very small to generalize them. In order to reduce the bias, we have excluded from our sample the scans with anomalous lateral inci-

sors, which might be a significant factor responsible for SIRR. Here we have put entire focus on factors related to canines, locally and gender and age, systemically.

Conclusion

Based on above mentioned findings we can safely ascertain that:

1. Females are more prone to canine impaction with a female to male ratio of 2.3:1.
2. Age does not have statistically significant correlation.
3. 9.8% impacted teeth cause root resorption of lateral incisor.
4. Greater horizontal position, sector 3 of impaction more chances of palatal impaction.
5. Greater angulation, grade 3, of impacted canine to the midline have shown more chances of impaction.
6. Vertically, canines located in middle third region of incisor root, have shown highest incisor root resorption.
7. Size of dental follicle surrounding the impacted canine was significantly associated with females.

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