Evaluation of impacted maxillary canine using panoramic radiograph and cone beam computed tomography

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Abstract
Aim: The aim of the study was to evaluate the position and the relation of impacted maxillary canines using panoramic radiograph and CBCT, along with the evaluation of root resorption of the permanent incisors and involvement of the maxillary sinus proximity.
Materials and Methods: A total of 25 patients with 34 impacted maxillary canine, age group ranging from 13 to 32 years of both genders were included in the study. Digital panoramic radiograph and CBCT was taken for all the patients and the impacted maxillary canine were evaluated for type, position, root resorption and maxillary sinus involvement. Statistical analysis using Chi-square test and Fisher's exact test was performed.
Results: Most of the impacted maxillary canine (IMC) position in panoramic radiograph were located at sector 5 followed by sector 1, sector 4, sector 3 and sector 2. The common labiopalatal positions of impacted maxillary canine in CBCT was palatal followed by labial and mid alveolus. Correlation between sector location on panoramic radiograph and labiopalatal position in CBCT were done and the result were statistically significant (P value = 0.002). Measurement of agreement shows high values for type of impaction in both radiographic techniques. Root resorption and Maxillary sinus involvement were statistically significant in panoramic radiograph than CBCT.
Conclusion: In the present study, CBCT imaging was significantly better than that of panoramic radiograph for determining position of impacted canines according to sector location & labiopalatal position, type of impaction, root resorption and maxillary sinus involvement. However, further studies should be carried out in future with large sample size to determine the accuracy of localization of impacted maxillary canine.

Keywords: Impacted maxillary canine, Panoramic radiograph, Cone beam computed tomography.

Introduction
Impaction is a pathological condition which is defined as lack of eruption of a tooth in the oral cavity within the time and physiological limits of normal eruption process.[1] A fully developed tooth which remains in the jaw bone or under the mucosa even after its normal eruption time is known as an impacted tooth. Most commonly encountered impacted teeth are third molars, followed by maxillary canine and mandibular 2nd premolar.[2] Disturbances in the eruption of maxillary permanent canines are common because they have the longest period of development and the most difficult path of eruption compared with any other tooth in the oral cavity.[3,4] Also, existence of additional teeth in the eruption path is an important factor for delaying maxillary canines from eruption.[5] Impacted canines may result in several complications such as displacement and root resorption of adjacent teeth, cystic degeneration, canine ankylosis, shortening of the dental arch or combinations of these factors.[6] Therefore, it is imperative to locate and categorize impacted canines accurately for their optimal management.[7] Management of an impacted tooth usually requires interventions of an orthodontists or oral and maxillofacial surgeon. The interventions could be very different including removing the impacted tooth and replacing it with a premolar or prosthetic restoration, removing lateral tooth and replacing it with the impacted canine, removing premolar teeth and bringing the impacted canine inside the arch, or even doing no intervention. Some parameters such as location of the impacted tooth, prognosis of the interventions on the impacted tooth and the adjacent teeth, surgical accessibility, and final treatment functionality have influences on the selection of the intervention. The radiographic examination is certainly an indispensable tool for precise diagnosis and optimal management without any further complication because it provides valuable information about tooth position, number and morphology of roots, and relationship of tooth adjacent to anatomical structures. Always the first choice of imaging modality should be the conventional radiography when an impacted tooth is suspected after clinical examination. For preoperative diagnosis of routine cases, intraoral and panoramic radiographs are sufficient to determine the position of the impacted canine. But additional information from other imaging modalities is needed in the second plane to analyse the exact location, inclination and relationship of impacted tooth in three-dimensional view. Moreover, panoramic radiographs have their inbuilt drawbacks like superimposition and distortion of images due to projection of 3D structures in 2D. Hence the advanced imaging is necessary for the assessment of impacted canines.

CBCT (cone beam computed tomography) is a recent technology initially developed for angiography in 1982 and subsequently applied to maxillofacial imaging. It uses a divergent or "cone"-shaped beam of ionizing radiation and a two-dimensional detector fixed on a rotating gantry to obtain multiple sequential projection images in one complete scan of the area of interest. It is only since late 1990s that it has become possible to produce clinical systems that are both inexpensive as well as small enough to be used in the dental office.[8] CBCT imaging has the benefit of lesser radiation exposure to the patient as compared to conventional

radiographs. With the advent of CBCT, it has become very convenient, simple and easy to determine the exact location of impacted tooth in the jaw and its relation to the adjacent teeth. With CBCT, additional information such as 3D orientation of an impacted tooth and direction of path of eruption is best revealed. Currently, many attempts through various studies have been made to investigate the position of impacted teeth using CBCT and panoramic radiograph which are still controversial. Hence, our study aimed to evaluate the position and the relation of impacted maxillary canines using panoramic radiograph and CBCT, analyse the type of impaction, assess proximity to maxillary sinus and evaluation of the root resorption of permanent incisors.

Materials and Methods

Study group

The study was performed in the oral medicine and radiology department between January to December 2013 which was approved by Ethical Committee Review Board and informed written patient consent form was obtained from all the subjects. A total of 25 patients, out of which 15 females and 10 males age ranging from 13 to 32years with 34 clinically missing maxillary canines were included in this study. Patients with clinically missing incisors, undergoing orthodontic treatment, craniofacial syndromes, pregnant patients and mentally retarded patients were excluded.

Radiographic evaluation

Digital panoramic radiograph (kodak 8000c) was taken for all the patients using parameters such as 12mA, 73kV, 13.9seconds with radiation exposure 2.9 to 11µSv. Routine radiation safety procedures were followed. Patient was positioned in a standing antero-posterior orthogonal plane by making the patient to keep the maxillary and mandibular incisors into the notch of the bite block. The position of the impacted canine in panoramic radiograph was evaluated according to Alessandri et al sector classification which can be seen in Fig. 1. Sector 1 corresponds to the space occupied by the deciduous canine, Sector 2 indicates the distal aspect to the midline of the lateral incisor; Sector 3 indicates the midline of the lateral incisor to the distal aspect of the central incisor; Sector 4 indicates the distal aspect to the midline of the central incisor; and Sector 5 indicates the midline of the central incisor to the midline of the maxillary arch.

Kodak 9500 CBCT with CMOS sensor technology were used for all the patients to record CBCT images using parameters 10mA, 90kV, 10.8 seconds with radiation exposure 36.9 to 50.3µSv. Patient was positioned in a standing position. Radiation safety procedures were followed as per NCRP guidelines. Position of the impacted canine in CBCT was evaluated according to labiopalatal classification seen in Fig. 2. Other variables such as type of impaction, root resorption of permanent incisors and involvement of maxillary sinus were also evaluated in panoramic radiograph. Panoramic radiograph and CBCT images were reviewed by an experienced oral and maxillofacial radiologist.

Fig. 1: Panoramic radiograph

Fig. 2: CBCT

Statistical analysis

Data analysis was performed using SPSS version20 software. Descriptive analysis was used for distribution based on gender, root resorption and maxillary sinus involvement. Fisher's exact test was used to calculate the correlation between sector location in panoramic findings and labiopalatal position in CBCT findings. Intra-observer agreement was evaluated using the kappa (κ) statistic for type of impaction in CBCT and Panoramic findings.

Results

Table 1 summarizes the distribution of impacted maxillary canine based on gender. Out of 25 patients 15 (60%) were female and 10(40%) were male in the study. Table 2 shows distribution of root resorption of permanent incisors and maxillary sinus involvement in CBCT and Panoramic radiograph. Root resorption in panoramic radiograph was 59% and in CBCT was 29% and maxillary sinus involvement in panoramic radiograph was 59% and in CBCT was 41% showing significant results. Table 3 proves statistical significance for type of impaction in CBCT and panoramic radiograph which is determined by kappa test showing good measurement of agreement in both the techniques with value $k = 0.938$ ($P < 0.001$). Table 4 summarizes the correlation between labiopalatal position in CBCT and sector location in panoramic radiograph by Fisher's exact test with statistical significance ($P < 0.002$).

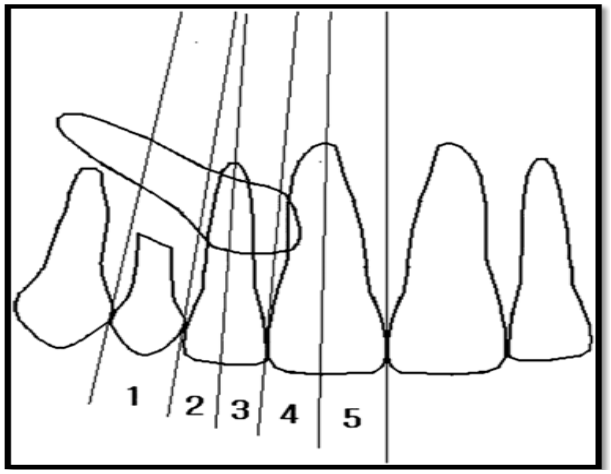

Fig. 3: Alessandri et al sector classification

Table 1: Distribution of impacted maxillary canine based on gender

Gender	Number of patients (n = 25)	Percentage %
Male	10	40
Female	15	60

Table 2: Distribution of root resorption of permanent incisors and maxillary sinus involvement in CBCT and Panoramic radiograph

Radiographic findings	Root resorption of permanent incisors		Maxillary sinus involvement
	Central incisor	Lateral incisor	
Panoramic radiograph	14.7%	44.1%	58.8%
CBCT	5.9%	23.5%	41.2%

Table 3: Correlation of Type of impaction in CBCT and Panoramic radiograph

Type of impaction	CBCT	Panoramic Radiograph	P-value	kappa value
Oblique	24	23	<0.001	0.938
Horizontal	4	5		
Vertical	6	6		

Table 4: Correlation between sector location on panoramic findings and labiopalatal position findings in CBCT

Sector Location in Panoramic Radiograph	Labiopalatal Position in CBCT			P – value
	Labial	Mid alveolus	Palatal	
Sector 1	6	2	0	<0.002
Sector 2	2	0	0	
Sector 3	4	0	2	
Sector 4	1	3	4	
Sector 5	0	1	9	

Discussion

Impacted teeth can be defined as teeth that are prevented from eruption due to a physical barrier within the path of eruption.[9] Maxillary canines have the highest frequency of impacted localization after the third molars, with a prevalence ranging from 1% to 3%, and 2:1 female to male ratio.[10] Accurate knowledge of the position of an impacted canine may contribute to the decision to perform a less invasive procedure when exposure of the canine is required and even in the prognosis of impaction procedure. The use of various techniques such as parallax method, occlusal radiography, panoramic radiograph, computed tomography and cone beam computed tomography has been advocated for localization.[11] However, many studies earlier performed the evaluation of impacted maxillary canine using CBCT and panoramic radiograph. But our study was done to standardize the position and relations of the impacted maxillary canine (IMC), type of impaction, involvement of maxillary sinus and root resorption of the permanent incisors using panoramic radiographs and CBCT. Out of 25 patients in the study, 16(64%) patients had unilateral and 9(36%) patients had bilateral impacted maxillary canines. The majority of patients in our study were female which may be due to the differences

of craniofacial growth and developmental factors between the genders. On observation the most common type of impaction determined in panoramic radiograph was oblique (68%), followed by horizontal (15%), and vertical (17%). In CBCT, it was oblique (71%), followed by horizontal (12%) and vertical (17%). Only one case showed difference in both panoramic and CBCT finding. The correlation between panoramic and CBCT findings for type of impaction was done in our study which showed good measurement of agreement between both the techniques. ($p<0.001$, kappa = 0.938).

The sector location (mesiodistal position) of the canine tip in relation to adjacent teeth in panoramic radiograph was classified according to Alessandri et al classification. However, Alessandri et al analysed a sector location on panoramic radiographs from patients aged between 8 and 11 years who were not seeking orthodontic treatment.[12] They found that in these non-orthodontic patients only 7% of canines were in Sectors 3, 4 and 5 which was not in consistence with this study finding. Out of 34 cases in our study, 8 (24%) at sector 1, 2 (6%) at sector 2, 6 (18%) at sector 3, 8 (24%) at sector 4 and 10 (28%) at sector 5. Most of the impacted maxillary canine were located at sector 5 followed by sector 1, sector 4, sector 3 and sector 2. Earlier studies reported that canines impacted in Sectors 4 and 5 emerged after 21 months of treatment and canines in Sectors 2 and 3 emerged after 8 months of treatment.[13] Therefore, sector location of impacted canines on panoramic radiography could be helpful in treatment planning for impacted canines. Warford et al also found that sector location provided a greater influence on the prediction of impaction than on angulation, with 48.6% of impacted canines locations were found in Sectors 3, 4 and 5.[14] Our results were in accordance with the previous studies. The labiopalatal position of impacted maxillary canine in CBCT revealed 13 (38%) were labial, 6 (18%) were mid alveolus and 15 (44%) were palatal impacted maxillary canines. Most common type of impaction according to labiopalatal position in CBCT was palatal followed by labial and mid alveolus. Previous literature reported that palatally placed impacted canines (64%) are more common than buccally placed impacted canines (32%).[15] However, study by Jung et al, 41% were labial, 31.5% were mid alveolus and 27.4% were palatal due to differences in the sample size and selection criteria.[16] Hence in our study, there was a statistical significance between sector location in panoramic radiograph and labiopalatal position in CBCT findings ($P < 0.002$).

Diagnosing root resorption in impacted canines might provide proper evaluation for treatment plan and reduce complications during treatment. In the present study, root resorption of central incisors and lateral incisors were determined separately using both panoramic radiograph and CBCT. Root resorption was more common in sector 4 and 3 in panoramic analysis and mid alveolus region in CBCT analysis. Many studies reported that 65% of root resorption was more common in sector 3,4 and 5 in panoramic radiograph.[17] In our study, root resorption in panoramic was 59% and in CBCT was 29%. This may be due to superimposition of adjacent structures in panoramic radiograph. The root resorption of permanent incisors cannot be accurately judged from panoramic radiograph alone. CBCT imaging was significantly better than that of panoramic radiography for determining root resorption. The study observes that when canine impactions are suspected in Sectors 3, 4 and 5 on panoramic radiography, then CBCT should be considered to diagnose root resorption.

Maxillary sinus involvement was determined in both panoramic radiograph and CBCT. In Panoramic finding, 59% showed maxillary sinus involvement and 41% in CBCT. Our results were not in consistence due to age and gender with the earlier study done by Hoseini Zarch et al in which panoramic radiograph showed 2% maxillary sinus involvement and CBCT showed 24% involvement.[18] Hence, CBCT should be taken to assess the true relationship of maxillary sinus and impacted maxillary canine during and before treatment plan.

Our study has merits and drawbacks. Limitations such as quality of images and standardization of different methods for position of impacted canine were questionable. Therefore, CBCT is more specific in analysing the position, type, root resorption and maxillary sinus involvement of impacted maxillary canine than panoramic radiograph.

Conclusion

Position, type, root resorption and maxillary sinus involvement of impacted maxillary canine in CBCT imaging was significantly better than that of panoramic radiography. Sector location on panoramic radiography could be used to predict the labiopalatal position of impacted canines. Further studies should be carried out in future with large sample size to determine the accuracy of sector location in localization of impacted maxillary canine. This can give a better insight in using CBCT as an indicator in evaluating the impacted tooth for the treatment plan.

Source of Funding

None.

Conflict of Interest

None.

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