Original Research

Evaluation of Cone Beam Computed Tomography in Diagnosis and Treatment Plan of Impacted Maxillary Canines

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Abstract

Introduction: Maxillary canines have important roles in facial appearance, development of arch, and functional occlusion. Radiographs are important in evaluating the location and nature of these anomalies. The purpose of this study was to evaluate two types of 2D and 3D imaging technique in diagnosis and treatment of maxillary impacted canines. **Methods:** Thirty eight patients (50 impacted canines) were enrolled. An oral radiologist assessed all of patients' panoramic radiographs and then cone beam computed tomography (CBCT) to determine the presence of adjacent teeth root resorption, root dilacerations before dental extraction, dental rotation, and buccolingual localization ofimpacted canine crown and root contact with sinus and nasal cavity.Then using the patient's radiographs the treatment plan of each impacted canine was determined by an orthodontist. **Results:** Differences between panoramic radiography and CBCT in diagnosis of root resorption and dental rotation were significant. There was an agreement between panoramic radiographs and CBCT in localization of impacted teeth crown. Only the treatment plans of 20% of impacted canines were different between panoramic radiographs and CBCT and treatment plan of 80% of impacted teeth was similar. **Conclusion:** These results showed that 2D and 3D images of impacted maxillary canines can produce different diagnoses and treatment plans.

Key Words: CBCT, impacted tooth, panoramic radiography, root resorption, treatment plan.

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Introduction

Impacted teeth are those whose eruption times are significantly delayed. Permanent maxillary canines are the second most frequent impacted teeth after third molar with 2% prevalence rate in the general population (1,2). Impacted maxillary canines frequently occur since they have an extended development period deep in maxilla and a long path of eruption comparing to other teeth (2). Also, existence of additional teeth in the eruption path is an important factor for delaying maxillary canines from eruption (3).

Canines play an important functional and aesthetical role in face. Moreover orthodontics have emphasized the importance of preserving impacted maxillary canines and introduced various effective techniques for the treatment of this condition (2). Therefore, it is imperative to locate and categorize impacted canines accurately for their optimal management (4). Localization of an impacted tooth necessitates an accurate investigation of the adjacent anatomical

structures (5). Contacts between impacted tooth and adjacent teeth roots may have resorptive impacts on the impacted tooth (6). Precise detection of an impacted maxillary canine is the first step of management. Early detection of impacted maxillary canines could reduce the time, complexity, and cost of the treatment as well as its complications (3).

Management of an impacted tooth usually requires interventions of an orthodontic 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. Conventional two-dimensional (2D) radiographic imaging was the most common imaging modality for the diagnosis of impacted maxillary canines as well as treatment planning. Besides, panoramic radiography is widely accepted as a standard in orthodontics for the preoperative diagnosis of such cases. However some weaknesses such as distortion projection errors, blurred images, and complex maxillofacial structures projected onto a 2D plane could reduce the accuracy and validity of 2D panoramic radiographies and increase the risk of misinterpretation (5,7).

Although accurate diagnosis and localization of the impacted maxillary canine especially investigating root resorption requires three-dimensional (3D) imaging, such techniques are expensive and expose the patient to a high dosage of radiation. Cone Bean Computed Tomography (CBCT) is a new imaging technique that recently became increasingly important in treatment planning and diagnosis in dentistry. This technique offers undistorted 3D images of patients' teeth without exposing them to high dosages of radiation comparing to conventional CT scans (8-12). Unlike panoramic radiographies CBCT does not distort the images of the impacted teeth (5). Therefore, the present study is designed to investigate whether using either 2D or 3D imaging techniques could result in different diagnoses offering different therapeutic interventions.

Materials and Methods

In this cross-sectional study, fifty impacted canines from thirty eight patients who were referred to a private radiology center in Mashhad, Northeast of Iran during 2010 to 2011 were enrolled. From the thirty eight patients, 12 had bilateral impacted maxillary canines (24 teeth), 14 had left impacted canines, and 12 had right impacted canines.

Only the patients who had both panoramic and CBCT images were included in the study. Panoramic images obtained using Promax (Planmeca, Helsinki, Finland) and CBCT images were produced using Promax 3D (Planmeca, Helsinki, Finland).

Firstly, all panoramic and CBCT images were separately reviewed by an oral radiologist to evaluate different characteristics of the impacted canines including root resorption (external resorption in the middle third and apical part of the tooth), dilaceration (≥45 degrees dilaceration was recorded), rotation (over longitudinal axis), buccolingual tooth crown position in relevance to the root of the lateral tooth, and root contact with sinus and nasal cavity.

Next, all panoramic and CBCT images along radiologist's reviews were presented to an orthodontist to propose the treatment plan for each patient. Different treatment plans were exposure to surgery and orthodontic treatment, removing the impacted tooth and replacing it with premolar or prosthetic reconstruction, removing the lateral tooth and replacing it with the impacted canine, and removing premolar and bringing the impacted canine inside the arch.

Then treatment plans based on panoramic and CBCT images were compared and differences were statistically analyzed to find statistical significance. To achieve sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of panoramic imaging for the detection of various parameters CBCT was regarded as the standard.

This study is approved by the research deputyship of Mashhad University of Medical Sciences regarding both ethical and methodological issues. A written consent was obtained from each individual following a comprehensive explanation about aims and procedures of the study.

Data were registered and analyzed using SPSS V.16.0. McNemar's test was applied to the data and kappa value calculated for the comparisons. Relative tables were produced to discuss the results. P-values ≤ 0.05 were considered as statistically significant.

Results

A total number of 38 individuals (50 impacted maxillary canines) aged from 12 to 35 years (mean age of 17±5 years) were included in the study. From the 50 evaluated teeth 20% were in males and 80% were in females.

Panoramic images could detect impacted teeth root resorption in 92% of the cases but in 6% of the cases it could not definitely detect the presence of root resorption. In 1 case (2%) panoramic image could not

show the impacted tooth (Table 1). A significant difference was present between panoramic and CBCT imaging regarding root resorption (P=0.011 kappa=0.054) (Table 2). The sensitivity, specificity, PPV, and NPV of panoramic images in the detection of root resorption was 61%, 45%, 30%, and 75%, respectively (Fig.1 (A & B)).

Panoramic images could detect dilaceration in 90% of cases and only 8% had an indefinite diagnosis (Table 1). McNemar's test showed no significant difference between panoramic and CBCT images in the detection of dilaceration in impacted canines (P=0.375, kappa=0.39) (Table 2). The sensitivity, specificity, PPV, and NPV of panoramic imaging in detecting dilaceration was 33%, 97%, 67%, and 90% respectively.

Regarding rotation in impacted canines, panoramic images showed definite results for all cases (Table 1). A significant difference between panoramic and CBCT images in the detection of rotation was present (P=0.002, kappa=0.461) (Table 2). The sensitivity, specificity, PPV, and NPV of panoramic images in the detection of rotation was 57%, 95%, 94%, and 58%, respectively.

Panoramic images could definitely detect the presence or absence of tooth contact with sinus space in 74% of the impacted teeth while 24% had indefinite results (Table 1). No significant difference was present between panoramic and CBCT images in the detection of impacted tooth contact with sinus (P=0.5, kappa=0.479) (Table 2). Moreover panoramic images could not detect contact between impacted teeth and the nasal cavity (Table 1).

Detecting the position of impacted tooth crown in relation to adjacent structures some differences between the two imaging techniques were emerged. Panoramic images showed only 2% (n=1) buccally, 24% midline, and 56% palatally impacted canines and left 16% indefinite, while CBCT detected 22% buccally, 14% midline, and 64% palatally impacted canines.(Fig. 2 (A & B)). A significant agreement was present between panoramic and CBCT images in the localization of tooth crown (contingency coefficient (CC)=0.58, P<0.001). Whenever panoramic images localized tooth crown, there was 89.3% and 83.3% agreement in palatally and midline locations between panoramic and CBCT images. However, there was only 14.3% agreement in buccally impacted canines between the two techniques (Table 3).

The proposed treatment plan for impacted maxillary canines according to either panoramic or CBCT images was similar in 80% of the cases. Also, 70% (n=7) of the remaining impacted teeth with different treatment plans had different reports of root resorption and tooth crown position. A significant agreement between the two imaging techniques regarding treatment plan was also present (CC=0.797, P<0.001) (Table 4).

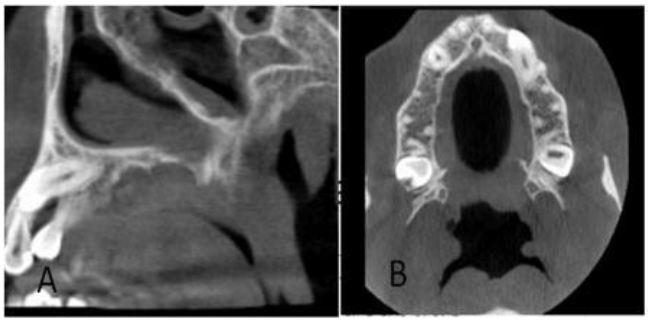

Figure 1 (A & B). Coronal and axial view of CBCT show root resorption in cervical surface of adjacent tooth

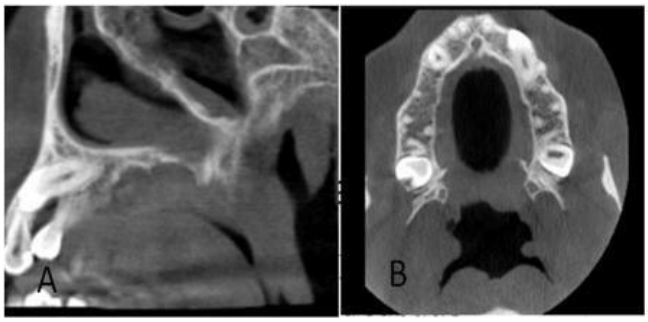

Figure 2 (A & B). Saggital and axial view of CBCT show buccally position of impacted canine

Table 1. The frequency of each assessed parameter in panoramic and CBCT images

			Positive	Negative	Undetermined	Undetected teeth
Root resorption	Panoramic	Number	26	20	3	1
		Percent	52	40	6	2
	CBCT	Number	16	34	0	0
		Percent	32	68	0	0
Dilacerations	Panoramic	Number	3	42	4	1
		Percent	6	84	8	2
	CBCT	Number	6	44	0	0
		Percent	12	88	0	0
Rotation	Panoramic	Number	18	31	0	1
		Percent	36	62	0	2
	CBCT	Number	31	19	0	0
		Percent	62	38	0	0
Contact with sinus	Panoramic	Number	1	36	12	1
		Percent	2	72	24	2
	CBCT	Number	12	38	0	0
		Percent	24	76	0	0
Contact with nasal cavity	Panoramic	Number	0	45	4	1
		Percent	0	90	8	2
	CBCT	Number	5	45	0	0
		Percent	10	90	0	0

Table 2. Comparative analysis of assessed parameters between panoramic and CBCT images

			CBCT	
			Positive	**Negative**
Panoramic	Root resorption	Positive	8	18
		Negative	5	15
	Dilacerations	Positive	2	1
		Negative	4	38
	Rotation	Positive	17	1
		Negative	13	18
	Contact with sinus	Positive	1	0
		Negative	2	34

Table 3. The frequency of different localizations of impacted canine crown in panoramic and CBCT

	Panoramic		**CBCT**	
	Number	Percent	Number	Percent
Buccally	1	2	11	22
Palatally	28	56	32	64
Midline	12	24	7	14
Unknown	8	16	0	0
Undetected teeth	1	2	0	0

Table 4. Comparative analysis of different recommended treatment plans between panoramic and CBCT images

		CBCT							
		1*		2*		3*		4*	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent
Panoramic	1*	30	81.1	0	0	0	0	1	20.0
	2*	0	0	1	50.0	0	0	0	0
	3*	5	13.5	0	0	6	100	1	20.0
	4*	2	5.4	0	0	0	0	3	60.0
	Undetected	0	0	1	50.0	0	0	0	0

* 1= exposure to surgery and orthodontic treatment

2= removing the impacted tooth and replacing it with premolar or prosthetic reconstruction

3= removing the lateral tooth and replacing it with the impacted canine

4= removing premolar and bringing the impacted canine inside the arch

Discussion

Accurate detection of impacted maxillary canines is very important for both orthodontists and maxillofacial surgeons since it could lead to very different treatment plans that sometimes would be expensive and time consuming.

Also the choice of treatment is influenced by other factors such as the rotation, root resorption, and localization of the impacted canine. Therefore, radiologic evaluations play an important role in the diagnosis and management of these conditions. Meanwhile, CBCT is commercially available and promises to improve the diagnosis of impacted canines. Many recent studies reported successful application of this technique and the potential of 3D imaging techniques for the diagnosis of impacted teeth (8-12). Therefore, this study is designed to investigate the differences between CBCT and panoramic radiography for the detection of impacted maxillary canines as well as to evaluate the impact of such techniques on the management plans offered by orthodontists based on radiographic data.

A recent study reported that the prevalence of impacted maxillary canines varies from 0.9% to 3% (13) and also they were mostly seen in females rather than males (8,14,15). In our study similarly the majority of patients were female (80%) which may be due to the differences of craniofacial growth and development factors between both sexes or even may be a result of frequent orthodontic visits among females with aesthetic purposes.

Mah and Alexanderiani (13) reported that palatally impacted canines (64%) are more common than buccally impacted canines (32%) which were similar to our results.

We found that there are different results between panoramic and CBCT images for each parameter having been evaluated. Although all these differences were not tended to be significant, some showed significance including root resorption, rotation, and buccopalatally tooth crown localization.

Orthodontists and maxillofacial surgeons face challenging difficulties in the treatment of impacted canines. The most common challenge is the adjacent incisor root resorption which is present in 27% to 67% of lateral incisors and 9% to 23% of central incisors (8,10,12). Haney et al. (16) found 63% agreement between panoramic and CBCT imaging in the detection of root resorption. In the present study, a significant difference between both techniques in the detection of root resorption was present. However, panoramic technique could not detect root resorption in 6% of the evaluated teeth. Also, Alqebran et al. (7) found differences between panoramic and CBCT techniques in the detection of root resorption. They also reported the sensitivity and specificity of panoramic images in the detection of root resorption as 78% and 38% respectively while similar values for CBCT were 95% and 75%, respectively. The sensitivity and specificity of panoramic images in our study was 61% and 45% respectively comparing to CBCT as the gold standard. Therefore panoramic radiography would not be an accurate technique for the detection of root resorption.

The most important challenge for a maxillofacial surgeon in keeping or removing the impacted canine is the buccopalatally localization of the tooth crown. Although 2D imaging techniques could accurately localize the majority of impacted teeth sometimes they show weaknesses in the accurate detection of buccolingual location of the impacted tooth and its adjacent structures. Ericson and Kurol (17-19) reported

that 8% of impacted maxillary canines could not be accurately localized in periapical radiographs. Haney et al. (16) found 82% agreement between 2D and 3D imaging techniques in the localization of impacted tooth crown. We similarly found good agreement between both techniques ($P<0.001$, kappa=0.58). There was 89.3% and 83.3% agreement between panoramic and CBCT images in localizing impacted tooth crown in palatally and midline impacted teeth respectively while for buccally impacted teeth the agreement rate fell to 14.3%.

Also, we found a significant difference between both techniques in the detection tooth rotation showing that obtaining panoramic images alone is not sufficient for treatment planning. Moreover, we did not find any significant difference between the two techniques for the detection of root dilaceration and sinus and nasal cavity contact showing that panoramic images could be regarded as the only required imaging modality.

Haney et al. showed that treatment plan is significantly influenced by the imaging technique (16). They reported 36% agreement between 2D and 3D imaging techniques regarding treatment planning (16) while we had 80% agreement in treatment planning between the two techniques. The 20% disagreement in our study mainly was a result of different root resorption and tooth crown position reports between the two techniques. Ericson and Bjerkin also mentioned 64% treatment plan changes after presenting CT images to orthodontists that in 53% of cases changes were due to different root resorption reports (20).

Conclusion

The overall results of this study showed good potential of panoramic images in the preoperative evaluation of impacted canines. However it is also important to note that panoramic images alone are not sufficient for offering treatment plans. Therefore, in the cases that require orthodontic or surgical interventions CBCT images should also be requested in advance of treatment.

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