ORIGINAL ARTICLE

A Comparative Evaluation of Cone Beam Computed Tomography and Periapical Radiography in the Detection of Simulated Resorption Defects

Promila Verma, Rhythm Bains, A P Tikku, Anil Chandra and Sanghmitra

ABSTRACT

Aim: To compare the accuracy of digital periapical radiography and Cone Beam Computed Tomography (CBCT) in the detection of simulated external resorption defects in extracted human teeth.

Methodology: Simulated external root resorption defects of 0.5 mm were created with round burs on buccal and proximal surfaces of extracted premolars. They were then imaged with digital radiography (at two angulations), and CBCT. Thereafter, the defects were increased to the size of the 1 mm and a final set of CBCT scans and periapical radiographs was then taken. All images were analysed blindly by six different examiners, comprising three endodontists (n=3) and three prosthodontists (n=3). This procedure was performed twice at an interval of 15 days by same observers. For the purpose of statistical analysis, a linear map scale from [1 to 5; 1 = definitely not present and 5 = definitely present] was used.

Results: Examiners were able to diagnose accurately using CBCT scans. More than 90% perforations were correctly diagnosed using CBCT [sensitivity ~ 0.91(0.065)] scans while only 70% were diagnosed with radiographic images [sensitivity ~ 0.68(0.1467)]. Ratings given by different examiners are more coherent for CBCT scans (kappa=0.2467) than radiographic images (0.13402). Ratings given by an examiner are more coherent across sessions for CBCT scans (kappa=0.4267) than radiographic images (0.3412).

Conclusion: All examiners indicated superior results with the use of CBCT with a sensitivity of 1 as compared to radiograph which had a sensitivity of 0.71. The mean visibility scores for CBCT were higher as compared to those for radiographic assessment.

Keywords: Cone- Root resorption, Digital radiography, Beam Computed Tomography

Dr Promila Verma completed her graduation (BDS) from King George's Medical College, Lucknow, in year 1997and post-graduation (MDS) in Conservative Dentistry& Endodontics from same institute in 2000. Currently,she is working as Professor, Department of Conservative Dentistry & Endodontics,Faculty of Dental Sciences, King George's Medical University, Lucknow (UP), India.

Department of Conservative Dentistry & Endodontics, Faculty of Dental Sciences, King George's Medical University, Lucknow.
Address for Correspondence:
Dr. Rhythm Bains, Department of Conservative Dentistry & Endodontics, Faculty of Dental Sciences, King George's Medical University, Lucknow (UP), 226003, India.
Contact: +91 9935033439,
E-mail: docrhythm77@gmail.com.

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INTRODUCTION

Resorption may be defined as a gradual, physiological or pathological loss of dental hard tissue, namely cementum and dentine, brought about by the odontoclats.[1] It may be broadly classified as internal or external resorption depending on its location on the root surface. While internal resorption affects the inner wall of root canal wall, external resorption invades the outer surface of the root.[2,3] It is a rather obscure affliction, without any clinical signs or symptoms and is usually detected by the clinicians accidentally during routine clinical or radiological examiniation.[4]

Radiographs have traditionally served as an essential tool for the diagnosis of these lesions. However, conventional radiographs come with several limitations, as these compress a three-dimensional image into a two-dimensional format. Hence, periapical radiographs are adequate only in revealing

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details present on the mesio-distal aspect of teeth and periradicular bone. The visualization of structures on the buccolingual axis is often insufficient. There are further disadvantages of superimposition of overlying anatomy and the density of cortical bone, making visualization of juxtaposed structures often difficult.[5]

Early detection of the exact location of resorption is essential for a favourable prognosis of the affected tooth, however, a correct diagnosis is often challenging using periapical radiograph alone and may result in inappropriate treatment. External and internal root radiolucency is typically not evident on radiographs at an early stage (when they are small) because of the limitations of this two-dimensional method. These problems may be overcome with the use of Cone Beam Computed Tomography (CBCT). CBCT is a relatively new imaging device in the quiver of endodontist for an effective diagnosis as it demonstrates anatomic features in three dimensions that intraoral and panoramic images cannot.[6] CBCT units reconstruct the projection data to provide inter relational images in three orthogonal planes (axial, sagittal and coronal). A CBCT image can be very supportive in not only detecting the location of the lesion but also in differentiating if the lesion is buccal or lingual. Also, compared to the conventional CT, CBCT produces a much lesser radiation exposure to the patient, specially when a small field of view is used.[7]

The present study was thus conducted to compare the accuracy of digital periapical radiography and CBCT in the detection of simulated external resorption defects in extracted human teeth.

METHODOLOGY

Ten intact extracted human teeth were collected from the department of Oral & Maxillofacial Surgery. These were cleaned thoroughly and examined meticulously under a magnifying glass for the assessment of any external resorption or any other superficial pre-existing injury. All the teeth were then mounted on 1 cm thick wax. The wax simulates soft tissues and avoids the differences in density between air and teeth which helped to reduce artefacts in the images.

To simulate root resorption defects, steel round burs with diameter 0.5 mm were used to create simulated external resorption defect on the mesial aspect of root and another defect was created on the buccal aspect, 3 mm apical to the cementoenamel junction with the help of contra-angled hand piece at slow speed. Thus, ten proximal and ten buccal defects were prepared resulting in 20 defects. Same procedure was repeated after increasing the defect size to 1 mm in all teeth.

Radiographic Technique: A digital photo stimulable phosper plate (PSP) system was used to capture the intraoral radiographic images. The samples were exposed with an X- ray unit operating at 65 kv and 7 mA. The exposure time was 0.2 seconds. All the samples were radiographed by exposing them at two different angles because the use of multiple radiographs provides additional information. An X-ray cone was used first with an alignment of 90 degrees centred on the X- ray tube and a second image were then taken using a 10-degree horizontal alignment for both 0.5 mm defects [Fig. 1(a) & 1(b)]. This digital system helped in producing images in

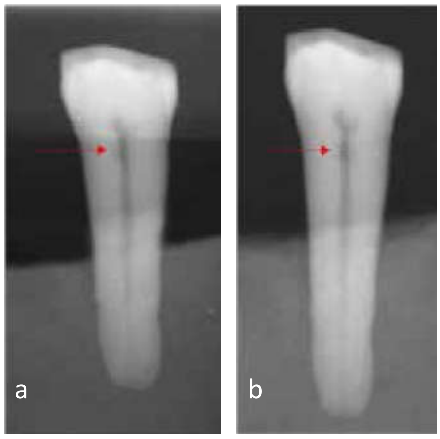


Figure 1 : (a) Parallel and (b) parallex digital periapical radiograph following creation of 0.5mm simulated resorption cavity.

which brightness and contrast can be easily altered. The images were viewed as power point slides. For the CBCT images, an exposure parameter of 90 kv, 3.0 mA and 13 seconds were used (Planmeca, USA) [Figure 2(a), 2(b) & 2(c)]. After initial radiographic

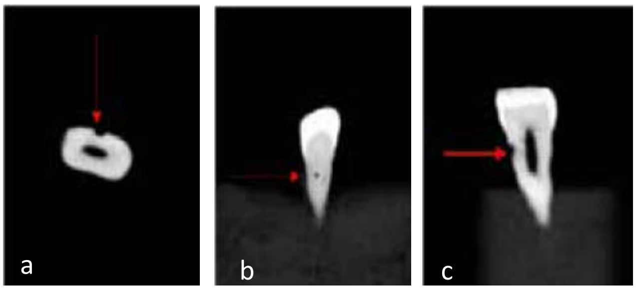


Figure 2(a) Axial (b) Coronal and (c) Sagittal reconstructed CBCT images following creation of 0.5mm simulated resorption cavity. The lesion can be identified on all of the reconstructed images

and CBCT images, the defects were then increased to the size of the large cavities (1 mm) and a final set of periapical radiographs [Figure 3(a), 3(b)] and CBCT scans [Figure 4(a), 4(b) & 4(c)] was then taken. All the images were uploaded on a computer.

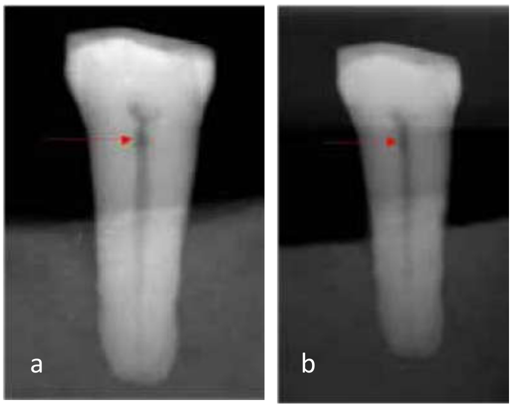
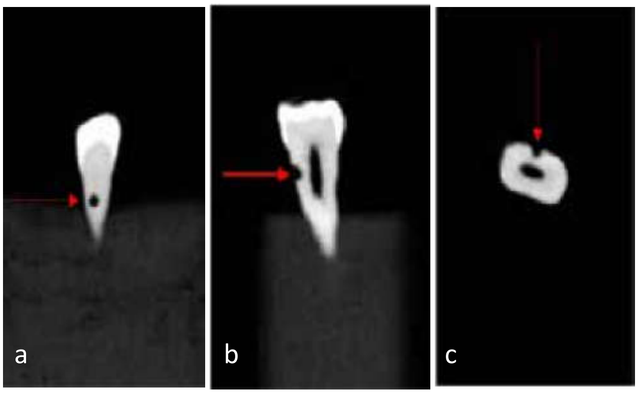


Figure 3 (a) Parallel and (b) Parallex digital periapical radiograph following creation of 1mm simulated resorption cavity.



Figiure 4(a) Axial (b) Coronal and (c) Sagittal reconstructed CBCT images following creation of 1mm simulated resorption cavity.

Examination procedure: Two radiographic views were provided for each tooth, one at 90 degrees and another with a 10-degree horizontal orientation. All the images were analysed blindly by six different examiners, comprising three endodontists (n=3) and three prosthodontists (n=3). All the examiners were trained how to use the CBCT software and how to adjust the contrast of the digital periapical radiographs in the following sequence over four sessions. This procedure was performed in two phases i.e., initial phase and second phase after 15 days for the same images and with the same observer.

For the CBCT scans, the examiners were presented with the primary reconstructed CBCT data and were trained how to scroll through the axial, coronal and sagittal slices for each tooth.

Examiners were asked to evaluate the images for two criteria using a five-point scale i.e. confidence in their observation was recorded using a five-point scale as follows: 1 score external resorption lesion definitely not present; 2 score probably not present, 3 score unsure, 4 score probably present; and 5 score definitely present.

RESULTS

For the purpose of statistical analysis, a linear map scale from [1 to 5] (1= resorption definitely not present and 5= resorption definitely present) was used.

This study explored the possibility of CBCT scans and Radiographic images to detect perforations in teeth accurately. Examiners were able to detect correctly all the teeth with perforation using CBCT scans while only 71% of the same with radiographic images. Table 1 depicts Mean, Sensitivity and FNR of individual examiner for the perforation size = 0.5 mm and Table 2 for the perforation size 1 mm. From both the tables, it is clear that all the examiners were able to diagnose accurately using CBCT scans. More than 90% perforations were correctly diagnosed using CBCT [sensitivity ~ 0.91(0.065)] scans while only 70% were

Table 1. Mean, sensitivity, FNR for individual examiner (perforation size = 0.5 mm)

	CBCT		**Radiography**	
	Sensitivity (0.5 mm)	**FNR (0.5 mm)**	**Sensitivity (0.5 mm)**	**FNR (0.5 mm)**
Examiner 1	0.9	0.1	0.5	0.5
Examiner 2	0.9	0.1	0.5	0.5
Examiner 3	1	0	0.8	0.2
Examiner 4	0.8	0.2	0.8	0.2
Examiner 5	0.9	0.1	0.7	0.3
Examiner 6	0.8	0.2	0.8	0.2

Table 2. Mean, sensitivity, FNR for individual examiner (perforation size = 1mm).

	CBCT		Radiography	
	Sensitivity (1 mm)	FNR (1 mm)	Sensitivity (1 mm)	FNR (1 mm)
Examiner 1	0.9	0.1	0.6	0.4
Examiner 2	1	0	0.4	0.6
Examiner 3	0.9	0.1	0.9	0.1
Examiner 4	1	0	0.8	0.2
Examiner 5	1	0	0.8	0.2
Examiner 6	0.8	0.2	0.7	0.3

diagnosed with radiographic images [sensitivity ~ 0.68(0.1467)].

Sensitivity and False Negative Ratio (FNR) for the observation done by examiners with perforation size of

Table 3. Sensitivity and FNR for observation done by examiners using radiography and CBCT

	Perforation size	Sensitivity	FNR (False Negative Ratio)
Radio graphy	0.5 mm	0.7166666667	0.2833333333
	1 mm	0.75	0.25
CBCT	0.5 mm	1	0
	1 mm	1	0

Table 4. Mean (standard deviation) and median (inter-quartile range) for rating given by examiners based on Radiography and CBCT

	Perforation size	Mean (SD)	Median (inter-quartile range)
Radio graphy	0.5 mm	0.7933333333 (0.142)	0.8(0.15)
	1 mm	0.8 (0.1395229969)	0.8(0.15)
CBCT	0.5 mm	0.88 (0.1032795559)	0.8(0.15)
	1 mm	0.89 (0.1039230485)	0.9(0.15)

0.5 and 1.00 mm are presented in Table 3. It is clear that detection of perforations with radiographs (sensitivity 0.71) was less effective than CBCT (sensitivity 1). Inter-examiners agreement on the presence/absence of perforations was also analysed (Table 5). Cohen's kappa value was calculated for inter-examiner ratings to understand how much ratings of various examiners' vary from each other. It was noted that ratings given by different examiners are more coherent for CBCT scans

Table 5: Cohen's kappa value for inter examiner rating agreement.

Radiography		CBCT	
0.5 mm	0.1340206186	0.5 mm	0.2403763901
1 mm	0.1339214114	1 mm	0.3763621123

(kappa=0.2467) than radiographic images (0.13402).

Intra-examiners agreement on the presence/absence of perforations were analyzed and calculated the Cohen's kappa value to understand how much ratings of the same examiner vary across different sessions (Table 6). It was noted that ratings given by an examiner are more coherent across sessions for CBCT scans (kappa=0.4267) than radiographic images (0.3412).

Table 6: Cohen's kappa value for intra examiner rating agreement across sessions

Radiography		CBCT	
0.5 mm	0.3410618557	0.5 mm	0.423026186
1 mm	0.3861138733	1 mm	0.523111878

DISCUSSION

The aetiology behind tooth resorption is uncertain. Among the various predisposing factors such as caries, pulpitis, periodontal diseases, orthodontic movement etc, trauma is the leading factor associated with most of the resorptive defects.[8,10] Early or timely detection of a resorptive lesion is desirable to initiate necessary treatment and halt the resorptive process which may otherwise lead to much loss of tooth structure. As the defect is usually asymptomatic, its detection relies mainly on the routine radiological examination. The purpose of a diagnostic test is to allow the clinicians to arrive at a correct treatment option for the particular disease and its prognosis. Intraoral radiographs have been a gold standard for the diagnosis of dental diseases, but as it is a two-dimensional image of three dimensional object, it does not allow for assessment of the actual extent of the lesion.The cone beam computed tomography (CBCT) provides the actual 3-dimensionsal picture of the location, spatial configuration and extent of the resorption defects and is an effective tool for not only diagnosing it early, but also differentially diagnosing an internal resorptive defect from an external resorption defect.[11]

The present study evaluated the efficiency of digital intraoral radiograph and CBCT for the identification of simulated external resorption defects. The simulated defects were created in using same round bur for each defect. Every effort was made to ensure standardization and reproducibility of the cavity sizes, but the lesions created were hemispherical in shape although in a clinical scenario, root resorption lesions are irregular in shape. Kalender *et al.*[12] stated that intraoral radiography is reasonably accurate in correctly diagnosing internal and external cervical root resorption, but cone-beam computed tomography (CBCT) scans results are more precise in the diagnosis of the presence and type of root resorption. In a study by Patel *et al.*,[13] CBCT proved to be 100 percent accurate in detecting root resorption lesions compared to conventional radiography. They concluded that CBCT was superior not just in diagnosing the defects, but also helped in making a better treatment plan especially in cases with root perforations.[13] In this study also, all the examiners indicated superior results with the use of CBCT with a sensitivity of 1 as compared to radiograph which had a sensitivity of 0.71 (Table 3). The mean visibility scores for CBCT were higher as compared to those for radiographic assessment.

Cohen's kappa value for inter-examiner and intra-examiner was more for CBCT than the radiographs. The ease of detection (clarity of images, confidence of observation to make a call on presence/absence) of perforations for studied for both CBCT and radiography. This study showed that it was much easier to detect perforations using CBCTs even if the perforation size was smaller (0.5 mm in our experiments). Examiners were asked to give a rating based on how sure they were of presence of the perforation. It was observed that average rating given using radiographic images (0.79) was lesser than that of CBCT scans (0.89) with confidence interval (CI=5). Moreover, ratings given using radiographic images (0.15) vary to a higher extent than that of CBCT scans (0.1). Examiners detected perforations more easily with CBCT scans than radiographic images and results vary very little across examiners. Thus, on comparing the diagnosing accuracy of small volume lesion with CBCT and intraoral radiography, examiners were more confident with CBCT than conventional radiography.

CBCT can be suggested as a reliable and effective imaging tool in detecting resorption compared to conventional radiography. Early screening with CBCT in "high-risk cases" such as those of traumatic dental injuries can be helpful as trauma has a high predilection for developing resorption defects. Moreover, it provides minimal radiation to the patient as compared to conventional CT. However, when radiography is compared to CBCT scans, radiation exposure is higher than digital radiography and hence the benefit to the patient using CBCT scans should outweigh the risks involved. In clinical situations in which a decision can be made based on conventional radiographs and clinical symptoms, the use of CBCT should be avoided and should be in accordance with the ALARA (as low as reasonable achievable) principle.[14]

CONCLUSION

The results of this study illustrate a limited efficacy of intraoral periapical radiography in the detection of simulated external root resorption. CBCT is superior in early diagnosis of root resorption and thus overcomes the shortcomings of digital radiography. Its use can be justified in high risk cases where early detection of resorption process needed for a prompt and appropriate treatment ultimately resulting in improved prognosis of a tooth.

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