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Comparative role of Conventional Radiography, Radiovisiography and Cone beam Tomography on 'Dimension Determination' of persistent periapical radiolucency in relation to treatment planning

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ABSTRACT: To compare the ability of endodontists to determine the size of apical pathological lesions and select the most appropriate choice of treatment based on lesions' projected image characteristics using two dimensional and three dimensional images.
Study Design: Seven subjects were selected. Radiographic examination of symptomatic study teeth with an intraoral periapical radiograph and Radiovisiography (RVG) revealed periapical lesions equal to or greater than 3mmin the greatest diameter. Cone-beam Computed tomography (CBCT) images were made of the involved teeth after the intraoral periapical radiograph confirmed the size of lesion to be equal to greater than 3 mm. Three observers (endodontists) viewed the periapical, RVG and CBCT images. Upon viewing each of the images from the two imaging modalities, observers (1) measured lesion size and (2) made decisions on treatment based on each radiograph
Results: No significant difference was noted in the treatment plan selected by observers using the three modalities. Post-operative radiographs did not shows any significant difference
Conclusion: Lesion size and choice of treatment of periapical lesions based on CBCT radiographs do not change significantly from those made on the basis of radiographs.

KEYWORDS: periapical pathology, periapical radiography, Radiovisiography, CBCT, Treatment planning.

1 INTRODUCTION

In Endodontics, clinical examination, and diagnostic imaging are essential components of the preoperative diagnosis [1] Accurate diagnostic imaging supports the clinical diagnosis and allows the clinician to better visualize the area in question.

At present, intraoral radiography is the technique of choice for diagnosing, managing and assessing endodontic disease [2] (Lofthag-Hansen et al. 2007, Nair & Nair 2007, Patel et al. 2007),

but it is well established that intraoral radiography is of limited use for detecting chronic apical periodontitis (Huumonen & Ørstavik 2002 [3].

1.1 Indications of Dental radiograph in Endodontics

1- Endodontic disease including apical pathology, pulp exposures and draining fistula.
2- Before, during and /after endodontic treatment
3- Pathology of the oral soft and hard tissues including tumours, fractures.
4- Crown/root pathology including odontoclastic resorptive lesions, crown or root fractures,.
5- Periodontal disease- assessment of bone levels, type of bone loss, combined periodontal-endodontic lesions.

Lee & Messer (1986) 4[4] suggested that periapical lesions, which have been successfully detected when confined to the cancellous bone, may not be readily observed if the thickness of the cortical bone is increased.

The cortical plate acts as anatomical noise, is also one of the reasons why the radiographic size of periapical lesions is under-estimated when compared with the actual size of the periapical lesion (Schwartz & Foster 1971, Shoha et al. 1974, Scarfe et al. 1999).[5]

Hence the influence the radiological size of the periapical lesion is the inability to take parallel radiographs in certain situations. (Bender & Seltzer 1961, Huumonen & Ørstavik 2002). [3]

Conventional two-dimensional radiographs provide clinicians with a cost effective, high-resolution imaging modality. But the information is difficult to interpret especially when the anatomy and background pattern is complex [6]

1.2 Radiovisiography (RVG)

RVG image enhancement produces images that are significantly more diagnostic then conventional radiograph (CR) within bone. RVG was more accurate in detecting periapical breakdown in earlier stages such as lamina dura perforation and medullary bone involvement. The clinical findings suggest that RVG could provide an accurate method for detection of periapical pathosis with less exposure.[7]

Advantages of RVG

- Reduced radiation with conventional X-ray up to 80%
- Digital intraoral sensor is used instead of X-ray film
- Faster imaging without X-ray film and developing images
- Immediate imaging on the computer screen
- High quality of the digital image that can be analyzed and processed
- Option of saving images in the electronic memory.

Limitation

- Small sensor size
- Thick sensor size
- Special device needed
- Expensive

1.3 Cone-Beam Computed Tomography (CBCT) Scan

CBCT has many advantages over conventional radiography for endodontic uses.

- Diagnosis of periapical pathology[8]
- Measurement of internal and external resorption lesions
- Identification of perforations,
- Fractures and trauma [9]
- Pre-Surgical treatment planning [10]

ADVANTAGES OF CBCT

- Elimination of superimposition of other tissues
- Computerized tomography, differences between the tissues with different physical densities.
- Three dimensional images of the tissues which are located on axial, coronal, sagittal planes.
- Treatment plan for dental implant
- No magnification and no distortion.
- Cysts/tumors, it can be determined whether cyst formation has a solid or a liquid structure by means of density measurements (Frederiksen, 2004) [11] CBCT is capable of providing images at a low radiation dose and with sufficient spatial resolution.

DISADVANTAGES OF CBCT

1- **Soft tissue space -** Cannot be determined accurately due to low contrast resolution of 14-bit. [6].
2- **Metal Restoration** artifacts due to metal restorations and motion artifacts due to patient movement still exist on CBCT images [12].
3- **Radiation –** More radiation espouser than digital radiography[13]

2 AIMS AND OBJECTIVES

The aim of this study is to evaluate if CBCT images provide more information than standard PA radiography and RVG to the degree that practitioners change their treatment plan when and if they see additional information after giving up initial treatment plan with suitable conventional radiograph.

The additional aim of this study is to assess the prognosis of the post operative healing by the PA radiography, RVG, and CBCT.

The objective of this study was to compare lesion size and choice of treatment relative to the available radiographic information from periapical radiography, RVG and CBCT.

3 MATERIALS AND METHODS

3.1 SAMPLE/STUDY POPULATION

The study group will be comprised of seven adult subjects.

All subjects that reported to the Department OF Conservative Dentistry &Endodontics with symptoms suggestive of a periapical lesion.

Subjects will be recruited consecutively during the period from January 2014 to February 2014.

3.2 INCLUSION CRITERIA

Inclusion criteria were as follows:

1. Patients older than 18 years,
2. Consented for a radio- logical examination.
3. An unremarkable medical history no physical or mental disability.
4. No history of drug allergy (local anesthesia).
5. Subjects will have a periapical lesion of size greater than 3 mm.
6. Single rooted teeth with periapical lesion size equal to or greater than 3mm on intraoral periapical radiography will be included in the study.
7. Previously root treated teeth and teeth with restorations.
8. Endodontically involved teeth with history of trauma or radiographic evidence of fracture.
9. Patients requiring surgical intervention due to complexity of conservative procedure or paucity of time.

3.3 EXCLUSION CRITERIA

- Patients younger than 18 years old
- Not consented for a radio- logical examination.
- Teeth that needed immediate therapy due to an endodontic emergency.
- Metallic restorations on the diseased tooth.
- Small periapical lesion (less than 3 mm) responsive to nonsurgical therapy

No specific control group will be used for either of the radiographic modalities tested since teeth other than the study tooth in the same jaw were also imaged and served as internal controls.

The internal control tooth will be scanned using the same CBCT scanning protocol.

4 IMAGE RECORDING

4.1 CONVENTIONAL RADIOGRAPHS

Two-dimensional radiographs (intraoral periapical) will be obtained with an intraoral dental X-ray machine (X Mind X Ray System)(SATELEC India Ptv Ltd) using the Paralleling Axis Technique and round collimator (2.86 inch diameter) with variable kVp and mAs and focal spot size 0.7mm × 0.7 mm. Conventional film images were obtained using KODAK E (KODAK) E-Speed size 2 film with an image exposure time of 0.4 s. Metallic grid was placed along with film.

Films will be automatically processed on the very day. The size of the periapical lesions was measured with the shadow of metallic grid (1mm) measurement tool available.

PAI score (1986 Orstivik et al.) to be used for to assess the periapical status on the periapical radiographs.[14]

4.2 RADIOVISIOGRAPHY

Digital images will be obtained using a direct digital intraoral charge-coupled device (CCD) sensor, (Digora), size 2 (36.5x25.8), with an image exposure time of 0.2 s. Digora -fMx software was used to display images in real-time on a monitor.

The images will be stored as 8-bit TIFF (Tagged Image File Format) files at maximum quality

The size of the periapical lesions was measured with a measurement tool available in the(Digora -fMx) software.

Teeth with periapical lesions equal to or greater than 3mm as seen on the two-dimensional radiographs will be further recommended for a CBCT scan.

4.3 CONE-BEAM COMPUTED TOMOGRAPHY (CBCT) SCAN

CBCT scan of the study patient will be acquired using the Platinum Next Generation SIRONA CBCT scanner and standard scanning protocols (pulsed exposure, 120 kVp, 3 to 7mA, 14.7 second exposure time, 0.25 × 0.25 × 0.25mm isotropic voxel size, 14 bit, maxilla or mandible) . Collimation will be fully adjusted to include the maxilla or mandible only. A limited (maxilla or mandible) FOV (field of view) will be used to scan the tooth involved. The FOV for the maxilla and mandible was 16 cm (*d*) × 6 cm (*h*).

Effective radiation dose will be varied from patient to patient. For the CBCT scans the score system suggested by Estrela [15].

5 IMAGE VIEWING

It is easier for observer to view CBCT images at a monitor attached to the CBCT scan acquisition hardware.

All images will be viewed under acceptable room lighting conditions.

The observation will be done to perform the following with the two imaging modalities separately:

a) Measurement of the extent of the periapical lesion (greatest distance (diameter) in millimeters.
b) Treatment plan for particular tooth (root canal treatment, periapical surgery, root canal treatment and periapical surgery and no endodontic treatment).

The observations will be performed in three separate sessions: one for PA images and one for RVG another for CBCT images.

Images from each modality were viewed only once by one observer.

This will be done to enable observer could score all images between the two modalities in a timely fashion.

The observation sessions were separated by two weeks between the each modalities.

The presentation of the images to the observer among sessions will be randomized. All observation was done for 7 images acquired from 7 different teeth (7 subjects) from the THREE imaging modalities.

The measurement the lesion size and scored their choice of treatment for each tooth. Overall, a total of (7 images for PA +7 images of RVG+ 7 images for CBCT) each for lesion measurement and treatment choice.

6 TREATMENT PLANNING

The datasets were collected by one investigator (endodontist) who did not participate on the evaluation of the images. Two previously calibrated examiners (both endodontists) scored each image separately for the assessment of the presence of periapical radiolucencies.

Several parameters were evaluated: (i) maximum dimension of lesion , (ii) numbers of lesion per tooth, (iii) number of teeth with lesions.. The observers were blinded to the patients' data. The examiners firstly assessed the PR then RVG and CBCT images and results were compared.

In addition to the radiographic diagnosis, the evaluator then selected from a list their preliminary treatment plan for each case based on their radiographic diagnosis. The list includes:

1) Conventional "First Time" Root Canal Treatment
2) Endodontic Surgery (May include perforation repair, Apicoectomy, Biopsy)

Also, if the tooth required a root canal retreatment followed by a surgery.

The list of choices includes:

1. Periapical Radiolucency >2mm – conventional root canal treatment (RCT)
2. Periapical Radiolucency >3mm - conventional root canal treatment+ surgery
3. Periapical Radiolucency > 4mm- RCT + surgery+ Bone graph

Table 1

Observer 1		Observer 2		Observer 3	
Treatment plan		Treatment plan		Treatment plan	
Case 1	Conventional RCT	Case 1	Conventional RCT	Case 1	Conventional RCT
Case 2	RCT + Surgery	Case 2	RCT + Surgery	Case 2	RCT + Surgery
Case 3	RCT +Surgery	Case 3	RCT +Surgery+ Bone graft	Case 3	RCT +Surgery
Case 4	RCT +Surgery +Bone graft	Case 4	RCT +Surgery+ Bone graft	Case 4	RCT +Surgery+ Bone graft
Case 5	RCT +Surgery	Case 5	RCT +Surgery+ Bone graft	Case 5	RCT +Surgery
Case 6	RCT +Surgery	Case 6	RCT +Surgery	Case 6	RCT +Surgery
Case 7	RCT +Surgery+ Bone graft	Case 7	RCT +Surgery	Case 7	RCT +Surgery+ Bone graft

Table 2

	Conventional radiography		Radio vesio graphy		CBCT		
	Lesion dimension		Lesion dimension		Lesion dimension		
	Pre operative	Post operative	Pre operative	Post operative	Pre operative	Post operative	Treatment
Case 1	2. mm	0.5mm	2.5mm	0.5mm	3.8mm	0.78mm	Conv RCT
Case 2	4mm	1mm	4.69mm	1 mm	6.8mm	0.2mm	Surgery+
Case 3	7mm	1mm	9.25mm	1mm	17.8mm	0.5mm	Surgery+ Bone graft
Case 4	6mm	1 mm	8.25mm	0.55mm	13.71mm	0.56mm	Surgery+ Bone graft
Case 5	5mm	1mm	8.15mm	0.68mm	11.17mm	0.64mm	Surgery+ Bone graft
Case 6	6mm	1mm	8.25mm	0.54mm	12.35mm	0.68mm	Surgery+ Bone graft
Case 7	7mm	1 mm	9.21mm	0.66mm	13.68mm	0.25mm	Surgery+ bone graft

7 Discussion

The quality and quantity of radiographic information is essential to endodontic therapy because it affects the diagnosis, treatment planning and outcome (Nakata et al. 2006). [16]

Rigolone et al.[17] first described the value of CBCT in planning for endodontic surgery. The treatment plan may vary according to the extent of bone defect or apical root protrusion. The horizontal and bucco/labio-lingual/palatal slice images of a tooth, including the root apex, by CBCT could clarify the bone defects in persistent periapical lesions of endodontically treated teeth. The conventional dental radiograph does not provide such information. The diagnostic information obtained by CBCT constitutes an excellent resource for endodontic therapy, including cases of persistent infections. Natkin et al. reported that if the radiographic lesion size is 200 mm^2 or larger, then the incidence of cysts was almost 100% and they have analyzed the data of different studies relating the radiographic lesion size to histology and surgical approach is mandatory[18].

The image quality of CBCT has been reported to be subjectively inferior to conventional film images for the evaluation of homogeneity and the length of root fillings in single-rooted teeth (Sogˇur et al. 2007). Although the accuracy of detecting alveolar bone loss was significantly better with CBCT than with conventional periapical radiographs, the accuracy in the anterior aspect of the jaws was limited, because the quality of CBCT slice images was insufficient to reliably resolve the thin alveolar crest (Mol & Balasundaram 2008) [19] . However, Mischkowski et al. (2007) indicated that CBCT provides satisfactory information about linear distances and volumes. In addition, CBCT can identify periapical lesions not detected with periapical radiographs (Lofthag-Hansen et al. 2007).

Lack of distortion, magnification and the relative low radiation dose will result in more clinicians adopting CBCT to enable accurate diagnosis and treatment planning, in addition to long-term follow-up and evaluation of healing (Nair & Nair 2007, Patel 2009). In our study, three endodontists viewed images from three modalities (PA,RVG and CBCT) and made their treatment decisions. The intraclass correlation with regards to the treatment decision was only moderate . This could be attributed to the varying clinical experience levels (novice to highly skilled). Previous studies indicate that the long-term stability of observers in detecting periapical radiolucencies on conventional radiographs was satisfactory[23].

Recently, CBCT has found to be useful in measuring the bone density before and after endodontic treatment [20]Thus, CBCT can be used for the assessment of periapical healing following root canal treatment and endodontic surgery. CBCT provides an effective and safe way of producing 3D information of individual teeth and adjacent structures and may in time change the way in which the outcome of endodontic treatment is assessed [21].

Lofthag-Hansen et al., 2007showed the limitations of PA compared to CBCT for preoperative diagnosis of posterior maxillary teeth scheduled to undergo apical surgery. Hence, the use of CBCT has been recommended for presurgical planning, and in particular for planning of apical surgery in multi-rooted teeth

Monitoring the healing of apical lesions is an important aspect of postoperative assessment in endodontics. Pinsky et al. [22] investigated the accuracy of CBCT in the detection of the simulated osseous defects of varying diameters and depths in an acrylic block and on the buccal cortex of a human mandible. CBCT imaging provides several advantages for preoperative treatment planning especially in maxillary posterior teeth with apical pathology.

8 Conclusion

Conventional intraoral radiography provides clinicians with an accessible, cost effective, high-resolution imaging modality that continues to be of value in endodontic therapy.

There are, however, specific situations, both pre- and postoperatively, where the understanding of spatial relationships afforded by CBCT facilitates diagnosis and influences treatment.

The usefulness of CBCT imaging can no longer be disputed—CBCT is a useful task specific imaging modality and an important technology in comprehensive endodontic evaluation.

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