Original Research Article

Diagnostic accuracy of PA Radiography, Complementary Metal-Oxide Semiconductor Sensor (CMOS), Photo Stimulable Phosphor Plate Receptor (PSP) and Cone Beam CT in the Detection of Internal Root Resorption; An In Vitro study"

Dr. Josey Mathew[1*], Dr. Gibi Syriac[2], Dr. A Devadathan[3], Dr. Manuja Nair[4], Dr. Jose Jacob[5], Dr. Rahul J[6]

[1]Professor, Dept of Conservative Dentistry & Endodontics, Annoor Dental College, Muvattupuzha, Kerala, India
[2]Assistant Professor, Department of Pediatric and Preventive Dentistry, Government Dental College, Kottayam, Kerala, India
[3]HOD and Professor, Dept of Conservative Dentistry & Endodontics, Pushpagiri College of Dental Sciences, Tiruvalla, Kerala, India
[4]Reader, Dept of Conservative Dentistry & Endodontics, Pushpagiri College of Dental Sciences, Tiruvalla, Kerala, India
[5]Reader, Dept of Conservative Dentistry & Endodontics, Pushpagiri College of Dental Sciences, Tiruvalla, Kerala, India
[6]Reader, Dept of Conservative Dentistry & Endodontics, Pushpagiri College of Dental Sciences, Tiruvalla, Kerala, India

Abstract

Background: Radiologic diagnostic methods for internal resorption include conventional periapical radiography (PA radiography), Complementary metal Oxide Semiconductor imaging (CMOS), Photostimulable phosphor (PSP) imaging and Cone beam Computed Tomography (CBCT). This study aims to examine the sensitivity and specificity of CBCT, PSP, CCD, and PA Radiography for early diagnosis of internal resorption. *Material & methods:* 72 single-rooted premolars were divided into three intervention groups and a control group. The teeth were split mesiodistally into two parts. Cavities of 0.3 mm depth were created on the buccal half of the root in middle one third in Group A. In Group B cavities of 0.4 mm, Group C cavities of 0.6 mm and in control Group D no cavities were created. Finally, the teeth fragments were fused using glue, fixed in sockets of one human dry mandible and were examined with the four different procedures. *Results:* The sensitivity of the four imaging procedures for diagnosis of internal root resorption of 0.3 mm was 100%, 60%, 73%, and 53% respectively. However, the sensitivity of all four procedures for diagnosis of internal root resorption with 0.4mm and 0.6 mm in depth was the same and equal to 100%. The specificity of the four procedures for diagnosis of internal root resorption of any depth was100%, 83%, 100%, and 75% respectively. *Conclusion***:** CBCT provides the most accurate information on the depth and location of root resorption followed by the CMOS and PSP respectively. Conventional intraoral periapical radiography was the least accurate procedure.
Keywords: Internal resorption, CBCT, PSP, PA X-Ray, CMOS.

INTRODUCTION

Physiologic or a pathologic process resulting in a loss of dentin, cementum, and/or bone is known as resorption [1]. It is classified as internal or external root resorption depending on its location.

Progressive defect of intra-radicular dentin and dentinal tubules along the middle and apical thirds of root canal walls caused by bacterial invasion and chronic inflammation of dental pulp tissue results in internal resorption [2]. Internal resorption is associated with irreversible pulpitis wherein dentin and cementum are dissolved by chelation. The possible causating factors are trauma and inflammation. Internal root resorption is asymptomatic but the untreated internal resorption can progress weakening the teeth causing fracture of the tooth [3]. Clinical decisions depend on early and accurate diagnosis resulting in more predictable outcomes. This makes early diagnosis and prompt treatment very important to improve the prognosis of teeth with resorption [4].

Radiologic methods used for diagnosis of internal resorption include conventional intraoral periapical radiography (PA radiography), Complementary metal Oxide Semiconductor imaging (CMOS) and photostimulable phosphor (PSP) imaging plate. Intraoral radiography can be done in two ways- analog and digital. The conventional films are exposed to radiation and fixed in the processing solution in analog method. Digital intraoral technique can be done

directly and indirectly. In the direct method images are visible immediately after radiography on the monitor (e.g. CMOS). In the indirect method, the sensor exposed to radiation is placed in a scanner. The scanner is then exposed to the laser beam and the image appears on the monitor (e.g. PSP). In addition to these, cone-beam computed tomography (CBCT) is used extensively for early detection of dental disease including root resorption. CBCT provides three-dimensional images of the maxillofacial structures using Cone beam [5, 6].

Conventional intraoral radiography offers two-dimensional image of three dimensional anatomies [7]. CBCT provides a three-dimensional view eliminating superimposition of structures that is inherent in conventional imaging and also offer axial, sagittal, and coronal views [8]. Very few studies have been conducted to investigate the accuracy of conventional and digital intraoral imaging techniques with CBCT for early detection of internal root resorption. This study aims to examine the sensitivity and specificity of four imaging procedures including CBCT, PSP, CCD, and PA Radiography for early diagnosis of internal root resorption.

MATERIALS & METHODS

Seventy two single-rooted premolars without root resorption were selected and saved in normal saline The teeth were divided into three intervention groups and a control group of 18 teeth each.

Preparing and simulating root resorption

A diamond disk was used to split the teeth mesiodistally into Two parts. (Fig 1) Then, cavities of 0.3 mm depth were created on the buccal half of the root in middle one third by round bur in first intervention group (Group A)using Bur No 45(Mani Inc., Japan). In Group B cavities of 0.4 mm in depth were prepared in the same location using round bur No 46(Mani Inc., Japan).In Group C cavities of 0.6 mm was prepared using round bur No 31(Mani Inc., Japan). The 18 teeth of the control Group D were split to be as similar as the teeth of intervention groups but no cavities were created in them. Finally, the teeth fragments were fused using glue and were fixed in sockets of one human dry Mandible. (Fig 2) Apical half of the teeth were cut off for ease of placement in the mandible. To simulate facial soft tissue, all surfaces of the mandibles were covered by approximately 2mm thick pink wax. Then, the teeth were examined with the four different imaging procedures. Fig 4 to Fig 7 shows PA Xray, CMOS, PSP and CBCT images showing internal resorption respectively.

Imaging techniques

Each specimen was subjected to PA Radiography, CMOS imaging, PSP imaging and CBCT imaging.

Group I - PA Radiography using Kodak E speed film and Best-x-DC, Xray Machine (NewLife Radiology Italy)at 70KV,180 mA for 0.540 sec
Group II - CMOS using Kodak 5100 RVG and Best-x-DC, Xray Machine (NewLife Radiology Italy) at 70KV, 220 mA for 0.180 sec
Group III - PSP using Vistascan mini plus imaging system (Durr Dental)
Group IV - CBCT using Planmeca CBCT at 90Kv, 8 mA and romexis viewer software

Finally groups can be summarised as
- Group I A; 0.3mm defect with P.A Radiography
- Group I B; 0.4mm defect with P.A Radiography
- Group I C; 0.6mm defect with P.A Radiography
- Group I D; 0 mm defect with P.A Radiography
- Group II A; 0.3mm defect with CMOS radiography
- Group II B; 0.4mm defect with CMOS radiography
- Group II C; 0.6mm defect with CMOS radiography
- Group II D; 0 mm defect with CMOS radiography
- Group III A; 0.3mm defect with PSP radiography
- Group III B; 0.4mm defect with PSP radiography
- Group III C; 0.6mm defect with PSP radiography
- Group III D; 0 mm defect with PSP radiography
- Group IV A; 0.3mm defect with CBCT
- Group IV B; 0.4mm defect with CBCT
- Group IV C; 0.6mm defect with CBCT
- Group IV D; 0 mm defect with CBCT

Interpretation of the images

The images were interpreted by two endodontists independently. They were blind to the presence or absence of root resorption. The observers' judgment on the images was categorized as either positive or negative.

STATISTICAL ANALYSIS

To estimate the sensitivity and specificity of the imaging methods, we divided the images as positive or negative based on the observers' judgments and reported as a percentage using results of CBCT imaging as the gold standard. All statistical analyses were performed at 95% significance level.

RESULTS

The sensitivity and specificity of CBCT, PSP, CMOS, and PA for diagnosis internal root resorption by resorption depth are shown in Table 1 and Table 2 respectively. The sensitivity of the four imaging procedures for diagnosis of internal root resorption of 0.3 mm in depth was 100%, 60%, 73% and 53% respectively. However, the sensitivity of all four procedures for diagnosis of internal root resorption with 0.4mm and 0.6 mm in depth was the same and equal to 100%. The specificity of the four procedures for diagnosis of internal root resorption of any depth was 100%,83%,100% and 75% respectively.

Table-1: Sensitivity of imaging techniques

Depth of cavity	PA X Ray	CMOS	PSP	CBCT
0.3mm	53	73	60	100
0.4mm	100	100	100	100
0.6mm	100	100	100	100
Average	84	91	87	100

Table-2: Specificity of imaging techniques

Depth of cavity	PA X Ray	CMOS	PSP	CBCT
0.3mm	75	100	83	100
0.4mm	75	100	83	100
0.6mm	75	100	83	100
Average	75	100	83	100

Fig-1: Teeth split mesiodistally

Fig-2: Tooth fixed in Mandible for imaging
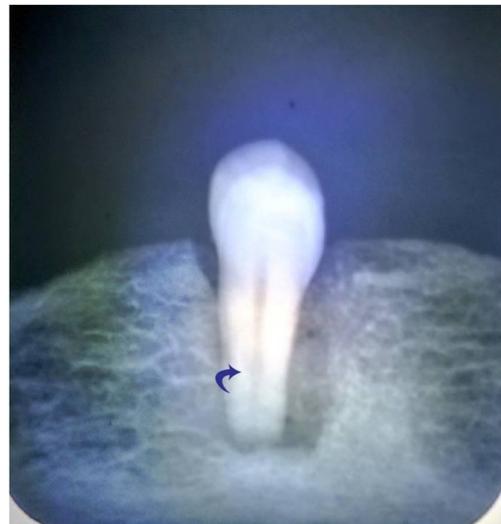
Fig-3: PA X Ray showing internal resorption

Fig-4: CMOS showing internal resorption
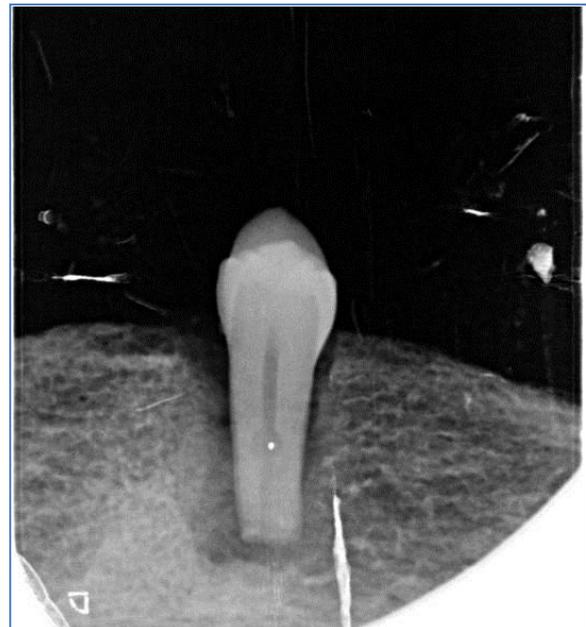
**Fig-5: PSP showing internal resorption**
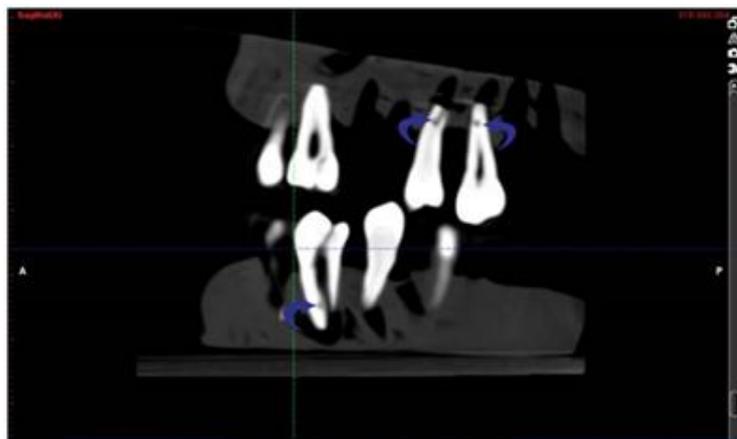
Fig-6: CBCT showing internal resorption

DISCUSSION

Diagnostic information offered by imaging procedures can influence clinical decisions. Accurate data provide clinically relevant information and can lead to better judgment. Early diagnosis of internal root resorption is critical for appropriate treatment [4].

This study shows that CBCT offers the most accurate and reliable information about internal root resorption compared to other procedures. The average sensitivity of CBCT, PSP, CMOS, and PA for diagnosis of internal root resorption 0.3 mm in depth was 100%, 60%, 73%, and 53% respectively. Average sensitivity of CBCT, PSP, CMOS, and PA for all lesion depths was 100%, 87%, 91%, 84% respectively. These results indicate that for diagnosing internal root resorption in the primary stages CBCT is better than conventional intraoral imaging techniques. This is due to the adjustment of the contrast and density of digital images as well as use of different software options such as noise reduction, magnification, enhancement etc [9].

Among digital intraoral imaging systems, CMOS has higher sensitivity compared to PSP. This shows that digital imaging systems are effective in diagnosing small internal root resorption. The results obtained in this study are in accordance with the results obtained in earlier studies [10].The study by Murphy et al to determine the accuracy and reliability of recording forensic information from cone beam computed tomography (CBCT) scans of the jaws when compared to conventional panoramic radiographs proved near-perfect repeatability and reproducibility for CBCT with 96.6% sensitivity and 98.4% specificity[11]. Ultra and high resolution CBCT has been proven to be effective in detecting similuated internal resorption defects [12].Shokri etal has stated that the most accurate information on the depth and location of root resorption is provided by CBCT followed by the PSP and CCD. Accordingly, conventional intraoral radiography was the least accurate procedure [13].

Although CBCT imaging system has higher accuracy than other systems, higher cost has limited its application for identifying the internal root resorption especially in the early stages. Therefore, CMOS is suggested to be considered as the first choice in diagnosing internal root resorption in patients with trauma because it can detect 73% of the internal root resorption of 0.3 mm in depth. If the results of PSP are negative at this stage, patients can be periodically followed up. If resorption is progressing, root resorption may be detected on follow up. However, CBCT may be used for more precise diagnosis especially when other diagnosis such as fracture is suspected [14]. There is no significant difference between CBCT and PSP in diagnosing internal root resorption of more than 0.4 mm in depth. Indeed, the diagnostic ability of all imaging systems increases with resorption depth as in previous studies [15].

The most important limitation of this study was that we created internal root resorption artificially and used dry human mandible for replacement of the prepared teeth. Although we tried to simulate the natural condition, the inherent difference between in vitro and in vivo may result in bias. Another limitation of this study was that we simulated root resorption and measured the ability of the imaging techniques in detecting internal resorption in single rooted teeth only. The results may vary in multi root teeth, especially the molars.

CONCLUSION

The current study examined and compared the accuracy of four different radiographic procedures in diagnosing internal root resorption. Based on the findings, CBCT provides the most accurate information on the depth and location of root resorption followed by the CMOS and PSP respectively. Conventional intraoral periapical radiography was the least accurate procedure.

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