

Experimental Comparison of the Diagnostic Accuracy of Conventional and Digital Radiography in Detection of External Root Resorption

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Abstract


Background and Aim: External root resorption is not detectable clinically and radiography plays a key role in its diagnosis. The present study aimed at comparing the diagnostic efficacy of conventional and digital radiography in detection of simulated root resorption cavities (In-vitro).

Materials and Methods: This experimental observational study evaluated 39 extracted teeth. All roots, except for the palatal root of upper molars, were hypothetically divided into apical and coronal sections. Half these sites were considered as the control group. Buccal cavities were randomly made in the remaining sections using # 1/2, 2 and 4 round burs. Each tooth was imaged using a CCD-based digital system and E-speed film. Radiographs were taken at 0 and 20° mesial angulation. Six image groups were interpreted by two experienced oral and maxillofacial radiologists and one endodontist. Conventional and enhanced digital radiographs were also taken at 0 and 20° mesial angulation. Conventional radiographs were viewed at 2X magnification by a magnifying glass. Sensitivity, specificity, false positive and false negative percentages and accuracy of each method were compared with the gold standard. The degree of agreement among these techniques was measured by kappa coefficient.

Results: Conventional radiography at 2X magnification had the highest sensitivity and specificity. No significant difference was found in sensitivity of digital radiography and enhanced digital radiography. Enhanced digital radiography ranked second in terms of specificity. Conventional radiography at 2X magnification followed by enhanced digital radiography had the highest diagnostic accuracy. Mesial angulation of the cone increased sensitivity and decreased specificity in all three techniques and thus, it only improved the diagnostic accuracy of digital radiography with no significant effect on the other two techniques. The degree of agreement between the two digital techniques was higher ($k=0.68$).

Conclusion: Diagnostic efficacy of conventional radiography at 2X magnification is more than digital radiographs for detection of external root resorption.

Key Words: Conventional radiography, digital radiography, root resorption

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Introduction

External root resorption may occur for various reasons but if diagnosed early, the affected site may be repaired by cementum deposition following elimination of the causative agent [1]. Thus, early detection of external root resorption is necessary for a proper treatment planning. This condition can only be diagnosed radiographically and selection of an appropriate radiographic technique plays a key role in this respect [2]. At present, use of digital radiography is becoming increasingly popular because it does not have the problems of conventional radiography [3]. Therefore, it is especially important to further recognize the capabilities of this technique for detection of dental problems like external root resorption. Regardless of the radiographic technique, various confounding factors can complicate the process of diagnosis such as inter- and intra-observer differences, noise, etc [1]. Controversies also exist in this respect. Some believe that changing the horizontal angulation of the cone can be helpful for detection of these lesions; however, no consensus has been reached on this subject. According to several researchers, the higher the contrast, the more accurate the diagnosis. On the contrary, some others believe that higher contrast increases the structural noise as well. Thus, the mentioned hypothesis cannot be completely reliable [2].

The present study aimed at in-vitro comparison of the diagnostic accuracy of conventional and digital radiography for detection of external root resorption.

Materials and Methods

This experimental in-vitro study was conducted on 39 human extracted teeth (including 10 anterior, 6 canine, 8 premolar, 5 maxillary molar and 10 mandibular molar teeth) with no lesion on their root surface detectable with direct visual observation. After extraction, the teeth were stored in 70% ethyl alcohol. The teeth were then cleaned using a slow speed handpiece with prophylaxis polishing paste. All roots, except for the palatal root of maxillary molars, were hypothetically divided into two portions of coronal and apical from the CEJ to the

apex. By doing so, a total of 108 sections were available. Random cavities were prepared on these surfaces using # ½, 2 and 4 round burs and a slow-speed handpiece. In total, there were 54 sections with no cavity, 18 sections with a cavity prepared with # ½ round bur, 18 sections with cavities prepared with # 2 round bur and 18 sections with cavities prepared with # 4 round bur. On each section, only one cavity was prepared at the center of the surface. All roots were covered with one layer of dental red wax with one mm thickness to simulate periodontal ligament. The teeth were embedded in blocks made of dental stone and sawdust with 2/1 ratio. Soft tissue was simulated using a Plexiglass sheet. Four buccolingual radiographs were taken from each tooth:

- A conventional radiograph using a paralleling technique with a film holder (XCP, Dentsply Rinn, Elgin, IL, USA)

- A digital radiograph using a paralleling technique with a film holder (XCP, Dentsply Rinn, Elgin, IL, USA)

- A conventional radiograph with 20° mesial angulation of the cone

- A digital radiograph with 20° mesial angulation of the cone

All phases were carried out by one operator. The exposure angle, tooth position and receptor position (film and CCD) were maintained the same for all samples. For conventional radiography, the exposure settings were as follows:

Exposure time was 0.36 s for incisors, 0.46 s for canines, 0.18 s for premolars, and 0.22 s for molars. Focal spot-to-object distance was set at 26 cm and object-to-receptor distance was 0.5 cm. Both conventional and digital radiographs were taken with Gendex-Dentsply dental x-ray system (Oralix AC-type No.5303 0101, Italy) with 65 kVp and 7.5 mA. For conventional radiography, Primax RDX-58E soft (Primax, Berlin, Germany) E-Speed size 2 films were used. The films were processed in Gendex automatic processor (Clarimat 300) with Farhan processing solutions according to the manufacturer's instructions and placed separately in similar frames.

Digital images were obtained using a direct digital system with a 23 x 41 x 4 CCD receptor with 19 micron pixel size and CygnusMedia 3-0-1-397 dental imaging software, saved in a computer in 12 bit files with JPEG format and viewed in a 14 inch monitor with 1600 x1200 pixel resolution.

A total of 156 obtained radiographs were randomly evaluated and interpreted by two oral and maxillo-facial radiologists and one endodontist. Observers expressed their opinions based on the two scales of presence or absence of external root resorption. For digital radiographs, each image was first evaluated and the related form was filled out. Afterwards, the observers were given the opportunity to enhance the same image (by changing the contrast, brightness, zoom or negative options) then the second form was filled out.

Conventional radiographs were all evaluated on a view box with a magnifying glass at 2X magnification. After assessment, one of the mandibular molars was excluded from the study due to the poor quality of image. Observers' opinions were compared with the gold standard (a table indicating the actual size and location of each lesion) and sensi-

tivity, specificity, false positive and false negative percentages were calculated.

Results

Sensitivity, specificity, false positive and false negative percentages as well as the diagnostic accuracy of each technique are presented in Table 1. The highest sensitivity belonged to conventional radiography with 2X magnification. No statistically significant difference was observed in sensitivity of regular and enhanced digital radiographs. The highest specificity belonged to conventional radiographs with 2X magnification followed by enhanced digital radiographs. Mesial angulation of the cone increased the sensitivity and decreased the specificity of all three techniques. Mesial angulation of the cone improved the diagnostic accuracy of digital radiographic technique but had no significant effect on the diagnostic accuracy of the other two methods. The degree of agreement was higher between regular and enhanced digital radiographs (K=0.68).

Table 1: Five diagnostic indices in conventional and digital radiographs for detection of external root resorption

Diagnostic techniques	Conventional radiography	Conventional radiography with 20° mesial angulation	Digital radiography	Digital radiography with 20° mesial angulation	Enhanced digital radiography	Enhanced digital radiography with 20° mesial angulation
Sensitivity	90/7%	94/4%	76/7%	93/5%	77/5%	81/4%
Specificity	77%	75/4%	67/2%	67/1%	72/7%	70/5%
False negative (%)	26/4%	30/2%	37/7%	45/3%	28/3%	34%
False positive (%)	7/8%	3/9%	19/6%	3/9%	21/6%	15/7%
Accuracy	82/7%	82/7%	71/1%	75%	75%	75%

Discussion

Radiographic interpretation for diagnostic purposes is a difficult task. A series of factors can affect the performance of the observer such as the imaging system (analog or digital) [5], manipulation and enhancement of images [6], image viewing characteristics of the film and monitor and experience of

the observer. In the present study, each phase was conducted according to the accredited articles and opinions of experts [2,7,8]. Diagnostic accuracy of conventional radiographs with 0 and 20° mesial angulation (with 2X magnification) and regular and enhanced digital radiographs with 0 and 20° mesial angulation was evaluated.

In general, conventional radiography had a clearly higher sensitivity and lower false positive percentages compared to the other two methods. However, the sensitivity of two digital radiographic techniques (regular and enhanced) was not significantly different. Mesial angulation of the cone in all three techniques (especially digital radiography) improved sensitivity which was probably due to the fact that mesial angulation changed the circular outline of lesions to oval.

The results of this study showed that conventional radiography had the highest specificity and lowest percentage of false negative results while digital radiography had the lowest specificity and the highest percentage of false negative diagnoses. Mesial angulation of the cone in all three techniques (especially conventional and enhanced digital radiography) decreased specificity and increased the number of false negative diagnoses. Overall, the study results revealed that the diagnostic accuracy of conventional radiography was higher than that of the other two methods. Mesial angulation of the cone had no positive or negative significant effects on the diagnostic accuracy of conventional or enhanced digital radiography but could significantly increase the diagnostic accuracy of digital radiography. Overall, digital radiography with 0-degree angulation had the lowest diagnostic accuracy.

Evaluation of the number of false positive and false negative diagnoses indicated that in general, lesions located in the coronal halves were more easily diagnosed than those in the apical halves. However, in enhanced digital radiographic technique, no significant difference was noted in detection of lesions in the coronal or apical halves. This finding may be explained by the fact that the apical portion of the root has a smaller diameter and is over-exposed making the detection of lesions more challenging; but, in enhanced digital radiographic method, no significant difference was found in detection of coronal and apical lesions since the problem of over-exposure can be easily resolved. Evaluation of the number of false negative results re-

vealed that larger lesions were more easily detected.

Wenzel et al, in their study in 1991 demonstrated that digitized radiographs with contrast enhancement had a greater efficacy for detection of occlusal caries compared to conventional radiography [3]. The difference between their results and ours can be attributed to the fact that in our study, we allowed the observers to use a magnifying glass with 2X magnification for evaluation of conventional radiographs.

In contrast to the present study, Levander et al, in 1998 failed to find any significant difference in the sensitivity of conventional and digital radiography [9]. This difference may be due to the issue that Levander only used single-rooted teeth in his study (premolars); whereas, in the present study, we evaluated multi-rooted teeth, which provided us with a greater opportunity for the assessment and comparison of the diagnostic accuracy of conventional and digital radiographic techniques.

Borg in his study in 1998 stated that conventional and digital radiographs with the ability to enhance images at optimal exposure settings are both clinically acceptable [2]. In our study, however, various exposure settings were not evaluated and all images were obtained with the same exposure settings. Therefore, comparison of the results of Borg and ours is not feasible. Additionally, in Borg's study, buccal surface of the roots was divided into 6 sections. This issue may be responsible for the misinterpretation of the location of resorption. In order to avoid this problem, we divided the buccal root surface into two coronal and apical portions. Furthermore, one operator filled out all the questionnaires so that making a decision regarding the location of lesions would be uniform.

Tyndall et al. reported similar results in detection of caries under in vitro conditions by conventional and regular digital radiographs. However, the diagnostic accuracy decreased when enhanced digital radiographic technique was employed [10]. The difference between their findings and ours may be related to the use of the same exposure time for all

images by Tyndall; while, as we know, due to the higher X-ray sensitivity of digital receptors, digital radiographs must be obtained with a shorter exposure time.

Hu et al, in their study in 2000 clinically assessed the application of digital radiography for detection of caries and could not find any difference between conventional and enhanced digital radiography in this respect [11].

In Leach et al, study in 2001 no significant difference was reported in sensitivity of conventional and digital radiographs for detection of root resorption [12].

Westphalen et al, in 2004 compared the efficacy of conventional and digital radiographic methods in detection of cavities simulating external root resorption and found that digital radiography had a higher sensitivity in this regard [13]. However, in the present study conventional radiographs were evaluated with a 2X magnifying glass and thus had a higher sensitivity, specificity and diagnostic accuracy.

Wenzel in her study in 1991 [3] stated that the degree of agreement between digital techniques was higher than their agreement with conventional radiography which is in accordance with our findings.

Conclusion

Digital radiography provides us with several opportunities in dental practice. However, since correct and prompt diagnosis is extremely important for treatment of external root resorption and radiography is currently the only means for this purpose, conventional radiography with magnification is still superior over digital radiography.

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