Original Article

Conventional Versus Digital Radiography in Detecting Root Canal Type in Maxillary Premolars: An in Vitro Study

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Abstract

Objective: Successful endodontic therapy depends on adequate mechanical and chemical debridement of the canal which requires knowledge of the canal morphology. Conventional radiography has been used to evaluate the canal type; however, direct digital radiography has recently been practiced for this purpose due to the shortcomings of conventional radiography. The aim of the present study was to compare the accuracy of digital and conventional radiography taken at 0° and 30° angles in the diagnosis of the canal type of extracted maxillary premolars.

Materials and Methods: This diagnostic study was performed on 90 extracted maxillary premolars. Conventional and digital radiographies were taken of all teeth at 0° and 30° horizontal angles. The images were assessed by an oral and maxillofacial radiologist. The clearing technique was used as the gold standard. The canal type was determined using Weine classification. The agreement between each one of the 4 radiographic modalities and gold standard was determined by kappa statistics.

Results: The kappa values for the agreement of parallel conventional, 30° conventional, parallel digital and 30° digital modalities with the clearing technique were 0.059, 0.215, 0.043 and 0.391, respectively. Parallel modalities were unable to determine the tooth canal type. Radiographic images taken at 30° significantly determined the canal type, although only a poor level of agreement was noted between the two modalities and the clearing technique.

Conclusion: All modalities had limited value to determine the root canal type in maxillary premolars. However, direct digital imaging taken at 30° angle showed the highest accuracy for canal type assessment.

Key Words: Radiography, Dental; Digital; Root Canal Anatomy

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INTRODUCTION

The complexity of the root canal system demands extra care from the endodontist in the morphological analysis when treating a tooth. This requires information about the number and shape of roots and canals in order to plan and perform a satisfactory endodontic treatment [1-3].

Several techniques are used to determine root canal configuration such as the specimen transparent technique, conventional radiography, radiopaque contrast media, cross sectional cutting scanning electron microscope and cone beam computed tomography [4]. Radiography is the common diagnostic tool to evaluate the morphology of the root canal [2]. Conventional radiography is traditionally used in various stages of root canal therapy. Although conventional radiography may demonstrate the main features, it is unlikely to show the complexities of the root canal anatomy [3]. Conventional radiography has numerous disadvantages such as long preparation time, development and fixation errors, inability to archive and manipulate the images and a higher required dosage, especially when images need to be repeated [5,6].

Digital radiography benefits from various software potentials and ease of handling is one of its superior characteristics.

In spite of limited resolution of images, direct digital radiography is often more effective than conventional intraoral films, with features such as real time imaging , lower X-ray dose levels up to 60% [7], higher sensitivity, low noise levels at higher spatial frequencies, no silver halide, possibility of image manipulation and digital storage [2,8-10]. Despite these reports, conventional radiography is yet a definite method for determination of root canal morphology and there is a lack of sufficient studies to establish the potential of digital radiography in this era [7]. Intentional alteration in X-ray beam angulation may provide additional information not readily available from the orthoradial view. The recommended horizontal beam angulation for identification of two canals in one root depends on the amount of separation and divergence between the canals and a 20° to 40° is suggested [11, 12]. In assessing the canal configuration of mandibular first molar teeth, a 30° mesial horizontal beam angulation was suggested to offer additional detail not provided by 0 or 20° angulation [13].

In spite of these findings, some studies have shown that orthoradial images preset more diagnostic information compared to those of horizontal 30° angle radiographies, or the degree of angulation may even have no significant effect on diagnostic information [7, 14].

The aim of this study was to compare the diagnostic accuracy of conventional and digital radiographies taken at 0 and 30° horizontal angle to determine the root canal type of extracted maxillary premolars.

MATERIALS AND METHODS

This diagnostic study was performed on 100 permanent intact freshly extracted human maxillary premolars. Immediately after extraction, all teeth were stored in 10% buffered formalin. After four hours, each tooth was cleaned of attached soft tissues and calculus by scaling and polishing. All roots were covered with 1mm of red wax and mounted in blocks of dentistry stone plaster and saw dust (2:1 ratio). All the stages were performed by a trained operator. Four images were taken of each tooth including parallel conventional, 30° horizontal angle conventional, parallel digital and 30° angle horizontal digital radiographies.

Both digital and conventional radiographies were taken by Gendex-Densply (Oralix AC-Type number 53030101WW, Italia). Exposure parameters were set at 65 kVp, 7.5 mA and an exposure time of 0.80 seconds for conventional radiographs and 0.40 seconds for digital radiographs. The distance between the buccal surface and the focal spot was 20 inches. The D-speed film (Kodak) was used in the conventional method. The films were developed in the same day by an automatic Gendex clarimat-300. Digital images were taken by direct system using CCD receptor of 23×14×4mm size and displayed in a LG 14-inch monitor with 1600×1200 resolution. The images were prepared with Kodak software and saved in RVG format.

The images were randomly sorted and then assessed by an experienced oral and maxillo-

facial radiologist, with the possibility of manipulation of contrast and brightness of digital images.The clearing technique was used as the gold standard to determine the actual type of root canals. Endodontic access cavity was prepared in each tooth. All teeth were kept in 5.25% sodium hypochlorite solution for 24 hours to remove organic debris and pulp remnants. All the teeth were washed in running water for 12 hours and the canals were dried with paper points and ink was injected in the pulp chambers. Afterwards, all specimens were demineralized in nitric acid 10% for 24 hours and when the teeth were softened and the needle could penetrate the coronal region, the teeth were washed in water for 12 hours again. The next step was to dehydrate the samples with ascending grades of ethyl alcohol (70%, 95% and 100%) each for 12 hours. Finally, all the samples were immersed in methyl salicylate and cleared.

hydration in 100% ethyl alcohol; therefore, the samples reduced to 90 teeth. The root canal type was examined under ×10 magnification using a stereomicroscope and classified based on Weine classification:

-Type I (1-1): a single root canal extends from pulp chamber to the apex.

-Type II (2-1): two canals leave the pulp chamber and join near the apex to form a single canal.

-Type III (2-2): two separate canals extend from the pulp chamber to the apex.

-Type IV (1-2): one canal leaves the pulp chamber and divides short of the apex into two separate canals with separate apical foramens.

After data collection, statistical analysis was performed using SPSS version 18.0 software (SPSS Inc., Chicago, IL, USA).

The agreement between radiographic images and the clearing technique were determined by Kappa value.

Table 1. Distribution of Root Canal Types According to Clearing Technique and 4 Different Radiographic Modalities

Image Modality / Canal type	Gold Standard	Parallel Conventional	Conventional- 30 Degree Horizontal	Parallel Digital	Digital- 30 Degree Horizontal
Type I	18 (20%)	69 (76.7%)	23 (25.6%)	57 (63.3%)	10 (11.1%)
Type II	13 (14.4%)	3 (3.3%)	17 (18.9%)	1 (1.1%)	11 (12.3%)
Type III	55 (61.1%)	16 (17.8%)	48 (53.3%)	29 (32.2%)	66 (73.3%)
Type IV	4 (4.4%)	2 (2.2%)	2 (2.2%)	3 (3.3%)	3 (3.3%)
Total	90 (100%)	90 (100%)	90 (100%)	90 (100%)	90 (100%)

Kappa values less than 0.4 were regarded as poor, 0.41 to 0.6 as medium, 0.61 to 0.8 as good and higher than 0.81 were considered as total agreement.

RESULT

Table 1 shows the root canal types according to the clearing technique and four different radiographic modalities.

Comparison of the conventional technique with the gold standard showed that the parallel modality proved to be successful in 28 out of 90 teeth (31.1%), whereas the 30 degree horizontal technique was able to determine the correct morphology in 48 out of 90 teeth (53.4%).

Moreover, success rates in canal type determination for digital images were 32 out of 90 teeth (35.6%) and 62 out of 90 teeth (68.9%) for parallel and 30 degree techniques, respectively. The coincidence rates of each one of the four different radiographic techniques with gold standard were determined by Kappa value. The Kappa values for parallel conventional, 30° conventional, parallel digital and 30° digital radiographies were 31.1%, 53.4%, 35.6% and 68.9%, respectively. The results showed that 30 degree horizontal conventional and 30 degree horizontal digital images were able to determine the root canal type of maxillary premolars, whereas none of the parallel techniques showed sufficient accuracy in the

Table 2. Amounts of Kappa Value for Determination of Root Canal Type in Maxillary Premolar Teeth

Comparison	Kappa	P value
Parallel conventional images and gold standard	0.059	0.204
30 degree conventional images and gold standard	0.215	0.003*
Parallel digital images and gold standard	0.043	0.47
30 degree digital images and gold standard	0.391	0.0001*
Parallel and 30 degree conventional images	0.083	0.107
Parallel conventional and digital images	0.147	0.079
Parallel conventional and 30 degree digital images	0.045	0.22
30 degree conventional and parallel digital images	- 0.005	0.939
30 degree conventional and 30 degree digital images	0.242	0.0001*
Parallel and 30 degree digital images	0.099	0.004*

***** Significant

diagnosis of the canal type. The Kappa value for 30 degree digital images (0.391) and that of parallel digital images (0.043) were the most and the least values, respectively (Table 2).

DISCUSSION

Considering the drawbacks of conventional radiography, digital imaging has recently been developed as an alternative mean in the diagnosis process. The performance of direct digital radiography is similar to or even better than film-based radiography in detecting root canal fractures, caries or periodontal lesions [15-19].

In this study, the accuracy of parallel and 30 degree horizontal digital and conventional images in the diagnosis of the type of root canals in maxillary premolars was evaluated. The results showed that there was a poor coincidence between the different radiographic modalities and the gold standard. Additionally, parallel conventional and digital images had a low diagnostic accuracy and could only determine the type of root canal correctly in 31.1 percent and 35.6 percent of cases, respectively. By increasing the X ray angulation to 30 degrees, diagnostic accuracy significantly increased to 53.4 percent and 68.9 percent, respectively. Hence the highest diagnostic accuracy was achieved by horizontal 30 degree digital images and the least accuracy was seen in parallel digital images.

Wu et al. (2006) indicated a limited value for direct digital radiography as their study achieved a low kappa value, which was indicative of a poor agreement between direct digital radiography and the clearing technique [2]. In a study conducted by Omer et al. in 2004, the accuracy of conventional radiographic images was compared to the clearing technique in evaluating the type of root canal in maxillary molars and similarly the agreement was poor [3]. The Kappa value in this study was higher than our value and the value obtained by the study carried out by Wu et al., which might be because the observers were endodontists who were probably more familiar with root canal morphology.

Sharpness of an image and the information obtained from a radiographic image depend on radiographic density, contrast, resolution of the image, density of the object and the receptor type [20]. Low density of root canals may be an explanation to the obtained low accuracy of radiography in the diagnosis of root canal type in this study, since no specific technique was used to increase root canal density (such as injection of a contrast medium). Low contrast of the canal system may also affect the ability of different radiographic techniques to determine root canal type [21].

Digital and conventional radiographic images provide a two-dimensional image from a three-dimensional object. Therefore this hypothesis is suggested that alteration of the X ray angulation provides more diagnostic information about the object. This hypothesis was established in this study because conventional and digital images taken at 30 degree horizontal angle had a higher coincidence with the results of the clearing method, however were yet poor in congruence. Other studies suggest that 20°-40° is the optimum beam angulation for detecting the number of canals in one root [11-13]. Moreover, it has been reported that changing the horizontal angle of X ray may improve the ability to detect superimposed canals in first mandibular premolars [11]. Bardauil et al. (2010) found that a mesial alteration in the horizontal angle to 25º may offer a better identification of the roots and apexes without a twisted or blurred image and without superimposition of other anatomic structures, such as the maxillary sinus or canine root, which could occur with 40º angulation. A variation of 15º vertically, with the central beam directed towards the canine, maximized the dissociation of the root apexes of maxillary premolars in a vertical plane [1]. In contrast to our study, Naoum et al. (2003) showed that parallel radi-

ographic images were significantly better than 30° projections for detecting the number of canals, canal visibility along the entire root length, determining the level of canal termination and the level of merging of two canals [14]. Different results might be due to difference in diagnostic goals and different under study teeth in the two studies.

In this study, to diagnose the real tooth canal type, the clearing method was considered as the gold standard. This technique supports proper efficacy in the diagnosis of root canal system and prevents any loss of shape and the main structure of the tooth [22]. It also gives a three dimensional image of the pulp cavity in relation to the exterior of the tooth and helps to see the original form of root canals and their anastomoses [23].

In spite of the efforts to assimilate in vitro and in vivo studies, there are crucial differences between the laboratory and the oral environment. In vitro studies are usually performed on extracted teeth which lack surrounding bone and soft tissue. However, under in vivo conditions, the overlap of alveolar bone, periodontal ligaments and soft tissues affects the image sharpness. Despite the use of gold standard in experimental studies, it should be considered that there is no gold standard in the clinical environment.

Matberne R P et al. (2008) used cone beam computed tomography (CBCT) as a diagnostic tool to identify the root canal system (RCS) compared with the images obtained by charged couple device (CCD) and photostimulable phosphor plate (PSP) digital radiography in vitro. They showed that the endodontist with either CCD or PSP methods failed to identify at least 1 RCS in approximately 4 of 10, which could result in a lower optimal healing outcome if a missed RCS is left uninstrumented and unobturated [24].

The results of this study provide information about the impact of radiographic techniques and X ray angulation on the diagnostic accuracy of root canal type of maxillary premolars compared with the clearing technique.

Further evaluation with more observers specialized in endodontics and evaluation of the external and internal validity to obtain more definite results should be considered. Additionally, three-dimensional images such as cone beam computed tomography have recently been used for different diagnostic goals and it is logical to compare the efficacy of this technique with other radiographic modalities such as conventional and digital radiographies.

CONCLUSION

In conclusion, none of the proposed techniques was solely able to determine the root canal type of maxillary premolars; however, by increasing the X ray angulation from 0 to 30 degrees, the coincidence rate of conventional and digital methods with the gold standard could significantly increase. According to our data, the highest diagnostic accuracy for root canal types was obtained by horizontal 30 degree digital images and the least was gained by parallel digital images.

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