Comparison between the Accuracy of Digital and Conventional Radiographies for Evaluation of the Curved Canals Length

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ABSTRACT

Introduction: Proper cleaning and shaping of the root canal system is one of the most important aspects of endodontic therapy. To estimate the canal length before instrumentation in endodontic treatment, traditionally, conventional radiographic techniques and, recently, Direct Digital Radiography (DDR) are applied. The application of computer technology in radiography has allowed less exposure time for image acquisition, better storage and retrieval, and transmission to remote sites in a digital format, elimination of processing, and a considerable time saving. The purpose of this study was to compare the accuracy of DDR and conventional radiography in determination of working lengths of curved canals in first mandibular molars.

Methods: Forty extracted human first mandibular molars with root curvature were selected. Samples were divided into two groups: With root curvatures less and more than 25°. The samples were mounted in plaster blocks and their canal lengths were estimated by using DDR and conventional radiographs. Regression analysis, correlation coefficient, and t test were used for statistical analysis.

Results: In spite of the greater accuracy of conventional radiography in canals with curvature <25° and the grater accuracy of digital radiography in canals with curvature >25°, the differences were not statistically significant.

Discussion: Both conventional radiographs and DDR can be used to determine working length during endodontic therapy.

Key Words: Digital Imaging, Conventional Radiography, Working Length, Root Curvature.

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Introduction

Preparation of the root canal is one of the most important steps in endodontic therapy. Prior to cleaning and shaping the canal, the length of the canal needs to be determined. Inaccuracy in determination of working length can lead to undesirable treatment results [1].

Radiography has an important role in all aspects of dentistry, including root canal therapy. However, conventional radiography is time consuming and radiation exposure has negative side effects on body tissues. In order to overcome these difficulties, efforts have been made to make new radiological equipment, decreases exposure time and use new techniques. In digital radiography, there is no need for films and chemical processing.X raydosage and number of inappropriate films are also decreased. In this system, the received data is transferred to a computer which presents it as an image on the monitor and the quality of the image, including contrast and density, can be manipulated. The data is stored and can be transferred electronically along computer networks within a

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care facility and to other healthcare facilities [2]. Radiographic images are required during all the stages of endodontic therapy [3].

Cedeberg et al found that digital radiography, comparing with conventional radiography, was more accurate in determining the canal length [4].

In an invitro study by Lozano et al the accuracy of digital and conventional radiographies were compared in 70 extracted teeth. Both methods were more accurate when # 15 file was used. They reported that conventional radiography was still an acceptable method and digital radiography was appropriate when # 15 file was used [5].

Shearer and co-workers [6] used digital radiography to take photographs of teeth canals in their study. The study concluded that this technique can be used in dental root therapies because of good canal length measurement, need for lesser number of clichés and time.

Mentes and co-workers compared the accuracy of conventional and digital radiography in determining the length of curved canals. In their study, 60 extracted human mandibular molars with root curvatures, ranging from 5 and 52 degrees, were used. The lengths of the canals were estimated by using 2 and 3 clicks in digital radiography and a ruler in millimeters in normal E-speed conventional radiography. There was no significant difference between two methods. Even though, the estimated length was more than the actual length in both methods, the accuracy of the digital method increased by increasing in the canal curve. It was concluded that digital radiography can be used for measurement of the lengths of curved canals [7].

The measurement of the canal length becomes more complicated as the degree of root curvature increases. Therefore, the aim of this study was to investigate the accuracy of DDR versus conventional radiographies for point to point measurement of curved canals of mandibular molar teeth.

Methods and Materials

This was a descriptive, diagnostic, in vitro study. A total number of forty extracted mandibular molars with mesial root curvatures between 5 and 45 degrees were selected. The teeth were divided into two groups according to the root curvature [7]: less and more than 25 degrees [8, 9].

Intactness of at least one part of the crown, root curvature between 5 and 45 degrees with both external and internal root details and without calcifications and pulp stones were considered as inclusion criteria. Teeth not meeting the above mentioned criteria were excluded from the study.

The selected teeth were initially placed in an alcohol and glycerin mixture to be prevented from becoming dry and brittle. The teeth were stabilized using blue plaster (Alpha, Parsdandan, Iran) whose thickness on all sides of each tooth was 3mm and the apex was visible from the bottom of the plaster. All of the teeth were numbered. Access cavity was made in each tooth using number 734 burr fissure (Teezkavan, Iran). A number 15 K file (Mani, Japan) was used to measure all the curved canals. These files were placed in such a manner that their tips were visible from the apical ends. A part of the tooth crown was leveled so as to stabilize the placement of the rubber stop and location of the file.

In situations where it was not possible to place the number 15 K file in the mesial canal, number 8 and 10 files were used to open the route to place the Number 15 K file in the canal.

Prior to exposure of the teeth to the two radiographic methods, the actual length (distance between crown stop point and tip of the apex) was measured using the Vernier's scale with an accuracy of 0.1mm on the files and recorded (figure 1).

The files were again placed in the canals and were prevented from displacing by light cure composite. A conventional radiography machine (PLANMECA, Finland) with maximum 70 KVP and 8mA was used for periapical X-rays. The teeth were placed horizontally antero-posteriorly on the E-speed periapical radiography film (Dental Intraoral E-Speed Film, Kodak, USA). The tube was set at a distance of 4cm (same as digital radiography) and all the samples were radiographed in this manner (figure 2).

Figure 1: Measurement of canal length.

The films were exposed and processed by an automatic machine (MED 250, DURR, Germany) at 26 degrees Celsius for 4 minutes. Conventional radiographic exposure settings were 0.2 seconds, 8 mA and 63 KVP, but with similar conditions, the exposure time in digital radiography was 0.12 seconds.

For digital radiography, a conventional radiology machine (PLANMECA,Finland) connected to a RVG (Model 2000, Trophy, France) version 5 machine, with a 3×4 cm^2 sensitive CCD and picture clarity of 20 lines/mm, using Windows Trophy Software. The samples were placed horizontally antero-posteriorly on the sensor whose dimensions were approximately the same as the normal films. The tube was set at a distance of 4 cm above the samples (figure 3).

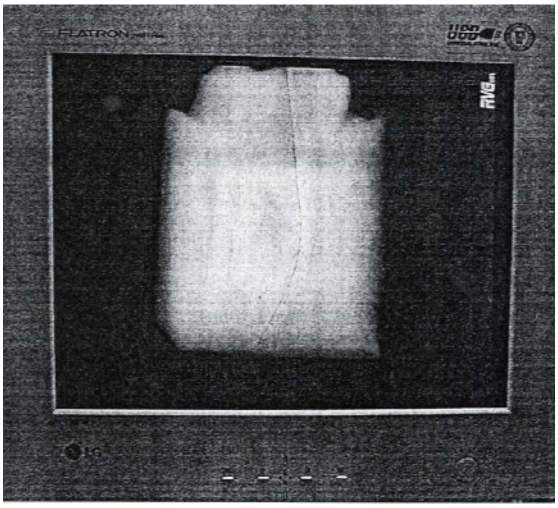

Figure 3: Digital radiograph of a sample with a file in place in a molar, mounted in a plaster block.

For measuring the canal length, the images were stored on the computer and then, by pointing the mouse curser on certain areas of the stored images and clicking, the lengths of the canals were measured. The first click measured the length from the rubber stop to the site of root curve, while the second click measured the distance from the root curve to the tip of the root apex. The computer calculated the distance. The estimated canal length was then measured as the distance from the occlusal reference point to the most apical extent of the file visualized. Then two radiologists measured the conventional and digital radiographs and the mean of the measurements of the two methods was calculated and recorded accordingly:(a) estimation by conventional radiography to the nearest 0.5 mm with a Vernier's scale and ×2 magnification;(b) estimation by the DDR measuring device, to the nearest 0.1 mm, with 2 clicks (first click at the reference point and the second one at the file tip) of the on-screen image;(c) True length determination by removing the file from each tooth and measuring the distance between the occlusal reference point and the file tip to the nearest 0.5 mm with a Vernier's scale and ×2 magnification.

At this stage, the radiographs were placed on the view box and the curves of the canals were measured using tracing paper and the Schneider technique, Briefly [7] (figure 4). To estimate degree of curvature, two straight lines were drawn: one from orifice through more coronal portion of curve and, another from apex through apical portion of curve. The interior angle formed by intersection of these lines is the degree of curvature [7].

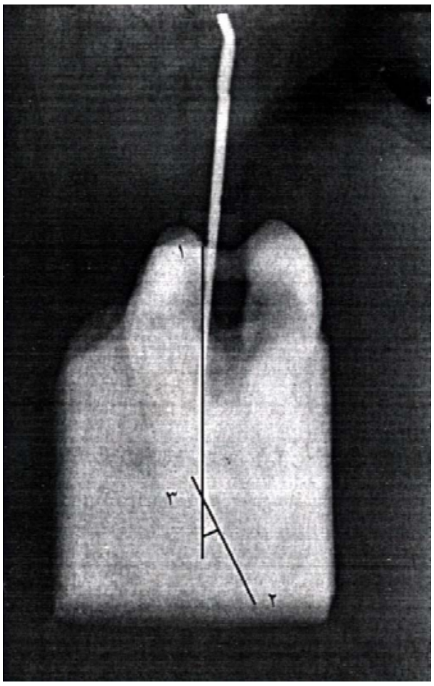

Figure 4: Schneider technique. Canal identification using tracing paper.

After determining the angle of canal curvature, using the Vernier's scale, the distances between points 1 and 2 and points 2 and 3 were measured and recorded (figure 4).

In the digital pictures of the teeth by double clicking, the length of the canal was calculated by computer and recorded. Therefore, three types of measurements were recorded: 1) actual measurement, 2) measurement on the radiological film, and 3) measurement by digital radiography. For grouping according to the angle of curvatures, they were divided into two groups; 1) curvatures between 5 and 25 degrees, and 2) Curvatures between 25 and 45 degrees [8, 9].

The data was analyzed by t test, regression analysis, using SPSS 11.0 software.

Results

The mean of actual lengths of the canals and measurements on conventional and digital radiographies of the teeth with curvatures less and more than 25 degrees is presented in Table 1.

Means of canal lengths in different techniques was compared between groups with canal curves < 25° and > 25° (table 2, 3).

The techniques, conditions, and the rate of magnification were the same in both the methods. All efforts were made to have minimum magnification while following the geometric laws of radiation. The canal lengths on conventional radiography were more than the actual lengths, but the difference in the mean values was not statistically significant (P=0.598). There was no statistically significant difference between conventional and digital radiographies in measurement of canal lengths with curvatures less than 25 degrees and both methods are appropriate, though the accuracy of the conventional method was relatively more.

Finally, after the evaluation of the results in teeth with canal curvatures less than 25 degrees and comparing the actual measurements with conventional radiographs, their relation was determined as the following formula: Y=a + bX, where Y=actual length, a=fixed number, b=angle coefficient, and X=length on conventional radiography. (In this study, a=4.353 and b=0.782). On the whole, the calculation was as follows:

Actual canal length=4.53 + 0.782 × length on conventional radiography,
Actual canal length= 6.828 + 0.67 × length on digital radiography.

These formulae were tested by regression analysis with P-values of 0.000 and 0.001 for conventional and digital radiographies, respectivly, which show acceptable validities.

In teeth with canal curvatures more than 25 degrees, the calculation was as follows:
Actual canal length= 0.17 + 0.98× length on conventional radiography,
Actual canal length= 0.495 + 0.967× length on digital radiography.

These formulae were tested by regression analysis with P-values of 0.000 for both conventional and digital radiographies, which show acceptable validities.

In order to study the accuracy of the two methods of measurement of the canal lengths, considering the gold standard in canals with curvature less than 25 degrees as the actual measurement, conventional radiography was 80% while digital radiography was 40% accurate (P-value=0.288). Therefore, conventional radiography is better than digital radiography for measurement of canal lengths with curvatures less than 25 degrees. In canals with curvatures more than 25 degrees, conventional radiography was 65%, while digital radiography was 95% accurate (P-value=0.000) . Therefore, digital radiography is better than conventional radiography for measurement of canal lengths with curvatures more than 25 degrees.

Canals with curvatures less than 25 degrees

In both the methods, there were differences more than 0.5mm from the actual length in 15% of the cases. In digital radiography, in 45% of the cases there was a difference of more than 0.5 mm from the actual length, while in 45% of the cases in conventional radiography, the difference was less than 0.5mm.

Canals with curvatures more than 25 degrees

5% of cases had a difference of more than 0.5 mm on digital and less than 0.5 mm on conventional radiographies. 35% of digital radiographs had an accuracy of less than 0.5 mm. 60% of the cases had an accuracy of less than 0.5mm of the actual length on both the radiographs (table 4).

Results of Pearson test in radiographs of canals with curvatures less than 25 degrees:

Correlation coefficient of digital radiography with actual length: r = 0.937 P = 0.000,

Correlation of conventional radiography with actual length: r = 0.888 P = 0.000.

Results of Pearson test in radiographs of canals with curvatures more than 25 degrees:

Correlation coefficient of digital radiography with actual length: r = 0.686 P=0.001,

Correlation of conventional radiography with actual length: r = 0.839 P = 0.000.

Therefore, both digital and conventional radiography measurements had positive, significant correlations with actual length of the canals.

Table 1: The mean values of samples with curvatures>25 and <25 degrees.

	Number		**Mean value**		**SD**	
	<25°	**>25°**	**<25°**	**>25°**	**<25°**	**>25°**

Actual length	20	20	20.2	20.55	1.056	1.234
Normal Radiography	20	20	20.275	20.8	1.134	1.119
Digital Radiography	20	20	19.920	20.745	1.083	1.197

Table 2: Comparison between means of canal lengths in different techniques (canal curve < 25°).

Comparison of ML in two techniques	Difference between two groups		P-value
	Mean	SD	
Actual WL to WL* conventional radiography	0.75	0.626	0.598
Actual WL to WL in digital radiography	0.230	0.847	0.240
Canal length in conventional and digital radiography	0.305	0.932	0.160

*Working Length

Table 3: Comparison between means of canal lengths in different techniques (canal curve > 25°).

Comparison of WL in two techniques	Difference between two groups		P-value
	Mean	SD	
Actual canal length to canal length in conventional radiography	0.250	0.568	0.064
Actual canal length to canal length in digital radiography	0.195	0.432	0.058
Canal length in conventional and digital radiography	0.055	0.467	0.605

Table 4: Accuracy of digital and conventional radiography according to the degree of curvature.

Curvature	Accuracy of digital radiography	Accuracy of conventional radiography			
		>0.5 mm		< 0.5 mm	
		No	%	No	%
<25 degrees	>0.5 mm	3	15	9	45
	<0.5 mm	1	5	7	35
>25 degrees	>0.5 mm	0	0	1	5
	<0.5 mm	7	35	12	60
Total	>0.5 mm	3	7.5	10	25
	<0.5 mm	8	20	19	47.5

- 7.5% of the cases had a difference of more than 0.5 mm both on normal and digital radiographies.
- 47.5% of the cases had a difference of less than 0.5 mm both on normal and digital radiographies.
- Accuracy: The difference between actual and measured distance < 0.5mm.

Discussion

The importance of accurate determination of the canal length is due to the fact that for appropriate treatment, the canal needs to be cleaned to a distance of 0.5 mm from the tip of the apex and all the canal contents must be removed completely before filling the entire canal length (to 0.5 mm from the tip of the apex) with special substance.

There was no significant difference between the accuracy of the two techniques and the actual measurements, and the accuracy of digital radiography was more in canals with curvatures more than 25 degrees, compared to canals with curvatures less than 25 degrees.

Sanderlink and co-workers [10] in their study of the quality of conventional and digital radiographs for root canal measurement concluded that both methods are appropriate. In the present study, the accuracy of digital radiography with number 15 file was measured which was more than conventional radiography in canals with curvatures more than 25 degrees. This could be due to the fact that the measurement of deviations more than 25 degrees was done with two clicks and the length was calculated by the computer. This measurement was performed by Vernier's scale and the naked eye in conventional radiography. In addition, it was possible to alter the density, contrast, and color in digital radiography, but the measurements had to be done on the original film in conventional radiography.

Hedrik and co-workers [11] studied the accuracy of conventional radiography and RVG and showed that conventional radiography was more accurate in measuring the length of the canals and its accuracy was more when the files were placed nearer to the apex. The present study also concluded that conventional radiology is more accurate in measuring lengths of canal with curvatures less than 25 degrees. It can be said that as the files were nearer to the apices, the measurements were more accurate. The accuracy could also be related to the type of digital machines and newer machines could have better performance.

In two different studies by Ellingser, [12, 13] these two types of radiographs were compared for accuracy in measurement of the canal lengths and determining the exact location of the file tips. In conventional radiography, the accuracy of canal length measurement was more with D, comparing with E films. It was possible to determine the exact location of the file tip in 70% of films with speed E. In the present study, only E films which have a higher speed with less resolution were used. However, in the present study, the accuracies of both the methods were the same. Previously, the digital machines had lower resolution, but the newer generation machines have very good resolution.

Ong. EY [14] and Kullendorf [15] concluded that there was no statistically significant difference between the accuracy of the two methods in measuring the length of the root canals which is the same as this study.

Huda [16] compared digital radiography (with more contrast and less magnification) with conventional E film clichés. In the present study, contrast of digital radiography was more, while magnification was less in canals with curvatures more than 25 degrees and more in canals with curvatures less than 25 degrees.

Burger and co-workers [9] compared conventional and digital radiographies in measurement of the lengths of canals with curvatures. The canal lengths were compared in 4 methods; conventional radiology, digital radiography with 2 clicks, 6 clicks and unlimited number of clicks. The results showed that none of the methods was 100% accurate and the difference between the results, without consideration of curvatures was not statistically significant. In the present study, two clicks were used in digital radiography so that it would be similar to the conventional method. (Measurement of two lines using Vernier's scale). The results were not statistically significant

In the study by Lozano and co-workers, [5] measurement by conventional method was more accurate. They concluded that conventional radiography is an appropriate method but considering factors like safety of the patient, technician and, workplace which is worth discussion today, digital radiography is an ideal method. The present study also suggests the same.

Mentes et al studied the accuracy of the two methods of direct digital and normal radiology in measurement and estimation of the canal lengths of canals with curvature by two clinicians [8]. There was no significant difference between the two methods, but the lengths measured by the two methods was more than the actual length and the accuracy of the digital method increased with increase in curvature.

Also, in present study too, there was no significant difference between the two methods and digital radiography was more accurate in canals with a greater curvature, which is similar to the results of the Mentes study.

The results of the present study showed that:

Even though there was no significant difference between the accuracy of the two methods of normal and digital radiographies in measurement of lengths of canals with curvatures less than 25 degrees, normal radiography was more accurate in measurement of the canal lengths than digital radiography.

Similarly, even though there was no significant difference between the accuracy of the two methods of normal and digital radiographies in measurement of lengths of canals with curvatures more than 25 degrees, digital radiography was more accurate in measurement of the canal lengths than normal radiography.

Considering the advantages of digital radiography like speed, decreased radiation exposure, electronic data storage and transfer capability of pictures to other centers, along with other mentioned positive points, it is suggested that this method should be used in clinics and all universities alongside normal radiography for research purposes.

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