



# Diagnostic Comparison of Indirect Digital Radiography (PSP) with Paper Print in Diagnosis of Grade I, II Furcation Involvement (*In vitro* Study)

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## ABSTRACT

**Statement of Problem:** The destruction of gingival tissue in the interradicular region of multi rooted teeth is called furcation involvement. The correct diagnosis of furcation lesions are the basis of a successful treatment.

**Purpose:** compare the quality of printed images on desirable papers and indirect digital radiography (PSP) in diagnosis of furcation involvements.

**Materials and Method:** Grade I and grade II furcation involvement were artificially created on 41 mandibular first and second molars and PSP radiography was prepared before and after induction of furcation involvement. Radiographs were printed on radiographic plates using Prima laser printer (Fuji, Japan) and on A4-sized papers (silk) using HP color laserjet 1600 printer. Two observers examined the radiographs and their observations were given to the statistics consultant for data analysis.

**Results:** Positive and negative predictive value (PPV and NPV) of grade I, II (together) furcation involvement for PSP was measured as 96.1% and 84.4%, respectively, and for paper print were measured as 100% and 71.9%, respectively, in which there were no significant differences between the two in the PPV ( $Z=1.5$ ,  $P \geq 0.05$ ) and NPV ( $Z=1.58$ ,  $P \geq 0.05$ ). The sensitivities of the plate and paper print in diagnosis of grade I ( $Z=0$ ,  $P > 0.05$ ) and grade I, II ( $Z=1.67$ ,  $P > 0.05$ ) were not significant. Although, in grade II ( $Z=2.03$ ,  $P \leq 0.05$ ), the plate sensitivity was significantly higher than paper print. The specificity of plate in comparison to paper print by considering the significant level of  $Z \geq 1.96$  did not show a significant difference ( $P \geq 0.05$ ).

**Conclusion:** In general, it seems that in case of lack of access to radiography plates, the use of paper prints can be a justified and appropriate action, due to its relatively good sensitivity and specificity. However, if you have access to radiography plates, it is certainly preferable to use it.

**Key words:** Furcation defect, Dental digital radiography, Paper

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## INTRODUCTION

The destruction of gingival tissue in the interradicular region of multi rooted teeth is called furcation involvement [1,2]. The furcation involvement usually

occurs in the mandibular first molars, and after this it often involves the mesial region of maxillary first molars, contrary to the furcation region of maxillary premolars that are rarely affected. Furcation involvement can lead to catastrophic consequences [2]. Loss of periodontal adhesion can occur vertically and apically around each root of molars. It can also spread horizontally from the facial or lingual towards the center of tooth in furcation region [3]. Various classifications have been proposed

for furcation involvement, all of which aim to help diagnose, provide appropriate treatment, and determine the prognosis of a tooth with furcation defect [4].

A detailed examination of radiography often shows evidence of the presence of furcation involvement. Although the researchers have pointed to the fact that in primary lesions where bone loss is minimal, there may not be a visible lesion in the radiographs. Another problem with simple radiology is their 2D nature and for this reason, primary furcation lesion may not be well seen in radiography [5,6].

The harmful effects of inadequate processing on the film's diagnostic quality and the difficulty of maintaining imaging solutions in high quality are the proved problems in conventional radiographies [7]. The advent of digital imaging has revolutionized radiography. In the digital radiographic system, radiographic information is transmitted directly (such as CCD) or after processing stages in indirect digital system (such as PSP) to the computer and it is displayed as image on a computer screen, and it allows changing the image quality, including contrast and density, as well as storing and transferring to other centers [8]. The use of digital dental imaging has started in the last decade, and its use by dentists has been steadily increasing. For this reason, more companies are developing software and hardware for digital imaging. It is obvious that radiographic diagnosis of diseases requires high diagnostic power of normal anatomy, and on the other hand, the effectiveness of diagnostic power, quality and the type of image processing method used are undeniable [9].

The use of different media in three stages of display, storage and recording of images is one of the major concerns in the scope of using digital radiography in dentistry. Meanwhile, in radiography with normal film, to perform these three steps, we need one media, which is the conventional radiography film, and no other mediator is used. This multiplicity of tools in the process may cause problems such as reduced image quality during operation or the difficulty of transferring images. When in the stage of display, paper printing is used as a medium for displaying and transmitting images, if the amount of image changes and quality degradation is more than acceptable, it leads to serious problems and errors in the diagnosis and treatment plan, and therefore, the overall performance of digital radiography might be questioned because of the prevalence of these errors [10].

So far, various studies have directly or indirectly investigated the quality of digital radiography on a glossy or regular paper, in which there are some contradictories between different studies [11,12]. Considering the contradiction between different studies in this field, as well as the increasing use of indirect digital technology in various diagnostic and therapeutic fields and their

advances in different parts of dentistry, and on the other hand, lack of radiography films, lack of domestic production, problems with maintaining it desirably, and given the improvement of the printing industry in the past decades, we decided to use this method to compare the quality of printed images on desirable papers with indirect digital radiography (PSP) in diagnosis of furcation involvements.

## MATERIALS AND METHODS

In this *in vitro* study, 41 freshly extracted mandibular first and second molars were collected, and were mounted using acrylic and bone powder at a ratio of 50% to an extent that furcation region would not be visible. Since most of the previous studies used acryl, which has a different texture than bone tissue, we decided to use the mixture of bone powder and acryl to make it more similar to bone tissue. Radiographs were prepared from all of the healthy teeth before milling, as the control group. Then, grade I, II furcation involvement were artificially created on them, and radiography was prepared.

In order to simulate the involvement in the furcation region, acrylic was removed by round diamond turbine burs size 0-14; in grade I group, to the point that furcation entry would be visible, and in grade II, slightly deeper, to the point that probing depth would be 3 mm and the probe do not get out from the opposite side based on the Glickman classification of furcation involvement (Figure 1).



**Figure 1: Samples mounted before and after simulation of furcation involvement**

Exposure conditions for preparing the radiographies were kVp-70, mA-8, s-0.32. At all stages, a PSP radiography plate was placed by a holder at a constant distance of 10 cm to the X-ray tube and the block prepared was also placed at equal distance between the radiation source and the sensor.

PSP was prepared in parallel technique from mounted teeth using de Gotzen Italian design device, and then it was processed by sordex-finland Digora optime device. After preparation of the radiographies, the images were made into the desired size using Scanora software and then printed by Prima laser printer (Fuji, Japan) (Figure

2). Again, to prepare paper prints, all of the images were printed by HP color laserjet 1600 with 2400 dpi on A4-sized paper (silk) (Figure 3).



Figure 2: Image of indirect digital radiography (PSP) plate

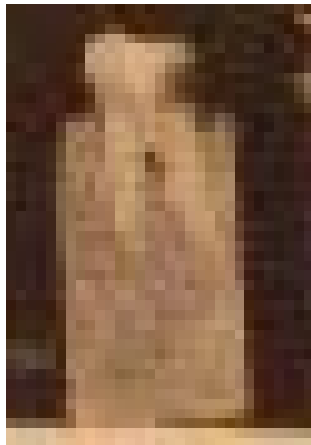


Figure 3: Image of indirect digital radiography (PSP) paper print

The images were coded in such a way that only the executor knew the code of the images and the observers were unaware of it. These images were evaluated by two oral and maxillofacial radiologists who had at least two years of digital image viewing experience. The presence or absence of furcation involvement, and type of involvement (grade I or grade II) were reported by two observers and recorded on certain forms.

Digital images (PSP) were observed in a semi-dark room and on a common negatoscope. Also, paper prints were examined in the same ambient light conditions. All of the cases including images of healthy teeth and teeth with furcation involvement was coded from 0 to 2 (0=lack of furcation involvement, 1=grade I involvement, 2=grade II involvement). All data were provided to the statistic consultant for statistical analysis. The results of this study were analyzed using SPSS version 22, so that the indicators of validity including: sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated through Cochran Q test to compare diagnostic methods with reality and also Binominal test used to compare data. This article does not contain any studies with human or animal subjects performed by any of the authors.

**RESULTS**

The aim of this study was to conduct a diagnostic comparison between indirect digital radiography (PSP) with paper print in diagnosis of grade I, II furcation involvement. In this study, 41 mandibular molars including 21 first molars and 20 second molars were used. Following results were obtained based on the observations of two radiologists (observers):

One of the goals of this study was to assess the ability of observers to detect furcation involvements by using PSP. As shown in Table 1, sensitivity of radiographic images in diagnosing grade I and grade II were 53.7% and 82.9% respectively. Also, the specificity of PSP image was evaluated through the detection of healthy teeth as 92.7%. The PSP images were more effective in identifying the healthy group, grade II furcation involvement, and finally grade I, respectively. The specificity of PSP in detecting grade I and II evaluated in total as 91.5%. Also, the specificity of PSP in detecting healthy teeth evaluated as 92.7%. Investigating the ability of observers to detect the condition of the teeth in terms of furcation involvement by observing PSP images in total indicates the efficacy of this method in detecting a healthy group versus grade I and II.

**Table 1: Comparing the ability of observers to detect the condition of the teeth in terms of furcation involvement by observing indirect digital radiography (PSP) images**

Golden Standard	Detecting the viewer		
	Healthy	Grade I	Grade II
<b>Healthy</b>			
N=41	38*	200.00%	100.00%
100.00%	92.70%	4.90%	2.40%
<b>Grade I</b>			
N=41	600.00%	22*	1300.00%
100.00%	14.60%	53.70%	31.70%
<b>Grade II</b>			
N=41	100.00%	600.00%	34*
100.00%	2.40%	14.60%	82.90%

P value ≤ 0.001; (Sign \* indicates a significant diagnosis of other diagnosis)

Another goal of this study was to evaluate the ability of observers to detect furcation involvement by using paper prints. According to Table 2, the sensitivity of paper print images in detecting grade I and grade II were 53.7% and 63.4%, respectively. Also, the paper print specificity for detection of healthy teeth was evaluated as 100%. The paper prints were more effective in detecting the healthy group, grade II involvement and finally grade I, respectively.

The sensitivity of paper prints in detecting grade I and II in total was evaluated as 80.5%. Also, the specificity of paper prints was evaluated as 100% through detection of the healthy teeth. Investigating the ability of observers to detect the condition of the teeth in terms of furcation

involvement by observing paper print images in total indicates the efficacy of this method in detecting a healthy group versus grade I and II.

In reviewing and comparing the ability of observers to detect furcation involvement by viewing the paper print and PSP images there was no significant difference between PSP images and paper print sensitivities in detecting grade I ( $P \leq 1$ ) and grade I, II ( $P \leq 0.096$ ), while in grade II, PSP sensitivity was significantly higher than paper print. Also, the specificity, positive and negative predictive values in the PSP images did not show significant differences with paper print ( $P \geq 0.05$ ).

**Table 2: Comparing the ability of observer to detect the condition of the teeth in terms of furcation involvement by paper print**

Golden Standard	Detecting the viewer		
	Healthy	Grade I	Grade II
<b>Healthy</b>			
N=41	41*	0	0
100%	100%	0%	0%
<b>Grade I</b>			
N=41	14	22*	5
100%	34.10%	53.70%	12.20%
<b>Grade II</b>			
N=41	2	13	26*
100%	4.90%	31.70%	63.40%

P value  $\leq 0.001$ ; (Sign \* indicates a significant diagnosis of other diagnosis)

## DISCUSSION

Furcation involvement is one the most important periodontal diseases that results in destruction of gingival tissues in the interradicular region of multi rooted teeth [1,2]. Furcation involvement is divided into different types based on the degree and type of involvement, and the correct diagnosis of these lesions is the basis of a successful treatment [4,6]. For the detection of furcation lesions, the most commonly used method is the use of radiographic methods. Although in primary lesions, radiologic study may not help in diagnosing [5].

Today, the use of paper print instead of radiography plate for displaying the images provided by indirect digital radiography technology has become more prevalent in some imaging centers in the country due to unfair sanctions in recent years and a significant increase in the price of radiography plates. Nevertheless, some radiologists have always questioned the quality of these printed images [11]. Obviously, if the amount of images changes and the quality of the images that are printed are more than acceptable, there will be serious problems and mistakes in the diagnosis and treatment plan [10]. So far, various studies have directly or indirectly investigated the quality of digital radiography on a glossy or regular paper, which is somewhat contradictory between these studies [11,12].

According to our searches, this study, for the first time in the world, examines the diagnostic power of

indirect digital radiography (PSP) and paper prints in the diagnosis of grade I, II furcation involvement in a laboratory study.

It should be noted that given the agreement of 100% between observers in their observations, the results obtained from the observations were presented as a single result (the Kappa agreement coefficient is 100%).

In our study, there was no significant difference between the degree of diagnostic sensitivity of radiographic image plates and paper prints in grade I and grade I, II (both grades together) furcation involvement, but in grade II furcation involvement, plate sensitivity was significantly higher than paper print. There were also no significant differences between the plate specificity and paper print specificity. This suggests that both methods are very effective in identifying really healthy people.

It seems that simple radiography, as well as paper print is not so effective in detecting grade I lesions, and if radiography is normal and there is a strong clinical suspicion, further evaluations are needed [5].

In the reviewing the positive and negative predictive value, there were no significant differences between indirect digital images and paper print in the detection of a healthy group and those with grade I, II (both grades together) furcation involvement. Although paper print has less diagnostic power than radiography images, this difference was not significant, therefore, paper print can, if necessary, be a relatively good replacement for radiography plates.

Considering that there was no similar research in the World research texts, in the following, we review the studies on diagnostic value of paper print in comparison to radiography plates in detecting other dental problems:

Similar to our study, Schulz et al. in an experimental study examined the diagnostic quality of commonly used printers individually for the detection of dental lesions and dental samples on a glossy paper. Radiographies were printed on ink-jet printers and dye-sublimation printers, and observers review the radiographies printed, as well as standard display of radiography on a monitor. The diagnostic accuracy was high for all printers and with a confidence level of 90%, no significant difference was found between the accuracy of the printer and monitor display [13]. Although the methods for evaluating images in this study were different from the present study (plate vs. monitor display), but the results of both studies are very close together, and indicates that although radiological judgment on the plate is preferred and is closer to the reality, but in cases of lack of access to it, paper print can be a good alternative to the plate.

Otis et al. evaluated the precision and accuracy of diagnosis of the proximal caries by radiography plate vs. photographic paper print. The images were in

two formats, one in dimensions of 3 × 4 cm and 1: 1 magnification, and other one in dimensions of 6 × 8 cm and 1: 4 magnification, and they were printed with 600 dpi quality with Medical ink-jet printer, and 14 dentists evaluated the images. The result was that the reduction in diagnostic sensitivity in the evaluation of enamel caries in a small format was seen in 6 printed images, but no significant differences were found between the two methods in the large format of the images, and in the study of dentin dental caries, paper print was identical to radiography film. In general, they found that the printed images could be used to detect the caries and the information obtained was equal to the standard radiographies [12]. Although the study was on caries and not on furcation involvement, but in their study, radiography plate was better than paper print in detecting lesions in small formats, which suggests a better diagnosis of detail, and it seems both studies concluded that the radiography plate worked better in detecting the details.

Bely et al. conducted a study in Germany in order to evaluate the diagnostic quality of radiography film and paper print. In this study, the phantom used included 60 high-contrast test objects and 60 low-contrast test objects. In half of them, cavities were made in diameters and depths of 0.5 to 2 mm. 15 radiographies from different areas of these objects were prepared and paper print were prepared from these images by high-quality prints. The diagnostic sensitivity of small lesions in radiographies on paper prints are significantly lower than that of the film, and therefore, the paper print diagnostic ability for evaluating small lesions is lower [11]. In our study, although with different approach, we find the details of radiography plate superior.

Benediktsdóttir et al. compared the radiography accuracy of 3 methods of "viewing images on a computer monitor, printed copies on glossy paper, and on blue transparent film" with each other in diagnosis and evaluation of the position and morphology of mandibular third molar. The evaluations were compared with surgical findings at the time of operation ("gold standard diagnosis"). Data analysis showed little difference in the diagnostic power of these three approaches compared to each other. Therefore, these differences were minor and negligible [14]. Although one of the methods for evaluating images was different in two studies (plate vs. monitor display), and their study was conducted on third molar, their results also confirmed the use of paper prints.

The limitations of this study were to collect high numbers of healthy teeth and also to investigate this invitro. Therefore, it is suggested that studies with larger sample size and *in vivo* should be done.

### CONCLUSION

Regarding the fact that there was no significant difference in the sensitivity and specificity of radiography plate

and paper print in detection of the grade I, II furcation involvement; In general, in cases of lack of access to radiography plates for the detection of furcation involvement, the use of paper prints due to their relatively good sensitivity and specificity is a justifiable and an appropriate action. However, it is worth noting that given the increased sensitivity in evaluating the grade II involvement, if radiography plate is accessible, it is certainly preferable to use it.

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### CONFLICT OF INTEREST

Authors have no conflict of interest to declare.

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