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Comparing Diagnosis Accuracy of Indirect Digital Preapical Radiography (PSP) and Paper Print in Assessing External Resorption in Cervical Root Area

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Abstract: **Background and aim:** Identifying exterior resorption of root can be challenging particularly when no clinical symptoms are observed. This study compares accuracy of indirect digital preapical radiography (PSP) and paper print in detecting exterior resorption in cervical root area.

Methodology: This study was performed on 60 single-root premolar teeth. Cavities were created by diamond circular milling machine with low speed and 1mm diameter. In this paper, indirect digital preapical radiographies (PSP) were provided from teeth and then they were printed by laser printer for radiography stereotypes and then they were printed on silk paper for paper print and then they were studied by two observer in half-dark room. Results were analyzed by SPSS software (22th version) through Kappa ,McNemar and Spearman correlation tests.

Results: Generally, sensitivity and specifity were respectively 90% and 40/8% for digital image and were 86/7% and 45% for paper print. There was no significant difference in sensitivity, specify and accuracy of digital image and paper print (p≤0/05). Positive predictive value and negative predictive value were 40/8% and 90% in digital image respectively and they were 45% and 86/7% in paper print, compatibility of digital images and reality was 0/308 and compatibility of paper print and reality was 0/317. There was significant difference between digital image method and reality and paper print and reality (p<0.001).

Conclusion: Generally, sensitivity and specificity of digital image was close to paper print. However results obtained from digital image in different depth of artificial resorption were different so that digital image had higher sensitivity and specificity in small resorption with 0/5mm depth.

Keywords: Exterior Resorption of Root, PSP, Paper Print.

INTRODUCTION

Root canal analysis is multi-cause approach which causes irreversible loss of dental structures and loss of dental hard tissues (dentin and cement) by osteoclasts (1). Pathologic root analysis might be created due to orthodontia treatments, intracoronal bleaching, traumatic damage to teeth, apical periodontitis, dentigerous cysts, neoplasms, auto transplantation or idiopathicfactors (2,3).

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This resolutive process is continuing for two to three weeks. If the tooth stimulation persists by infection or pressure, odontoblast continues to be active and cause resorbs root so they are harmful for tooth (4). Due to damage of surface cells that protect the root, inflammatory or replacement resorption happens in part of root (5). Cervical resorption is an external resorption that is called odentoblastoma or invasive external resorption of the canal. There is no definite reason for this resorption, however variant etiologic factors might be the possible cause including dental trauma, Intracoronal bleaching, orthodontia treatments, periodontitis treatments (6).

External cervical root resorption is mostly based on clinical examinations and radiography. Radiographies from different angles might clarify involving surface, however they do not show three dimensional image from created flaw (7,8). One of the problems with identifying root resorption by intraoral radiography is restriction they have for providing diagnostic information (4). Their information is restricted to a three dimensional anatomy in on two dimensional image. In addition, image size might estimate the resorption smaller than its real size (9). Detection of resorption can be challenging because incorrect detection may cause inaccurate treatment. Accurate diagnosis is basis and foundation of appropriate treatment (4,9). Diagnostic efficacy in clarifying place and size of external resorption of root is necessary for an accurate treatment and successful treatment in turn (10).

Today, there are various radiography films in the market produced and generated in order to reduce radiation dose for obtaining optimal images (11). Harmful effect of insufficient development and processing have negative effect on diagnostic quality of films and problems related to protecting chemical solutions of development and processing in optimal quality of conventional imaging(12). Digital imaging revolved radiography. In digital radiography there is no film and chemical development and processing. The numbers of bad images and patient exposure are reduced in turn. In these systems, receptors transfer visual information to computer and see it immediately on monitor, so it has capacity for changing image quality including contrast, density and also storing and transferring it to other centers (8,9,13). Digital imaging in dentist has been initiated from recent years and dentists are increasingly applying them (14). Consequently, more companies are producing software and hardware for direct digital imaging. Clearly, radiographic detection needs high diagnostic power of conventional anatomy and it has also undeniable effect on diagnostic power impacted by mean utility (for example diagnosis of caries, periodontal lesion and implant), quality and method of image processing (15).

Indirect digital method is able to change image quality, darkness rate and film contrast, magnification, use software tools for measurement, image storage in low volume, rapid transfer to other centers and easy access to it and its quality is not being changed after a while (1). Main aim of image processing is improving specifies of image in order to make it more appropriate and understandable for a special application. In this process, one or some specificities of image are corrected. Method of selecting these specificities and correcting image are determined based on considered application (16).

Considering a) ever-increasing of using indirect digital technology in different diagnostic and treatment situation and b) limitations and difficulties of this method such as film lack, lack of interior production, its high cost, problems of protecting them favorably and preventing low quality of image and regarding printing industry improve in recent decades and different paper prints with high quality in different industrial field and also good quality of paper in photography, we decided to use this method and compare diagnosis accuracy of indirect digital pre apical radiography (PSP) and paper print in detection of external cervical root lesion.

MATERIALS AND METHODS

This study was in vitro experimental study on 60 mandibular single rooted premolar teeth (#4,5) and maxillary rooted premolar teeth (#5) . Inclusion criteria was mandibular rooted premolar teeth (#4,5), maxillary rooted premolar teeth (#5), extraction of these teeth due to orthodontia or periodontal problem and there is no broken, cracked, decayed or suffering from external resorption of the root.

For repairing resorption, cervical part of root was used. Then teeth were divided into 4 groups randomly out of which one group with 18 teeth remained with no resorption (Group A) and in three subgroups with 14 teeth resorptions were generated in three different size:

1) A group without resorption (group A)
2) Cavities with small sizes (0/5mm) (group B)
3) Cavities with average size (1mm) (group C)
4) Cavities with large size (1/5 mm) (group D)

Crowns were located on plaster stand and cavity were created by diamond circular milling Machin (Buchler Ltd, Lake Bluff. IL, USA) with low speed in 1mm diameter so that for creating mentioned cavity half of milling machine diameter was interred into tooth surface. These cavities were created in mesial or distal part. Creating cavities in proximal part in each groups is as follow:

In Group A (n=18) no teeth had resorption. In Group B, in proximal (mesial or distal) part, 5 mm cavity was created and in some teeth 1 mm, and 1.5 mm and 0 mm cavities were created by milling machine. In group C in two teeth cavity were created with 1 an 1 mm, in two teeth 0/5 and 1, in other two teeth 1/5 and 1/5, in other two 1/5-0/5 and in 2 teeth 1/5-1 and in 8 teeth 1/5-0 mm diameter cavities were created.

Teeth were taken carefully from plaster base and then they were placed on sheep's jaw separately and randomly in groups with 10 teeth. Simulation of soft tissue was conducted by covering the bone with three layers wax in buccal and lingual parts then indirect digital preapical radiography (PSP) was provided by de Gotzen (Italian design) machine with 70 kVp exposure, 0 milliamper second, 0.32 seconds in parallel way. Indirect digital preapical radiography images are indicated in following figures:

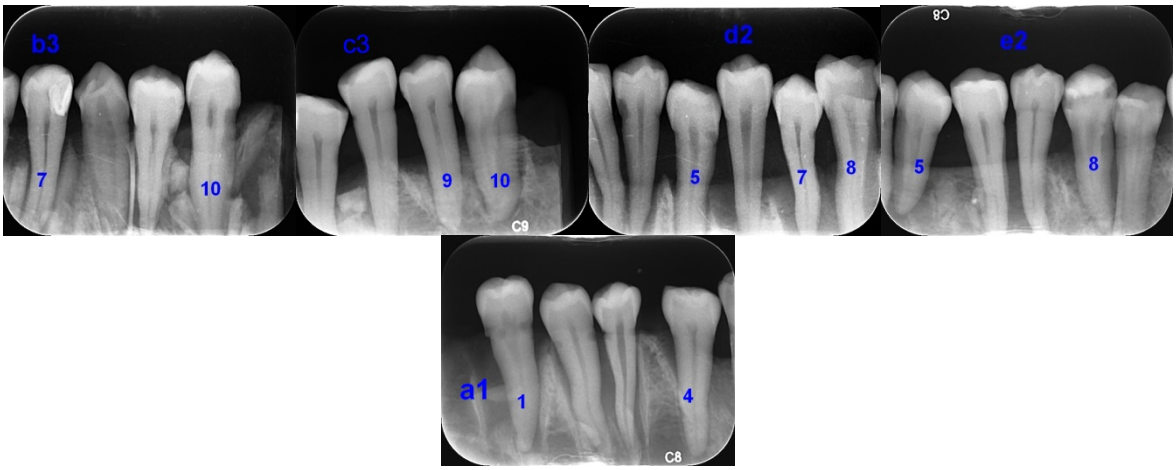

Figure 1: Indirect digital preapicalradiography images

Then it was processed by Digoraoptime (Soredex, Finland). After preparing radiographies by Scanora software, images were designed in mentioned size with the size and similar to film size and then radiography stereotypes were printed by laser printer Fuji, Japan).and then they were printed on Silk paper ((Fuji, Japan)) for providing paper print with Noritzu 3202 (Japan).Dry Pix, Prima).

Images were evaluated separately by 2 radiologists with at least 2 years' experience in observing digital images. Images were observed in one week interval. Observers were ignorant to resorption distribution. Thus the study was performed single blind way. Observers reported lesion existence or nonexistence; then their sensitivity and specificity of each method were calculated. Observers were not restricted in terms of time. Paper prints were studied in similar conditions considering environment light for observer and in observation time. Indirect digital images (PSP) were observed in half dark room on one negatoscope. In radiographies, cervical lesion was detected by radiolucent areas around the tooth neck. If there was no radiolucent area around the neck, tooth was considered healthy. Before diagnosis of radiography images, aim of the study and way of assessing image and required knowledge were explained to the observers. Then data was provided for statistical analysis to statistic consultant.

Results of the study were analyzed by SPSS software 22th version. So that indices intended to be estimated including Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value were calculated. In addition, by Mc Nemar test ad crosstabs and Kappa test, significant difference between diagnoses performed by observers and reality were investigated. Sensitivity and specificity were conducted by roc curve analysis. Furthermore, Spearman rank correlation coefficient was used for investigating sensitivity and specificity of radiography methods among intra observer and observers themselves. Significance level for all statistical tests was $P \leq 0.05$.

RESULTS

Data were studied in three groups: first observer, second observer and then both. According to Spearman correlation coefficient, agreement between intra observers was 100% among observers in two times observing and then we took one observation into consideration. Sensitivity, properties, accuracy of observer in different exterior resorption were indicated in table 1 and diagram 1 and 2.

Generally, no significant difference was observed between first observer and second observer in sensitivity, specificity and accuracy of digital stereotypes and paper print (P≥0.05).

In small resorptions with 0/5 mm depth there was no significant difference in sensitivity, accuracy of digital stereotypes and paper print (P≥0.05). There was significant difference in specificity of digital stereotypes and paper print (p≤0/05). In first observer's attempt, there was no significant difference in sensitivity, specificity and accuracy of digital stereotypes and paper print (P≥0.05). In small resorptions with 0/5 depth, based on second observer's observation, there was no significant difference between sensitivity of digital image and paper print (p≤0/05). However there was no significant difference between specificity and accuracy of digital image and paper print (P≥0.05). In addition, there was significant difference between accuracy of digital image and paper print in diagnosing external root resorption with 0/5 depth in second observer (P≤0.05).

In average resorptions with 1mm depth there was no significant difference in sensitivity, specificity and accuracy of digital image with paper print (P≥0.05). In first observer, there was no sighificant difference between sensitivity, specificity and accuracy.In second observer, there was no significant difference between sensitivity and accuracy of digital images and paper print (P≥0.05). But there was significant difference between digital images specificity and paper print (P≤0.05).

In large resorptions with 15 mm depth there was no significant difference between sensitivity and accuracy of digital images and paper print (P≥0.05). However there was significant difference between specificity of digital images and paper print (P≤0.05). In first observer there was no significant difference between digital image and paper print (P≥0.05). However there was significant difference between specificity of digital image and paper print (P≤0.05). in addition there was no significant difference between accuracy of digital image and paper print in diagnosis of large resorptions with 1/5 mm depth (P≥0.05). In second observer there was no significant difference between sensitivity, specificity and accuracy of digital image with paper print in diagnosis of large resorptions with 1/5 mm depth (P≥0.05)

Table 1: results related to each observers in different depth of exterior resorption

P value	accuracy	P value	specify	P value	sensitivity	Graph type	Observer	Resorption depth
0.05≥	65.4%	0.05≥	40.8%	0.05≥	90%	Digital stereotypes	First and second Observers	Total
	65.8%		45%		86.7%	Paper print		
0.05≥	58.3%	0.05≥	33.3%	0.05≥	83.3%	Digital stereotypes	First Observer	
	61.7%		38.3%		85%	Paper print		
0.05≥	73.5%	0.05≥	48.3%	0.05≥	96.7%	Digital stereotypes	second Observer	
	70%		51.7%		88.3%	Paper print		
0.05≥	65%	0.05≥	45%	0.05≤	85%	Digital stereotypes	first and second Observer	Mm0.5
	53.5%		40%		65%	Paper print		
0.05≥	50%	0.05≥	30%	0.05≥	79%	Digital stereotypes	First Observer	
	45%		40%		60%	Paper print		
0.05≤	80%	0.05≥	60%	0.05≤	100%	Digital stereotypes	second Observer	
	60%		50%		70%	Paper print		
0.05≥	57.5%	0.05≥	20%	0.05≥	95%	Digital stereotypes	First and second Observer	Mm1
	65%		30%		100%	Paper print		
	55%	0.05≥	20%	0.05≥	90%	Digital stereotypes	first Observer	
	60%		20%		100%	Paper print		
0.05≥	60%	0.05≤	20%	0.05≥	100%	Digital stereotypes	second Observer	
	70%		40%		100%	Paper print		
0.05≥	60%	0.05≤	30%	0.05≥	90%	Digital stereotypes	First and second Observers	Mm1.5
	65%		45%		85%	Paper print		
0.05≥	60%	0.05≤	30%	0.05≥	90%	Digital stereotypes	first Observer	
	65%		50%		80%	Paper print		
0.05≥	60%	0.05≥	30%	0.05≥	90%	Digital stereotypes	second Observer	
	65%		50%		90%	Paper print		

Based on table 2, results indicated that there is no significant difference in specify and sensitivity in detection of exterior resorption between observers (P≥0.05).

Table 2: Comparing Spearman correlation coefficient in specify and sensitivity of radiographies in detecting exterior resorption in cervical area of root in each observer

Observer						Radiography method
P-value	total	P-value	Second	P-value	First	
0.056	0.354	0.064	0.514	0.088	0.192	Digital stereotypes
0.058	0.348	0.078	0.430	0.085	0.264	Paper print

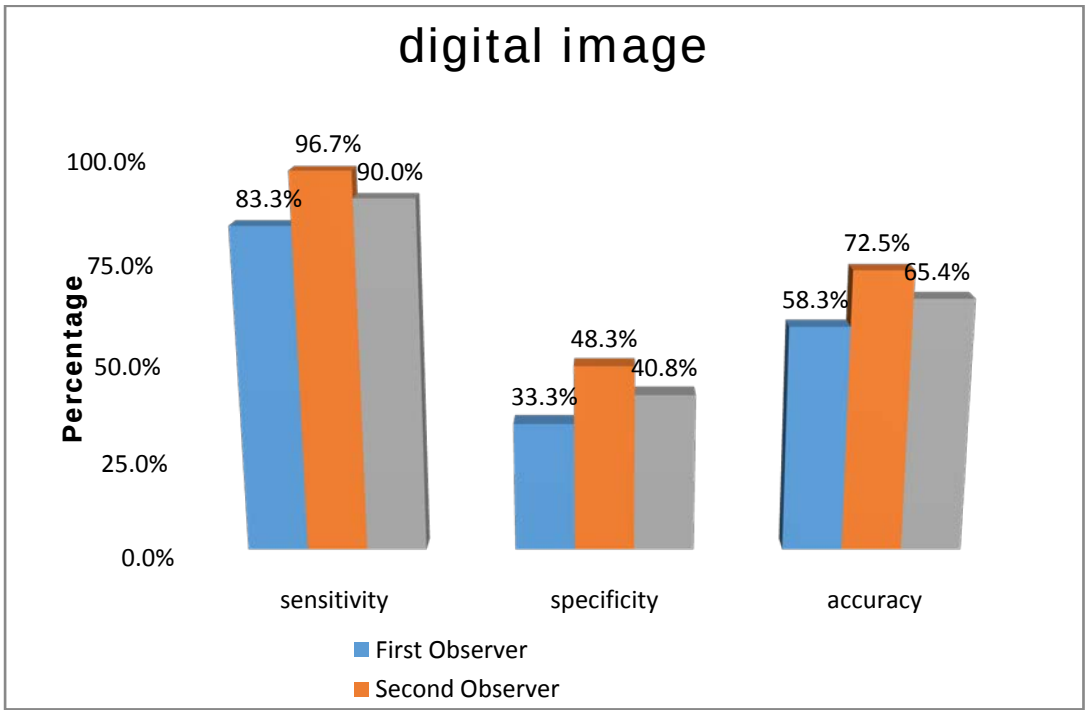

Diagram 1: comparing sensitivity, specify and accuracy in observers in digital image

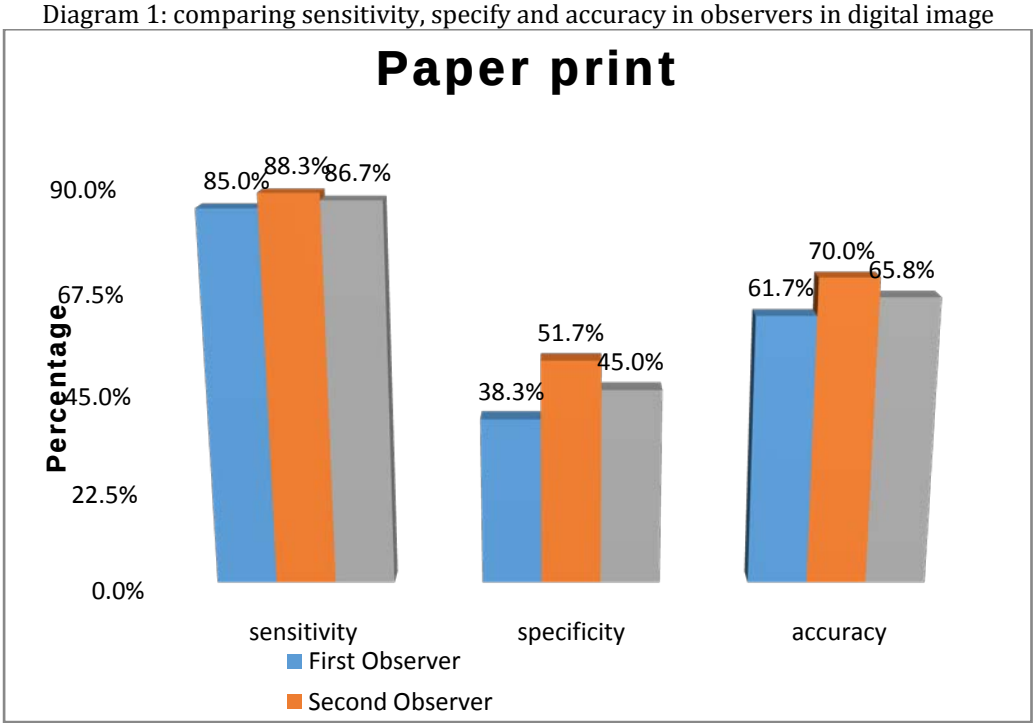

Diagram 2: comparing sensitivity, specify and accuracy in observers in paper print

Generally positive predictive value and negative predictive value in digital image method was 8%, 40% and 90% respectively. McNemar test indicated that there is significant difference between digital image and reality (p<0/001). The agreement between digital images and reality is 0/308. Generally, positive predictive value and negative predictive value in paper print method was 45%, 86.7% respectively. McNemar test indicated that there is significant difference between paper print and reality (p<0/001). The agreement between paper print images and reality is 0/317.

Generally, in first observer, positive predictive value and negative predictive value in digital image method was 33.3% and 83.3% respectively. McNemar test indicated that there is significant difference between digital image and reality (p<0/001). The agreement between digital images and reality is 0/167. Generally, positive predictive value and negative predictive value in paper print method was 38.3%, 85% respectively. McNemar test indicated that there is significant difference between paper print and reality (p<0/001). The agreement between paper print images and reality is 0/233.

Generally, in second observer, positive predictive value and negative predictive value in digital image method was 48.3% and 96.2% respectively. McNemar test indicated that there is significant difference between digital image and reality (p<0/001). The agreement between digital images and reality is 0/450. Generally, positive predictive value and negative predictive value in paper print method was 51.7%, 88.3% respectively. McNemar test indicated that there is significant difference between paper print and reality (p<0/001). The agreement between paper print images and reality is 0/400.

DISCUSSION

Root resorption is, indeed, hard tissue loss (dentin and cement) due to odontoblast cells' activity. This resorption process is continued only for two or three weeks. Although incitation might be continued by infection or pressure, odontoblasts continue their activation and cause resorption of root and damage tooth seriously (9).

Exterior resorption happens due to additional mechanical forces on tooth such as orthodontia treatments (9,12), preapical inflammation (8), cysts and tumors (11,12), dental trauma and additional occlusal forces (10-12), thick aloever grafts, lack of hormone balance, Intracorona Bleaching, paget's disease (11), local involvement of Herpes zoster (11), apical periodontitis (7,11,13,14), changing tooth place, bad tooth eruption (1, 16,17), pressure from latent tooth (5, 18,19,20). In radiography, exterior resorption is similar to a surface damaged by moth and it is represented as an area more radiolucent than other areas of tooth structure. If lesion does not damage pulp canal, accurate observation by radiography does not show unchanged canal in lesion area (11,21,22).

In different studies there are different factor effective on diagnosis of root resorption which include ray angle, exposure factors, sensitivity of visual receptor, processing factors, condition of image observation, place of root resorption and clinical status of tooth. In spite of all complicated issues, most of patients' root surface is treated if it is diagnosed early and incitation element is eliminated. The sooner the treatment is started root resorption is less severe (23).

Few studies have been performed on this subject: in a study it was indicated that PSP radiography in apical area had better sensitivity than other parts of the root in large and average resorptions which were probably due to thin and cone form of root tip so large lesions can be diagnosed by change of radiography angle and increment of clarity and vividness by digital software.

Vasconcelos et al (2017) assessed diagnostic accuracy of phosphor plate systems and conventional radiography in the detection of simulated internal root resorption. 20 single rooted teeth were used. Results proved similar function of normal radiography and PSP in detection of simulated internal root resorption (24).

Tallaeypor et al (2016) evaluated the diagnostic accuracy of digital intraoral radiography with PSP and CBCT in detection of horizontal and vertical dental root fractures. 60 mandibular teeth were evaluated. Results indicated that CBCT has higher sensitivity and specificity than PSP in detection of horizontal and vertical dental root fractures (25).

Abesi et al (2016) evaluated the agreement of paper and film printed panoramic radiographs in detection of dentinal caries. Radiographic images of 150 patients were used. Results indicated that Kappa coefficient rate between film prints and paper prints was 0.88 and 0.92 between monitor and film prints, respectively. So paper prints, as opposed to film prints, could be useful in diagnosis of dentinal caries in panoramic radiographies (26). Otis et al (2005) assessed the accuracy of caries diagnosis via radiograph: film versus print in detection of proximal decays. The authors digitized 15 posterior bitewing radiographs and printed them on photographic paper. Results indicated that he diagnostic accuracy of printed images

did not differ significantly from radiographic film images for dentinal caries (27). Mehralizadeh et a (2009) conducted a research titled as "comparison between digital intraoral radiography (PSP) and Cone Beam CT images in detection internal root resorption (in-vitro study)". They concluded that paper print's quality is similar to digital radiography so it can be used as tools of transferring digital radiography (28). In this study, it was illustrated that in average and large resorptions, sensitivity and specificity of radiography and paper print are approximately similar to each other so there was no significant difference in both methods.

Sakhdari et al (2015) studied diagnostic accuracy of charge-coupled device sensor and photostimulable phosphor plate receptor in the detection of external root resorption. They studied only 40 maxillary incisor teeth. No significant difference was observed between sensitivity and specificity of both methods and CCD was more valid that PSP censor. However there was no significant difference (29).

Bagis et al (2015) compared intraoral radiography and cone-beam computed tomography for the detection of periodontal defects. Samples included 10 maxillary and mandibular skulls. Results indicated that CBCT has highest sensitivity and specifitiy in dection of different periodontal flaws in different technics of radiography (two dimensional, three dimensional, PSP ،(Field of view) FOV ،TIFF (Tagged image file format) TFT(Flat-panel color-active matrix thin-film transistor (30,31).

Mesgarani et al (2014) studied accuracy of conventional and Digital radiography in detecting external Root Resorption. They used 80 mandibular premolar teeth. There was no significant different in those three method in detecting External Root Resorption.

Shokri et al used conventional intraoral film radiography, CCD, PSP, and CBCT for detecting External Root Resorption. They studied 54 maxillary premolar teeth. They studied showed there is no difference in different imaging methods in accurate detection of root analysis in all sizes (32). However in this study 60 maxillary and mandibular single rooted premolar teeth were used and it was clarified that sensitivity and specificity of PSP is higher than paper print.

Abesi et al (2012) studied diagnostic accuracy of digital and conventional radiography in the detection of Non-Cavitated proximal dental caries. 72 non-cavitated approximal surfaces of extracted human posterior teeth were radiographed. Results demonstrated that the diagnostic accuracy of digital images is similar to that of conventional film radiography in the detection of non-cavitated proximal caries.(33)

Kamburog˘lu et al (2008) compared diagnosis of artificially induced external root resorption using conventional intraoral film radiography, CCD, and PSP. In contrast to our results they found that digital imageof PSP has better results that paper print. In their study it was indicated that PSP has lower quality that intraoral conventional film and CCD receptor (34). May be its due to using circle milling Machin with 0/5 mm, 0/8 mm and 1/2 mm diameter while in this study they used 3 observer.

In Borg et al study (1998) the investigated effectiveness of PSP censors and CCD, and conventional radiography in detection of simulated root resorption cavities. Both censors had similar results (35).

Tirell et al (1996) used film and digital radiography for detection of simulated root resorption cavities for interpretation of chemically created lesions using direct digital images. They concluded that when there is no lesion, there is not significant difference between indirect digital technique and conventional radiography. However digital radiography showed lesions much more clear. But there is no significant difference between both techniques in shoeing lesion (36). Our study proved results of sensitivity and properties of radiography film and paper print are approximately similar.

CONCLUSION

Generally, sensitivity and specificity of digital image was close to paper print. However results obtained from digital imagein different depth of artificial resorption were different so that digital imagehad higher sensitivity and specificity in small resorption with 0/5mm depth.

REFERENCES

[1] Bakland L. Root resorption. Dent Clin North Am. 1992; 36 (2): 491-507.

[2] Andreasen JO AF. Essentials of traumatic injuries to the teeth: a step-by-step treatment guide. Munksgard: Copenhagen; 2000.

[3] Gunraj M. Dental root resorption. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1999; 88 (6): 647-53.

[4] Patel S DA, Wilson R, Horner K, Mannocci F. The detection and management of root resorption lesions using intraoral radiography and cone beam computed tomography - an in vivo investigation. Int Endod J. 2009; 42 (9): 831-8.

[5] Ne R, Witherspoon DG, JL. Tooth resorption. Quintessence Int. 1999; 30 (1): 9-25.

[6] Naser AZ, Farhadi N, Sepahvand M, Jafari N, Khorrami L, Shokraneh A. Comparison of the effects of lightening solutions and indirect digital technique on enhancement of the diagnostic quality of dark periapical radiographs. Journal of Isfahan Dental School. 2012; 8 (5): 463-9.

[7] Eraso F, Parks E, Roberts W, Hohlt W, Ofner S. Density value means in the evaluation of external apical root resorption: an in vitro study for early detection in orthodontic case simulations. Dentomaxillofac Radiol. 2007; 36 (3): 130-7.

[8] Ruddle C, Cohen S, Burns R. Pathways of the pulp. 2002. Philadelphia: St Louis. 8th. [115-28].

[9] Whites S, Pharoah M. Oral radiology principle and interpretation. 4th ed. W.C SANDERS: St Louis; 2000. p: 223-227.

[10] Goldberg F, De Silvio A, Dreyer C. Radiographic assessment of simulated external root resorption cavities in maxillary incisors. Endod Dent Traumatol. 1998; 14 (3): 133-6.

[11] Wang A MP, Moule AJ, Basford KE. A comparison of Kodak ultraspeed and Ektaspeed plus dental x-ray films for detection of dental caries. Aust Dent J 2002; 47 (1): 27-9.

[12] Razmus T, Williamson G. Current oral and maxillofacial imaging. Philadelphia1996.

[13] Seltzer S. Endodontology. 2nd ed. Philadelphia: Lea & Febiger; 1998. p:

[14] Wenzel A, Moystad A. Experience of Norwegian general dental practitioners with solid state and storage phosphor detectors. Dentomaxillofac Radiol. 2001; 30 (4): 203-8.

[15] Dabaghi A, Sharifi S, Shams N, Bayati S, Feiz A, Mohagheghi SA. Comparison of Different Medical Image Processing Techniques on Perception of Anatomical Structures and Overall Image Quality in Direct Digital Panoramic Radiographs. Jundishapur Sci Med J. 2014; 13 (4): 375-87. [Persian].

[16] Gijbels F, De Meyer AM, Bou Serhal C, Van den Bossche C, Declerck J, Persoons M, et al. The subjective image quality of direct digital and conventional panoramic radiography. Clin Oral Investig. 2000; 4 (3): 162-7.

[17] Fuss Z, Tsesis I, Lin S. Root resorption--diagnosis, classification and treatment choices based on stimulation factors. Dent Traumatol. 2003; 19 (4): 175-82.

[18] Pindborg JJ. Pathology of the dental hard tissues. Copenhagen, Denmark: Munksgaard; 1970. p: 338.

[19] Shafer WG, Hine MK, Levy BM. A textbook of oral pathology. 4 ed. Philadelphia PA: WB Saunders company; 1983. p: 328-332.

[20] Benenati FW. Root resorption: types and treatment. Gen Dent. 1997; 45 (1): 42-5.

[21] Kanas RJ, Kanas SJ. Dental root resorption: a review of the literature and a proposed new classification. Compend Contin Educ Dent. 2011; 32 (3): e38-52.

[22] Bender IB, Byers MR, Mori K. Periapical replacement resorption of permanent, vital, endodontically treated incisors after orthodontic movement: report of two cases. J Endod. 1997; 23 (12): 768-73.

[23] Dalili Z, Taromsari M, Mohtavipoor S, Ojhand I. Comparison between CMOS digital detector and film in detection of simulated external root resorption: an in vitro study. J Mash Dent Sch. 2011; 35 (2): 73-84. [Persian].

[24] Vasconcelos KdF, Rovaris K, Nascimento EHL, Oliveira ML, Távora DdM, Bóscolo FN. Diagnostic accuracy of phosphor plate systems and conventional radiography in the detection of simulated internal root resorption. Acta Odontol Scand. 2017; 75 (8): 573-6.

[25] Tallaeypor AR, Hafezi L, Yarahmadi A, Ghaznavi A, Iranparvar A, Sahabi L. Comparison of the diagnostic accuracy of digital intraoral radiography with PSP and CBCT in detection of horizontal and vertical dental root fractures. J Res Dentomaxillofac Sci. 2016; 1 (4): 32-8.

[26] Abesi F, Baghbani F, Haghanifar S, Khafri S. The Agreement of Paper and Film Printed Panoramic Radiographs in Detection of Dentinal Caries. Journal of Dentomaxillofacial Radiology, Pathology and Surgery. 2016; 5 (4): 23-5.

[27] Otis LL, Sherman RG. Assessing the accuracy of caries diagnosis via radiograph: Film versus print. The Journal of the American Dental Association. 2005; 136 (3): 323-30.

[28] MehrAli Zadeh S, Talayi poor A, Mehrvarzfar P, Edalat M, SHarifi SHoushtari S. Comparison between digital intraoral radiography (PSP) and Cone Beam CT images in detection internal root resorption (in-vitro study). journal of research in dental sciences. 2016; 13 (2): 102-8. [Persian].

[29] Sakhdari S, Khalilak Z, Najafi E, Cheraghi R. Diagnostic Accuracy of Charge-coupled Device Sensor and Photostimulable Phosphor Plate Receptor in the Detection of External Root Resorption In Vitro. J Dent Res Dent Clin Dent Prospects. 2015; 9 (1): 18-22.

[30] Bagis N, Kolsuz ME, Kursun S, Orhan K. Comparison of intraoral radiography and cone-beam computed tomography for the detection of periodontal defects: an in vitro study. BMC oral health. 2015; 15 (1): 64.

[31] Mesgarani A, Haghanifar S, Ehsani M, Yaghub SD, Bijani A. Accuracy of Conventional and Digital Radiography in Detecting External Root Resorption. Iran Endod J. 2014; 9 (4): 241-5.

[32] Shokri A, Mortazavi H, Salemi F, Javadian A, Bakhtiari H, Matlabi H. Diagnosis of simulated external root resorption using conventional intraoral film radiography, CCD, PSP, and CBCT: a comparison study. Biomed J. 2013; 36 (1): 18-22.

[33] Abesi F, Mirshekar A, Moudi E, Seyedmajidi M, Haghanifar S, Haghighat N, et al. Diagnostic Accuracy of Digital and Conventional Radiography in the Detection of Non-Cavitated Approximal Dental Caries. Iran J Radiol. 2012; 9 (1): 17-21.

[34] Kamburoglu K, Tsesis I, Kfir A, Kaffe I. Diagnosis of artificially induced external root resorption using conventional intraoral film radiography, CCD, and PSP: an ex vivo study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008; 106 (6): 885-91.

[35] Borg E, Kallqvist A, Grondahl K, Grondahl HG. Film and digital radiography for detection of simulated root resorption cavities. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1998; 86 (1): 110-4.

[36] Tirell B, Miles D, Brown C, Legan J. Interpretation of chemically created lesions using direct digital images. J Endod. 1996; 22: 74-8.