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Comparison of the Diagnostic Efficacy of Multi-Angled Digital Radiography and Cone-Beam Computed Tomography in Diagnosis of Root Perforation in Mandibular Molar Teeth

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Abstract

Root perforation (RP) is an important complication that can result in problematic orthodontic treatments. Therefore, early diagnosis of RP is necessary and of high importance. Current reports indicate the higher efficiency of Cone-Beam Computed Tomography (CBCT) compared to digital radiography (DR). This study aims to compare the efficacy of multi-angled DR and CBCT in the diagnosis of RP in mandibular molar teeth. Materials and methods: This diagnostic study checked 60 mandibular molar teeth. The studied teeth were groped in random in 4 equal groups namely: perforated obturated mesiobuccal, perforated without obturated, obturated imperforated and imperforated no-obturated. Digital radiography was conducted in mesial, distal and parallel views and CBCT was conducted in axial and cross-sectional views. Finally, the diagnostic value of both techniques was compared. Results: Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of DR and CBCT were 82% versus 27%, 83% versus 96%, 83% versus 63%, 82% versus 88% and 83% versus 58%, respectively. The sensitivity and negative predictive value of DR in no-obturated teeth was zero with an accuracy of 50% while those of CBCT were in an ideal level. In obturated teeth, however, CBCT showed a high sensitivity, a higher positive predictive value and a higher accuracy, compared to DR. **Conclusion:** CBCT has a higher diagnostic efficacy than DR in diagnosing PR in mandibular molar teeth.

Keywords: Cone-Beam Computed Tomography, Digital Radiography, Molar Tooth, Root Perforation

Introduction

Root perforation (RP) is the establishment of an artificial relationship between pulp cavity and periodontal tissues or a relationship between root canal and the external surface of root (Krupp and et al, 2013). Despite technological advances in endodontic methods, even experienced dentists may experience several problems, including RP, in every stage of endodontic treatments (Ng and et al, 2011). Previous studies have reported that iatrogenic RP occur in 2 to12 percent of cases (Farzaneh and et al, 2004; Shemesh and et al, 2011; Tsesis & Fuss, 2006 AlRahabi, 2017). Majority of such RPs occur due to canal position and special curvature of canal in mandibular molar teeth (Tsesis and et al, 2010).

RP threatens endodontic treatments and arises many problems. Therefore, early and accurate diagnosis of RP in teeth that have been previously underwent endodontic treatment is of high importance and can provide great help in selecting suitable treatment strategy, minimizing bone defect and predicting prognosis (Alhadainy, 1994). However, the accurate diagnosis of RP, especially in buccolingual surface of canal, is a challenging task because it needs scanning techniques to observe both the studied tooth and its adjacent bone tissues (Pretty & Maupomé, 2004; Bernardes and et al, 2009l Fuss and et al, 1996; Tamse, 2006). The treatment of such iatrogenic problems demands the accurate diagnosis of them so that the definitive diagnosis of RP affects tooth prognosis. Despite all advances in scanning techniques, radicular changes, such as RP, have still been remained as challenging discussions (Gordon, & Chandler, 2004). Different tools and methods, including electronic apex locater, surgical microscopy, endoscopy and different radiography techniques including panoramic radiography, conventional or multi-angled digital radiography, have been suggested to diagnose RP (Kim & Kratchman, 2006). Moshonov and et al, 2009; Haghanifar and et al, 2014; Kamburoğlu and et al, 2015; Koç and et al, 2018; Koç and et al, 2018; Bernardes and et al, 2012; da Silveira and et al, 2013; da Silveira and et al, 2013). Currently, periapical DR is the most conventional technique of endodontic treatments (Kamburoğlu and et al, 2015; Bernardes and et al, 2012;Takeshita and et al, 2013). Although the techniques have their own advantages and provide acceptable images of mesio-distal views, they fail to provide suitable images of buccolinual view (Kamburoğlu and et al, 2011). Multi-angled radiography fails to show the size and accurate position of RP due to the compression of a 3D structure in a 2D image and the overlap of anatomic structures and beam angle (Tsurumachi & Honda, 2007). CBCT has recently been introduced as a beneficial tool for diagnosing radicular problem, and determining the properties of periapical lesions and healing process. It has attracted researchers' attention (Shemesh and et al, 2011; Kobayashi and et al, 2004; Kamburoğlu and

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et al, 2010;Shokri and et al, 2015). Making decisions on utilizing/not utilizing a therapy strategy or a diagnosis technique demands further studies. Therefore, this study aims to compare the diagnostic efficacy of multi-angled DR and CBCT in diagnosing RP in mandibular molar teeth.

Materials and Methods

This is a diagnostic study conducted in 2017 where 60 mandibular molar teeth that have recently been extracted were studied. Exclusion criteria were: 1) single-canal teeth, 2) teeth with natural crack, 3) internal or external resorption, 4) immature teeth, 5) calcified canal, 6) previous endodontic treatment of root and 6) no access to root due to classification. Teeth were randomly grouped in 4 groups namely: mesio-buccal perforated with obturation (PO), perforated without obturated (PWO), obturated imperforated (OI) and imperforated and no-obturated (INO). It should be mentioned that two imperforated groups were included in the study as control group.

The studied teeth were first placed in an autoclave and dried. When access cavity was created manually to prepare and form canal, the functional length of mesiocanals was measured using file #10 (k-file). Then, the epical zone of the canals was cleaned using files #15, #20 and #25. Finally, flare canal was widened up to file #75. In all stages, canals were washed by ordinary saline solution. Mesiobuccal canal was perforated 1 to 3 mm lower than forcation zone using Gits-Gilden no. 2 in axial direction so that perforation was observable from the external surface of teeth and file #25 could pass through the zone with no resistance. Mesial canals were dried using paper point 41 and were obturated using GuttaPercha and ZOE sealer. To simulate PDL space, a thin layer of wax was placed around the teeth and the teeth were mounted on blocks of chalk. In addition, to simulate soft tissues, the samples were mounted inside self-cure acrylic resin. Direct DR was conducted at 15º mesial and 15º distal angles. DR was conducted by *photo stimulable phosphor storage plate receptor and Optim Digora* (soredex, Finland) with radiation duration of 0.25 second and with a power of 65KW and 7.5 mA. The device was place 30 cm from teeth and a tube was positioned normal to the film. The prepared DR images were saved in SCANORA 4.3.1. CBCT images were prepared for all teeth in axial and cross-sectional sections with a 0.3 mm thickness cut. They were prepared by VGi cone bean Newtom (Italy) device. The primary and final regeneration were performed by viewer version 2.17NNT. Radiation specifications were as follows: scan S18 and maximum 110KVp. The device was adjusted automatically. CBCT data introduced to NNT viewer version 2.27 and studied. Finally, two maxillofacial radiologists studied the images. Kappa coefficient of interobserver reliability was >0.8 for all angles. Therefore, after evaluating the first 15 samples, all samples were evaluated by a radiologist. It should be noted that the investigators were un-informed of the samples group. Data was analyzed using SPSS 17 and the relationship between variables was evaluated by chi-square. Sensitivity, specificity, positive predictive value, negative predictive value, ROC curve and ratio test were used to compare the diagnostic efficacy of mesial radiography, distal radiography, direct radiography and CBCT in RP diagnosis. $P<0.05$ was considered as significance level.

Results

CBCT was conducted in axial and cross-sectional sections. However, in cross-sectional section, only perforated teeth were diagnosed and imperforated teeth were not diagnosed. Therefore, cross-sectional section was completely excluded from calculations.

Table 1 shows the diagnostic efficacy of multi-angled digital radiography and CBCT in RP diagnosis. According to the table, sensitivity, positive predictive value and accuracy of CBCT are higher than DR whereas it shows lower specificity and negative predictive value than DR. It should be mentioned that 6 teeth were remained undiagnosed in mesial and distal views and researchers failed to determine perforated/imperforated teeth, 2 of which were perforated and 4 were imperforated.

Table 1- diagnostic efficacy of multi-angled digital radiography and CBCT in RP diagnosis

		Sensitivity	**Specificity**	**Positive predictive value**	**Negative predictive value**	**accuracy**
CBCT (axial)		82%	83%	83%	82%	
Digital radiography	Mesial	32%	100%	68%	100%	63%
	Parallel	37%	96%	68%	91%	62%
	distal	22%	100%	61%	100%	56%

Table 2 and table 3 show the diagnostic efficacy of digital radiography and CBCT in RP diagnosis considering oburation effect. It should be noted that researchers had failed to diagnose perforation in all obturated teeth in distal and parallel views of digital radiography. This is why the rows associated with these views were removed in table 3. In addition, ratio test showed that the higher efficacy of CBCT is significant ($p<0.05$).

Table 2- diagnostic efficacy of multi-angled digital radiography and CBCT in diagnosis of PO teeth

		Sensitivity	**Specificity**	**Positive predictive value**	**Negative predictive value**	**accuracy**
CBCT (axial)		93%	68%	80%	73%	91%
Digital radiography	Mesial	53%	87%	70%	80%	66%
	Parallel	73%	87%	80%	84%	77%
	distal	40%	68%	54%	54%	55%

Table 3- diagnostic efficacy of multi-angled digital radiography and CBCT in diagnosis of PWO teeth

		Sensitivity	Specificity	Positive predictive value	Negative predictive value	accuracy
CBCT (axial)		71%	100%	86%	100%	78%
Digital radiography	Mesial	0%	93%	48%	0%	50%

Finally, the diagnostic efficacy of each test was evaluated. Table 4 shows the results. The definitive diagnosis of RP and obturation was occurred when they were diagnosed in all the three mentioned views, i.e. mesial, distal and parallel views so that if RP is not diagnosed even in one of the views, the final diagnosis was the lack of RP and obturation interventions. Table 4 clearly shows that the diagnostic efficacy of digital radiography in RP diagnosis is significantly lower than that of CBCT.

Table 4- Diagnostic efficacy of multi-angled digital radiography and CBCT in diagnosis of RP with and without obturation

	Sensitivity	Specificity	Positive predictive value	Negative predictive value	accuracy
CBCT (axial)	82%	83%	83%	82%	83%
Digital radiography	27%	96%	63%	88%	58%

Discussion

The most important finding of this study is that, axial CBCT shows a higher diagnostic efficacy in diagnosing RP with and without obturation and could be used for this purpose.

Iatrogenic RP, especially in mandibular molar teeth, is a typical problem of endodontic procedures and can be associated with different problems (Farzaneh and et al, 2004; Shemesh and et al, 2011; Tsesis & Fuss, 2006; AlRahabi, 2017). In recent years, CBCT has attracted attention for its capability of diagnosing radicular problems, including RP, so that many studies with many different, and sometimes contradictory, results have been conducted to compare the diagnostic efficacy of CBCT and radiography techniques (Shemesh and et al, 2011; Kamburoğlu and et al, 2015; Koç and et al, 2018; Takeshita and et al, 2015 ; Bernardes and et al, 2012; da Silveira and et al, 2013; Patel and et al, 2009; Bechara and et al, 2013). Unlike our study, the study of Shemesh et al (2001) on 45 obturated, 2 groups of which were perforated using K-file #30 in the apex of mesiolingual canals, showed that CBCT shows a higher accuracy and sensitivity in diagnosing RP compared to DR, but the likelihood of incorrect diagnosis is high in both techniques. They finally suggested that there is no significant difference in diagnosing RP in obturated teeth between CBCT and DR (Shemesh and et al, 2011). Haghanifar et al conducted another study in 2014 and showed that DR has better performance than CBCT in diagnosing RP in obturated teeth (Kamburoğlu and et al, 2015). The reason of this difference may be rooted in the difference of RP size and CBCT devices. However, Shokri et al showed that RP size has no effect on the definitive diagnosis of radiography techniques (Bechara and et al, 2013). In 2015, Kamburoğlu et al compared the diagnostic efficacy of CBCT and periapical radiography in furcal perforation and suggested that there is no significant difference between the techniques but low-resolution CBCT is preferred to radiography due to low-dose exposure to ray (Koç and et al, 2018). Recently, Koç et al study suggested that CBCT gives similar, and sometimes better, results compared to periapical radiography and can serve as a supplementary tool of radiography in diagnosing endodontic treatment effects (Takeshita and et al, 2015). Takeshita et al (2015) compared the accuracy of CBCT, panoramic radiography, conventional radiography and periapical digital radiography in diagnosing RO, ERR (external resorption) and VRF. Their results showed that CBCT has the best diagnostic efficacy in

diagnosing VRF and ERR while periapical radiography and CBCT has the same results in diagnosing RP. Considering low-dose exposure to ray, Takeshital et al recommended periapical radiography in diagnosing RP (Bernardes and et al, 2012). It should be mentioned that bean hardening effect in canal filling substance is a factor that can reduce the diagnostic efficacy of CBCT (Bueno and et al, 2011). This study observed that the sensitivity, positive predictive value and accuracy of CBCT in obturated and no-obturated teeth are generally higher than DR. It should be noted that the specificity and negative predictive value of DR in mesial and parallel views are higher than CBCT indicating that if RP is not diagnosed in these views, it will be more likely that there is no RP. To avoid any confusion, however, our researchers decided to consider the accuracy of diagnosis as the main criterion indicating the superiority of the diagnostic efficacy of different techniques. As we know, the accuracy of a test shows the proportion of the correct answers of each diagnostic test and is the resultant of other parameters such as sensitivity and negative and positive predictive value. In our study, DR failed to diagnose RP in no-obturated teeth so that RP was diagnosed correctly in none of teeth. The reason may be the fact that 2D digital images result in the superimposition of anatomic structures. Therefore, intraoral radiography may make it difficult to accurately diagnose RP in no-obturated teeth. A group of previous studies supports our results. For example, Bernard et al showed that the sensitivity and accuracy of CBCT in diagnosing RP in no-obturated teeth are higher than those of periapical radiography (da Silveira and et al, 2013). In addition, Shokri et al (2015) showed that among periapical radiography, digital radiography, CBCT and MDCT, CBCT shows a higher diagnostic efficacy in diagnosing RP in obturated teeth (Bechara and et al, 2013). It should be noted that the difference of results on the diagnostic efficacy of CBCT may be rooted in artifacts, different detector types and different spatial resolution. Another important issue is that although our study shows that CBCT has a higher diagnostic efficacy than DR in RP diagnosis, it is a costly technique with high-dose exposure to ray serving as the most important barriers of employing this technique.

Similar to other studies, this study has its own limitations. The possibility of the penetration of dentin debris to perforated area is an example that can result in the entrance of filling material to the perforated zone and decrease diagnostic efficacy. Of course, there may be different clinical situations because such perforations generally engage a larger area on the thin wall of dentin on the internal curvature of root and the generalization of these conditions and standardization of them as in vitro standard is very difficult.

Conclusion

It seems that CBCT shows a higher diagnostic efficacy than DR in diagnosing RP. Moreover, among different digital radiography angels, direct angle has the highest diagnostic value in diagnosing RP in obturated teeth while the efficacy of digital radiography in diagnosing RP in no-obutrated teeth is not acceptable.

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