Original Article

Comparison of periapical radiography with cone beam computed tomography in the diagnosis of vertical root fractures in teeth with metallic post

Wilton Mitsunari Takeshita, Lilian Cristina Vessoni Iwaki[1], Mariliani Chicarelli da Silva[1], Sergio Sabio[1], Paulo Ricardo Febrairo Albino[1]

Department of Dentistry, Federal University of Sergipe, Aracaju — Sergipe, [1]Dentistry, State University of Maringá, Brazil

Abstract

Aim: To compare the diagnostic accuracy of conventional periapical radiography and cone beam computed tomography (CBCT) in detecting vertical root fracture (VRF) in tooth with metallic post (MP).

Materials and Methods: Twenty endodontically-treated teeth received MPs, artificial fractures were created in 10 teeth, and they were all examined with tomography and radiography. The sample consisted of periapical radiography with post and without post, and tomography with post and without post; each group with five fractured and five non-fractured teeth. The images were evaluated by three dental/maxillofacial radiologists and statistical validations were carried out using receiver operating characteristic (ROC) analysis.

Results: Sensitivity and specificity of the area under the ROC (Az) of tomography with post (Az = 0.953) and without post (Az = 0.956) were significantly higher than those of periapical radiography with post (Az = 0.753) and without post (Az = 0.778).

Conclusion: CBCT was more accurate than conventional periapical radiography in detecting VRF.

Keywords: Cone beam computed tomography; dental; digital radiography; diagnosis; radiography; tooth fractures

INTRODUCTION

Vertical root fracture (VRF) is a challenge to dentists due to its difficult diagnosis. It can be caused by physical and occlusal trauma, pathological resorption, repetitive parafunctional habits, as well as iatrogenic complications during and after endodontic treatment, particularly inadequate placement of metallic post (MP). The incidence of VRF is higher in maxillary incisors, about 68% for centrals and 27% for laterals, rarely affects mandibular incisors (5%)[1,2] and represents between 8.8 and 10.9% of the reasons for endodontic treatments and extractions.[3] Endodontically treated teeth are structurally more susceptible to root fractures.[4] Among the type of fractures, the diagnosis of the vertical one is a challenge for endodontic treatment.[1] Its clinical signs and symptoms are not pathognomonic for VRF and the prognosis is unfavorable.[5] VRF is a catastrophic complication during or after root canal treatment presenting a significant clinical problem, which is difficult to diagnose and treat.[6] Radiographically, the lesion shows thickening of the periodontal ligament, deep localized vertical bone loss, and localized periradicular bone loss.[1,3] Cohen *et al*.,[3] argue that conventional radiographs are not an efficient diagnostic method to detect VRF, as they reveal merely 27.63% of the cases, and only if the X-ray beam is parallel to the fracture.[1,3] In addition, intraradicular materials, such as MPs, can further complicate the diagnosis.

Duret *et al*.,[7] also highlighted some disadvantages in the use of MPs: Unfavorable esthetic, high modulus of elasticity, susceptibility to corrosion in the oral environment, increased likelihood of tooth fracture, and lack of adhesiveness.[7] However, for endodontically treated teeth that no longer have sufficient structure to provide foundation for prosthetic restorations, MPs can reestablish both their form and their function.

Address for correspondence:
Prof. Wilton Mitsunari Takeshita, Department of Dentistry, Federal University of Sergipe, Claudio Batista s/n - Cidade Universitária Santo Antônio, Zip Code: 49060-100, Aracaju - Sergipe, Brazil.
E-mail: wmtakeshita2@gmail.com

Date of submission : 08.12.2013
Review completed : 20.02.2014
Date of acceptance : 25.02.2014

Access this article online	
Quick Response Code:	Website: www.jcd.org.in
	DOI: 10.4103/0972-0707.131781

Cone beam computed tomography (CBCT) overcomes the limitations of conventional radiography in the detection of VRF,[7] such as overlapping images; and provides more structural details, and in multiple planes.[8-13] In addition, CBCT requires lower radiation dose than helical CT, has lower operation cost, and the equipment is smaller in size.[13]

Given the increasing use of CBCT in dentistry and that most research shows its greater accuracy in the diagnosis of VRF, practitioners should reevaluate its indication. An accurate diagnosis is essential to avoid confusion with other diseases, loss of work time, additional costs to the patient, and unnecessary procedures.

The aim of the present study was to compare diagnostic accuracy between CBCT and conventional periapical radiography in detecting VRF in teeth with MPs.

MATERIALS AND METHODS

The study was approved by the Standing Committee on Ethics in Human Research in accordance with the Declaration of Helsinki. Twenty extracted human teeth were used, from the Human Teeth Bank of the university, whose reasons for extraction as well as age and sex of donors were unknown. Sample size calculation was made based on pilot study [Table 1].

Prior to root canal preparation, all teeth were inspected with a binocular stereomicroscope (CGA-674, Prolab, São Paulo, Brazil) to ensure absence of fractures, either complete or incomplete, cracks, and gaps.[10] The dental crowns were sectioned 2 mm above the dentinoenamel junction in order to facilitate root canal preparation and posterior insertion of material, as well as to eliminate the risk of tooth fracture during preparation.[14,15] Step back technique was used for endodontic treatment (Kerr files, Dentsply, São Paulo, Brazil), the canals were expanded with a direct technique using patterns in red acrylic resin (Duralay, Polidental, São Paulo, Brazil), and were filled leaving 4 mm of material apically. Nickel-chromium alloy MPs were cemented in the canal with zinc phosphate cement (SSWhite, Rio de Janeiro, Brazil).

Fractures were created in 10 of the 20 teeth in a universal testing machine (DL 1000, EMIC, São José dos Pinhais, Brazil), using adequate strength for static tensile and compression tests. The strength was applied vertically to the MPs, which were slightly worn to adapt the machine's strength applicator tip. Fracture test was carried out at a crosshead speed of 0.05 cm/min with a load cell of 500 kgF, and evaluated with a stereomicroscope (Binocular CGA-674, Prolab, São Paulo, Brazil).

Table 1: Sample size based on a study pilot

Sample size calculation	
Standard deviation	0.081
Difference to be detected	0.140
Significance level	5%
Power of the test	95%
Sample size for each group calculated	7

The 20 teeth were scanned and radiographed; and the images were divided into four groups, each with ten items: Conventional periapical radiography without MP and with MP, and CBCT without MP and with MP. Each group had five fractured and five non-fractured teeth. They were placed in a dry human mandible, which was filled with acrylic resin and utility wax. Dental wear, using a metal matrix, was done in order to standardize the outer perimeter of the teeth. Two millimeters of the crown were exposed out of the dry human mandible.

Conventional radiography [Figure 1a] was taken using parallax principle (orthoradial, mesioradial at 20 degrees, and distoradial at 20 degrees) using a dental X-ray machine ×70 (DabiAtlante, São Paulo, Brazil). Exposure parameters were 70 kVp, 8 mA, cylindrical locator with 40-cm focal length, and exposure time of 0.4 s. The parameters had been previously piloted according to the ALARA principle (as low as reasonably achievable) to find the shortest exposure time able to produce an optimal image with adequate brightness and contrast.

CBCT images were obtained using i-CAT scanner (Hatfield, PA, USA), with 14-bit of greyscale, 6 cm field of view (FOV), 0.125 mm voxel, and 36.2 mAs exposure [Figure 1b]. Reconstruction images consisted of panoramic, axial, transverse, and sagittal planes, with 1 mm thickness and 1 mm slice spacing.

The images were evaluated by three dental/maxillofacial radiologists with experience in both CT and conventional

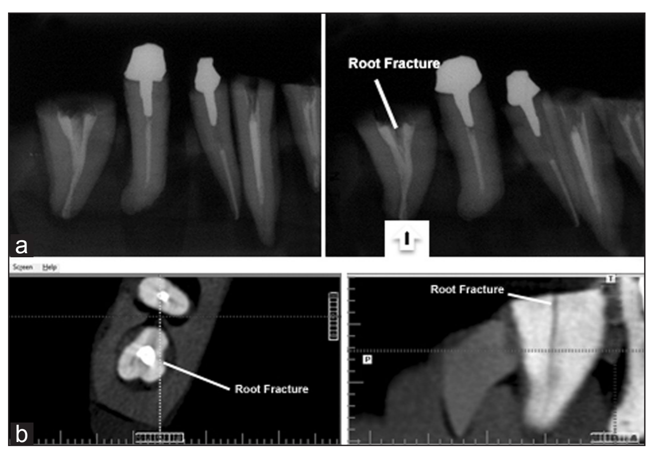

Figure 1: (a) Conventional periapical radiograph using parallax principle. The arrow indicates the tooth with vertical root fracture (VRF). (b) Cone beam computed tomography (CBCT) using i-CAT Vision software. VRF is seen in parasagittal section

radiography. CBCT images were evaluated using the software that accompanies the scanner on a computer (Intel Core I7, 6 GHz RAM, 500 Gb HD) with a 20-inch liquid crystal display (LCD) monitor (AOC, Top Victory Electronics, Taiwan). Conventional radiographs were examined on a light viewing box, in a dark room, using a ×10 magnifying glass. The examiners used a 5-point scale to classify VRF:

1. Definitely present,
2. Probably present,
3. Uncertain,
4. Probably absent, and
5. Definitely absent.[16]

The data were subjected to statistical analysis using receiver operating characteristic (ROC) methodology, with 5% significance level using Statistical Package for Social Sciences (SPSS) 17.0 (SPSS Inc, Chicago, IL).

RESULTS

The results [Table 2 and Figure 2] showed that the sensitivity and specificity of the area under the ROC curve (Az) were higher for CBCT images and lower for conventional periapical radiographs using parallax principle.

Between and within comparisons of Az of CBCT and conventional periapical radiography [Table 3], reveal no statistical difference whether MP is present or not, both for conventional radiography ($P = 0.827$) and for CBCT ($P = 0.959$). In contrast, there are significant differences between periapical and CBCT when both techniques have MP ($P = 0.016$), and when both do not have it ($P = 0.048$), between periapical with post and CBCT without post ($P = 0.035$), and between CBCT with post and periapical without post ($P = 0.044$).

Table 2: Area under the ROC curve and standard error of each type of radiographic method, both with and without metallic post

Radiographic method	MP	Az	SEM
Conventional periapical radiograph	With	0.753	0.077
	Without	0.778	0.073
CBCT	With	0.953	0.072
	Without	0.956	0.081

ROC: Receiver operating characteristic, CBCT: Cone beam computed tomography, MP: Metallic post, Az: Area under the ROC curve, SEM: Standard error or the mean

Table 3: Comparisons of the areas under the ROC curves between CBCT and conventional periapical radiography, with and without metallic post

MP	Radiographic technique			*P*-value	SEM
Both with	Periapical	vs	CBCT	0.016*	0.083
Both without	Periapical	vs	CBCT	0.048*	0.090
With vs without	Periapical	vs	Periapical	0.827	0.112
	Periapical	vs	CBCT	0.035*	0.096
	CBCT	vs	Periapical	0.044*	0.087
	CBCT	vs	CBCT	0.959	0.043

*Statistical significance: $P < 0.05$, ROC = Receiver operating characteristic, CBCT: Cone beam computed tomography, MP: Metallic post, SEM: Standard error of the mean

DISCUSSION

Accurate diagnosis of VRF depends on a careful clinical examination, complete evaluation of the case, and on an imaging examination which assesses the integrity of the bone and of the dental structure.[17] Detection of VRF is not only influenced by the type of imaging examination, either conventional radiography or CBCT, but also by the presence of material in the root canal, such as MPs, filling material, or remaining restorative material. We studied teeth treated endodontically because they are structurally more susceptible to root fractures.[4] Research has shown that CBCT shows superior accuracy than conventional radiography, not only it evaluates the fracture but also shows bone loss due to inflammatory process.[17]

An *in vitro* study[18] evaluating the efficacy of CBCT in the detection of VRF showed that fractures were accurately diagnosed in 7.5% of the teeth with MPs and 66.8% of the teeth without MPs. de Souza Coutinho-Filho *et al*.,[18] conclude that detection of VRF can be impaired by the presence of metallic material in the root canal, different from the results of the present study. Perhaps the difference is due to the limited number of teeth in the sample of de Souza Coutinho-Filho *et al*.,[18] only six.

da Silveira *et al*.,[19] compared the ability to detect VRF between conventional radiography and CBCT and found that CBCT shows better results depending on the voxel used. They also found that the presence of root canal filling and of MP reduced the sensitivity of periapical radiography, but does not affect its specificity. The present study, however, did not use different voxels in the detection of VRF.

Two other studies[9,19] also compared the accuracy of conventional radiography and CBCT in detecting VRF,

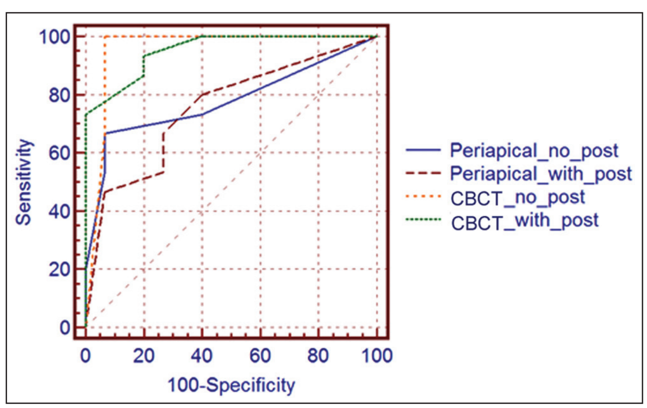

Figure 2: ROC curve analysis for CBCT and conventional periapical radiograph, with and without metallic post (MP)

assessing the influence of root canal filling on fracture visibility. Hassan *et al*.,[9] concluded that CBCT was more accurate to detect VRF, as material in the canal reduced the specificity of CBCT but not its overall accuracy; whereas, both sensitivity and accuracy of conventional radiographs were influenced by root canal filling. Wang *et al*.,[20] found similar results — CBCT was in general more accurate than conventional radiography in detecting VRF, despite the finding that the presence of root canal filling reduced sensitivity of CBCT, but not its specificity, in contrast to conventional radiography that showed unaffected sensitivity and specificity. Zou *et al*.,[21] who investigated three molars with VRF, one being endodontically treated and two not, also concluded that CBCT is more accurate in detecting VRF than conventional radiography. Different from the two previous studies, Zou *et al*.,[21] did not observe loss of accuracy for the CBCT images due to root canal filling; while conventional radiography was able to detect fracture lines in one tooth only, CBCT identified such lines in the two teeth without endodontic treatment.

Several other studies have shown the superiority of CBCT over conventional radiography in detecting VRF. Tang *et al*.,[17] evaluated two cases and concluded that CBCT shows clear fracture lines and can be useful in rapid diagnosis of VRF. Wang *et al*.,[22] evaluated four VRF cases and observed that CBCT was significantly more accurate and provided more information about the fractures than conventional radiographs. Fayad *et al*.,[23] evaluated seven cases and also asserted that CBCT can provide valuable additional diagnostic information for the diagnosis of VRF, which may help prevent unnecessary treatment.

Edlund *et al*.,[1] examined 32 teeth with clinical signs and symptoms of VRF and found that CBCT provided higher accuracy and specificity in the diagnosis of fractures. Bernardes *et al*.,[24] investigated 20 patients with suspected VRF using CBCT and conventional radiography. They found that CBCT showed superior performance in the diagnosis of root fractures and that it is an excellent diagnostic method. An *in vitro* study[8] with 60 teeth, 30 of which were with VRF, showed that CBCT was better than conventional radiography in detecting the fractures.

In contrast, other studies did not corroborate the superiority of CBCT. Khedmat *et al*.,[25] used three imaging methods for detecting VRF of endodontically treated teeth — digital radiography, CBCT, and multidetector CT — and found that the latter showed more accuracy, sensitivity, and specificity than the other two methods. However, due to the higher radiation dose of multidetector CT, its use becomes more restricted.

Finally, Kambungton *et al*.,[26] who used CBCT, conventional intraoral film and high-resolution complementary metal oxide semiconductor digital imaging system for detecting VRF in mandibular single-rooted teeth, found no significant differences between CBCT and the other two imaging methods.

Thus, the present study supports the findings of Tang *et al*.,[17] Edlund *et al*.,[1] and Bernardes *et al*.,[24] as CBCT was more accurate than conventional radiography in detecting VRF, and contradicts the results of Kambungton *et al.*[26]

Although different imaging methods have shown their relevance in the diagnosis of VRF, Tsesis *et al*.,[27] systematically reviewed the literature concerning the diagnostic accuracy of clinical signs and symptoms of VRF and radiographic indices in the detection of root fractures. They concluded that there is not sufficient evidence-based data concerning the accuracy of clinical and radiographic indices in the detection of VRF. The authors[27] also affirm that although CBCT has improved the detection of VRF, its diagnosis is still a difficult one, even among experienced practitioners, hence the need of further research on the matter.

Therefore, given that some factors can affect the diagnosis of VRF, such as the type of root filling material, the type of equipment and the parameters used to obtain the images, further research is needed to elucidate the diagnostic potential of different imaging methods to detect VRF.

CONCLUSION

CBCT was more accurate than conventional periapical radiography in detecting VRF. MPs did not influence the diagnostic accuracy of fractures for either imaging methods. The present study used the smallest voxel resolution and FOV, future studies that aim to reduce radiation exposure could examine the influence of the voxel size, FOV, and different CBCT equipment.

REFERENCES

1. Edlund M, Nair MK, Nair UP. Detection of vertical root fractures by using cone-beam computed tomography: a clinical study. J Endod 2011;37:768-72.
2. Bornstein MM, Wölner-Hanssen AB, Sendi P, von Arx T. Comparison of intraoral radiography and limited cone beam computed tomography for the assessment of root-fractured permanent teeth. Dent Traumatol 2009;25:571-7.
3. Cohen S, Berman LH, Blanco L, Bakland L, Kim JS. A demographic analysis of vertical root fractures. J Endod 2006;32:1160-3.
4. Ganesh A, Venkateshbabu N, John A, Deenadhayalan G, Kandaswamy D. A comparative assessment of fracture resistance of endodontically treated and re-treated teeth: An *in vitro* study. J Conserv Dent 2014;17:61-4.
5. Shemesh H, van Soest G, Wu MK, Wesselink PR. Diagnosis of vertical root fractures withoptical coherence tomography. J Endod 2008;34:739-42.
6. Kumaran P, Sivapriya E, Indhramohan J, Gopikrishna V, Savadamoorthi KS, Pradeepkumar AR. Dentinal defects before and after rotary root canal instrumentation with three different obturation techniques and two obturating materials. J Conserv Dent 2013;16:522-6.
7. Duret B, Reynaud M, Duret F. New concept of coronoradicular reconstruction: The Composipost. Chir Dent Fr 1990;540:131-41.

8. Mora MA, Mol A, Tyndall DA, Rivera EM. *In vitro* assessment of local computed tomography for the detection of longitudinal tooth fractures. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;103:825-9.
9. Hassan B, Metska ME, Ozok AR, van delStelt P, Wellelink PR. Detection of vertical root fractures in endodontically treated teeth by cone beam computed tomography scan. J Endod 2009;35:719-22.
10. Kamburoğlu K, Ilker Cebeci AR, Gröndahl HG. Effectiveness of limited cone-beam computed tomography in the detection of horizontal root fracture. Dent Traumatol 2009;25:256-61.
11. Wenzel A, Haiter-Neto F, Frydenberg M, Kirkevang LL. Variable-resolution cone-beam computerized tomography with enhancement filtration compared with intraoral photostimulable phosphor radiography in detection of transverse root fractures in an *in vitro* model. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;108:939-45.
12. Özer SY. Detection of vertical root fractures by using cone beam computed tomography with variable voxel sizes in an *in vitro* model. J Endod 2011;37:75-9.
13. Tyndall DA, Kohltfarber H. Application of cone beam volumetric tomography in endodontics. Aust Dent J 2012;57:72-81.
14. Melo SL, Bortoluzzi EA, Abreu M Jr, Corrêa LR, Corrêa M. Diagnostic ability of a cone-beam computed tomography scan to assess longitudinal root fractures in prosthetically treated teeth. J Endod 2010;36:1879-82.
15. Ferreira RI, Bahrami G, Isidor F, Wenzel A, Haiter-Neto F, Groppo FC. Detection of vertical root fractures by cone-beam computerized tomography in endodontically treated teeth with fiber-resin and titanium posts: An *in vitro* study. Oral Surg Oral Med Oral Pathol Oral Radiol 2013;115:e49-57.
16. Takeshita WM, Iwaki LC, Da Silva MC, Filho LI, Queiroz AD, Geron LB. Comparison of the diagnostic accuracy of direct digital radiography system, filtered images, and subtraction radiography. Contemp Clin Dent 2013;4:338-42.
17. Tang L, Zhou XD, Wang Y, Zhang L, Zheng QH, Huang DM. Detection of vertical root fracture using cone beam computed tomography: Report of two cases. Dent Traumatol 2011;27:484-8.
18. de Souza Coutinho-Filho T, Leal da Silva EJ, Gurgel-Filho ED, Martins J, Henriques L, Ferreira C. Vertical root fracture detection using computed tomography in the presence or absence of metallic cores. Rev Port Estomatol Med Dent Cir Maxilofac 2012;53:96-8.
19. da Silveira PF, Vizzotto MB, Liedke GS, da Silveira HL, Montagner F, da Silveira HE. Detection of vertical root fractures by conventional radiographic examination and cone beam computed tomography — an *in vitro* analysis. Dent Traumatol 2013;29:41-6.
20. Wang P, Yan XB, Lui DG, Zhang WL, Zhang Y, Ma XC. Detection of dental root fractures by using cone-beam computed tomography. Dentomaxillofac Radiol 2011;40:290-8.
21. Zou X, Liu D, Yue L, Wu M. The ability of cone-beam computerized tomography to detect vertical root fractures in endodontically treated and nonendodontically treated teeth: A report of 3 cases. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:797-801.
22. Wang P, He W, Sun H, Lu Q, Ni L. Detection of vertical root fractures in non-endodontically treated molars using cone-beam computed tomography: A report of four representative cases. Dent Traumatol 2012;28:329-33.
23. Fayad M, Ashkenaz PJ, Johnson BR. Detection of vertical root fractures by using cone-beam computed tomography: a clinical study. J Endod 2011;37:768-72.
24. Bernardes RA, de Moraes IG, Húngaro Duarte MA, Azevedo BC, de Azevedo JR, Bramante CM. Use of cone-beam volumetric tomography in the diagnosis of root fractures. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;108:270-7.
25. Khedmat S, Rouhi N, Drage N, Shokouhinejad N, Nekoofar MH. Evaluation of three imaging techniques for the detection of vertical rootfractures in the absence and presence of gutta-percha root fillings. Int Endod J 2012;45:1004-9.
26. Kambungton J, Janhom A, Prapayasatok S, Pongsiriwet S. Assessment of vertical root fractures using three imaging modalities: Cone beam CT, intraoral digital radiography and film. Dentomaxillofac Radiol 2012;41:91-5.
27. Tsesis I, Rosen E, Tamse A, Taschieri S, Kfir A. Diagnosis of vertical root fractures in endodontically treated teeth based on clinical andradiographic indices: A systematic review. J Endod 2010;36:1455-8.

How to cite this article: Takeshita WM, Iwaki LV, da Silva MC, Sabio S, Ricardo P, Albino F. Comparison of periapical radiography with cone beam computed tomography in the diagnosis of vertical root fractures in teeth with metallic post. J Conserv Dent 2014;17:225-9.

Source of Support: Nil, **Conflict of Interest:** None declared.