

Diagnosis of Vertical Root Fracture Using Digital Radiography, Helical Computed Tomography And Cone Beam Computed Tomography.

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Abstract:

Introduction: This study aimed to compare the accuracy of Conventional Radiographs, Spiral computed tomography and Cone Beam computed tomography in detecting vertical root fractures. **Material And Methods-** Sixty extracted single rooted teeth were selected. The roots were divided into two groups. Group-1 had teeth with induced root fracture and Group-2 had teeth with no fracture. In the first group, the crack was made by Instron system. All samples were imaged with three imaging modalities and were statistically analysed. **Results-** CBCT gave the most accurate diagnosis with 90% sensitivity and a false negative of 10% in the group with fractured teeth and 80% specificity and a false positive of 20% in teeth with no fracture. This was followed by Digital Radiography and Spiral CT gave the least accurate results. **Conclusion-** Within the limits of this study, CBCT gave the most accurate results in detecting the vertical root fracture. It was followed by Digital Radiography followed by Helical CT.

Keywords: Cone Beam Computed Tomography, Spiral CT, Vertical Root Fracture.

I. Introduction

According To Barkhordar et al (1988) (1), Vertical Root fracture (VRF) is one of the most common failures encountered in endodontically treated teeth; moreover its diagnosis encloses several problems. Due to VRF's poor prognosis, a reliable and valid detection method is critical for treatment planning. These are reported in 3.69% of root canal treated teeth. (Wenzel A, Kirkevang LL, 2005) (2). The diagnosis of VRF is usually problematic because it often necessitates prediction rather than a definite identification. Conventional radiography is a common method for determination of VRF; however there are several problems, particularly when fragments are not displaced (3). One third of VRFs are radiographically detectable; this is when the x-ray beam is perpendicular to a complete fracture line or there is fragment separation due to granulation tissue formation between the splinters.⁴ Since the X-ray beam is usually directed obliquely to the fracture line, repeating the radiographs with different angles is required. This results in increased patient radiation dose.

Digital radiography is a good alternative for conventional radiography. There is reduction in patient absorption dose, digital image quality enhancement, convenient application, electronic saving and transferring of the data and elimination of processing chemicals. Beam angulation is critical with these systems and poses problems. The interpretation of an image can be confounded by the anatomy of both the teeth and surrounding structures. Having the ability to assess an area of interest in 3 dimensions might benefit both novice and experienced clinicians alike (4).

Helical (or Spiral) computed tomography is a type of three dimensional computed tomography (CT) in which the source (usually of x-rays) describes a helical trajectory relative to the object while a two dimensional array of detectors measures the transmitted radiation on part of a cone of rays emanating from the source. It involves continuous patient translation during x-ray source rotation and data acquisition. However, the radiation dose involved in MDCT scans, the limited availability, and the increased costs impede its use in dentistry (5,6).

In the late 1990s Italian and Japanese groups (Arai et al. 1999, Mozzo et al. 1998), working independently of each other, developed a new tomographic scanner known as cone beam computed tomography (CBCT). A divergent pyramidal or cone-shaped source of ionizing radiation is directed through the middle of the area of interest onto an area x-ray detector on the opposite side of the patient. These systems have the benefits such as high image quality and resolution less radiation dose compared to CT systems, rapid scan time and it also eliminates blurring and overlapping of the structures.

Therefore, we wished to compare the diagnostic accuracy of Digital Radiography, Helical Computed Tomography and Cone Beam Computed Tomography in Vertical Root Fracture detection.

II. Materials And Methods

60 extracted canines without root fracture and with single canal were selected. The teeth were debrided and were decoronated to a standard length of 14mm from the apex using a diamond disk under water spray.

For the working lengths, 1mm was reduced from the measurement when the file emerged from the apex. The lengths were confirmed by digital radiographs. Glide path was established using No. 10 K-file & 17% Ethylenediaminetetraacetic acid. The root canals were then prepared using Rotary Protapers (DentsplyMaillefer) to a size of F3 till the working length, using 2.5% NaOCl as an irrigant. The canals were obturated using 6% Taper GuttaPercha Cones corresponding to size F3 with Zinc Oxide Eugenol as a sealer. Under saline irrigation, the post space were created using Peeso Reamers No. 1-4 to a length of 9mm in each specimen. 4-5 mm of GuttaPercha was left in the canal. The glass fibre posts (Reforpost, Angelus), of diameter 1.3mm (No. 2) were selected and prepared for luting. The posts were cemented following manufacturer's instructions and using LuxaCore Z – Dual (DMG). The teeth were then divided into two groups of 30 each.

30 teeth were then fractured under Instron Machine. Another group had teeth with no fracture. Every single tooth was evaluated using digital radiography, Helical CT and CBCT. Digital radiographs were taken using RVG. The source object, object-receptor distances and exposure times were kept constant. Teeth were scanned using Helical CT (Optima CT660, GE Healthcare). CBCT was done and the images were analysed using "On Demand software". The three sets of images (Digital, Helical CT and CBCT) were evaluated by a radiologist who was blind to the roots number and grouping.

The observer recorded the observations on a five-point confidence scale as follows:

- 1 - Fracture definitely present
- 2 - Fracture probably present
- 3 - Unsure
- 4 - Fracture probably **not**present
- 5 - Fracture definitely **not**present.

III. Result:

Results of Digital Radiography diagnosis

| Root fracture diagnosis | Present N (%) | Absent N (%) |
|-------------------------------|---------------|--------------|
| Definitely Present | 5 (50%) | 1 (10%) |
| Probably Present | 2 (20%) | 1 (10%) |
| Unsure | 1 (10%) | 2 (20%) |
| Probably Not Present | 2 (20%) | 3 (30%) |
| Definitely Not Present | 0 | 3 (30%) |

Results of Helical CT diagnosis

| Root fracture diagnosis | Present N (%) | Absent N (%) |
|-------------------------------|---------------|--------------|
| Definitely Present | 3 (30%) | 2 (20%) |
| Probably Present | 2 (20%) | 1 (10%) |
| Unsure | 2 (20%) | 3 (30%) |
| Probably Not Present | 1 (10%) | 2 (20%) |
| Definitely Not Present | 2 (20%) | 2 (20%) |

Results of CBCT diagnosis

| Root fracture diagnosis | Present N (%) | Absent N (%) |
|-------------------------------|---------------|--------------|
| Definitely Present | 8 (80%) | 0 |
| Probably Present | 1 (10%) | 2 (20%) |
| Unsure | 0 | 0 |
| Probably Not Present | 0 | 1 (10%) |
| Definitely Not Present | 1 (10%) | 7 (70%) |

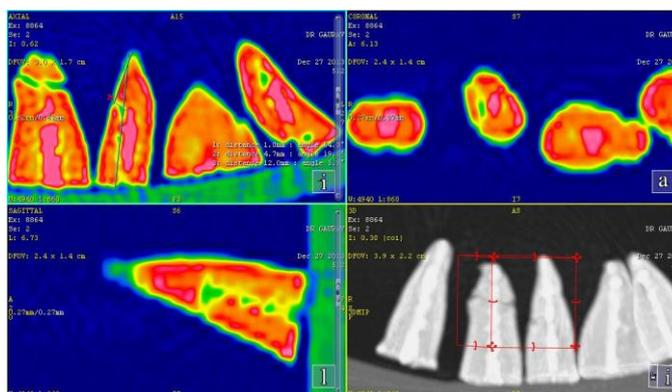
The group which was scanned by digital radiography using RVG showed Sensitivity of 77.8% and false negative of 22.2% was reported in fractured teeth. Specificity of 75% and false positive of 25% was seen in non-fractured teeth. Kappa factor was 0.429. In the Spiral/Helical CT group, 62.5% sensitivity and 32.5% false negative results were obtained in teeth with induced fracture. In the group of non-fractured teeth, specificity of 57.14% and false positive of 42.6% was seen. Kappa factor was 0.175. CBCT gave the most accurate diagnosis with 90% sensitivity and a false negative of 10% in the group with fractured teeth. However, in the group with teeth having no fracture, 80% specificity and a false positive of 20% was reported. Kappa factor was 0.598. The kappa factor was found to be statistically insignificant. This could be attributed to the small sample size.

IV. Discussion

Radiographic evaluation is critical for diagnosis; several factors impact on radiographic interpretation such as imaging modality, analogue versus digital, image manipulation and improvement, characteristics of image presenting on monitor and film, experience of observers and the existing data for comparison (7). In the present study, diagnostic accuracy of three methods; digital radiography, helical CT and CBCT was assessed; CBCT was found to have the highest sensitivity (90%) and specificity (80%) in VRF detection followed by digital radiography (RVG) with a sensitivity of 77.8% and specificity of 75%. It was followed by Spiral CT group which showed a sensitivity of 62.5% and specificity of 57.14%. Kambruroglu et al. performed a study for detecting horizontal root fractures by conventional and digital radiography and CBCT, and showed that the highest efficiency was for CBCT as sensitivity and specificity were 92% and 97% respectively. Our study also suggests that CBCT was superior, but in detection of VRF's over digital radiography. This may be because of the limitations associated with RVG. The limitation associated with digital radiography is the result of a combination of factors: superimposition of overlying and adjacent anatomical structures, processing errors from manual film processing or from automatic film processing machines, a beam direction that may not be parallel to the fracture line and the display of a two-dimensional (2D) image of a three dimensional (3D) object (8,9). This study showed that the sensitivity of CBCT was much better than spiral CT for the detection of vertical root fracture. It may be due to the difference of spatial resolution ability of these modalities, more specifically, the slice thickness which affected the special resolution of the reconstructed images (CBCT- mm and Spiral CT- 0.62mm). Hassan b. et al (6) in their study showed that the three-dimensional nature of CBCT scans allows visualizing the fracture line from multiple angles and different orientations at very thin slices and at a very high contrast. Further, Patel S (10) have stated that Cone beam computed tomography scan times are typically 10 to 40 seconds long, depending on the scanner used and the exposure parameters selected. The X-ray beam is pulsed, therefore the actual exposure time is a fraction of this (2-5 seconds), resulting in up to 580 individual 'mini-exposures' or 'projection images' during the course of the scan. This contrasts with the continuous exposure of CT and conventional tomography, and affords the major advantage over CT scanners of substantially reduced radiation exposure. Further reduction comes from fast scanning times and the use of advanced image receptor sensors. However there would still be some limitations with CBCT e.g. streaking and beam hardening artefacts, although these artefacts are less than those in CT. Radiopaque substances such as gutta-percha cones create distinct star-shaped streak artifact on tomographic slices that can mimic fracture lines on CBCT images (11). This needs to be investigated further.

V. Conclusion

Within the limits of this study, CBCT gave the most accurate results in detecting the vertical root fracture. It was followed by Digital Radiography followed by Helical CT.



References:

- [1]. Barkhordar RA. Treatment of vertical root fracture: a case report. *Quintessence Int.* 1991 Sep;22(9):707-9.
- [2]. Wenzel A, Kirkevang LL. High resolution charge-coupled device sensor vs. medium resolution photostimulable phosphor plate digital receptors for detection of root fractures in vitro. *Dent Traumatol* 2005;21:32-6.
- [3]. Kositbowornchai S, Sikram S, Nuansakul R, Thinkhamrop B. Root fracture detection on digital images: effect of the zoom function. *Dent Traumatol* 2003; 19: 154-9.
- [4]. Hannig C, Dullin C, Hülsmann M, Heidrich G. Three-dimensional, non-destructive visualization of vertical root fractures using flat panel volumetric detector computer tomography: an ex vivo in vitro case report. *Int Endod J* 2005;38:904-13.
- [5]. Cotton TP, Geisler TM, Holden DT, Schwartz SA, Schindler WG. Endodontic Applications of Cone-Beam Volumetric Tomography. *JOE* 2007;33(9):1121-32.
- [6]. Hassan B. Detection of Vertical Root Fractures in Endodontically Treated Teeth by a Cone Beam Computed Tomography Scan. *Journal of Endodontics* 2009;35(5):719-22.
- [7]. Valizadeh S, Khosravi M, Azizi Z. (2011) Diagnostic accuracy of conventional, digital and Cone Beam CT in vertical root fracture detection. *IEJ, Iranian Endodontic Journal* 2011;6(1):15-20.
- [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: 825-829.
- [9]. Nair MK, Nair UD, Gorn Dahl HG, Webber RL, Wallace JA. Detection of artificially induced vertical radicular fractures using tuned aperture computed tomography. *Eur J Oral Sci* 2001; 109: 375-379.
- [10]. Patel S. New dimensions in endodontic imaging: part 2. Cone beam computed tomography. *IEJ* 2009.
- [11]. Zhang Y, Zhang L, Zhu XR, et al. Reducing metal artifacts in cone-beam CT images by preprocessing projection data. *Int J Radiat Oncol Biol Phys* 2007;67:924-32.
- [12]. Kositbowornchai S, Nuansakul R, Sikram S, Sinahawattana S, Saengmontri S. Root fracture detection: a comparison of direct digital radiography with conventional radiography. *Dentomaxillofac Radiol* 2001; 30: 106-109.
- [13]. Cohenca N, Simon JH, Roges R, Morag Y, Malfaz JM. Clinical indications for digital imaging in dento-alveolar trauma. Part 1: traumatic injuries. *Dent Traumatol* 2007; 23: 95-104.
- [14]. Berman LH, Hartwell G. Diagnosis. In: Cohen S, Hargreaves KM, eds. *Pathways of the pulp*. 9th ed. St Louis, MO: Mosby; 2006:2-39.
- [15]. Iikubo et al. (2009) Accuracy of intraoral radiography, multidetector helical CT, and limited cone-beam CT for the detection of horizontal tooth root fracture. (*Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009;108:e70-e74).
- [16]. Kamburoglu K, Ilker Cebeci AR, Grondahl HG. (2009) Effectiveness of limited cone-beam computed tomography in the detection of horizontal root fracture. *Dent Traumatol* 2009;25:256-61.
- [17]. Wang P. et al (2011) Detection of dental root fractures by using cone-beam computed tomography. *Dentomaxillofac Radiology* (2011) 40, 290-298, doi: 10.1259/dmfr/84907460.
- [18]. Ozer S. Y (2011) Detection of Vertical Root Fractures by Using Cone Beam Computed Tomography with Variable Voxel Sizes in an In Vitro Model. *JOE*; 37(1).
- [19]. J Kamburton. Assessment of vertical root fractures using three imaging modalities: cone beam CT, intraoral digital radiography and film. *Dentomaxillofac Radiology* (2012) 41, 91-95.
- [20]. Cotton et al. Endodontic Applications of Cone-Beam Volumetric Tomography. American Association of Endodontists. doi:10.1016/j.joen.2007.06.011.
- [21]. Hegde et al. Vertical root fractures: Review and case report. *Journal of Interdisciplinary Dentistry / Jul-Dec 2011 / Vol-1 / Issue-2*.
- [22]. Nathani et al. Endodontic Applications Of Spiral Computed Tomography. *People's Journal of Scientific Research*; 2(1), Jan. 2009.
- [23]. Patel et al. New dimensions in endodontic imaging: part 1. Conventional and alternative radiographic systems. doi:10.1111/j.1365-2591.2008.01530.x.