ORIGINAL RESEARCH

Diagnostic ability of Cone Beam Computed Tomography to assess vertical root fractures in endodontically treated teeth – An in vitro study

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ABSTRACT
Background: Vertical root fractures in endodontically treated teeth have been found in good percentage of cases and must be diagnosed early to prevent the damage of supporting structures of teeth. Clinical and radiographic findings being non specific warrant the use of advanced diagnostic aids like cone beam computed tomography for early detection and management of vertical root fractures. **Aim:** To detect the diagnostic viability of Cone Beam Computed Tomography in presence of intra-radicular obturating materials in human teeth. **Methodology**: Human mandibles with intact teeth were used in which teeth ere atraumatically extracted, root canal preparation done and incomplete fractures induced in half of the sample teeth. CBCT scans were taken before obturation and after obturation of root canals to compare sensitivity and specificity. **Results**: Results showed that presence of radio dense intra canal obturating materials results in decrease of both sensitivity and specificity of detecting vertical root fractures with high rate of false positives due to streaking artefacts from obturating materials.**Conclusion**: Presence of Intracanal radiopaque materials decreases the reliability of CBCT as a diagnostic tool in detection of vertical root fractures of teeth.
Keywords: Vertical Root fracture, Cone Beam CT, Diagnostic imaging.

INTRODUCTION

Vertical root fracture (VRF) is a longitudinally oriented fracture of the root that originates from the apex and propagates to the coronal part.[1] Vertical root fractures are common in endodontically treated and restored teeth although cases of VRF have been found in non-endodontically treated teeth.[2] Vertical root fracture has been reported to be present in 3-13% of endodontically treated teeth[3,4] and the reason of extraction of root filled teeth in 32% of cases.[5]

Clinical features of vertical root fracture include direct visualisation of fracture line, sinus, a deep narrow isolated periodontal pocket, and mobility.[6] Radiographically, there may be a halo or J shaped radiolucency around the fractured root or even complete separation of the fractured root segments.[7] However, a systematic review of clinical features of VRF showed that there is a lack of evidence based data regarding diagnostic accuracy of commonly used clinical and conventional radiographic signs for diagnosing VRF[8] especially in cases of incomplete root fractures.[7]

An accurate and early diagnosis needs to be made to allow the tooth in question to be extracted as soon as

possible to reduce unnecessary alveolar bone loss because of direct correlation between bone resorption and time.[9] Various studies have shown limited application of conventional film and digital radiography for diagnosing vertical root fracture.[10] In the recent years use of Cone Beam Computed Tomography has been shown to be more accurate in determining presence of vertical root fracture.[11] Most of studies for detection of vertical root fractures using CBCT have been conducted on extracted posterior teeth placed in artificial arches or in teeth with incomplete obturation of root canal spaces. To our knowledge, none of clinical simulation studies has been done. Aim of our investigation was to determine the diagnostic accuracy of CBCT in actual clinical conditions.

MATERIAL AND METHODS

Eight mandibular incisors, four mandibular canines, eight premolars and sixteen molars from 4 dry human mandibles were used for this study. To reduce surface tension of bone and increase its water absorption each mandible was soaked for 90 minutes in warm water into which hand dishwashing liquid (Pril, Henkel AG & Co, Germany) was added.[12] Teeth were extracted atraumatically,inspected with the aid of stereo-microscope (Kyowa Getner, Japan) to confirm absence of VRFs and firmly replaced in their sockets. Baseline CBCT scans were performed using New Tom CBCT machine (Verona, Italy). Access cavities were prepared in each tooth. Canals were initially negotiated and patency was confirmed with a size 10 K Flexofile (Dentsply Maillefer, Ballaigues, Switzerland). The canals were then prepared upto Protaper F3 rotary instrument (Dentsply, Maillefer) according to manufacturer's instructions. Patency was maintained and canals irrigated with 5% sodium hypochlorite and dried with F3 absorbent paper points (Pearl Dent, Korea). Teeth were re-extracted atraumatically and embedded in vinyl polysiloxane impression putty (Affins, Coltene Whaledent) in a steel cylinder (diameter 30mm, height 40mm) which was placed on fixed platform.Fractures were induced in vertical plane in half of the roots by using an electromechanical universal testing machine (HEICO, New Delhi, India) with crosshead speed of 0.2mm/min. The load increased to 500-700N until fracture occurred and then load was immediately stopped asshown by the display monitor. Two teeth were lost in the process due to complex fractures.

Root surfaces were observed directly for the presence of fracture line (gold standard) under stereomicroscope. Only in a few teeth complete separation of root halves resulted those were glued together at one point by cyanoacrylate based superglue to simulate immediate post trauma situation. Teeth were firmly replaced in their sockets and coded in preparation for CBCT scans by examiner 1.

CBCT SCANS

Each mandible was coated with three layers of dental wax buccally and lingually to simulate soft tissue. To allow each mandible be placed in reproducible position for every scan, impression of Chin rest of New Tom CBCT machine was made with vinyl polysiloxane impression materialand lower border of each mandible gently pushed 3-4 mm intoupper surface of impression material placing occlussal planeparallel to floor.

CBCT Scan 1

Each mandible was scanned with New Tom CBCT with following scan parameters:

90kv, 3.0mA and 9.0 s, FOV 8X5 (Hi Res), Voxel Size 0.1mm (100μ)

CBCT Scan 2

Before second CBCT scan, Protaper F3 gutta percha points (Dentsply, Maillefer) were inserted into canals and another series of CBCT scans taken with same exposure parameters.

CBCT Scan 3

Protaper F3 points were removed and AH Plus Sealer applied with help of GP points and GP cones inserted. Accessory cones if needed were placed passively without using spreaders. Excess GP lacerated at CEJ and slightly condensed with help of hand pluggers.

Another series of CBCT scans was taken with same exposure parameters.

CBCT Scan Assessment

4 examiners (One Endodontist, One Periodontist, One Oral Surgeon and One Oral and Maxillofacial Radiologist) individually assessed each of CBCT series after being calibrated for presence and absence of VRF's from example of images representing vertical root fractures. Brightness and contrast of all images were optimized to allow the best possible visualization of VRF's. Each examiner assessed the presence or absence of VRF on a dichotomous scale (fractured/non-fractured).

STATISTICAL ANALYSIS

Statistical analysis was done by SPSS 20 software for calculation of sensitivity, specificity, positive predictive value, negative predictive value and overall accuracy.

RESULTS

Sensitivity of CBCT for detecting the presence of incomplete VRFs in absence of any intraradicular material was higher (75%) and presence of gutta percha and gutta percha plus root canal sealers resulted in decreased sensitivity and specificity with a very high chances of false positive and false negatives as shown in Table below.

Group (n=50)	Sensitivity (%)	Specificity (%)	PPV	NPV	Accuracy
CBCT without gutta-percha	75%	89%	86%	80%	82%
CBCT with gutta-percha	71%	70%	62%	80%	70%

CBCT with gutta-percha and AH Plus Sealer	62%	44%	50%	57%	53%

Statistically significant difference (P<0.05)

Accuracy of CBCT with GP did not decrease significantly as compared to non filled teeth (P=0.161)whereas there is statistically significant difference in accuracy of CBCT with GP and sealer in comparison to CBCT of non-filled (P=0.002) and CBCT with GP filled teeth (P=0.041)

DISCUSSION

Human mandibles were used in this study with soft tissue equivalent closely corresponding clinical images on patients. This had the advantage of standardizing the order of magnitude of the fracture widths and achieving the soft tissue attenuation and scatter as in patients.[12,13]A pilot scan confirmed that the images captured using this soft tissue equivalent closely mimicked corresponding clinical images on patients. The study included evaluation of both anterior and posterior teeth.

Previous studies showed that the poor sensitivity of periapical radiographs in detecting VRFs is most probably due to several factors which included poor resolution of the image, the compression of the anatomy and anatomical noise of the surrounding bone. The superimposition of one root over another in molar teeth as well as X-ray beam having to be coincidental with the line of VRF are other reasons for lack of accuracy of periapical radiographs in detecting VRF.[14-16]

Sensitivity and specificity of CBCT in non-filled and root filed teeth in our study was lower than studies of Hassan et al,[14]Melo et al[17] and Wenzel et al[18] probably due to the fact that width of fractures induced in their studies was much higher, while most of the fractures in present study being hairline fractures.

Sensitivity and specificity is higher than study ofPatel et al[12] and can be attributed to lower voxel size(0.1mm) in present study and High resolution mode of scanning used in our study.Also width of VRF in our study could be higher resulting in better sensitivity and specificity.

Both sensitivity and specificity of obturated teeth (GP + AH Plus sealer) was significantly decreased as compared to non filled teeth due to the various artefacts caused by presence of radio dense intracanal materials. The overall poor specificity was most probably due to the streaking artefacts caused by the radiopaque root fillings,[19,20] this streaking mimics the appearance of a VRF.

None of the studies could be found in the literature using GP and sealer to obturate root canals simulating clinical conditions for evaluating viability of CBCT in diagnosing VRF's thus making this study first of its kind.

CONCLUSION

Within the limitations of this study, it can be concluded that CBCT is not accurate in detecting the presence and absence of simulated VRF'S with imaging artefacts resulting in over estimation of vertical root fractures and reducing its overall diagnostic viability.

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