INTRODUCTION
Vertical root fractures have been described as longitudinally oriented fractures of the root, extending from the root canal to the periodontium.\(^1\) Vertical root fractures represent 2 to 5\% of crown/root fractures, with the greatest incidence occurring in endodontically treated teeth and in patients older than 40 years of age.\(^2\)

Leubke\(^3\) described two types of root fractures based on the separation of the fragments: Where total separation is visible or fragments can be moved independently. This is defined as a complete fracture. An incomplete fracture is said to occur in the absence of visible separation. Root fractures may originate at the coronal tooth structure or at the apex. The vertical root fracture may involve the whole length of the root or only a section of it and may involve only one or both sides of the root.\(^4,6\)

The cause of vertical root fracture is mainly iatrogenic, attributable to dental treatment, such as excessive canal shaping, excessive pressure during compaction of gutta percha.\(^7,8\) Excessive width and length of a post space in relation to the tooth anatomy or excessive pressure during placement of dowel.\(^9,10\) This excessive force exceeds the binding strength of existing dentin causing fatigue and fracture. The accompanying signs and symptoms bring the fracture to the attention of patient or dentist.

The ability to clinically detect VRF is currently limited to the use of conventional radiography. This technique is restricted by its two-dimensional nature and its inability to reveal longitudinal fractures which traverse in any direction not parallel to the X-ray beam.

Furthermore, superimposition of other structures limits the sensitivity for detection of these fractures.\(^11\) As a result, radiographic evidence is often absent even when the fracture is readily apparent at surgical exposure.\(^1\) The inability to accurately visualize VRFs using conventional imaging modalities calls upon the need for the development of alternative imaging systems for the improvement of diagnosis of VRFs.\(^12\)

The advent of medical computed tomography (CT) in 1972 revolutionized the medical imaging field and has allowed for detailed three-dimensional visualization of soft and hard tissues.\(^15\) Major concern with CT machines is the large radiation dose received by the patient, as well as the cost and large size of the machine.\(^14\) As a result, these issues make this imaging modality impractical for regular use in dental clinics.\(^15\)

In 2001, Arai et al\(^17\) demonstrated a model of cone beam CT (CBCT). CBCT, is also called digital volume tomography (DVT).\(^16\) The CBCT produces clearer images with an orofacial view and a smaller patient radiation dose.\(^15,18\) The advancement and utilization of CBCT technology has become increasingly popular, and since 2007, there are at least 12 cone beam systems specifically designed for dental use.\(^14,19\)

Conventional multidetector computer tomography (MDCT) scans were found superior to periapical radiographs in detecting vertical root fracture.\(^20\) However, the radiation dose involved in MDCT scans, the limited availability, and the increased costs limit its use in dentistry.\(^19,21\)

CBCT scanners utilize a cone-shaped X-ray beam to acquire a three-dimensional image of the patient’s head in a single 360° rotation, allowing for scans dedicated to dentomaxillofacial imaging.\(^22\) This offers many advantages over medical CT, including reduced image artefact, reduced patient radiation dosage, rapid scan time, improved image accuracy, and X-ray beam localization.\(^14\)

As a result, CBCT has established success in the field of dentistry, particularly in endodontics for increased diagnostic accuracy, surgical assessment of pathology or temporomandibular joint disorders.\(^12,18\) The selection of the reconstruction plane (axial, sagittal or coronal) used for the detection or the type of tooth could have an influence on
VRF detection. Axial slices are found to be more accurate than sagittal and coronal slices for detecting VRF.\textsuperscript{21} CBCT, as with any technology, has known limitations. There are also numerous CBCT equipment manufacturers and models available. In general, CBCT can be categorized into large-, medium- and limited-volume units based on the size of their ‘field of view’.\textsuperscript{24}

**Volume Size(s)**

The size of the ‘field of view’ (FOV) describes the scan volume of CBCT machines and is dependent on the detector size and shape, beam projection geometry and the ability to collimate the beam. Beam collimation limits the X-radiation exposure to the region of interest and ensures that an optimal FOV can be selected based on disease presentation. Smaller scan volumes generally produce higher resolution images, and since endodontics relies on detecting disruptions in the periodontal ligament space measuring approximately 200 $\mu$m, optimal resolution is necessary.\textsuperscript{25}

The principal limitation of large FOV cone-beam imaging is the size of the field irradiated. Unless the smallest voxel size is selected in these larger FOV machines, there is also reduced resolution compared to intraoral radiographs or limited volume CBCT machines with inherent small voxel sizes. The limited volume CBCT imaging in endodontics is advantageous, but by irradiating only one site or area, projections acquired may not contain the entire region of interest.

Reconstructed images may suffer from truncation artifacts when comparing medical CT with CBCT reconstructed images; medical CT scans provide the most suitable images for tumor-derived alterations due to their capacity for soft tissue visualization.\textsuperscript{26,27} For most endodontic applications, limited volume CBCT is preferred over large volume CBCT for the following reasons:

1. Increased spatial resolution to improve the accuracy of endodontic-specific tasks, such as the visualization of small features including accessory canals, root fractures, apical deltas, calcifications, etc.
2. Highest possible spatial resolution that provides a diagnostically acceptable signal-to-noise ratio for the task at hand.
3. Decreased radiation exposure to the patient.
4. Time savings due to smaller volume to be interpreted.

**DOSE CONSIDERATIONS**

Every effort should be made to reduce the effective radiation dose to the patient for endodontic-specific tasks. Using the smallest possible FOV, the smallest voxel size, the lowest mA setting and the shortest exposure time in conjunction with a pulsed exposure mode of acquisition is recommended. If extension of pathology beyond the area surrounding the tooth apices or a multifocal lesion with possible systemic etiology is suspected, and/or a nonendodontic cause for devitalization of the tooth is established clinically, appropriate larger field of view protocols may be employed on a case-by-case basis. Interpretation of the entire acquired volume will be essential to justify the use of task-specific modification of acquisition protocol in such cases.\textsuperscript{24} CBCT has a significant advantage over medical grade CT as radiation doses from commonly used CBCT acquisition protocols are lower by an order of magnitude.\textsuperscript{28}

Selection of the most appropriate imaging protocol for the diagnostic task at hand is paramount.

**PATIENT SELECTION CRITERIA**

CBCT must not be used routinely for endodontic diagnosis or for screening purposes in the absence of clinical signs and symptoms. The patient’s history and clinical examination must justify the use of CBCT by demonstrating that the benefits to the patient outweigh the potential risks. The clinical and radiographic diagnosis of vertical root fractures is often complicated. A local deep pocket, dual sinus tracts, and a halo type of lateral radiolucency are among the symptoms.\textsuperscript{1,29,30} Often these symptoms are not convincing to justify tooth extractions, which usually is the elected treatment because the prognosis of VRFs is poor. Therefore, the exact diagnosis to VRF is crucial to avoid erroneous extractions. Clinicians should use CBCT only when the need for imaging cannot be answered adequately by lower dose conventional dental radiography or alternate imaging modalities.

This CBCT image of 36 region image shows (Fig. 1):

- A thin radiolucent line seen in all axial sections extending from crown to the level of furcation at mesiolingual aspect suggests of vertical fracture.
- A well-defined radiolucency seen in the periapical region of mesial root and ill-defined radiolucency seen IRT distal root extending till 37.
- There is generalized PDL widening IRT 36 and 37.

**RADIOLOGIC IMPRESSION**

**Vertical Fracture IRT 36**

**Patient Consent**

Significant risks, benefits and alternatives of special importance should be explained by disclosure and patient education, and then documented in a patient’s record. The use of CBCT will expose the patient to ionizing radiation that may pose elevated risks to some patients (e.g. cases of
pregnancy, previous treatment with ionizing radiation and younger patients). Patients should be informed that CBCT volumes cannot be relied upon to show soft tissue lesions unless they have caused changes in hard tissues (teeth and bone), and some of the images may contain artifacts that can make interpretation difficult. A patient may understand the relevant facts and implications of not following a recommended diagnostic or therapeutic action and still refuse the proposed intervention. This is known as the medicolegal concept of ‘informed refusal’ and is recognized in the court of law. Should a patient be incapable of understanding or responding to an informed consent presentation or be a minor, the informed consent or informed refusal should be documented in the patient’s record and signed by an individual legally responsible for the patient.31

CONCLUSION

Conventional intraoral radiography provides clinicians with an accessible, cost-effective, high-resolution imaging modality that continues to be of value in endodontic therapy. There are, however, specific situations, both pre- and postoperatively, where the understanding of spatial relationships afforded by CBCT facilitates diagnosis and influences treatment. The usefulness of CBCT imaging can no longer be disputed—CBCT is a useful task specific imaging modality and an important technology in comprehensive endodontic evaluation.

REFERENCES


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