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ENDODONTIC RADIOGRAPHY- A REVIEW ARTICLE

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ABSTRACT
Dentistry has witnessed tremendous advances in all its branches over the past three decades. With these advances, the need for more precise diagnostic tools, specially maging methods, have become mandatory. From the simple intra-oral periapical X-rays, advanced imaging techniques like computed tomography, cone beam computed tomography, magnetic resonance imaging and ultrasound have also found place in modern dentistry. Changing from analogue to digital radiography has not only made the process simpler and faster but also made image storage, manipulation (brightness/ contrast, image cropping, etc.) and retrieval easier. The three-dimensional imaging has made the complex cranio-facial structures more accessible for examination and early and accurate diagnosis of deep-seated lesions. This paper is to review current advances in imaging technology and their uses in different of dentistry.

KEYWORDS: Computed tomography, cone beam computed tomography, cone beam volumetric tomography, Radiovisiography, ultrasound, MRI, Endodontics.

INTRODUCTION

In endodontics, radiographs are very essential tool which is most accurate with least subjective bias available for diagnosis of diseases affecting maxilla and mandible. Radiographs are an important part of root canal therapy, especially for diagnosis, treatment, and follow-up. Conventional X-rays using an analog film or digital receptor produce two-dimensional (2D) image of a three-dimensional (3D) object. The anatomical structures surrounding the tooth, will superimpose and make it difficult for the interpretation of conventional x-ray image.[1-3] However, routine radiographic procedures do not accurately demonstrate the presence of every lesion, the real size of the lesion or its spatial relationship with the anatomical structures.[4]

To overcome the disadvantages of Conventional X-rays using an analog film technique, newer imaging techniques has been introduced, which includes.

- Conventional Intraoral periapical radiograph
- Ultrasonography (USG)
- Radio visiography (RVG)
- Digital subtraction radiography (DSR)
- Computed tomography (CT)
- Tuned aperture computed tomography (TACT)
- Cone beam volumetric tomography (CBVT)/ cone beam computed tomography (CBCT)
- Magnetic resonance Imaging (MRI)

ROLE OF IMAGING IN ENDODONTICS

Preoperative
• To analyze dental and alveolar hard tissue morphology
• Pathological alterations
• Morphology of tooth, including location and number of root canals, pulp chamber size, calcifications, root structure, direction, and curvature
• Iatrogenic defects
• Crown and root fractures

Intraoperative
• To determine the proper working length of the root canal system
• Tooth and bone changes

Postoperative
• To evaluate the root canal obturation and seal
• Tooth and periapical hard tissue changes after treatment
• Planning for surgical considerations.[8]

VARIOUS RADIOGRAPHIC TECHNIQUES

CONVENTIONAL INTRAORAL PERIAPICAL RADIOGRAPH

Intraoral radiographs are one of the most important imaging modalities available in dentistry to the dental practitioner. It provides high spatial resolution imaging of teeth and associated dental and jawbone diseases. Two types of exposure techniques used for intraoral periapical radiography: the paralleling and the bisecting angle technique. With the paralleling technique, the tooth and the sensor are both kept on a parallel plane. This technique provides less image distortion and reduces excess radiation to the patient.[28]

In bisecting angle technique, the receptor is placed as close as to the tooth. The central ray of the x-ray beam should be directed perpendicular to an imaginary line that bisects or divides the angle formed by the long axis of the tooth and the plane of the receptor.[28]

As technology advances, digital detectors are gaining in popularity since they are considered part of optimization to reduce the radiation dose, maintaining high image quality. Additional computerized advantages include the ability to enhance the image for viewing.[28]

RADIO VISIOGRAPHY

Radio visiography is one of the direct digital radiographic techniques used in dentistry. It is based on digital image capture with a charged coupled device (CCD) which is capable of image enhancement using up to 256 shades of gray. It was first commercially used in the United Kingdom in 1989; since then it has undergone several changes.[12]

It comprises of four basic components, an x-ray unit, an electronic timer, an intraoral sensor, a display processing unit (DPU), and a printer.

Applications of radio visiography in endodontics

- Diagnosing carious lesions
- Measuring root lengths
- Detecting periapical pathology
- Root fractures.[13]

Feature of radio visiography

Image enhancement

- The gray window effect, known as the x function, allows the operator to select and expand on a specific 60 levels of gray from the 256 available, which may aid in the diagnosis of accessory root canals.[14]
- The millimeter grid incorporated in the system helps in measuring the length of the root canal.
- The use of pseudo color assigns different colors to certain gray levels, which can help to visualize particular features that are unclear on image.
- RVG requires 23% of the radiation dose when compared to the conventional radiograph.[15] Resolution of RVG is nineline pairs/mm, which is inferior to conventional X-ray films, but it is adequate for most diagnostic tasks. Advantages and disadvantages of RVG are.

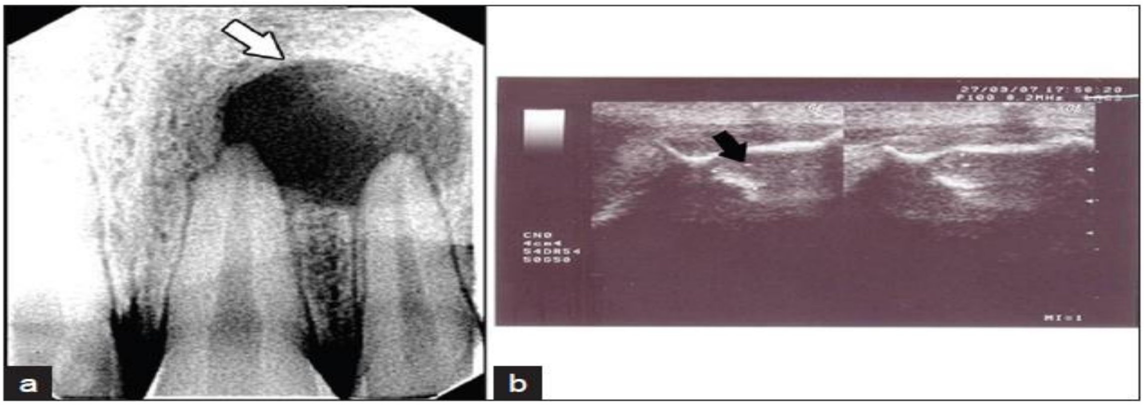


Figure 1: (a-b) Radiovisio graphic (RVG) and Ultrasound (US) images of a periapical lesion (1a) RVG image shows a well-circumscribed, radiolucent, periapical lesion with a sclerotic border, measuring about 2 x 1 cm in diameter (white arrow) (1b) USG shows a hypoechoic, well-contoured cavity, with no evidence of internal vasculature (Black arrow).[1]

Advantages

• Substantial radiation dose reduction
• Production of instantaneous images
• Control of contrast
• Ability to enlarge specific areas that may be of use in visualizing instrument location during endodontic treatment
• Potential for storage in a computer and subsequent transmission of the images

Disadvantages

• Loss of resolution from screen to print images
• Relatively small sensor size
• Greater thickness than conventional films.

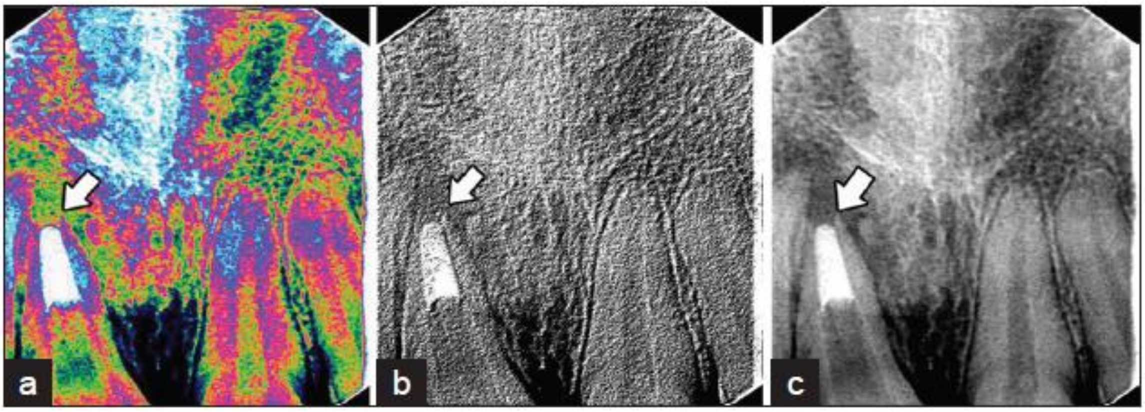


Figure 2: Various RVG images (a) Pseudo color RVG image shows obturation in the apical third of the root canal and resorption of the root apex. (b) 3D RVG image of a periapical lesion and root canal obturation. (c) Normal RVG image of a periapical lesion and root canal obturation.[1]

DIGITAL SUBSTRACTION RADIOGRAPHY

Subtraction method was introduced by B.G. Zeides des Plantes in the 1920s.

Digital subtraction radiography (DSR) is a technique used to determine qualitative changes that occur between two images taken at different points in time.

The first image is taken as baseline image and the second image shows the changes that have occurred since the time the first image was taken.[13] DSR cancels out the complex anatomic background against which this change occurs. For DSR to be diagnostically useful, it is important that the baseline projection geometry and image intensities be reproduced. Dove *et al*[14] reported that angulation errors should be limited to two degrees. DSR helps to detect the alveolar bone changes of 1%-5% per unit volume and of crestal bone height change of 0.78mm.[15,16]

Parsell *et al*[17] in 1998 found that digital subtraction radiography with or without enhancement improved the likelihood of a correct cancellous defect diagnosis when compared to other methods to detect oral cancellous bone lesions. However, it is only used for research purpose, as it is difficult to reproduce images with similar projection geometry every time

COMPUTED TOMOGRAPHY

Computed tomography **(**CT) produces 3D images of an object by using a series of 2D image data, to mathematically reconstruct a cross-section of the object. It provides images of combination of soft tissues, bone, and blood vessels [18]. The technique of Dental CT also known as Dentascan was developed by Schwartz et al The Dental CT can be performed with a conventional CT, a spiral CT, or a multislice CT scanner.[19]

The first commercial computed tomography (CT) scanner was developed in 1972 by Sir Godfrey N. Hounsfield, an engineer at EMI, Great Britain. Since then, the introduction of clinical X-ray computed tomography has transformed medical imaging and may be described as the greatest advancement in radiology. Computed tomography uses a narrow fan-shaped X-ray beam and multiple exposures around an object to reveal its internal structures which helps the clinician to view morphology and pathology of a structure in three-dimensions.[20]

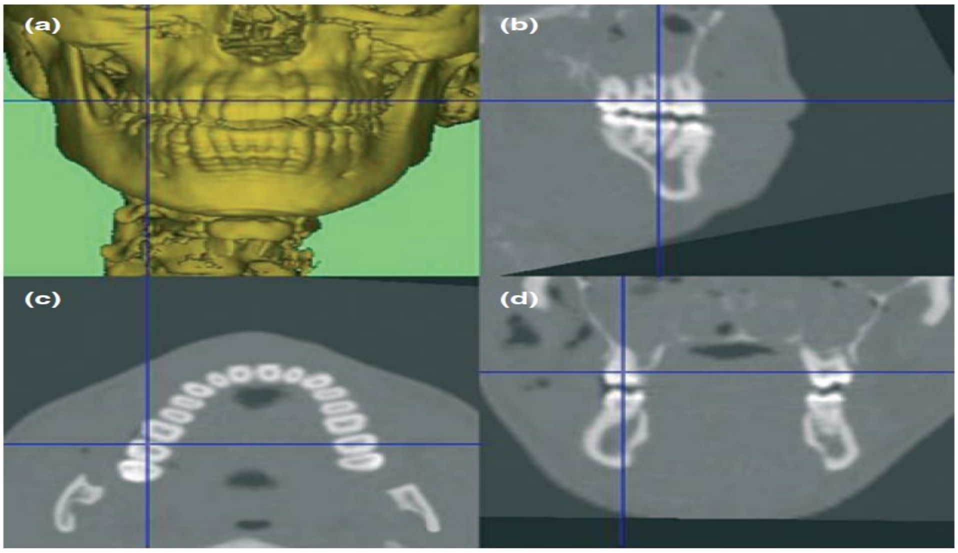
CT scanner consists of a radiographic tube which is attached to a series of scintillation detectors or ionization chambers. The patient is advanced in the circular aperture in the centre of the gantry. The tube head and reciprocal
detectors within the gantry either rotate synchronously around the patient, or the detectors may form a continuous ring around the patient and the X-ray tube may move in a circle within the detector ring.[21]

Current CT scanners are called multi-slice CT scanners and have a linear array of multiple detectors (up to 64 rows) that simultaneously obtain tomographic data at different slice locations. It provides various advantages including significant reduction in scan time, reduced artifacts, and sub-millimetre resolution (up to 0.4 mm isotropic voxel).[22]

Computed tomography technology has been applied to the management of endodontic problems.

Tachibana & Matsumoto (1990) published one of the first reports on the application of CT technology in endodontics. They were able to gain additional information on the root canal anatomy and its relationship to vital structures such as the maxillary sinus using reconstructed axial slices and three-dimensional reconstruction of the CT data.

Velvart et al. (2001) compared the information derived from CT scans and periapical radiographs of 50 mandibular posterior teeth scheduled for periapical surgery to the clinical findings at the time of surgery. They founded that CT detected the presence of an apical lesion and the location of the inferior alveolar nerve in all cases, compared with 78% and 39% respectively with periapical radiographs.



(a) Reconstructed three-dimensional CT image, (b–d) sagittal, axial and coronal reconstructed slices from a CT scan.[23]

TUNED APERTURE COMPUTED TOMOGRAPHY

Tuned aperture computed tomography (TACT) is a simple, faster method for reconstructing tomographic images, which was developed by Webber and colleagues. It is based on the concept of tomosynthesis and optical-aperture theory. TACT uses 2-D periapical radiographs acquired from different projection angles as base images and permits retrospective generation of longitudinal tomographic slices (TACT-S) lining up in the Z axis of the area of interest.

It produces true 3-D data from any number of arbitrarily oriented 2-D projections.

TACT has shown to be a very good alternative to other conventional modalities for a number of clinical applications. The overall radiation dose of TACT is not greater than 1 to 2 times that of a conventional periapical X-ray film.

The resolution is stated to be similar with 2-D radiographs. Artefacts associated with CT, such as starburst patterns seen with metallic restorations, do not exist with TACT.

In 1998, Nair *et al* reported TACT to be more effective imaging modality than film or individual digital *al* in 1999 also found TACT to be diagnostically more informative.

Nance et al reported that with TACT 36% of extra canal [second mesio-buccal (MB 2)] were detected in maxillary molars and 80% of third (mesio-lingual) canals in mandibular molars. TACT has proved to be effective in the determination of root fractures, especially vertical fractures.

Nair *et al* found that TACT was a more effective and accurate imaging modality for non- destructive quantification of osseous changes within the healing bony defects. It was found to be better than planar images for the detectability of trauma-induced radicular fractures and mandibular fractures in *in-vitro* studies.

Liang *et al* reported that TACT provides an alternative to conventional tomography for pre-surgical implant imaging. However, TACT is still under the study for dental applications but appears to be a promising imaging modality for the future.

CONE BEAM COMPUTED TOMOGRAPHY

conventional radiographic techniques, regardless of whether they are film based or digital have limitations. These include the two-dimensional nature of the images produced (Brynolf 1967, Velvart et al. 2001), anatomical noise masking the area of interest to varying degrees (Bender & Seltzer 1961, Paurazas et al. 2000) and geometric distortion (Vande Voorde & Bjorndahl 1969, Forsberg & Halse 1994).

Cone Beam Computed Tomography (CBCT) has seen to overcome some of these limitations, and does generate three-dimensional images.

Clinicians must have depth knowledge of CBCT radiography before prescribing CBCT scans, and must regularly update their knowledge (Brown et al. 2014). The principles of radiation protection must be adhered to (IRMER 2000, Holroyd & Gulson 2009, Patel & Horner 2009)

A CBCT scan should have a benefit to the management of a patient's (suspected) endodontic problem. While using ionizing radiation imaging device, the radiation dose should be kept 'as low as reasonably achievable' (ICRP 2007).

The size of the 'field of view' (FOV) varies between CBCT scanners, from 3 to 4 cm up to 20 cm. Some scanners have a fixed FOV; others have the option to change the FOV size to suit the clinical situation. Only a limited FOV is suitable for endodontic purposes as it limits the area being irradiated to only the region of interest (SEDENTEXCT 2012, Brown et al. 2014). By this, the effective dose to the patient is reduced, and the reconstructed images produced have typically a higher spatial resolution than larger FOV scans (Pauwels et al. 2012).

The diagnostic accuracy of CBCT compared with intraoral radiographic techniques was investigated in two in vitro studies (Patel et al. 2009, Sogur et al. 2009) of moderate quality (Table 6). Both studies used mandibles from skeletal material. The studies showed that CBCT had higher sensitivity, specificity and Az values at ROC analysis compared with intraoral radiographs. This result is supported by findings from clinical studies where CBCT revealed additional periapical bone destructions compared with intraoral radiographs (Lofthag-Hansen et al. 2007, Christiansen et al. 2009).

Digital and film periapical techniques both have a limited capacity to show small bone lesions, but a high capacity to identify normal periapical conditions. CBCT is more sensitive and shows minor bone lesions more readily than periapical radiography.[24]

APPLICATIONS OF CBCT IN VARIOUS BRANCHES OF DENTISTRY

- CBCT is majorly used in oral and maxillofacial surgery for surgical evaluation and planning for surgery for impacted teeth, cysts and tumors, orthognathic and implant surgeries and diagnosis of fractures and inflammatory conditions of the jaws and the sinuses.
- CBCT has been used for preoperative and postoperative dental implant assessment.
- CBCT images have been used in orthodontic assessment and cephalometric analysis.[74] CBCT helps to determine root angulations, although variations are seen from the true anatomy.[75] CBCT is valuable tool to assess the facial growth, age, airway function and disturbances in tooth eruption.
- CBCT has proved to be a practical clinical tool to detect intra-bony and furcation defects, dehiscence, fenestration, and periodontal cysts.[24]

CONE BEAM COMPUTED TOMOGRAPHY APPLICATIONS IN ENDODONTICS

• Diagnosis of radiographic signs of periapical pathosis when there are contradictory (nonspecific) signs and/or symptoms.

• Confirmation of nonodontogenic causes of pathosis.

• Assessment and/or management of complex dento-alveolar trauma, such as severe luxation injuries, suspected fracture of the overlying alveolar complex and horizontal root fractures, which may not be readily evaluated with conventional radiographic views.

• Appreciation of extremely complex root canal systems prior to endodontic management (for example, class III & IV dens invaginatus).

• Assessment of extremely complex root canal anatomy in teeth treatment planned for nonsurgical endodontic re-treatment.

• Assessment of endodontic treatment complications (for examples, [post] perforations) for treatment planning purposes when existing conventional radiographic views have yielded insufficient information;

• Assessment and/or management of root resorption, which clinically appears to be potentially amenable to treatment.

• Pre-surgical assessment prior to complex periradicular surgery (for example posterior teeth).[24]

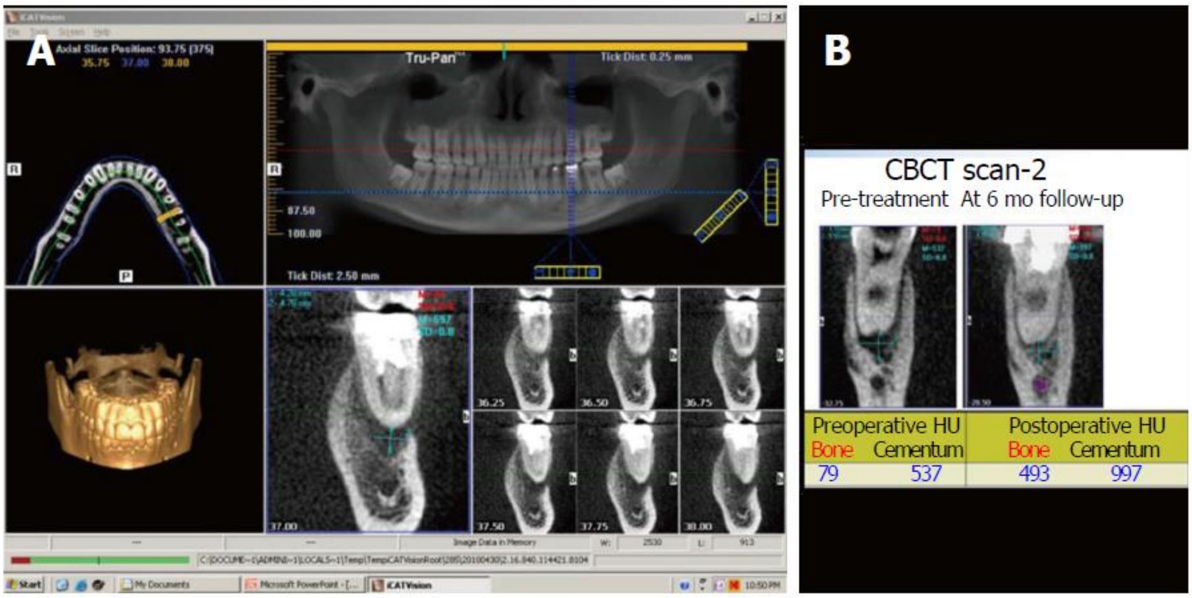


Figure Cone beam computed tomography. A: A cone beam computed tomography scan gives a three-dimensional view of the area of interest. In this case, the periapical lesion is being evaluated; B: The image gives values in Hounsfield unit of cementum and alveolar bone density to measure posttreatment healing. CBCT: Cone beam computed tomography.[21]

CONCERN FOR RADIATION EXPOSURE

Radiation exposure for panoramic radiograph is 14.2-24.3 mSv, for lateral cephalogram, it is 10.4 mS and for a full mouth intraoral X ray series is 13-100 mS. Digital X ray require a much lower radiation exposure, that is 50%-75% less than equivalent film image. Digital panoramic radiation dose is 0.020 mSv and for cephalogram it is 0.007 mSv. CBCT units have radiation exposure in the range of 87-206 mSv for a full craniofacial scan.[26]

Based on these values, it is inferred that CBCT radiation exposure is equivalent to or slightly higher than traditional imaging. However, CBCT must not be used routinely for dental diagnosis or for screening purposes. The patient's history and clinical examination must reflect the use of CBCT by demonstrating that the benefits to the patient overweighs the potential risks.[25]

Dose reduction and optimization

To ensure patient safety, personnel who use a CBCT scanner must have appropriate training and knowledge of patient radiation doses related to the specific CBCT scanner they are using. For endodontic purposes, the FOV should be limited to the region of interest, that is, the FOV should encompass the tooth (or teeth) under investigation and its surrounding structures. This is an effective way to reduce the patient dose. The tube current (mA) selected should be as low as possible, so that the image produced is of sufficient diagnostic yield even though there may be a degree of noise. The effective dose is also dependent on the region of the oral cavity being scanned (Loubele et al. 2009, Pauwels et al. 2012). Radiosensitive tissues, (e. g. salivary and thyroid gland) will be irradiated when certain areas of the the jaws are being scanned.[26]

Limitations

Metal restorations, metal posts and root fillings and to some extent adjacent dental implants typically cause artefacts to the reconstructed images (Scarfe & Farman 2008). The potentially deleterious impact this may have on reconstructed images should be considered before considering a CBCT scan (So gur et al. 2007, Bueno et al. 2011).

The scan time of CBCT devices can be as long as 20 s and is therefore significantly longer compared with that of an intra-oral radiograph (<0.3 s). Therefore, even the slightest movement of a patient during the scan may render the resulting reconstructed images of minimal diagnostic use. Therefore, this may cause problem with children, elderly patients and those with neurological disturbances, for example Parkinson's disease.

The spatial resolution of even the smallest voxel size may be too low to identify small objects, such as fractured instruments, or diagnostically challenging problems, for example incomplete vertical root fractures (VRFs) (D'Addazio et al. 2011, Brady et al. 2014, Patel et al. 2013).[26]

MAGNETIC RESONANCE IMAGING

An MRI scan is a specialized imaging technique which does not use ionizing radiation. It involves the behaviour of hydrogen atoms (consisting of one proton and one electron) within a magnetic field which is used to create the MR image. The patient's hydrogen protons normally spin on their axis. The patient is placed within a strong magnetic field, which aligns the protons contained within hydrogen atoms along the long axis of the magnetic field and the patient's body. A pulsed beam of radio waves which has a similar frequency to the patient's spinning hydrogen atoms is then transmitted perpendicular to the magnetic field. This knocks the protons out of alignment, resulting in the hydrogen protons processing like tiny gyroscopes, moving from a longitudinal to a transverse plane. The atoms behave like several mini bar-magnets, spinning synchronously with each other. This generates a faint radio-signal (resonance) which is detected by the receiver within the scanner.

Similar radio-signals are detected as the hydrogen protons relax and return to their original (longitudinal) direction. The receiver information is processed by a computer, and an image is produced (White & Pharaoh 2004, Whaites 2007b).

The main dental applications of MRI till now has been the investigation of soft-tissue lesions in salivary glands, investigation of the temporomandibular joint and tumour staging (Goto et al. 2007, Whaites 2007b). MRI has also been used for treatment planning for dental implant placement (Imamura et al. 2004, Monsour & Dhudia 2008). Recently, Tutton & Goddard (2002) performed MRI on a series of patients with dental disease. They were able to differentiate the roots of multi-rooted teeth; smaller branches of the neurovascular bundle could be clearly identified entering apical foramina. The authors also said that the nature of periapical lesions could be determined as well as the presence, absence and/or thickening of the cortical bone.

MRI scans are not affected by artefacts caused by metallic restorations (for example amalgam, metallic extracoronal restorations and implants) which can be a major problem with CT technology (Eggars et al. 2005). Cotti & Campisi (2004) suggested that MRI may be useful to assess the nature of endodontic lesions and for planning periapical surgery.

Magnetic resonance imaging has several drawbacks.

These include.

- Poor resolution compared with simple radiographs and long scanning times.
- great hardware costs
- limited access only in dedicated radiology units
- Different types of hard tissue (for example enamel and dentine) cannot be differentiated from one another or from metallic objects; they all appear radiolucent.

It is for these reasons that MRI is of limited use for the management of endodontic disease.[26]

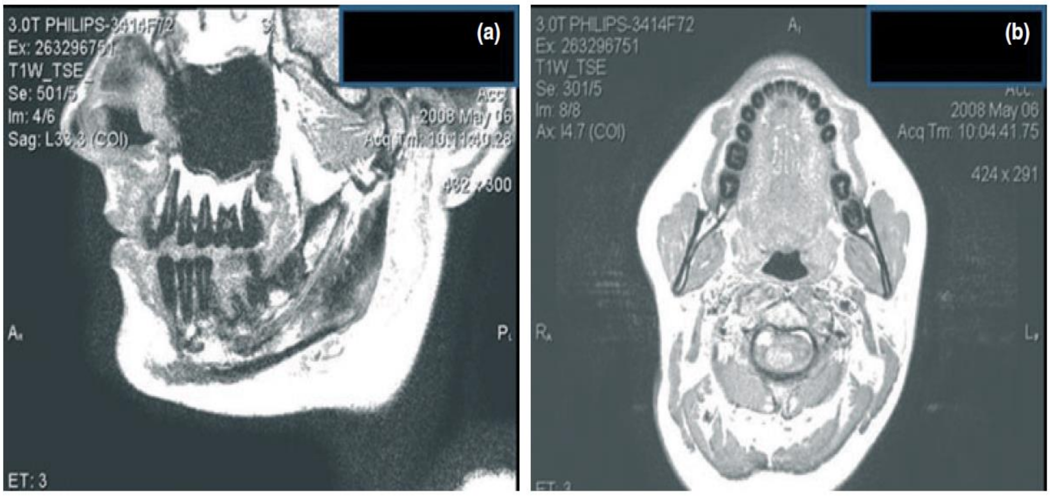


Figure (a) A sagittal MRI scan of the head. Bone and teeth do not give a signal and therefore appear dark. The root canals can be clearly visualized, as can the maxillary root apices relationship to the maxillary sinus. (b) An axial MRI scan, the soft tissues can be clearly identified. Courtesy of Dr Crawford Gray, Aberdeen, UK.[23]

ULTRASOUND IN ENDODONTICS

Ultrasound uses sound waves with a frequency outside the range of human hearing (20 kHz) and can be used to view normal and pathological conditions involving the bones and soft tissues of the oral and maxillofacial regions.[8] US can be used in place of conventional X-rays as it has a greater ability to differentiate between cystic and non-cystic lesions.[9] The alveolar bone appears as a total reflecting surface (white), if healthy; the root contours of the teeth are even whiter (hyperechoic). A fluid-filled cavity in the bone appears as a hypo-reflecting surface (dark).

The degree of reflection depends on the clarity of the fluid (hypoechoic). A simple serous filled cavity has no reflection (anechoic or transonic). Solid lesions in the bone have a mixed echogenic appearance, which means their echoes are reflected with various intensities (shades of gray). If the bone is irregular or resorbed in the proximity of the lesion, the scan is seen as an inhomogeneous echo. If the bony contour limiting a lesion is reinforced, then it is very bright.[10]

Ultrasound in dentistry is used for the detection of facial fractures, to detect parotid lesions during fine needle aspiration cytology, to assess the content of the lesions before surgery.[11] However, it is difficult to use in the posterior region of the oral cavity, because of thick cortical plate in the posterior region which prevents ultrasound waves from traversing easily.

LIMITATIONS OF CONVENTIONAL RADIOGRAPHY FOR ENDODONTIC DIAGNOSIS

Conventional images, whether captured on X-ray film or digital sensors yield limited information for several reasons.

Compression of three-dimensional anatomy.

Conventional images compress three-dimensional anatomy into a two-dimensional image or shadowgraph, greatly limiting diagnostic performance (Webber & Messura 1999, Nance et al. 2000, Cohenca et al. 2007). Important features of the tooth and its surrounding tissues are visualized in the mesio-distal (proximal) plane only. Similar features presenting in the bucco-lingual plane (i. e. the third dimension) may not be fully appreciated. The spatial relationship of the root(s) to their surrounding anatomical structures and associated periradicular lesions cannot always be truly assessed. The location, nature and shape of structures within the root under investigation (for example, root resorption) may bedifficult to assess (Cohenca et al. 2007, Patel et al. 2007, Whaites 2007a, b). Diagnostic information in this missing 'third dimension' is of particular relevance in surgical planning (Velvart et al. 2001, Low et al. 2008), where the angulation of the root to the cortical plate, the thickness of the cortical plate and the relationship of the root to key adjacent anatomical structures such as the inferior alveolar nerve, mental foramen or maxillary sinus should be understood.[27]

Anatomical noise

Anatomical features may obscure the area of interest, resulting in difficulty in interpreting radiographic images (Revesz et al. 1974, Kundel & Revesz 1976, Gro¨ndahl & Huumonen 2004). These anatomical features are referred to as anatomical, structured or background noise and may be radiopaque (for example zygomatic buttress) or radiolucent (for example incisive foramen, maxillary sinus). The more complex the anatomical noise, the greater the reduction in contrast within the area of interest (Morgan 1965, Revesz et al. 1974, Kundel & Revesz 1976) with the result that the radiographic image may be more difficult to interpret.

The problem of anatomical noise in endodontics was first observed by Brynolf (1967, 1970), who noted that the projection of the incisive canal over the apicies of maxillary incisors may complicate radiographic interpretation. Several studies (Bender & Seltzer 1961, Schwartz & Foster 1971) have concluded that periapical lesions, which are confined to the cancellous bone are not easily visualized on radiographs. This is another example of anatomical noise,the area of interest being masked by the denser overlying cortical plate.[27]

Temporal perspective

Radiographic images represent a ‘snapshot’ in time of the area being assessed (Horner et al. 2002). To assess the outcome of endodontic treatment, radiographs exposed at different points in time should be compared (Friedman 2002). Pre-treatment, post-treatment and follow-up radiographs should be standardized with respect to their radiation geometry, density and contrast to allow reliable interpretation of any changes which may have occurred in the periapical tissues as a result of treatment (Gro ¨ndahl & Huumonen 2004).

Poorly standardized radiographs may lead to under- or over-estimation of the degree of healing or failure. Customized stents have been used to increase the reproducibility of radiation geometry when using paralleling technique. Elastomeric impression material is placed onto the bite block of the paralleling device, which is then positioned in the most favourable position and the patient asked to bite on it until it sets (Duckworth et al. 1983, Rudolph & White 1988). The same bite block may then be used for subsequent radiographs to ensure that the X-ray film, tooth and X-ray beam are consistently aligned. Even with these techniques, serial radiographs will still show small inconsistencies (Rudolph & White 1988).[27]

CONCLUSION

Imaging technology aids in the diagnosis of endodontic pathosis and canal morphology, assessing root and alveolar fractures, in the analysis of resorptive lesions, identification of the pathosis of non-endodontic origin, and pre-surgical assessment before root-end surgery. When compared with CT, CBCT has increased accuracy, higher resolution, reduced scan time, a reduction in radiation dose, and reduced cost for the patient. As compared with conventional periapical radiography, CBCT eliminates the superimposition of the surrounding structures, providing additional, clinically relevant information. The drawbacks of CBCT include limited availability, significant capital investment, and medico-legal considerations.

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