Modern Imaging Techniques In Endodontics: A Review

Abstract

Dental radiology has played an exciting and critical diagnostic role in dentistry. Radiographs are essential for diagnosis and treatment planning, determining anatomy, managing treatments and assessing outcomes.Many undetected conditions can be identified with the help of radiographs. An oral examination without dental radiographs limits the practitioner to what is seen clinically- the teeth and soft tissue. With the use of dental radiography, the dental professional can obtain a wealth of information about the teeth and supporting bone.

Contemporary imaging systems such as the panoramic imaging, digital imaging, ultrasonography, cone beam imaging, computed tomography, magnetic resonance have revolutionized the imaging techniques in endodontic diagnosis.

Keywords: Imaging, Digital, CBCT, Ultrasonography.

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Introduction

Dental radiology has long played an exciting and critical diagnostic role in dentistry, never truer than now with the rapidly expanding array of imaging modalities.[1]Radiographs are essential for diagnosis and treatment planning, determining anatomy, managing treatments and assessing outcomes.

The use of x rays was not available to the dental profession until early in the last century. In the year 1895, Roentgen discovered X rays after which intra oral radiography was brought in use.[2]

In dentistry, radiographs enable the dental professional to identify many conditions that may otherwise go undetected and to see conditions that cannot be identified clinically.

An oral examination without dental radiographs limits the practitioner to what is seen clinically- the teeth and soft tissue. With the use of dental radiographs, the dental professional can obtain a wealth of information about the teeth and supporting bone.[2]

Extra oral imaging including cephalo-metric radiography, followed soon thereafter. Panoramic radiography has provided broad coverage of the teeth and surrounding structures since the mid twentieth century. Each of these modalities have adapted to digital revolution.

Recent decades have seen the development of panoramic imaging, digital imaging, ultrasonography, cone beam imaging, computed tomography, magnetic resonance imaging and nuclear medicine.

Conventional intra oral periapical and bitewing radiographs are familiar and ubiquitous, and when well made, they provide excellent images for most dental radiographic needs.[1]

Panoramic imaging has been evolving continuously since its introduction in the 1950s.[1] It produces a wide single image that shows maxillofacial region including maxilla, mandible and the adjacent structures on a single film.[3]

The term radiography comes from the words “radiation” and “photography”. That is, making a photographic image using radiation. Today, we can create images within a computer using digital sensors, phosphor plates or ultrasound and no longer need the photographic process. Hence the term imaging has come to replace radiography when referring to all the different ways we can create images of a patient. The difference between digital images and radiographs is that digital images have no physical form.

They exist only as numbers in a computer file that tell the computer how to reconstruct the image so that it can be displayed on a monitor, laptop screen, printer or other viewing device.

Ultrasonography has been widely used diagnostic technique in many fields of medicine. It is a technique based on sound waves that acquires images in real time and without use of ionizing radiation.[4]

Cone beam computed tomography has gained broad acceptance in dentistry in the last 10 years although it has been in clinical use for 20 years. It can be simply defined as the use of the x ray based imaging method to produce 3 dimensional images usually displayed in the form of image slices.[1]

Magnetic resonance imaging is the latest non-invasive imaging modality that uses electrical signals generated from response of hydrogen nuclei to strong magnetic field and radiofrequency pulses to produce an image.

History

In 1895, X-rays were discovered by German physicist Wilhelm Roentgen. In 1947, panoramic radiography was introduced by YRJO Paatero of Finland, who is considered as the father of panoramic radiography. In 1987 intraoral digital radiography was introduced.[2]In 1946 Purcell and Bloch, two independent scientists, discovered the nuclear magnetic resonance phenomemon.[5]Hounsfield and Cormack, in 1979 invented the first CT technique.[6]

Intraoral Radiograph

Intraoral radiographic examinations are the backbone of imaging for the general dentist. It is the two-dimensional image of a three dimensional structure. Intraoral radiographs when well exposed and properly processed can provide considerable diagnostic information to complement the clinical examination.[4]

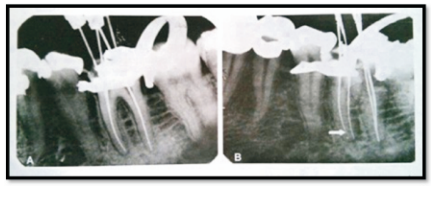


Figure 1.Disclosing canals by radiography. A, Right angle horizontal projection reveals four files in separate canals superimposed. B, Horizontal angulation varied 30 degree mesially reveals all four canals and file short of working length in mesiolingual canal. (Image from Ingle's 6th edition)

Clinical Applications[7]

- Aid in diagnosis of hard tissue alterations of the teeth and periradicular structures.
- Determine the number, location, shape, size, and direction of roots and root canals.
- Estimate and confirm the length of canals.
- Localize hard-to-find or disclose unsuspected, pulp canals by examining the position of an instrument within the root.
- Aid in locating a pulp space markedly calcified and/or receded.
- Confirm the position and adaption of

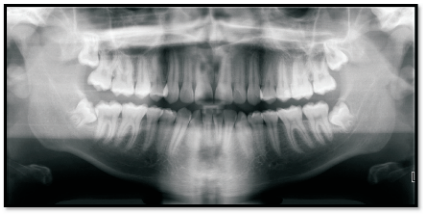
master cones and aid in evaluation of obturation.

- Confirm, following root-end surgery and before suturing, that all tooth fragments and excess filling material have been removed from the apical region and the surgical flap.
- Evaluate in follow up films, the outcome of treatment.
- They form the essential component of the patient record

Though they are less technique sensitive, they have certain disadvantages like Radiographs are two dimensional shadows on a single film. They are suggestive only and are not the singular final evidence in judging a clinical problem.[7]

Panoramic Imaging

Also known as pantomography is a technique for producing a single tomographic image of the facial structures that includes both the maxillary and mandibular dental



arches and their supporting structures.

Figure 2: Panoramic Radiograph

Clinical Applications[2,3]

1. To detect diseases, lesions and conditions of the jaws.
2. Examination of the facial bones after trauma
3. Evaluation of large bony lesions.
4. To evaluate impacted teeth.
5. To evaluate temperomandibular joints and their supporting structures.
6. It is used to assess extensive and unique pathosis like cyst and tumor and to know their size and shape.
7. It is also used for evaluation of developmental anomalies like missing, impacted, and embedded teeth.
8. Evaluation of the vertical height of the alveolar bone before inserting Osseo integrated implants.

Though the panoramic radiograph is relatively simple and requires minimal radiation exposure to the patient, it results in certain amount of magnification, distortion, and overlapping, even when proper technique is used.

Digital Imaging

The use of radiographs as a diagnostic tool has become an indispensable routine in medicine and dentistry. Digital imaging in dentistry was first introduced for intraoral imaging. The development of sensors with dimensions suitable in the mouth was possible only after the progress of miniaturization of the electronic circuitry.

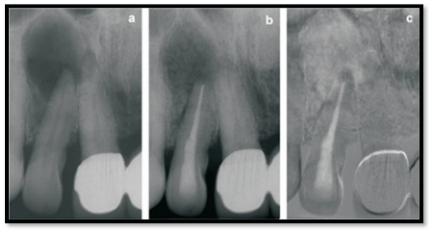


Figure 3. Digital Radiograph (a) pre-operative, (b) post-operative (c) Root filling and healing zone are emphasized in lighter shades of grey by using Digital subtraction radiography (Image from Ingle's 6th edition)

Clinical Applications[2,7]

- It can be used in the detection of periapical lesions and evaluation of assessment of root canal length.
- To detect lesions, diseases, and conditions of the teeth and surrounding structures.
- In the detection of root canal anatomy.
- It can also be used to detect internal and external root resorption.
- To detect presence of vertical or horizontal fractures in a tooth.
- To document the condition of a patient at a specific point in time.

Although the initial cost of purchasing a digital imaging system is a significant disadvantage, it has superior gray scale resolution,reduced exposure to x-radiation, there isincreased speed of image viewing, there iselimination of darkroom processing errors and there is increased efficiency in image storage and communication.

A feature that can be used to enhance a diagnostic image is **digital subtraction.**

With the digital subtraction, the gray-scale is reversed so that radiolucent images appear white and radiopaque images appear black.

Digital subtraction also eliminates distracting background information.

Additional features common to image processing software includes brightness, contrast, sharpness, image orientation, and pseudocolor alteration.

Cone Beam Computed Tomography

CBCT has gained broad acceptance in the last five years. CBCT is a precise, nondestructive technique for endodontic research that allows the canal system to be

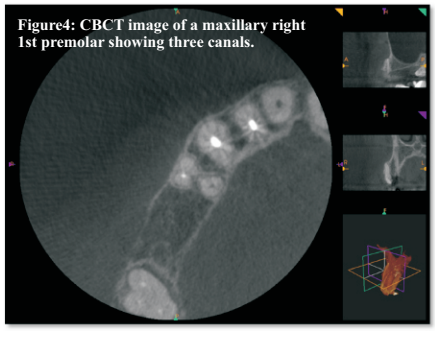


Figure4: CBCT image of a maxillary right 1st premolar showing three canals.

explored both qualitatively and quantitatively (Michetti et al. 2010).[8]The major innovation compared with intraoral and panoramic imaging is that it provides high quality, thin slice images. Cone beam machines emit an x-ray beam shaped like a cone, rather than a fan, in conventional CT machines. Because the beam covers the entire region of interest, it is only necessary for the x-ray source to make one pass or less around the patient's head, while acquiring images.[9]

Clinical Applications

- Assessment of internal and external root resorption[2]
- Treatment planning and assessment of traumatic dental injuries[2]
- Assessment of root fractures presurgical anatomic assessment[2]
- Treatment planning for tooth anomalies such as dens invaginatus.[2]
- Diagnosing the presence of resorption lesions, periapical bone defects and root fractures.[2]
- CBCT provides three dimensional undistorted images of the maxillofacial skeleton, including the teeth and their surrounding tissues, and this technique has demonstrated efficacy in a large number of endodontic applications, including but not limited to complex dental anatomy.[10]
- CBCT has been shown to be useful for assessing the complex anatomy of teeth.[10]
- Limited volume CBCT can provide noninvasive 3D images or simultaneously axial, coronal and sagittal 2D sections of target objects that can be applied in endodontic diagnosis.[8]
- Intraoperative applications of CBCT include localization of calcified canals, evaluation of root resorption and root fractures and assessment of iatrogenic errors such as perforation, fractured instruments and extruded obturation materials.[11]
- Interpretation of root canal anatomy.[11]
- It can also be used in endodontic working length measurements.[12]
- CBCT has become the standard in medicine for visualizing the maxillary sinuses because of the ability to visualize both bone and soft tissues in multiple views with thin sectioning. [13]
- CBCT can also be used in the detection of presence or absence of periapical lesions when compared with periapical radiographs.[14]

-Fewer studies support the use of CBCT as a method of measuring bone changes volumetrically (Agbaje et al. 2007, Kamburoglu et al. 2010) [15]

- CBCT is superior to digital radiograph for the detection of vertical root fracture in the absence of root fillings (Kamburoglu et al 2010, Ozer 2010) [16]
- De Paula-Silva et al. 2009, Wu et al. stated that CBCT can be applied in endodontic epidemiologic investigation

and clinical outcome study.[8]

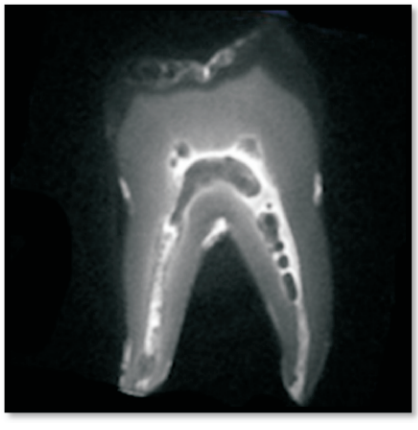
- Rate of healing following periapicalpathosis can also be assessed by CBCT (Wu et al. 2009) .[15]
- CBCT can help identify a MB2 canal in maxillary molars (Zhang et al. 2011b) and a separate distolingual canal in mandibular first molars (Wang et al 2010) Neelkantan et al. (2010) reported that CBCT has the capacity to detect the root canal system as accurately as canal staining and clearing techniques.[17]
- Patel and colleagues found CBCT to be efficacious in endodontic surgery, periapical surgery treatment planning, identification of root canals not seen on 2D images.[18]

Published reports indicate that the effective dose for various CBCT devices ranges from 52 to 1025 microsieverts depending on the type and model of CBCT equipment and imaging protocol used. These values are approximately equivalent to 4 to 77 digital panoramic radiographs or 5 to 103 days equivalent per capita background dose. Patient radiation dose can be lowered by collimating the beam, elevating the chin, and using thyroid and cervical spine shielding. CBCT provides a range of dose reductions of between 96% and 51% compared with conventional head CT.[4]Mah et al. stated that scans carried out at 360 degrees for 17.5 s is a constant drive to reduce the effective dosage of radiation that patients are subject to.[15]

Magnetic Resonance Imaging

Paul Lauterbur described the first magnetic resonance image in 1973 and Peter Mansfield further developed use of the magnetic field and the mathematical analysis of the signals for image reconstruction.To make a magnetic resonance image the patient is first placed inside a large magnet. It involves the behavior of hydrogen atoms (consisting of one proton and one electron) within a magnetic field.[4]

One of the principal advantages of MR imaging is that no radiation is used to obtain



images, and no biologic damage has been reported so far.[5]

Figure 5: MRI of tooth

Clinical Applications[4]

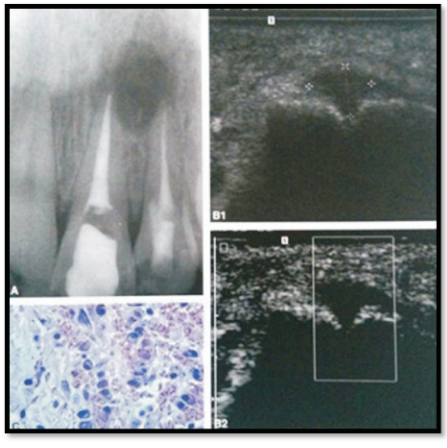
MRI is useful in evaluating soft tissue conditions, for instance,

- The position and integrity of the disk in the TMJ.
- For soft tissue disease especially neoplasia involving the soft tissues, such as tongue, cheek, salivary glands, and neck; determining malignant involvement of lymph nodes.
- Determining perineural invasion by malignant neoplasia.
- MRI may be used for the investigation of pulpal and periapical conditions, and the specification of the extent of the pathosis and the anatomic implications in surgical decision-making.
- MRI becomes the diagnostic technique of choice for the cases when an infective lesion like a periapical abscess is expanding fast in the jawbones and in corresponding soft tissues, degenerating into Osteomyelitis.

With MRI, we can obtain direct, sagital, coronal and oblique image which is impossible with radiography and CT. The disadvantage is because of the strong magnetic field used in patient electrically, magnetically or mechanically activated implants such as cardiac pacemakers cannot be used and also it may cause claustrophobia for a patient.[3]

Ultrasonography

Sonography is a technique based on sound waves that acquire images in real time and without the use of ionizing radiation. The phenomenon perceived as sound is the result of periodic changes in the pressure of air against the eardrum. The periodicity of these changes lies anywhere between 1500 and 20,000 Hz. Ultrasound has a periodicity greater than the audible range. Diagnostic ultrasonography, the clinical application of



ultrasound, uses vibratory frequencies in the range of 1 to 20 MHz.[4]

Figure 6:Ultrasound real time imaging of endodontic origin in the maxilla A, intraoral radiograph showing a periapical lesion involving upper left central and lateral incisors. B1 Periapical lesion as seen in the ultrasound images. B2 The same lesion with the CPD which shows the presence of blood vessels within the lesion. The lesion was diagnosed as periapical granuloma. C, Histopathologic features. (Image from Ingle's 6th edition)

Clinical Applications

- Cotti et al, have reported the use of ultrasound in the examination of bone lesions of endodontic origin.[19]
- Cotti et al. reported positive findings using ultrasound in the differential diagnosis of periapical lesions.[19]
- Bab et al, Zo et al and Gazit et al demonstrated that surface waves of a new ultrasound system could detect proximal caries lesions.[20]
- It can be used to distinguish between a cyst and a granuloma.[19]
- Recent advances include three dimensional imaging to allow multiplanar reformatting, surface renderings and color Doppler sonography for evaluation blood flow.[4]
- Granuloma shows a poorly defined hypoechoic area, showing rich vascular supply on color Doppler examination
- Ultrasonography gives a three dimensional image of a periapical lesion, measures its dimensions and evaluates its contents (fluids, solid, or a combination of both), obtains information on the patterns of expansion, vascularization, evolution in time and response in time.[7]

Ultrasonography uses no ionizing radiations and it entails lower biologic adverse effects but it can be used only if there is a bony defect over the lesion.[21]

Conclusion

Images acquired using periapical radiographs may not reveal adequate information for the detection and assessment of endodontic lesions and other relevant features. In certain situations, when it is important to evaluate the real extension, content, precise relationship to anatomic landmarks, vascularization, pattern of bone destruction and evolution in time, advanced imaging techniques may be extremely useful for providing detailed and specific information.

Reference

References are available on request at editor@healtalkht.com