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REVIEW ARTICLE

AN INTRODUCTION TO THE ADVANCED DIAGNOSTIC TECHNIQUES IN ENDODONTICS

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ABSTRACT:
Introduction of digital computers in the early 1940's fuelled the revolutionary change of rapid development in the various fields of science, including the beginning steps in digital imaging for diagnostic application. The specialized radiographic technique is used for specific diagnostic task. Some of the techniques have been available to diagnose at years, others are more recent. Advance imaging techniques have advantages like reduced exposure 3D reconstruction with the help of computers, easy to store patient data. Although general dental practitioners do not use most of these techniques routinely, some techniques are used occasionally to aid in diagnosis of oral conditions in oral cavity. Within the last 20 years, conventional radiography has been replaced by digital radiography. Diagnostic digital imaging modalities in dentistry include periapical, bitewing, panoramic and cephalometric imaging. The drawbacks of two dimensional imaging include inherent magnification, distortion and overlap of anatomy. To overcome the inherent problems of 2D imaging, tomographic "slices" of oral and maxillofacial anatomy came; this process is termed as "linear" or "multidirectional tomography".

Keywords: Digital Radiography, Computed Tomography, Cone Bean CT, Optical Coherence Tomography

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INTRODUCTION

Diagnosis is defined as 'identification of a disease or condition by a scientific evaluation of signs, symptoms, history and laboratory test results and procedures' .The purpose of making diagnosis is to be able to offer the most effective and, safest treatment and most accurate prognostication.[1]

Today's dentists are highly sophisticated health professionals who provide a wide range of oral health care that contributes to the general health and quality of their patients' lives. Dentists are instrumental in the early detection of oral cancer and systemic conditions that manifest in the mouth. They also can serve as first responders in the event of a large-scale health emergency. Today's dentists are at the forefront of a range of new developments in dental implants, computer generated imaging, and cosmetic and aesthetic procedures.[2, 3]

Diagnosis procedures may be used to: identify people at risk of developing disease (at risk); detect early stage disease in clinically asymptomatic individuals (screening); classify disease categories (classification); predict likely responders to specific treatments (treatment planning);monitor treatment efficacy and detect disease recurrence (monitoring).[4]

The specialized radiographic technique is used for specific diagnostic task. Some of the techniques have been available to diagnose at years, others are more recent. Advance imaging techniques have advantages like reduced exposure 3D reconstruction with the help of computers, easy to store patient data. Although general dental practitioners do not use most of these techniques routinely, some techniques are used occasionally to aid in diagnosis of oral conditions in oral cavity.[5]

DIGITAL RADIOGRAPHY

The variation in image quality due to the variables inherent to conventional radiography can be reduced with the use of digital intraoral radiography. Digital radiography enables the use of computerized images which can be stored manipulated and corrected for under and over exposures.[6] Digital radiography may yield almost equal image properties compared with conventional radiographs but through digital storage and processing diagnostic information can be enhanced .The main advantageof digital radiography is dose reduction of radiation obtained with this technique.(between 1/3rd to ½ dose reduction with conventional radiography)[7]

Two digital radiography systems rely on the sensor- the direct and the indirect methods. A number of components are required for direct digital image production. These components include an X-ray source an electronic sensor, a digital interface card, a computer with an analog to digital converter (ADC), screen monitor software and a printer. Direct digital sensors are either a charged coupled device (CCD) or a complementary metal oxide semiconductor active pixel sensor (CMOS-APS).[8] The individual CCD pixel size is approximately 40micron with the latest version in the 20 micron range. The rows of pixels are arranged in a matrix of 1604 x 1208 pixels which is increased up to 2048 X 1680 pixels.[9]

There are two types of digital sensor array designs area and linear.Area arrays are used for intraoral radiography while linear arrays are used for extra oral imaging. Area arrays are available in sizes comparable to size zero, size 1and size 2 films, but the sensors are rigid and thicker than radiographic film and have a smaller sensitive area for image capture.[10] The sensor communicates with a computer through an electric cable. Area array CCD has two primary formats: Fibre-optically coupled sensors and direct sensors. Fibre-optically coupled sensors utilize a scintillation screen coupled to a CCD. When x-ray interacts with a screen material, light photons are generated, detected and stored by CCD .Direct sensor CCD arrays capture the image directly. The complementary metal oxide semiconductor active pixel sensor (CMOS-APS) is the latest development in direct digital sensor technology. Externally CMOS sensors appear identical to CCD detectors but they use an active pixel technology and are less expensive to manufacturers

COMPUTED TOMOGRAPHY

The development of computed tomography was a milestone in radiology. This first clinical computed tomography X-ray unit first developed in 1972 by G.N. Horse field in England.[11]

The pursuit of 3-d information has led to exploring the value of CT for the assessment of alveolar bone height. While CT provides exquisite 3D views, its ability to show very small details remains limited , usually not more than 1-2 mm.

ADVANTAGES:

CT has several advantages over conventional film radiography and film tomography: CT completely eliminates the superimposition of images of structures outside the area of interest, Superior to MRI when evaluating skull fractures,[12] Provide detailed images of brain nervous system, Is excellent for individuals involved in head trauma, Much cheaper than MRI and equally as fast, Artefacts are less of problem with a CT scan compared to MRI.

DISADVANTAGES

The disadvantages are as follow: Increased radiation dosage: Economically not used for routine dental treatment, Never be done in a pregnant female because of the exposure of radiation risk to the foetus, The dye used in CT is iodine based and is often a cause of allergy, CT is not very good at identifying pathosis of soft tissue, CT is not good at identifying areas of inflammation or infection of the brain.

USES

Primarily because of its high contrast resolution and ability to demonstrate small differences in soft tissue density, CT has become useful for the diagnosis of disease in the maxillofacial complex, including the salivary gland and TMJ. However with the advent of magnetic resonance imaging, which has proved superior to CT for depicting soft tissues the use of CT scanning for assessment of internal de-arrangement of the TMJ has decreased significantly. Additionally CT has been shown to be useful for evaluation of patients before placement of endo-osseous oral implants. Despite the fact the similar information about the maxillary and mandibular anatomy can be obtained with film tomography, CT allows reconstruction of cross section image of the entire maxilla or mandible or both from a single imaging procedure.

CONE BEAM COMPUTEDTOMOGRAPHY

Recently a more practical new generation of CT, cone beam CT (CBCT) has become available. CBCT

technology has been exploited in mechanics specially designed for head and neck imaging. CBCT is a 3D radiographic tool that allows us understood the maxillofacial complex and the spatial relationship of anatomic structures. CBCT has a potential to become a routine noninvasive diagnostic instrument for various dental application in which defect characterization, localization, and volume are important.[13]

USES:

The uses are as follows: Evaluation of root canal morphology, Diagnosis of endodontic pathosis, Assessment of pathosis of non endodontic organ, Evaluation of root fracture, Analysis of internal and external root resorption, Diagnosis of invasive cranial resorption, Endodontic surgical planning, Identifying an untreated or missed canal, Visualized extruded root canals materials which are affecting surrounding anatomical structures.[14]

The diagnostic accuracy of both imaging modalities was low for anterior teeth. The difference in the diagnostic accuracy of CBCT between anterior and posterior teeth is likely the result of the difference in the morphology of the periodontal bone between these areas the buccal and lingual plates are considerably thinner in the anterior region and the bone tapers towards the crest. Apparently the quality of the CBCT images slices is insufficient to resolve the alveolar crest reliably in the region despite the higher diagnostic accuracy of CBCT, bone height measurements been only slightly between than those for conventional radiography, Both modalities resulted in average measurement errors larger than 1mm.[15]

ADVANTAGES

The advantages are as follows:Increased accuracy, Higher resolution, Reduced scan time, Reduction in a radiation dose, Reduced cost for the patients, CBCT eliminates superimposition of surrounding structures, producing additional clinically relevant information, CBCT can give a three dimensional image that is size of cavity, size and shape of pulp canal etc.[16, 17]

DISADVANTAGES

The disadvantages are as follows: Limited availability, Significant capital investment, Extensive knowledge of radiological interpretation.[18]

OPTICAL COHERENCE TOMOGRAPHY

During the last 20 years, optical coherence tomography (OCT) has evolved into a powerful technique for imaging a transparent and translucent structures.[10] OCT is an attractive noninvasive, non-touch imaging technique for obtaining high resolution images. Optical coherence tomography (OCT) generates cross sectional images of biological tissue using a near infrared light source. The light is able to penetrate into the tissue without biologically harmful effects. In the Todea C et al study the quality of endodontic treatments and root canal fillings were investigated with CFOCT technology.[19] Areas of apical micro-leakage were detected between the gutta-percha cones and the filling material of the root canal space.

USES[20]

The uses are as follows: Assess early carious lesion, Endodotic imaging from inside the root canal, Used for detection of gaps and voids at the interface as this could have an impact on both the marginal seal and microleakage, Create digital impressions in orthodontic treatment planning.

ADVANTAGES[21]

The advantages are as follows: High resolution, Safe, versatile and inexpensive, Readily adapted to clinical dental environment.

DISADVANTAGES

The disadvantages are as follows:Limited penetration depth.

COMPUTER ASSISTED DENSITOMETRIC ANALYSIS SYSTEM

In the computer assisted densitometric image analysis system (CADIA), a video camera measures the light transmitted through a radiograph and the signals from the camera are converted into gray scale images. The camera is interfaced with an image processor and a computer that allow the storage and mathematic manipulation of images.[22]

CADIA appears to offer an objective method for following alveolar density changes quantitatively over time. Also compared with digital subtraction analysis, CADIA has shown a higher sensitivity and a high degree of reproducibility and accuracy. This technique has also been applied to longitudinal clinical studies.[23] In general the aim of radiographic analysis is to detect changes in hard tissue, such as bone dentin and enamel. Until recently, a radiographic assessment of periodontal soft tissue conditions was not done. However, using under exposed serial radiograph, computer assisted densitometric image analysis may reveal progression

of disease or healing events in the supra-crestal soft tissue after periodontal treatment.[24]

USES

The uses are as follows: In the detection of incipient carious lesion, To assess density of the alveolar bone.

ADVANTAGES

The advantages are: High degree of reproducibility and accuracy

DISADVANTAGE

The disadvantages are: More sensitive than conventional radiographic interpretation.

STEREOSCOPY

Stereoscopy was introduced by J Mackenzie Davidson in 1898 after discovery of x-rays by Roentgen's. Over the next 30 to 40 years the technique grew in popularity among radiologists because of its educational value, understanding normal anatomy is simplified with stereoscopic images. Stereoscopic imaging requires the exposure of 2 films one for each eye & thus delivers twice the amount of radiation to the patient. Between exposures the patient is maintained in position, the film is changed & the tube is shifted from the right eye to the left eye position.[25]

USES:

The uses are as follows: Evaluation of bony pockets in patients with periodontal disease and the endodontic therapy, Assessment of the relationship of the mandibular canal to the roots of un-erupted mandibular 3rdmolar, Assessment of the bone shape when placement of dental implant.[26]

CONCLUSION

Advanced diagnostic technologies are increasingly playing a more vital role in both data collection and assessment capabilities, and the utilization of the information obtained. Diagnostic modalities available to clinicians today expand greatly on the foundation of a comprehensive visual assessment, which has been and will be the cornerstone of the diagnostic process. The diagnostic clinician today is able to obtain a seemingly endless amount of information to assess the patient's oral health, which in turn gives them and the patient's other healthcare providers tremendous knowledge about the patient's overall health and wellness. An excellent example is the advancement of radiographic imaging.

It is to conclude that specialized radiographic techniques are not used routinely in dental clinics but they are important for accurate diagnosis of lesions and for treatment plan. Digital radiography is widely used in dental clinics because it has many advantages like reduced radiation, elimination of dark room, greater contrast and easy to process.

The most overlooked aspects of incorporating new technology into a dental practice are education and training on that specific technology and fully understanding its true role and value, but even more importantly, its limitations. This aspect cannot be overstated! Education and training should involve the entire team. It is important to remember that the first people most patients turn to for advice and comfort on any procedure is the office's staff.

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