

Recent Advances in Imaging Technologies in Dentistry - A Review Article

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Abstract:- For past three decades dentistry has witness with immense advances in all branches. For more than 25 years digital radiograph are available in dentistry. Starts from the basic intra-oral periapical x-rays to the highly developed techniques like CT, MRI found place in modern dentistry. Deepness of structure cannot be obtained and localized using 2-dimentional static imaging. Three dimensional imaging gained a valuable place in dentistry.3-D imaging and modelling technologies such as cone beam computed tomography , with relatively long history of CAD CAM,it will become of increasing importance. Nowadays digital radiograph are more common and dentists are wondering that how it impossible to replace plain film with digital system,but it has been proved successfully.

I. INTRODUCTION

Diagnostic imaging in dentistry has seen enormous development in last few decades. Intraoral radiograph is the common imaging that is employed in dental practice. The shift from analog imaging to digital imaging is considered as a revolution in oral radiology. X ray was discovered by a physicist Wilhelm Roentgen in the year 1895.Xrays remains as a corner stone in modern medicine in diagnosis as well as treatment planning of the patient in the field of dentistry. Imaging techniques in dentistry can be classified broadly into extraoral and intraoral imaging(2). The disadvantages of the 2Dand 3D imaging has been overcome by the advent of the introduction of digital radiographic imaging. The first system that was developed in digital imaging is theradiovisiography (RVG). The three types of digital radiography used for digital imaging include the charged couple device (CCD),complementary metal oxide

semiconductors(CMOS) and photostimulable phosphor (PSP)(3,4). The dental imaging plays an important role in the clinical examination of the internal structure of the teeth and supporting bones and helps in the interpretation of periodontal and periapical disease, dental caries and other osseous lesions.

II. DIMENSIONAL IMAGING

❖ INTRA ORAL

➤ PERIAPICAL RADIOGRAPH:

It is used mainly for assessing the pulp and root canal morphology, alveolar bone status in the interdental region and used to detect the periapical pathology of crown and root fractures. It is specially used for endodontic treatment for evaluating the root morphology, lesion in the periapical region, determination of working length, extention of obturation and monitoring after the treatment. This technique also reduces the geometric distortion, avoid overlapping the anatomic structures, which covers the shadow of the teeth(1).

➤ OCCLUSAL RADIOGRAPH:

Periapical radiograph cannot be viewed in which occlusal radiograph displays a large segment of the dental arch for example tumor and osseus lesions. It used to locate the foreign bodies present in the jaw and the impacted teeth.(1)

➤ BITEWING RADIOGRAPHS:

Bitewing radiographs are used to evaluate the interproximal surface of both upper and lower teeth .The flap which is seen in a film,patient used to bite the film

against the crown of both upper and lower teeth simultaneously (bitewing). Bitewing films are used especially for detecting interproximal caries and crestal bone loss (1)

❖ EXTRA ORAL

➤ PANORAMIC IMAGING:

It is used to visualize the maxilla, mandible, temporomandibular joints and associated structures on a film. It is used as a preliminary screening radiograph in identifying impacted teeth and for assessing caries, periapical and periodontal lesions and occlusion of the dentition (1)

➤ CONE BEAM COMPUTED TOMOGRAPHY:

In this technique it is based on cone shaped x-ray beam using 2 dimensional detector. This technology increases the utilization of x-ray and less electrical energy when compared with fan beam technology. Cone scanning in x-ray tubes are much less expensive when compared to conventional CT (1)

➤ LIMITATIONS OF CBCT:

The diagnostic accuracy and the quality of image in CBCT is affected by the scatter and beam hardening artifacts caused by high density structures such as radiopaque material and enamel. The indication for CBCT is imaging hard tissues.

➤ LIMITATIONS OF 2D:

Radiographs give a two-dimensional image of an three dimensional objects. The objects are visualized in both apical-coronal and mesial-distal plane. Because of the complication of maxillofacial skeleton, 2D radiographic images will not accurately replicate the image that is being assessed. In case of diagnosis and treatment plan of special case, 3D modalities reveal additional information (1).

III. DIMENSIONAL IMAGING

❖ COMPUTED TOMOGRAPHY

The body structure of a three dimensional image is composed of a series of plane of cross-sectional images that is made along the axis in a computer. The imaging in CT is made into cone beamed and fan beamed (5). Patient are positioned horizontally on the table. The table slowly moves over the center of a X-ray machine. This procedure is considered as a painless when compared to other test (6)

➤ Clinical application

Diagnosis of salivary gland pathologies
TMJ ankylosis
Fractures
Maxillary sinus examination
Implant placement (7,8,9,10,11)

➤ Advantages

Desired image details are obtained. Fast image rendering
Filters may sharpen or smoothen reconstructed images.

➤ Disadvantages

Expensive

Artifacts due to the presence of foreign objects, restoration and prosthetics of the tooth

❖ CONE BEAM COMPUTERIZED TOMOGRAPHY (CBCT)

Cone beam computerized tomography are mainly designed to overcome the limitations of conventional computed tomography. (12) CBCT differs from CT in positioning of the patient, time requirement, radiation exposure and clinical uses. (13) The CBCT scans the entire head and the chin region. (14) Patients visualize less radiation dose in CBCT when compared with CT (13,15). The radiation dose of CBCT is equal to 12 panoramic radiograph average and it provides less radiation dose compared to conventional CT that is roughly around 15 times. (16)

➤ Advantages

Cost effective compared to CT

Better image with good spatial resolution

Emits upto 98% less radiation

➤ Disadvantages

Artifacts due to metal brackets and restorations. It fails to determine the color of skin and soft tissue. (16) Unwanted image distortion due to movement of patient. The device is more expensive and requires more space when compared with conventional X-ray equipment. The contrast of soft tissue is poor in this imaging technique..

❖ MAGNETIC RESONANCE IMAGING (MRI)

MRI is a non invasive procedure that is highly sensitive as well as specific. MRI uses magnetic field as well as radio wave in imaging an organ or tissue in the body. MRI employs a magnetic field that helps in forcing the protons from the hydrogen nucleus in the body to align in the field. The radiofrequency is pulsed in patient so that the protons are being stimulated and spin against the pull of magnetic field. Then the radiofrequency is offed and the sensor in MRI is used to detect the energy that is released with realigning. The slice obtained is scanned and produced in the computer which is finally transferred to film. MRI is considered as a gold standard imaging in the field of medicine. (18)

➤ Clinical application

Detection of intracranial and extracranial lesions

TMJ disorders

Salivary gland pathology

Rhabdomyosarcoma

Neuroblastoma

Retinoblastoma

Fractures

Inflammatory conditions

hematoma

➤ Advantages

Radiation free imaging technique

Used in patient with allergic to contrast agent

➤ *Disadvantages*

Expensive and require a complex equipment
Time consuming
Contraindicated in claustrophobic patient
Produce artifacts due to prosthetic crowns and orthodontic brackets.(19,20)

❖ *TUNED APERTURE COMPUTED TOMOGRAPHY*

The National Institute of Dental Research in 1990, determined to support the development of manufacturing 3D images not comparable from a device including multi-tube X-ray and X-ray charge-coupled device screen. From the over all result it is concluded that TACT system can change many three dimensional pictures (21). Tuned-Aperture Computed Tomography or TACT (Wake Forest University, School of Medicine, Winston-Salem, North Caroline, USA) was developed by Richard Webber (22). It is an low-dosage 3-dimensional imaging system. However, it does not meet the strong request for definite control and collecting information of the imaging geometry. In this technique, the object and image sensor(electronic device that converts an optical image into an electronic signal) must be fixed and the position of the X-ray source can be the elective. The calibration marker permits to decide on the imaging geometry used to display the perfect imaging from the over all final result image. This technique grants the processing of all resultant images into 3D volume. In medicine this technique is most commonly used, but it can also be used in the dentistry. TACT assume to have a greater diagnostic value in its ability to detect caries, impaction, and to evaluate pre-implant images. (23,24)

❖ *DIGITAL IMAGING*

Digital radiography is a filmless imaging system and the image is obtained by a sensor that breaks into pieces of electrons that is being stored in the computer. The cells in the digital image is arranged in rows and columns. The cells are categorized into three numbers they are X , Y coordinate and gray value. The two advancement in imaging include direct and semi direct. The direct image is obtained by a sensor. The sensor are based on CCD, CMOS and CMOS-APS chips. The semidirect digital imaging are obtained from a photostimulable phosphor.(25)

❖ *CHARGED COUPLE DEVICE (CCD)*

The charged couple device was the first intraoral digital imaging in dentistry that was introduced in the year 1987 . The charged couple device consist of two main parts such as1. color filter and 2. pixel array. The recording of CCD is based on wafers of silicon . On exposure xrays are converted to electrons that are being deposited in electronic wells and then it is transferred to a amplifier. The signal is converted to a digital signal which is responsible for visible of x-ray image on the monitor. The size of sensor ranges from size 0-2 responsible for different film sizes that is used clinically. The two type of digital sensor array used include the area array and linear array. Intraoral imaging makes use of area array and the extraoral imaging uses linear array. The sensor are available in both wire and wireless.(26,27)

➤ *DISADVANTAGE*

Increased possibility of artifacts due to movement of patient.

❖ *COMPLEMENTARY METAL OXIDES SEMICONDUCTORS (CMOS)*

CMOS is considered as the basis of consumer graded cameras. The CMOS differ from CCDs in the way that the pixel isbeing isolated from its neighbouring and is connected directly to the transistor, does not require charge transfer. The CMOS consist of four parts namely the color filter, pixel arrays, digital controller and ADC(analog to digital converter). Light from the lens is being processed by color filter and reaches pixel array. Each sensor from the pixel coverts light into voltage as signal. The pixel arrays receives signal from the digital controller and it captures intensity level of filtered light in wavelength and results as a signal of analog voltage. This analog is then converted to digital by analog digital converter (28).

❖ *PHOTOSTIMULABLE PHOSPHOR (PSP)*

PSP is based on the energy form the x rays that is absorbed and stored when stimulated by the light source. The PSP material used for imaging is europium barium fluorohalide.(29)

❖ *DIGITAL SUBTRACTION RADIOGRAPHY*

The DSR was introduced in the year 1980s.DSR is obtained mainly by eliminating the anatomical sturctures on the radiography and storing it digitally and combining it with the post treatment image and displayed as the final subtracted image.(30)

It is used in the diagnosis of periodontal bone resorption and in the analysis of level of bone in implants and in accessing the process of healing in periapical lesions.(31)

❖ *TELERADIOGRAPHY*

Teleradiography is the process of transferring the data of the patient to a farther site. In order to execute this teleradiography both user and sender must be able to produce image that is being viewed by a software system. It helps in interpretation of non invasive imaging such as digital, MRI,CT, ultrasound and nuclear medicine.(32)

❖ *DIGITAL IMAGING AND COMMUNICATIONS IN MEDICINE (DCIOM Standard)*

It is a set of collection of instructions that explains format, exchange the information regarding image. DICOM standard was first adopted by medical professional to overcome the difficulty in imaging system communication and in data exchange. Presently in dentistry digital radiographic vendors had adopted it and is universally accepted(33)

➤ *ADVANTAGES OF DIGITAL IMAGING*

There is a reduction in radiation dose upto 50-60% in intraoral imaging and 50-70% in extraoral digital imaging.
Short processing time
Diagnostic accuracy

IV. CONCLUSION

The development of advancement in dental imaging paves way in the diagnostic and treatment planning. Dentists must have acquired clear knowledge about its working principles, requirements and its hazards and clinical usage of the current advanced diagnostic systems. The proper imaging must be able to provide a precise interpretation of the condition with ALARA principles, cost effective and helps in decreasing the mortality and morbidity rate with the accurate diagnosis with the short interval of time with minimum exposure to radiation. The emerging newer technologies reduces the challenges faced by the dentist in their day to day life.

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