

## Recent Advances in Endodontic Radiography

Dr. Anil K Tomer<sup>1</sup>, Dr. B. Vinay Goud<sup>2\*</sup>, Dr. Akankshita Behera<sup>3</sup>, Dr. Nitish Mittal<sup>4</sup>, Dr. Artika Gupta<sup>5</sup>, Dr. P. Tirupathi Naidu<sup>6</sup>

<sup>1</sup>Professor & Head DJ College of Dental Sciences, Modinagar Uttar Pradesh, India

<sup>2-6</sup>Post Graduate students DJ College of Dental Sciences, Modinagar Uttar Pradesh, India

### Review Article

#### \*Corresponding author

Dr. B. Vinay Goud

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**Abstract:** The value of digital radiography in dental and medical diagnosis is well known, especially during operative procedures where time to image is important. Key advantages of digital radiography are: reduction in radiation dose to the patient; patient education; image optimization and computer-aided feature extraction; workflow improvement; the avoidance of shipping, darkroom, or chemical processing errors; environmental waste reduction; improved electronic communications; image archiving; and projecting a technologically advanced practice image. There are many advances in radiology such as CBCT, TACT, DSR, SCT, MCT so that it will help accurate diagnosis.

**Key words:** Radiology, CBCT, DSR, MCT, SCT.

### INTRODUCTION

Radiography is a main diagnostic tool for detecting dental and maxillofacial lesions. Radiologic images have two dimensions of three dimensional realities; hence, the images of different anatomical structures are superimposed on each other and, thus, make it difficult to detect the lesions. Radiographic examination is still left much to be desired as a diagnostic tool: First of all, because of frequent disagreement among evaluators on its interpretation and discrepancies of the same evaluator's interpretation at different times. Secondly, dental and maxillofacial lesions often progress slowly, so they cannot be easily evaluated with sequentially obtained radiographs, and thirdly, structural 'noise' produces visual confusion and limits the detection of small lesions.

### DIGITAL SUBTRACTION RADIOGRAPHY

Digital subtraction of images has been applied to dental radiography for more than 20 years. Film subtraction was the established standard method for cerebral angiography and was widely used until digital subtraction fluoroscopy became available in the late 1970s. Nowadays, filmless' photoelectronic imaging systems, specially video fluoroscopy, are used to subtract diagnostic images [1].

### METHODS AND APPLICATIONS

Temporal subtraction and energy subtraction are two considerable methods in digital fluoroscopy, each has distinct advantages and disadvantages when the two techniques are combined, the process is called "Hybrid Subtraction". Image contrast is still enhanced further by hybrid subtraction because of reduced patient motion between taking subtracted images.

DSR has also been used in the evaluation of the progression, arrest, or regression of caries lesions. The caries lesions are not well-defined radiolucencies, thus the measurement of their extent is difficult in conventional radiography. Subtraction consists of

subtracting the pixel values of the baseline image from the pixel values of the second image. When nothing has happened, the result is zero. When caries regression or progression has occurred in the meantime, the result will be different from zero. When there is caries regression, the outcome will be a value above zero. In case of caries progression, the result is opposite and the outcome will be a value below zero.

### CONE BEAM COMPUTED TOMOGRAPHY

Cone beam computed tomography (CBCT) is a relatively new method to visualize an individual tooth or dentition in relation to surrounding skeletal tissues and to create three-dimensional images of the area to be examined. The use of CBCT in Endodontics is rapidly increasing worldwide. Compared with traditional radiographic methods, which reproduce the three-dimensional anatomy as a two-dimensional image, CBCT is a three-dimensional imaging method that offers the possibility to view an individual tooth or teeth in any view, rather than predetermined 'default' views. Therefore, CBCT can be a powerful tool in endodontic diagnosis, treatment planning and follow-up. At the same time CBCT has limitations, and

radiation dose to the patients must always be taken into consideration when selecting the modes of diagnostics. There is a need for evidenced-based guidelines on when to use CBCT in Endodontics, thus aiding the decision on when it is appropriate to take a CBCT scan[2].

Patient exposure to ionizing radiation such as X-rays must never be considered as routine. A CBCT examination should only be prescribed by a clinician who has:

- Appropriate Training In CBCT Radiology [6];
- Adequate Knowledge Of The Endodontic Applications Of CBCT;
- Experience In The Interpretation Of CBCT Images;
- An Appreciation Of The Limitations Of CBCT[3].

### Cone-beam CT image production

The four components of CBCT image production are

- acquisition configuration,
- image detection,
- image reconstruction, and
- imagedisplay[2]

### OPTICAL COHERENCE TOMOGRAPHY (OCT)

OCT is a new diagnostic imaging technology that was first introduced in 1991. OCT is an attractive noninvasive imaging technique for obtaining high-resolution images. OCT combines the principles of an ultrasound with the imaging performance of a microscope, although ultrasound produces images from back-scattered sound echoes. OCT uses infrared light waves that reflect off the internal microstructure within the biological tissues. OCT is based on low-coherence interferometry (LCI) and achieves micron-scale cross-sectional image. LCI has evolved as an absolute measurement technique which allows high resolution ranging and characterization of optoelectronic components. Using the principle of LCI it achieves depth resolution of the order of 10  $\mu\text{m}$  and in a plane resolution similar to the optical microscope. By scanning the probe along the imaged specimen while acquiring image lines, a two dimensional or three-dimensional image is built up. Due to the high potential of the low coherence interferometer to provide thin section slices from the tissue, the technology was termed as optical coherence tomography [4].

The OCT light source has a wavelength of 1300 nm. Visible light that has a shorter wavelength is prone to a higher level of scattering and absorption and produces shallower imaging depth. The frequency and bandwidths of infrared light are significantly higher than medical ultrasound signals, resulting in increased image resolution. In endoscopic OCT imaging, near-infrared lighting is delivered to the imaging site (usually blood vessels) through a thin fibre. The imaging tip contains a lens prism assembly to focus the beam and direct it towards the vessel wall. The fibre can be

retracted inside the catheter sheath to perform a so-called ‘pullback’, allowing the user to make a stack of cross-sections, scanning the investigated vessels lengthwise. Modern OCT systems reach a 6 mm imaging depth, with 8- $\mu\text{m}$  resolution at 50 to 80 frames per second [4].

### Advantages

- Real time imaging
- Sub surface resolution
- No radiation exposure
- No site preparation before taking image
- Incomparable spatial resolution

Thus OCT can be aptly being called as “OPTICAL BIOPSY” without any excision requirement in comparison to the conventional biopsy.

### TUNED APERTURE COMPUTED TOMOGRAPHY (TACT)

Tuned aperture computed tomography works on the basis of tomosynthesis. A series of 8–10 radiographic images are exposed at different projection geometries using a programmable imaging unit, with specialized software to reconstruct a three-dimensional data set which may be viewed slice by slice [4].

Webber & Messura [7] compared TACT with conventional radiographic techniques in assessing patients who required minor oral surgery. They concluded that TACT was ‘more diagnostically informative and had more impact on potential treatment options than conventional radiographs’. Nance *et al.* [8] compared TACT with conventional radiographic film to identify root canals in extracted mandibular and maxillary human molar teeth. With TACT, 36% of second mesio-buccal (MB2) canals were detected in maxillary molar teeth and 80% of third (mesio-lingual) canals were detected in mandibular molars. None of these were detected on conventional X-ray films.

Tuned aperture computed tomography appears to be a promising radiographic technique for the future. However, at present it is still only a research tool and has mostly been evaluated ex-vivo[4].

### MICRO COMPUTED TOMOGRAPHY

The X-ray micro-computed tomography (micro-CT) was developed in the early of 1980s. It is a noninvasive, non-destructive method for obtaining two- and three-dimensional images. Principal of the technique is based on multiple X-ray converging on the sample and captured by a sensor. The projected X-ray is converted into digital images. The volumetric pixel (voxel) provided by micro-CT range in 5-50  $\mu\text{m}$ . Smaller the voxel size higher is the resolution of image, also the decrease in the distance between scanning steps demand longer time of X-ray exposure. Depending on the material to be scanned, scanning time varies.

Micro-CT presents several advantages over other methods, like Scanning electron microscopy, stereomicroscopy and confocal laser microscopy as it allows the use of the same sample for different tests without destruction of the sample. This characteristic is very important particularly when is required to evaluate volume pre and post instrumentation, quality of root canal instrumentation, obturation or removal of the material from root canal (retreatment). Also there is possibility of repeated scanning and the manipulation of image using specific software. But, radiation level of exposure restricts its use for in vivo studies. Moreover, micro-CT permits the examination of specimens of limited size, which restrict some analysis. Instead, cone beam computed tomography (CBCT) could be used in patients despite its lower resolution[4].

Applications of micro-CT in endodontic research

- To analyse internal anatomy of teeth,
- Instrumentation of root canal,
- Root canal fillings,
- Retreatment
- Physical and biological properties of materials.

Although Animal in vivo studies have proved microCT imaging to be a rapid, reproducible and noninvasive method that produces results comparable with those of histological sections and that 3-D analysis of microCT images has a high correlation with 2-D cross-sections of periradicular lesions. To date, microCT is not available for use in a daily clinical setting; however, attempts are being made to develop a system to make 3-D imaging of teeth possible in vivo. In addition, microCT allows assessment of microstructural features as well as subregional analysis of developing lesions.

Micro CT has potential application in preclinical training of students with regard to tooth morphology and endodontic procedures [4].

### **SPIRAL COMPUTED TOMOGRAPHY**

Existing diagnostic methods such as the computerised transverse axial scanning (CT) greatly facilitates access to the internal morphology of the soft tissue and skeletal structures. Recently, a newer CT technique, Spiral Computed Tomography (SCT) or volume acquisition CT has been developed that has its inherent advantage. By employing simultaneous patient translation through the X-ray source with continuous rotation of the source detector assembly, SCT acquires raw projection data with a spiral-sampling locus in a relatively short period. Without any additional scanning time, these data can be viewed as conventional transaxial images, such as multiplanar reconstructions, or as three dimensional reconstructions. With SCT, it is possible to reconstruct overlapping structures at

arbitrary intervals and thus the ability to resolve small objects is increased [4].

### **Endodontic Applications**

- Potential endodontic applications include diagnosis of endodontic pathosis and canal morphology
- Evaluation of root fractures
- Assessment of pathosis of non-endodontic origin
- Analysis of external and internal root resorption and invasive cervical resorption
- Presurgical planning
- Treatment of aberrant and extra root canals, developmental anomalies like dens invaginatus, C-shaped canals [4].

### **CONCLUSION**

Digital Radiography is an excellent alternative to film-based radiography and continues to grow in popularity. Diagnostic accuracy using DR is as good as with film in most cases and disadvantages associated with earlier types of equipment have been resolved with advances in technology. However, regardless of the type of system purchased, users should expect some technical problems and the need for future upgrades of hardware (computer and DR equipment) and software. With careful purchase planning and realistic expectations, users will avoid disappointment in system performance.

The three-dimensional imaging technique overcomes the limitations of conventional radiography and is a beneficial adjunct to the endodontist's armamentarium. Nevertheless, the effective radiation dose to patients when using CBCT is higher than in conventional intraoral radiography and any benefit to the patient of CBCT scans should outweigh any potential risks of the procedure, in order to be justified. The radiation should be as low as reasonably achievable (ALARA). The decision to prescribe CBCT scans in the management of endodontic problems must be made on a case-by-case basis and only when sufficient diagnostic information is not attainable from other diagnostic tests, be they clinical or radiographic.

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