REVIEW ARTICLE

Cone Beam Computed Tomography: A Third Eye For Dental Surgeon

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ABSTRACT

Cone beam computed topography is a diagnostic imaging technology that is changing the way dental practitioners view the oral and maxillofacial complex as well as teeth and surrounding tissues. Cone-beam computed tomography (CBCT) systems have been designed for imaging hard tissues of the maxillofacial region. CBCT is capable of providing sub-millimetre resolution in images of high diagnostic quality, with short scanning times (10–70 seconds) and radiation dosages reportedly up to 15 times lower than those of conventional CT scans. This article provides an overview of currently available maxillofacial CBCT systems and reviews the specific application of various CBCT display modes to clinical dental practice.

KEYWORDS: Cone beam, Implantology, Radiology

INTRODUCTION

Radiographic investigations are essential for diagnosis purpose and treatment planning in medical and dental field. In dentistry, the interpretation of an image on the field can be altered by the anatomy of both the teeth and surrounding structures. The information obtained from periapical radiographs is two-dimensional interpretation of an object. Due to radiographic errors, periapical radiographs reveal a limited aspect of three-dimensional anatomy.

The disadvantage of CT scan like high radiation dose, high cost, poor resolution and difficulty in interpretation have resulted in limited use of CT imaging in dentistry. These problems may be overcome using small volume cone-beam computed tomography (CBCT) imaging techniques.[1]

CBCT imaging can be used for diagnostic purposes. In fact, it can be used in diagnosing a variety of cancers, including those affecting the lungs, pancreas, and liver. Using CBCT imaging, not only can physicians confirm that tumors exist, but they can also pinpoint their locations, accurately measure the size of tumors, and determine whether or not they have spread to neighbouring tissues.

How to cite this article:
Alok A, Singh ID, Panat SR, Singh S, Kishore M. Cone Beam Computed Tomography: A Third Eye For Dental Surgeon. Int J Dent Med Res 2014;1(3):144-148.

CONE BEAM TECHNOLOGY

CBCT scanners are based on volumetric tomography, using a 2D extended digital array providing an area detector. This is combined with a 3D x-ray beam.[2] The cone-beam technique involves a single 360° scan in which the x-ray source and a reciprocating area detector synchronously move around the patient's head, which is stabilized with a head holder. At certain degree intervals, single projection images, known as "basis" images, are acquired.[3] These are similar to lateral cephalometric radiographic images, each slightly offset from one another. This series of basis projection images is referred to as the projection data.[4] Software programs incorporating sophisticated algorithms including back - filtered projection are applied to these image data to generate a 3D volumetric data set, which can be used to provide primary reconstruction images in 3 orthogonal planes (axial, sagittal and coronal).[5]

ADVANTAGES OF CBCT

CBCT is well-suited for imaging the craniofacial area. It provides clear images of highly contrasted structures and is extremely useful for evaluating bone. Although limitations currently exist in the use of this technology for soft tissue imaging, efforts are being directed toward the development of techniques and software algorithms to improve signal-to-noise ratio and increase contrast.[2,3] The use of CBCT technology in clinical practice provides a number of potential advantages for maxillofacial imaging compared with conventional CT (Table No.1).[4,5]

APPLICATION OF CBCT

Grondahl in a study reported the frequency of use of CBCT between different oral specialities.[6] His result showed that the use of CBCT was maximum in implantology (40%), oral surgery (19%), orthodontics (19%), endodontics (17%), otorhinolaryngology:ENT (2%), temporomandibular joint (1%), other investigations like forensics, periodontology, research (2%).[6]

IMPLANTOLOGY

In the field of implantology, assessment of the condition of teeth and surrounding alveolar bone depends largely on two-dimensional imaging modalities such as conventional and digital radiography though these modalities are very useful and have less radiation exposure, they still cannot determine a three-dimensional architecture of osseous defects.[7] Hence it is essential to improve the diagnostics potential of a tooth and surrounding structures. CBCT provides three-dimensional images that facilitate the transition of dental imaging from initial diagnosis to image guidance throughout the treatment phase.[8] This technology offers increased precision, lower doses and lower costs when compared with medical fan-beam CT (Table No.2).[9]

Table No.1: Potential advantages for maxillofacial imaging compared with conventional CT

- X-ray beam limitation
- Image accuracy
- Rapid scan time
- Dose reduction
- Display modes unique to maxillofacial imaging
- Reduced image artefact

Table No.2: CBCT use in implantology

- To assess the quantity and quality of bone in edentulous ridges.
- To assess the relation of planned implants to neighboring structures.
- To assess the success of implant osseointegration
- To provide information on correct placement of implants
- During planning and in designing a surgical guidance template.

ORTHODONTICS

Prior to seeing the patient, the three-dimensional view of the CBCT is screened for any observable pathology which was done in a limited manner with two-dimensional. The second task is to review the airways like retro-glossal airway, retropalatal airway, nasal passageways and all sinuses because adequacy of airways can affect skeletal growth patterns in growing individuals and can also affect dental stability in growing as well as non-growing individuals.[10]

Recognizing asymmetries and developing symmetries is an extremely important crucial part of the orthodontic diagnostic process as this has profound effect upon clinician plans for the individual's treatment. Following the CBCT investigations, clinician will build the TMJ studies examining form, volume and position of the condyles within the fossa as well as the anatomy of the fossa itself.[11] The diagnostic information provided by the CBCT and the information obtained by various questionnaires enhance the diagnosis, treatment planning, and educational process.

USES OF CBCT IN HEAD AND NECK REGION

CBCT is being increasingly used for head & neck imaging. This technique provides relatively high isotropic spatial resolution of osseous structures with a reduced radiation dose compared with conventional CT scans. CBCT, advancement in CT imaging has emerged as a potentially low-dose cross-sectional technique for visualizing bony structures in the head and neck region. CBCT is used in various fracture detection in oral maxillofacial region. This helps in treatment and healing. CBCT can be used in various orbital fractures, dento-maxillofacial fractures, TMJ fractures and condylar fracture.[12]

DENTOMAXILLOFACIAL FRACTURES

The benefits of three-dimensional medical CT imaging are already well established in certain dental specialities. The greatest uptake of this technology has been in the management of trauma to the maxillofacial skeleton. A dento-maxillofacial fractures are easy to locate in CBCT than in two-dimensional radiographs. Various tooth fracture, avulsion, luxation and dislocation can be easily found out in CBCT.[1]

MRI is more sensitive but CBCT can assess high contrast structure fractures like lateral fracture and medial walls or search for foreign bodies. The advantage of CBCT in orbital, condylar and other fractures is that large volume CBCT scanners acquire the entire maxillofacial region within a field of view upto 20 cm in diameter. This helps in imaging a greater field of fracture and helping clinician in treatment.

ENDODONTICS

CBCT may also prove useful in the diagnosis of dent-alveolar trauma, because the exact nature and severity of alveolar and luxation injuries can be assessed from just one scan. It has been reported that CBCT has been used to detect a horizontal root fracture. The same fracture may have needed multiple periapical radiographs taken at several different angles to be detected and even then may not have been visualized. Recently CBCT scans have been successfully used in the management of external cervical resorption lesions. Perhaps the most exciting area in which CBCT may be applied in endodontics is in determining the outcome of treatment.[13]

Detailed CBCT scans should result in a more objective and therefore more accurate determination of the outcome of endodontic treatment. The CBCT images are geometrically accurate and there is no distortion of the teeth being assessed or superimposition of overlying anatomy as often seen with conventional film and digitally captured periapical radiographs.[14]

Future research may show that root-filled teeth that appear to have 'healed' on conventional radiographs may still have signs of periapical disease (e.g. widened periodontal ligament space, periapical radiolucency) when imaged using CBCT. This finding in turn may have implications for decision making and selection criteria when considering (re-) placing coronal restorations on teeth that have previously been endodontically treated and appear to have successfully healed radiographically.[15]

USE OF CBCT IN PROSTHODONTICS

Today's computer-aided design & manufacture (CAD/CAM) technologies contribute greatly to restorative dentistry & provide clinicians with advanced treatment options for various indications including inlays, onlays, fixed dentures & full dentures, thin veneers and crowns. These systems also allow use of many restorative materials, including metal, metal-ceramic, compositive & all ceramic, to best meet the needs of the care & patients. Further, CAD/CAM systems are available for laboratory applications, so dentists can create highly aesthetic & strong restoration in office.[16]

LIMITATIONS OF CBCT

Crowns or any other metal elements in the mouth cause many artifacts during the acquisition of a three-dimensional image due to absorption of the x-ray beam. The nature of the metal leads to great variations in the quality of the image. Artifacts produced by metals limit the image reading. Sometimes interpretation even becomes impossible.[17]

CONCLUSION

Even with CT imaging, clinicians have laboured to link the information to the surgical site, transferring angles and positions manually. This can be overcome with interactive software applications that provide this information seamlessly. As CBCT has become a state-of-the-art, the race is on to identify opportunities that benefit from the digital information embedded in each scan. Guided implant surgery has evolved as an important modality and aid in transferring the virtual three-dimensional plan to the patient. Surgical templates can then be laboratory fabricated on stone casts, or directly CT derived via stereolithography, taking the scan data and turning it into solid resin models of the patient's mandible or maxilla. However, as more companies invest in three-dimensional digital dentistry solutions, linking the technologies together has become a reality. This presentation will demonstrate how digital dentistry is evolving into a mainstream dentistry, allowing everyone to achieve successful "restoratively-driven" implant dentistry.

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Source of Support: Nil
Conflict of Interest: Nil