Advancement of Oral & Maxillofacial Surgery with CBCT

Santosh Mishra[1], Rahul Mishra[2], Madhuri Shukla[3], Varun Arya[4]

[1,2,3,4]Dept., of Radiodigonosis, SS Medical College Rewa MP. 486001

Abstract:

Cone Beam Computed Tomography (CBCT) is a most valuable imaging technique used in oral and maxillofacial surgery. The introduction of CBCT for imaging the oral and maxillofacial region, holds a major change from two dimensional to three-dimensional approach. CBCT provides a complete 3D view of the oral and maxillofacial structures with high resolution which helps for accurate diagnosis, treatment planning and postoperative outcomes compared to conventional 2D images. Radiation exposure to the patient is very low in CBCT. The main clinical applications of CBCT are in oral and maxillofacial surgery, orthodontics, periodontics and in endodontics. The aim of this article is to review on the advantages, disadvantages and clinical applications of CBCT in the oral& maxillofacial surgery.

Keywords: Cone-beam computed tomography, resolution, 3D imaging, oral and maxillofacial surgery, maxillofacial imaging, radiography, Oral surgery.

Introduction

Accurate diagnostic imaging is a key point for diagnosis and treatment planning. Since the use of CT in the 1970s, it has become one of the most commonly used imaging methods and made a revolution in diagnostic imaging [1]. 3D images provided by CT technology gives the oral and maxillofacial images without superimposition and distortion. Compared to conventional 2D procedures, CT involves higher radiation doses [2]. CBCT for maxillofacial imaging was invented to curtail the limitations of conventional CT [3]. Maxillofacial surgeons frequently operate in areas of the face and jaws. While surgery there are risks of damage to critical structures, such as nerves and blood vessels. Complex surgical procedures, such as orthognathic surgery, oncology surgery and treatment of trauma requires proper preoperative planning. Therefore imaging modalities that provides detailed information, accurate diagnosis and good clinical outcomes should be used. CT is simply defined as the use of X-ray-based imaging method to produce 3D images usually displayed in the form of image slices [4]. The CBCT machine uses cone-beam imaging technology rather than a fan-shaped X-ray beam as hat used in conventional CT machines. CBCT provides a complete 3D view of the maxilla, mandible, teeth, and supporting structures with relatively higher spatial resolution and lower radiation dose to the patient [5]. CBCT is used for clinical surgical procedures like removal of impacted teeth and dental implants placement. This review explains about the application of CBCT in the various fields of oral and maxillofacial surgery, advantages and limitations.

History

Sir Godfrey N. Hounsfield developed the first CT in 1967, which made great change in imaging techniques. In 1982, the first CBCT scanner was constructed for angiography at Mayo. In 1997, the department of radiology of the Nihon University School of Dentistry developed a new technology- limited cone-beam computed tomography [6]. In 2000, the first CBCT to be approved by the FDA for dental use in the US was Newtom from Verona

Principles of Cone-Beam Computed Tomography

CBCT follows the principle of tomosynthesis. X-ray source and X-ray sensor rotate around the patient's head and acquires multiple scans of the site. The obtained scans undergoes image reconstruction, which produces the

imaging area into a single, 3D volume that comprises volume elements known as VOXELS [7]. In Cone beam CT 2D digital array are used providing an area visualization than a linear detectors as in CT. 3D X-ray beam with circular collimation are used so that the resultant beam is in the shape of a cone, hence the name "cone beam [8]. The field to be viewed can be adjusted to include a portion of the entire oral and maxillofacial region. The software allows reformatting and viewing of the image. With this software, the entire anatomy can be peeled away layer by layer to locate the desired anatomy in all three dimensions [9].

Application of CBCT in Oral and Maxillofacial Surgeries

Impacted and Supernumerary Teeth

Surgical removal of impacted teeth is a routine procedure in oral and maxillofacial surgery. Location of the inferior alveolar nerve canal and its close proximity to the third molar are the risk factors to be noted prior to surgery [10]. Panoramic radiographs and periapical radiographs were used to locate the canal Inferior alveolar canal follows tortuous path, and not properly seen on a 2-D image. The CBCT is also used for pre-surgical evaluation of impacted teeth, supernumerary teeth, and their relations with associated structures like adjacent teeth, maxillary sinus, inferior alveolar nerve, mental nerve [11]. Complications, such as root displacements are more accurately seen with CBCT. In 1990, Rood explained about the seven radiographic signs such as darkening, narrowing or deflection of the root, dark/bifid apex, cortical interruption, diversion, or narrowing of the canal commonly associated with IAN r injury, which were later studied by other authors [10]. CBCT provides coronal and sagittal dimensions which helps to view the IAN proximity, course of the IAN measure the exact distance between the root and IAN in all dimensions [12]. For impacted maxillary third molars, OPG and IOPA images are not sufficient to determine their relationship to the maxillary sinus and adjacent tissues due to imaging distortion and superimposition [13]. In CBCT, a root protruding into the maxillary sinus are seen clearly. Bouquet found in a clinical study that 3-dimensional scans were more precise than the panoramic radiograph. Impacted maxillary canines are a great challenge and proper treatment plan and surgical approach are needed [14]. Buccolingual location, Tooth angulation, root dilaceration, and proximity of adjacent teeth are to seen prior to surgical removal of impacted canines [15]. OPG has been used in combination with occlusal and periapical films to provide multiple views. However CBCT is more accurate in viewing the exact location of impacted maxillary canines [16].

Dental Implantology

CBCT help to locate the vital structures and its distance between the implants. Alveolar bone width are measured using CBCT. CBCT helpsin selecting the most appropriate implant size, location and angulations, reduces surgery time [17].

Preoperative imaging is a crucial step in treatment planning for implant surgery. In anterior maxilla CBCT has main advantage in measuring alveolar bone height in nasal floor region [18]. When immediate implant is planned in anterior maxillary region, CBCT is used due to the capability of measuring buccal alveolar bone width. In maxillary premolar and molar region, bone quality and vertical height in relation to the maxillary sinus, buccal and lingual cortical thickness are imaged properly with CBCT[20]. In the mandible, bones with greater density and thicker cortical plates are present. Vital structures like IAN canal and mental foramen must be seen prior to implant placement [19]. The volume and quality of bone are key for implant success. Bone volumes are accurately measured with CBCT [20, 21]. CBCT are advantageous in evaluating alveolar fenestrations and dehiscences, which determines the need for alveolar bone grafting at the time of implant placement [22]. Custom guides for implant placement are fabricated using CBCT [23]. Postoperative evaluation of implant is necessary for success and to monitor progress over time. CBCT detects periimplantitis, bony defects, but limited in visualising dehiscences [24].

Oral and Maxillofacial Pathology

Pathologic lesions including infections, cysts, tumours and osteonecrosis can be visualized by CBCT. The

CBCT aids to visualize the accurate localization of pathology and its association with vital structures in multiple views. For osteonecrosis of the jaws, CBCT imaging provides a high-resolution 3D analysis. 3D model

preparation and adaptation of the reconstruction plates to the jawbone before surgery are possible with CBCT imaging for maxillofacial reconstruction patients [25]. CBCT images are used to visualize growth change, appreciate borders and relative approximation of adjacent vital structures. CBCT is limited in soft tissue

analysis, though it does possess certain clinical applications in the evaluation of malignancies. but benign soft tissue lesions demonstrate poor diagnostic potential with CBCT [26]. Advantages of CBCT are it provides high quality image with minimal distortion, decreased cost and lower radiation exposure when compared to MRI and CT. Disadvantages are lack of soft tissue definition. CBCT provides sufficient imaging for most odontogenic lesions. CT or MRI is indicated if there is evidence of soft tissue involvement.

Temporomandibular Joint

CBCT imaging are useful in diagnosing degenerative changes, ankylosis, joint remodelling, and malocclusion, congenital and developmental malformations. CBCT are used to supplement other imaging techniques, such as MRI. CBCT are used to measure condylar volume and surface area, as well as a comparison between the condyles [27].

Orthodontics

CBCT are used for 3D views of vital structures and impacted tooth, TMJ assessments, Orthognathic growth assessments, assessment of skeletal symmetry, treatment planning and for placement of dental implants while placing temporary anchorage devices [28].

Maxillofacial Traumatology

Patients can be assessed with CBCT for proper treatment planning. CBCT are used in detecting orbital floor fractures. CBCT could be used in detecting fractures. The CBCT technology can also be used in combination with specific computer software for preoperative planning and fabrication of reconstruction plate for mandibular fractures [29]. When CBCT and CT were compared in diagnostic imaging of midface, it was concluded that CBCT provided better image quality and high resolution. CBCT was not ideal for postoperative facial imaging compared to CT in terms of viewing maxillofacial bony

structures in contact with the osteosynthesis materials [30].

Conclusion

In this review clinical applications of CBCT in oral and maxillofacial surgery was discussed. Wide range of advancements have been seen after the introduction of CBCT imaging in oral and maxillofacial practice. The advantages of CBCT for maxillofacial imaging are explained in several studies. CBCT helps in proper diagnosis, treatment planning, evaluation of treatment outcome and research purposes.

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