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Review Article

Application of CBCT in oral & maxillofacial surgery

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ABSTRACT

Cone Beam Computed Tomography (CBCT) is beneficial radiographic diagnostic tool in oral and maxillofacial surgery (OMS). It helps maxillofacial surgeons to develop treatment approach in various conditions. Study of head and neck structures three dimensionally allows surgeon to do planning accurately, as a result enhances operative precision, and assess post-operative result. CBCT imaging have specific indications and limitations. The purpose of this article is to focalize on the advantages, drawbacks, limitations, and clinical applications of CBCT as a headmost CT imaging technique in the OMF region.

1. Introduction

The radiographs serve as a valuable aid in the diagnosis of oral diseases, in addition to clinical examination. The routinely used two dimensional intra-oral periapical and extra-oral panoramic radiographs in dental practice have certain limitations. However, these limitations prevail over by three-dimensional (3 D) imaging modalities like cone beam computed tomography (CBCT), magnetic resonance imaging (MRI) and ultrasound.[1] Usually, x-ray transmission projections and panoramic radiography together can provide adequate information in several clinical situations, but radiographic assessment facilitated by multiplanar images as computed tomography in certain circumstances.[2]

Oral and Maxillofacial surgeons most frequently operate in face and jaw region. Clinical examination alone is not sufficient, as there is possibility of injury to critical structures. Complex surgeries like orthognathic surgery and cases of trauma require precise preoperative planning. Hence, it is important to employ imaging techniques which provides specific information to ensure correct diagnosis and good clinical results.[3]

2. Why is Computed Tomography Advantageous Over Others?

The innovation of computed tomography (CT) technique is the revolutionary step in diagnostic imaging.[4] The added benefit of 3-D imaging provided by CT technology is that, it provides the chance to the surgeon for examination the oral and maxillofacial (OMF) region without superimposition and distortion of the image. CBCT precisely outlined for oral and maxillofacial imaging to offset some of the limitations of conventional CT scan.[5] It is possible to generate panoramic, cross-sectional and 3D reformatted images of the alveolar bone and adjacent structures by means of high-resolution CBCT.[3,4] These images provide correct information about height and width of bone and alveolar ridge for dental implantation.

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2.1. Advantages of CBCT over conventional CT scan[6–8]

1. CBCT is a compact system, providing in-office imaging and also is cost effective.
2. Low dose of radiation is required.
3. It gives reconstruction of multi-planar image & due to high resolution, provides better presentation of mineralized structures.
4. Precise images with less artifact are obtained.
5. Has exclusive display mode for maxillofacial imaging.

2.2. Drawbacks of CBCT over CT scan[8]

1. Scattered radiation with restricted dynamic range of the X-ray detectors.
2. Due to the small detector size, limited scanned volume and FOV.
3. Contrast resolution is limited & restricted soft tissue contrast.
4. Lower quality of images in regions near high-density neighbouring structures such as dental restorations and implants.

2.3. Use of CBCT in Maxillofacial Region

Earlier, use of CBCT was restricted only to implantology and dental imaging. Recently, CBCT is used in all medical and dental fraternity practicing in maxillofacial area. The major use of CBCT in the maxillofacial region includes surgical planning for impacted teeth, implant surgeries cysts and tumours, orthognathic and diagnosis of fractures and inflammatory conditions of the jaws and the sinuses, OMF pathology, maxillofacial trauma, temporomandibular joint (TMJ) disorders and cleft palate.

3. Dental Implantology

Treatment planning, assessment of quality of bone and quantity of bone are the preoperative parameters for the successful dental implants. The cross-sectional views are recommended by American Association of Oral and Maxillofacial Radiology for planning of a desired implant site.[9] The 3-D visualization provided by CBCT of the height, width and thickness of alveolar bone and spatial proximity of incisive & inferior alveolar canals, maxillary sinus, and nasal cavity. Both the quality and quantity of available bone for implants are key factors deciding the successful implant treatment. During last few years, the concept of using CT-derived Hounsfield unit (HU) values had increasing popularity for quantitative assessment of bone density.[10,11] CBCT can also be used for evaluation of bone quality along with the quantitative assessment of bone.

3.1. Dentoalveolar surgeries

In most of the usual dentoalveolar procedures, 2-dimensional radiography is sufficient for purpose of treatment planning. For assessment of impacted teeth and its position relative to vital structures requires a more comprehensive 3-dimensional imaging. In such situations, CBCT image is indicated.[12–14] In addition to above, complications, such as root displacement or fragmentation, presence of supernumerary teeth, are more accurately depicted with CBCT.[15]

4. Impacted Third Molars

In cases of surgical removal of mandibular and maxillary impacted molars, specifically third molars, there is due risk of damage to nearby vital structures, including the inferior alveolar nerve (IAN), the maxillary sinus, blood vessels. Panoramic radiograph such as CBCT has proven to be the gold standard for evaluation of third molars in the context of nearby vital structures.[16] Rood in 1990, studied seven radiographic signs commonly related with an increased risk for IAN injury, which were later modified by several authors.[17] CBCT makes available sagittal and coronal sections which shows dimensions of the relationship of the IAN and the mandibular third molar. This helps to understand the IAN proximity in a vertical, lateral, and depth dimension.

With the help of CBCT accurate localization of impacted canines is possible. This provides important information regarding bucco-palatal position, condition of the adjacent teeth, amount of bone overlying the tooth, the inclination of the long axis of the tooth, resorption of adjacent teeth, & also the stage of dental development.[18–21]

4.1. Oral and maxillofacial pathology

It is possible to monitor various pathologic lesions which affects hard tissue in the maxillofacial area including cysts, tumors, infection, and osteonecrosis through CBCT imaging. The maxillofacial surgeon can determine the site of pathology and its relation with adjacent vital structures. For cysts, the inventive use of routine tumor surveillance imaging together with CBCT imaging provides a high-resolution 3D analysis.[21]

4.2. Maxillofacial traumatology

CBCT has a significant role in deciding appropriate surgery plan for maxillofacial trauma patients. CBCT can also be used for detection of the fractures as a reliable substitute to CT scan.[8] The specific software aided CBCT technology can also be used for preoperative virtual planning required for manufacture of customized reconstruction plate for mandibular fractures.[22] During the comparison of CBCT with multi-detector CT in diagnostic imaging of midface, CBCT provided better image quality at comparatively lower doses, comparable image quality at higher doses, and superior spatial resolution in standard- and reduced-dose settings.[23,24]

5. (TMD) Temporomandibular Joint Disorders

CBCT can be used for the diagnosis of temporomandibular disorders secondary to degenerative changes. In TMD, the disorders associated with bony structures such as condyle, the glenoid fossa, and articular eminence which includes flattening of articular surface, condylar hyper-, hypo-, or aplasia, cortical erosion, osteophytes and ankylosis can be diagnosed.[25,26]

6. Limitations of CBCT

Structures with high density like enamel and radiopaque materials not only scatter the beam but also cause beam hardening. This affects quality of image & accuracy of CBCT.[27–31] Furthermore, scattered radiations reduce the contrast & limit the imaging of soft tissues. Therefore, CBCT is particularly indicated for hard tissue imaging.[32] It is difficult to use CBCT for estimation of bone density, as because of distortion of Hounsfield Units. The scanning time for CBCT is prolonged around 15-20 sec. & the patient should be totally immobile during scan period.

7. Conclusion

The maxillofacial area is understood for its complicated anatomy. Hence, the advances in diagnostic methods in oral and maxillofacial surgery introduced the techniques into day-to-day practice to confirm safe and reliable surgery. The role of CBCT for maxillofacial imaging is significant in various studies for diagnosis, treatment planning, evaluation of treatment outcome, and research purposes. All the clinicians working in this field must know the working principles, indications & contraindications, and hazardous effects of CBCT for appropriate use.

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9. Conflict of Interests

The authors have no competing interests to declare that are relevant to the content of this article.

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