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Review Article

A Review on Cone Beam Computed Tomography in Orthodontics

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Abstract:

Cone Beam Computed Tomography (CBCT) is a vital source of three-dimensional (3D) imaging analysis in clinical orthodontics. CBCT can supply more reliable information as compared to conventional two dimensional radiographs due to the advancement in the technology, reconstruction algorithms and viewing software for CBCT. CBCT is used widely for evaluation of impacted teeth. CBCT can allow to localize such impactions accurately and also to evaluate root resorption of teeth. The three dimensional nature of CBCT allows the volumetric assessment of airway structures. In addition, it enables the visualization of abnormalities of temporomandibular joint (TMJ), analysis of malocclusion, identifying the ideal bone insertion sites for mini-screws in the palate, mandibular ramus, alveolar bone, and also planning for orthognathic surgery. While recording CBCT, the justification, risks, and benefits of CBCT should be kept in mind. This review article describes the advantages, disadvantages, and utility of CBCT in orthodontics.

Keywords: *cone beam computed tomography, orthodontics, impacted canine, orthodontic treatment planning, root resorption.*

Introduction

The key to a successful orthodontic treatment is accurate diagnosis, growth evaluation, and treatment planning. The diagnosis of the patients begins with the history recording and diagnostic records including intra and extra-oral photographs, radiographs, and clinical examination of the patients. The maxillary and mandibular dental casts whether with dental stone or digital casts are also a vital part of the orthodontic records. An important component is the imaging of the dentition. For radiographic assessment of the dentition, panoramic radiographs, lateral cephalometric radiographs, periapical radiographs if desired are commonly used for orthodontic diagnosis. Upper occlusal radiograph can also be used in certain conditions such as impacted canines. Imaging is required to obtain more information regarding the structures that cannot be seen clinically. The radiographic examination is used to confirm or rule out any clinical findings.[1-3]

In the past few years, the orthodontic field has seen a rise in the use of three dimensional (3D) radiographs such as cone beam computed tomography (CBCT) images. 3D radiography overcomes a lot of the limitations of the 2D radiographic images. CBCT has been developed from computed tomography (CT). CT was developed for medical imaging of structures in 3 dimensions. CT however, had a high radiation dose and that is why was not popularly used in dentistry. With the advent of CBCT, the radiation dose could be reduced significantly as compared to CBCT. The cost of CBCT systems is lower compared to that of CT and the space requirements were not as complex. These advantages resulted in a more widespread use of CBCT in the dental and orthodontic field.

With CBCT, the craniofacial complex can be visualized in three dimensions. The treatment plan for orthodontics can change depending on the CBCT visualization of the structures. A competent orthodontists should be knowledgeable regarding the current imaging modalities, and what they offer so that they can select the appropriate radiographic records.[1]

Advantages of CBCT

CBCT provides a real size 3D scan of the patients which means that the structures are visualized without magnification.[1] The accuracy of image geometry is increased. CBCT does not lead to distortion which is seen in 2D radiographs.

Therefore, the measurements from CBCT are more accurate. The clinician is able to view the structures and perform quantitative measurements in three different planes. The CBCT image also allows to section the image at specific axial, coronal, and sagittal cuts to evaluate a specific area of interest.[4-14]

CBCT also allows the volumetric analysis of structures such as pharyngeal and nasal airway space.[15] This is dependent on the thresholding of the airway space analysis.[16] Studies have been conducted to identify whether the airway volume measured from CBCT is equivalent to the airway function measured from respiratory functional tests.[17] The diagnosis and treatment planning of temporomandibular joint disorders requires special extraoral radiographs that can show the condyle.[18,19] However, it is difficult to obtain a complete visualization of the condyle from any 2D radiograph. CBCT allows the complete visualization of mandibular condyle in all dimensions.[20] The assessment of asymmetry traditionally required the use of posterioanterior cephalograms, but they showed magnification and distortion. With CBCT, the assessment of asymmetry can be done easily without by identifying a mid-sagittal plane and evaluating the structures on the right and left with respect to the mid-sagittal plane. In summary, CBCT can be used to generate multiple types of radiographic images and perform measurements on a single 3D scan.[21-25]

Disadvantages of CBCT

The exposure to radiation with CBCT is higher than with 2D radiographs. This is a major issue with 3D imaging. However, the radiation exposure is lower than that of spiral medical CT.[26] With advancing technology the dose of CBCT is brought further down. CBCT has difficulty in differentiating the soft-tissue in a CBCT scan because of low contrast resolution.[27,28] The norms for CBCT imaging in normal population is still not known. As CBCT are relatively new as compared to lateral cephalometric radiographs, detailed information regarding the CBCT norms is still not available. The landmark identification on the three planes namely coronal, axial, and sagittal plane on the CBCT can require more time compared to a 2D image.

Utility of CBCT in Orthodontics

CBCT is commonly used for assessment and localization of impacted teeth in three dimensions.[29] Furthermore, CBCT allows for the reorientation of images in contrast with lateral cephalometric radiographs.[30] The identification of landmarks is easier in CBCT as there is not overlapping or superimposition of structures. Therefore, the landmark identification has been reported to be of high precision. CBCT can results in less variability and higher reliability of measurements compared to conventional 2D Imaging. Also, when performing transverse measurements with CBCT, they provide a more reliable view as compared to the posteroanterior cephalograms for identification of maxillary transverse discrepancies. CBCT can be useful in evaluation of size of unerupted teeth.[31] Dimensions of alveolar and basal bone, and soft-tissue anthropometric measurements. The bone in maxilla and mandible such as palatal bone, ramus bone can be identified with the help of CBCT.[32] This can help in deciding the insertion site for mini-implants and safe limits from sensitive structures for mini-implant insertion. The adjustment of head position is not very critical for CBCT as the head orientation can be changed even after recording the CBCT. CBCT plays a very important role in the diagnosis of impacted canines, impacted molars, supernumerary teeth etc.[31] CBCT can be used for the detection of root resorption with orthodontic treatment.[33,34] It enables the isolation of each tooth and also orientation of the CBCT slice to the long axis of the tooth. By measuring the linear measurement of the tooth before and after treatment, root resorption with orthodontic treatment can be identified. It has been shown in the recent study that different types of orthodontic expansion such as conventional rapid palatal expansion (RPE) and mini-screw assisted rapid palatal expansion (MARPE) do not show increased root resorption compared to controls.[35] Furthermore, volumetric analysis of roots can also be performed with 3D imaging modalities.[36] The specific area of interest for volumetric analysis of roots has to be defined for evaluating the change in the root volume due to orthodontic treatment.[37,38] CBCT can also be used for the planning for orthognathic surgery in patients with severe maxillomandibular discrepancies.

In addition, CBCT can be used for the custom appliance design. The occlusal view of maxilla can be used for performing a custom trans palatal arch design.[39] In addition, it can also help in designing a custom-made expansion appliance. Furthermore, CBCT allows the visualization of the bone in the palatal vault. This is helpful in determining the exact location of insertion of palatal mini-screws. This can help in successful insertion of mini-screws as such the success of palatal mini-screws has been reported to be high.[40] For a complete digital patient record, the CBCT scan can be combined with 3D digital scan of the teeth. When this is done, the aligner treatment can be performed with more accuracy as it can enable the identification of root position and therefore the center of resistance of teeth.[41] Aligners are a popular orthodontic treatment modality in the recent times and with the help of knowledge of biomechanics, even complex movements can be performed with aligner therapy.[42]

The future research based technological advancements in the file of CBCT would be focused on reducing the radiation dose.[43] Furthermore, with the help of artificial intelligence, the accuracy co landmark identification will be higher.[44] The technological evolution of CBCT and innovation of the reconstruction algorithms will enable better image quality of CBCT scans.[45] This can help in achieving better soft-tissue contrast in CBCT images in the future enabling a higher reproducibility of the measurements with CBCT.[46]

With the help of 3D photos, 3D digital scans, and 3D radiography such as CBCT, a combined digital patient can be created. Future investigations in reducing the dose levels of CBCT will result in a more widespread acceptance of this imaging modality.

Conclusions

CBCT has gained increased popularity in recent years and is identified as the preferred imaging technique by clinicians across the world for diagnosis and treatment planning procedures. This article summarized the advantages, disadvantages, and utility of CBCT in orthodontics. Clinicians should have comprehensive knowledge regarding the advantages, disadvantages, and the higher radiation dose before deciding to use CBCT. Evidence based research on the use of CBCT and clinical treatment outcomes are needed to identify whether CBCT leads to an improvement in the treatment outcomes for orthodontic patients.

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