

# The clinical application of cone beam CT in orthodontics

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## Abstract

**Introduction:** Cone Beam Computed Tomography (CBCT) is a recently developed imaging technology which gives advantageous low-dose radiation and high resolution dental imaging of the cranio-maxillofacial anatomic structures in three dimensions (3D). During the last decade, many research studies have been done on the clinical efficacy of CBCT in dentistry.

**Material and Methods:** Computer databases, including PubMed, Science direct and Google advance search were searched.

**Results:** Many studies were retrieved initially. 56 studies were closely related to the current topic under review.

**Conclusions:** From the current literature, it's obvious that even though a lot of research has been done on CBCT, no clear decision has been made about the application of CBCT in orthodontics. In this article, we focused on understanding the basic concepts of CBCT and its application in orthodontics. Future research needs to be done about various clinical application of CBCT in orthodontic treatment planning, procedures and final outcomes.

**Keywords:** Cone Beam CT; CBCT; 3D

## Introduction

Cone Beam is a rapidly advancing dental imaging technology which is gaining popularity by producing low-dose, high resolution and accurate three dimensional images of cranio-facial anatomic structures in dentistry.<sup>1, 2</sup> The first CBCT manufactured for oral and maxillofacial region was in late 1990's.<sup>3</sup> It has been increasingly used since then in Orthodontics, Oral and Maxillofacial Surgery and Dental Implantology. Although CBCT has proved its efficacy in diagnosis of oral and maxillofacial pathology with production of detailed images, but still a vast amount of literature exists which contradicts the efficacy of CBCT citing lack of standardized methodological approach during the studies.<sup>4, 5</sup>

Although CBCT information can play a significant role in diagnosis and treatment planning in orthodontics but it can also expose the limitation of orthodontists in interpretation of the detailed information

attained from CBCT.<sup>6-10</sup> Diagnosis of pathologies that are not routinely diagnosed on panoramic 2D imaging leading to confusion and clinical error.<sup>11-14</sup> Without understanding the implication of pathology seen through CBCT (e.g. external root resorption) we cannot utilize the 3D information from CBCT, even if it aides in the diagnosis and treatment planning. As the CBCT technology becomes cheaper and easily available in general dental practices for orthodontic procedures, it is clear that the lack of training and experience will play a role in inadequate reporting of dental pathologies. The Ionizing Radiation Exposure 2000 states that all radiation exposure should be justified including CBCT.<sup>15-18</sup> Current guidelines on the use of CBCT state that, it should only be used in specific clinical situations and conventional radiography should be the preferred mode of imaging modality in all cases. Orthodontic procedures which are recommended for being diagnosed with CBCT are the presence of cleft lip/palate, unerupted teeth, generalized root resorption and planning for orthognathic treatment.<sup>3, 19-22</sup> This guideline is based on current literature stating that certain clinical

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conditions use of CBCT outweighs the risks involved with radiation exposure. It should also be noted that if CBCT field of view for dental images includes the base of skull and associated anatomic structures, then clinicians have a responsibility to give a detailed reporting of all additional structures and not just the limited area of interest. If any pathology is missed by the clinician which is of serious nature, this can lead to medico-legal implications. Almost 20,000 CBCT scans are taken daily in USA, but it's not clear whether they are leading to a positive treatment outcome or not.<sup>23-25</sup> Based on ALARA principle (as low as reasonably achievable), CBCT radiation exposure should be beneficial for patients seeking orthodontic treatment.

## Material and Methods

Computer databases, including PubMed, Science direct and Google advance search were searched. Internationally published research literature, review articles and relevant citations were included. After the electronic literature search, a hand search of key orthodontic journals was undertaken to identify recent articles.

## Results

A broad search of published articles was done using both electronic database and hand searching. Many studies were retrieved initially. 56 studies were closely related to the current topic under review.

## Discussion

**Comparison between conventional CT scans and CBCT:** The increased use of CBCT in dentistry is basically derived from initial studies which proved beneficial results of Conventional Computed Tomography Scans in Oral and Maxillofacial surgery.<sup>5,26</sup> The high radiation dose involved with conventional CT scans limits its usage in general dentistry.<sup>11</sup> With the development of less expensive

radiation X-rays tubes, more sensitive detectors and more powerful computer processors, CBCT systems are widely gaining acceptance in dentistry. The first commercially available CBCT machine was in 1990's (the New Tom 9000), after which 30 different CBCT machines became available for commercial use.<sup>26</sup>

CBCT, otherwise referred to as digital volume tomography uses a cone beam shaped X-ray beam which projects rays to a parallel detector. Both rotate 360° around the patients head and forms multiple cubes of images in the computer. These 3D blocks of images are known as Voxels. This is different from CT scans which produces multiple slices of images.<sup>27</sup> Each voxel represents a specific degree of X-ray beam absorption in dental imaging. Using computer software processing the images are combined by sophisticated algorithms and reconstructing images in three orthogonal planes; sagittal, coronal and axial.

**Advantages of CBCT in Orthodontics:** CBCT imaging is very useful in hard tissues visualization.<sup>28</sup> In addition to easy availability and affordability, the advantage in CBCT imaging is considerably less radiation exposure as compared with the conventional CT scans. The approximate effective dose of CBCT is almost 20% of that of a conventional CT scan.<sup>29</sup> The effective dose of CBCT is almost equivalent to the dose from a full mouth screen by periapical radiographs, depending on the machine and resolution.<sup>30,31</sup> The CBCT scanners also allow collimation which allows radiation exposure to specific areas of jaws thus reducing the overall radiation exposure as well.

**Localized Use of CBCT:** CBCT has numerous applications in the oral and maxillofacial region. Here, we have outlined the relevant application in orthodontics.

### **Impacted and ectopic teeth:**

Currently, the majority of orthodontists use periapical x-rays and panoramic imaging for assessing the vertical depth and mesiodistal

relation of unerupted impacted teeth in jaws.<sup>32</sup> It's important to establish the anatomical relationship of unerupted tooth with adjacent anatomic structures and teeth. The conventional radiographs can be supplemented with the occlusal and lateral cephalogram X-rays as well.<sup>33-36</sup> The panoramic imaging has potential disadvantages of distortions, magnifications and imaging artifacts which might result in error in distance relationship measurements.<sup>37-39</sup> Previous researchers identified that the efficacy of 3D imaging in establishing accurate relationship of unerupted teeth with adjacent structures does play a significant role in treatment outcomes.<sup>40</sup> The accurate position by the 3D imaging leads to an active approach of surgical exposure and orthodontic tractions compared to 2D imaging. Another important finding was the exact localization of impacted canine which leads to a more precise flap design and exposure by the surgeon.<sup>41</sup> This leads to a considerably reduced surgical trauma and more favorable periodontal healing outcome. Knowledge of the exact location of impacted canine also leads to a predictable treatment outcome with the precise orthodontic traction force.

**Root Resorption associated with impacted teeth:** A fundamental component of diagnosis is not only the accurate location of an impacted teeth, but also detection of any adjacent tooth root resorption. The information from CBCT can lead to the improved diagnosis of root resorption by as much as 50%.<sup>42</sup> There is no long term study which evaluates the use of CBCT in assessing the root resorption caused by orthodontic treatment forces. A recent study found that orthodontists tend to decrease the aggressiveness of orthodontic forces when root resorption is diagnosed in lateral incisors.<sup>42</sup>

**Developmental anomalies:** In various developmental analogies the CBCT plays an

important role in treatment planning. For example in Talon Cusp where the incisal surface needs to be reduced for aesthetic consideration.<sup>43</sup> Previously, no exact method was available where the exact length of the pulpal extension in in the tooth crown could be evaluated, but after CBCT imaging information, precise reduction of the crown is possible.

**Root Fracture:** The management of a root fracture depends on the establishment of exact fracture line. Retention of a fractured tooth by endodontic treatment can play an important role in orthodontic treatment planning by maintaining space in younger patients.<sup>44-46</sup> The CBCT allows exacts location of fracture line which can help in treatment decision of whether to retain the proximal part of tooth or extraction of tooth is the only possible outcome.

**Planning for temporary anchorage devices:** CBCT has been extensively used to evaluate the residual alveolar bone thickness in the pretreatment dental implant planning. It can be said that all temporary anchorage devices should be placed after thorough assessment of bone thickness in jaws.<sup>47</sup> Although researchers have argued that the treatment outcome from these devices also depends on the orthodontic forces applied but the role of adequate evaluation of bone thickness remains ambiguous. This could effectively be done with CBCT imaging.

**Rapid Maxillary Expansion (RME):** Few studies have been done in assessing the effects of Rapid Maxillary Expansion on the periodontal health and skeletal structural changes. Before CBCT, the changes made by RME were evaluated by changes in the dental casts and conventional dental radiographs. With CBCT, clinicians can accurately assess the 3D changes in the skeletal structures quantitatively.<sup>48</sup> The confusion about whether greater expansion is achieved in anterior or posterior segments of maxilla after RME was not cleared until a recent CBCT study proved that anterior segment has more expansion.

Also CBCT studies highlighted that tipping caused by RME was due to the decrease in buccal bone thickness. This research finding is interesting, but no long term study has been found in this regard.

**Cleft Palate:** Before CBCT, the conventional CT scan was considered the gold standard for evaluating the bony defect caused by Cleft Palate in maxilla. Various studies have now found CBCT to shows adequate visualization of bony defect in cleft palate in maxilla before any surgical interventional is undertaken at an expense of lower radiation dose than conventional CT scans.<sup>49-55</sup> Although, no quantitative literature is available to show the advantage of CBCT on panoramic imaging, the majority of dental cleft centers continue to use the conventional CT scans or Panoramic imaging for evaluation of bony defect in cleft palate patients.

**Orthognathic surgery:** Superimposition of two CBCT images allows to quantitatively study the changes in the craniofacial region. This is done by using a color map and color spectrum imaging indicating the amount and direction of imaging changes. These 3D superimposition techniques have already become a detailed method to assess 3D skeletal and soft tissue changes of facial structures.<sup>56</sup> Just like pretreatment dental implant planning through use of soft wares in CBCT imaging, dental orthognathic treatment planning has been done recently with positive results. More research needs to be done for evaluating the success of CBCT software in orthognathic treatment planning.

## Conclusions

CBCT is a recent developed dental imaging which has effective applications in orthodontics. Its lower radiation dose, higher accuracy, easy availability and lower cost makes it a candidate for widespread use in orthodontic diagnosis and treatment planning. Although the current literature provides support for efficacy of CBCT imaging in orthodontic procedures, but there

is a strong need for further long term research studies which quantifiably proves the beneficial role of CBCT over conventional 2D imaging or 3D CT scans. The current guidelines rightly support the use of CBCT imaging in complex cases and use of conventional radiography as first line of investigation in simple orthodontic treatment cases.

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