Review Article

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CBCT in Orthodontics: What is Justified?

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ABSTRACT

Background: CBCT was introduced to dentistry seventeen years ago which means, it is a relatively new technology. Considering that the orthodontic patients are mostly children or adolescents who stand to lose more from increased radiation exposure, using utmost caution is necessary before prescribing a CBCT. The intention of this article is to review the current literature so that the orthodontic practitioner can make evidence-based decisions on when to prescribe CBCT for a patient.

Keywords: Cone beam computed tomography; CBCT; orthodontics; evidence-based guidelines.

INTRODUCTION

Cone beam computed tomography or CBCT was introduced in late 1998 in Europe[1] and in 2001 in the United States[2]. India followed suit with the first dental education institute installing a CBCT unit in 2013.[3] Thus CBCT is a relatively new imaging tool and as with any new technology, it can be under-used, over-used or mis-used. Scientific evidence that the utilization of CBCT alters diagnosis and improves treatment plans or outcomes has only begun to emerge recently for some of its suggested applications.[4] The intention of this article is to review the current literature so that the orthodontic practitioner can make evidence-based decisions on when to prescribe CBCT for a patient.

CBCT presents high accuracy and precision, sensitivity and specificity, as well as absence of image amplification.[5-11] Numerous linear (e.g. lateral and posteroanterior cephalometric images) or curved planar projections (e.g. simulated panoramic images) currently used in orthodontic diagnosis, cephalometric analysis, and treatment planning can be derived from a single CBCT scan. Also, using software, CBCT data can be reconstructed to provide unique images previously unavailable in orthodontic practice, e.g. three-dimensional visualization of the maxillofacial skeleton, airway space and soft tissue boundaries such as the facial outline.[12]

In the light of above advantages, can CBCT be routinely advised for orthodontic cases?

CBCT has the drawback of having a higher radiation dose compared to conventional radiographs frequently requested in Orthodontics.[12,13]

The following guidelines are suggested for the use of CBCT in orthodontics:

1. Image appropriately according to clinical condition
2. Assess the radiation dose risk
3. Minimize patient radiation exposure
4. Maintain professional competency in performing and interpreting CBCT studies[12]

1. Image appropriately according to clinical condition

a. The decision to perform a CBCT examination is based on the clinical examination, available radiographic imaging, and the presence of a clinical condition for which the benefits to the diagnosis and/or treatment plan outweigh the potential risks of exposure to radiation.

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b. Avoid taking conventional 2D radiographs if the clinical examination indicates that a CBCT study is indicated for proper diagnosis and/or treatment planning or if a recent CBCT study is available.

Fig 1: CBCT image showing severe external root resorption of the palatal surface of the central incisor root (due to the impacted canine) which was not seen on a 2D radiograph due to superimposition.

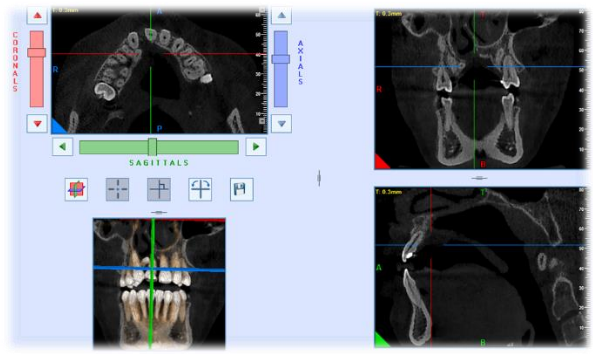

Fig 2: CBCT image giving precise information about the volume of the defect, position of the impacted teeth in an unilateral cleft palate case

Both European and US radiography guidelines specify that routine radiographs are not indicated for any patient in any dental discipline,[14-16] including orthodontics,[12] because the risk of unnecessary exposure to ionizing radiation may outweigh its benefits. This concern is amplified in children and young adults, who form most of the orthodontic patient population, as they present tissues with higher radiosensitivity, greater number of cell divisions and a longer lifetime span for carcinogenesis development.[17]

2. Assess the radiation dose risk:

To standardize comparison of radiation dose risk between various imaging procedures, the use of Relative Radiation Levels (RRLs) is recommended.[12] The orthodontist is advised to calculate the risk/benefit before advising the radiation exposure. The detailed assessment method has been presented in these guidelines given by the American Academy of Oral and Maxillofacial Radiology.

3. Minimize patient radiation exposure

CBCT units from different manufacturers vary in dose by as much as 10-fold for an equivalent FOV examination. In addition, adjustments of exposure factors to improve image quality are available in many CBCT units and can cause as much as 7-fold differences in patient doses.[12] Hence to minimize patient exposure to radiation, following is recommended:

a. Restrict the field of view (FOV): CBCT can be requested with a small (maxilla or mandible), medium (maxilla and mandible) or large (face and cranium) FOV. The greater the field of view, the greater the radiation dose.

b. Minimize exposure (mA and kVp), the number of basis images, and resolution yet permitting adequate visualization of the region of interest: The smaller the voxel (voxel = volume + pixel) dimension, the better the spatial resolution, but the greater the radiation dose. CBCT scans with high resolution (0.1 mm or 0.2 mm voxel size) should only be requested when in need of visualization of small details and delicate structures, such as mild root resorption, bone dehiscence and tooth fracture.

c. Use patient protective shielding (such as, lead aprons and thyroid shields) to minimize exposure to radiosensitive organs outside the FOV of the exposure.

d. Ensure proper calibration and maintenance of the CBCT equipment.

4. Maintain professional competency in performing and interpreting CBCT studies:

Clinicians have an obligation to attain and improve their professional skills through lifelong learning in regards to performing CBCT examinations as well as interpreting the resultant images.

According to the current literature, CBCT is indicated in following cases:

Impacted teeth: CBCT enhances the ability to localize impacted teeth accurately, evaluate their proximity to other teeth and structures, determine the follicle size and the presence of pathology, estimate space conditions, assess resorption of adjacent teeth (Figure 1), assist in planning surgical access and bond placement, and aid in defining optimal direction for extrusion of these teeth into the oral cavity[18-23] Studies demonstrate that the original treatment plans derived from 2D radiographs are changed for more than 25% of the impacted teeth when orthodontists viewed these teeth in CBCT images as opposed to the 2D radiographs typically used for this purpose.[4]

Cleft lip and palate defects: CBCT may provide more precise information on the numbers, quality and location of teeth in proximity of the cleft site,[24] eruption status and path of canines in grafted cleft sites,[25] and diagnosing for implant placement.[26] At a later stage of treatment pre-alveolar graft radiographs provide the orthodontist and the surgeon with information on how much expansion and graft material will be needed to provide sufficient space for the canine to erupt including the volume of the alveolar defect[26-28] (Figure 2).

Orthognathic surgery: CBCT images can be exported into an orthognathic surgical planning software which further allows multiple hard and soft tissue surgical simulations. After a treatment plan is finalized, the same data can be used to design and fabricate templates used for surgery.

CBCT may be advised based on clinical judgment in the following cases:

Root resorption: Relative to CBCT, panoramic radiographs underestimate the presence of external apical root resorption (EARR).[29,30] CBCT imaging also enables the visualization of buccal and lingual root surfaces which is not seen on 2D radiographs. A thorough CBCT evaluation could be beneficial especially in orthodontic retreatment cases showing some root resorption on an OPG. Currently, however, evidence that detection of moderate-to-severe EARR differs between 2D and CBCT radiography is awaited.[4]

Other tooth anomalies: Transposition, supernumerary teeth can have additional information as with impacted teeth available when seen on a CBCT, which may be beneficial depending upon the case.

Alveolar boundary conditions: These include cases presenting with clinically noticeable thin alveolar bone phenotypes that may not tolerate significant labio- or buccolingual displacements; cases with pre-existing periodontal disease; cases requiring orthodontic tooth movements that extend beyond pre-treatment alveolar boundaries; and cases where a tooth may need to be translocated past another tooth or obstruction.

Temporomandibular joint (TMJ) imaging and airway analysis: Three dimentional volumetric study of these structures can be done by a CBCT. This is not routinely done by the orthodontist, hence not elaborated upon in this article.

CONCLUSION

Orthodontic practitioner ordering CBCT should be mindful that frequent use of supplemental CBCT increases the total radiation dose to the patient. This is even more critical in children and adolescents, as they are more sensitive to radiation. At the same time, CBCT can be a valuable tool in diagnosis, treatment planning and treatment execution which can result in better and more long-lasting outcome to the patient.

Subject to future inputs from research, we must use CBCT in conditions for which it has been proven to have distinct benefit over conventional 2D radiography and use utmost caution in cases where clinical judgment is advised. Assessing the radiation dose risk, minimizing patient radiation exposure and maintaining professional competency in performing and interpreting CBCT studies are to be followed to increase the benefits of CBCT to the patient.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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