Use of CBCT in Orthodontics

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Abstracts: Cone-beam Volumetric Imaging (CBVI) or CBCT is an imaging modality that is being more frequently applied to orthodontic assessment in recent years. It provides the third dimension in imaging of the craniofacial complex with a greater degree of accuracy and reproducibility. It has made a quantum leap as an orthodontic diagnostic tool. This article highlights to give a brief introduction to CBVI imaging technology and explores a number of issues regarding its usage in an orthodontic and clinical set-up.

Key Words: CBVI, image

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Introduction:

Cone-beam volumetric imaging (CBVI), also called cone-beam computed tomography (CBCT), has been used in dentistry since 1998[1, 2] the images it produces are not improved digital images, but true three-dimensional images, without the distortion seen in either film pictures or digital cephalometric and panoramic x-rays. It is an imaging modality that is being more frequently applied to orthodontic assessment.[3]

Medical CT v/s CBVI:

Conventional CT has been applied medically since 1971, [1, 4] but its application in dentistry was limited until recently because of cost and radiation exposure. Operating the CBVI machine is about as simple as operating a panoramic x-ray machine. CBVI emits a cone-shaped x-ray beam rather than the linear, fan-shaped beam of medical CT machines. CBVI requires only one rotation around the patient, whereas medical CT requires many rotations.[5]

Radiation exposure and doses:

Roughly speaking, however, patient exposure to radiation from CBVI is only about 20% of that from medical CT, and roughly equivalent to the exposure from a full-mouth periapical series.[6-7] Although the lower radiation used by CBVI compared to medical CT prevents clear visualization of many soft tissues, particularly the brain, it does render excellent images of hard tissues such as bones and teeth.

Annual background radiation dose is about 3.0 mSv (3000 µSv). [8] To allow a meaningful comparison of radiation dose, and thus risk, radiation exposures are frequently converted to effective doses, measured in Sieverts (Sv or milli- [mSv] or micro- [_µSv]). Published effective doses for digital panoramic radiographs range from 5.5 to 22.0 µSv, when the salivary glands are considered 2.4-6.2 µSv without, [9] while digital cephalometric radiographs have effective doses of 2.2 to 3.4 µSv with salivary glands, 1.6 to 1.7 µSv without.[10] Therefore, a typical panoramic cephalometric orthodontic examination will expose the patient to 7.5 to 25.4 µSv effective dose (with salivary glands) (for radiation dose exposure refer to table-1).

Acquiring the images:

Scanning Procedure: The typical CBVI scan takes between 4.8 and 26.9 seconds to perform, depending on the machine, FOV, resolution, and indication for scanning. The scan is a pulsating x-ray that captures thin visual slices, which can then be built and saved into the images we are accustomed to seeing.

TABLE

EFFECTIVE RADIATION DOSES[22]

Examination	Exposure (µSv)	Equivalent Natural Background Radiation
Dental		
Panoramic	3-11	One-half to one day
Cephlogram	5-7	One-half to one day
Occlusal film	5	One-half day
Bitewing	1-4	One-half day
Full-mouth series	30-170	4-21days
TMJ series	20-30	3-4 days
CBCT exam	40-135	4-17 days
Medical		
Chest X-ray	100	10-12 days
Mammogram	700	88days
Medical CT	8000	1000days

Careful examination of the images is required, because periapical lesions and periodontal problems that might not be evident on periapical films are often visible in CBVI.[12] The clinician can also identify non-dental pathology—which is reportedly present in more than 21% of orthodontic patients undergoing CBVI, [13] and especially in older patients—for referral to the appropriate specialist (primary-care physician, otolaryngologist, allergist, vascular specialist, or oral surgeon).

Data acquisition:

In practice, the orthodontic technician positions the patient in the same way as for panoramic or cephalographic imaging. The time required is about the same as for x-rays using a combination pan-ceph machine.[5] In contrast to traditional x-ray procedures; however, many practices have the patient wear a chin cup during CBVI to prevent motion. More than 30 different machines are commercially available.

Building the Images: From the computerized slices of the scan, the technician builds and saves images required for routine orthodontic diagnosis, along with images of areas of interest such as impactions, supernumerary teeth, pathologies, and other suspicious findings. The i-CAT machine comes with the software needed to build many of these images, but third-party software can provide additional features. The use Dolphin 3D software to build and save the images. Initial data slices from the scan are preserved in the universal Digital Imaging and Communications in Medicine (DICOM) format, which compresses the original 200MB of data by 3:1 with no loss of quality. These files are saved on a local hard drive and an off-site server. The images are saved in 2D format or occasionally as a short movie clip.

Evaluating the Images:

Panoramic View:-Because the teeth are not separated during scanning (Fig. 1A), there will be some vertical overlap. We prefer this arrangement because we like to view the condyles in the fossae during maximum intercuspation, or in centric relation if appropriate. The occlusion can then be

assessed with a concurrent view of the condylar position. If the teeth were separated, TMJ images might misrepresent the condylar position in the glenoid fossa, and cephalometric measurements might also be altered. Other views, such as the embossed panoramic view (Fig. 1B) and the maximum intensity projection (MIP) panoramic view (Fig. 1C) can be produced by clicking the corner of the image in the Dolphin program.

Lateral Cephalometric View:-The lateral cephalometric view can be built in a 2D format to allow comparison against established norms (Fig. 2)[25]. Lateral cephalometric images can also be created in 3D versions for superior evaluation and to view the right and left sides of the face simultaneously. Whenever it is difficult to identify landmarks, the image can be seen in Maximum intensity projection.

The lateral cephalometric view can be used to assess the developmental stage of the cervical vertebrae for determining skeletal maturation, which could eliminate the need for hand-wrist films.

Lateral View (Sagittal Slice):-The sagittal slice gives a clear view of the upper or lower incisors within the alveolar bone, visually establishing the potential range of orthodontic movement for each tooth (Fig. 3). Both sets of incisors can sometimes be well visualized in one image.

Frontal Cephalometric View:-The frontal view can be created in either 2D or 3D. Historically, frontal films have been difficult to trace and assess due to poor visualization of landmarks, but the 3D version can alleviate this problem. The hard-tissue version of the frontal view provides a better diagnostic look at the skeleton and offers the ability to evaluate the root structure and potential pathology. The 3D view with skull rotation allows the clinician to fully appreciate the maxillofacial skeleton.

Coronal View:**-**The coronal image can be focused on any of the posterior teeth to establish the buccolingual inclination of the teeth within the supporting bone (Fig. 4). The width of the maxilla and dimensions of the alveolar bone can be accurately measured

Axial View:**-**The axial view will occasionally reveal ectopic and supernumerary teeth (Fig. 5). If pathology is present, we suggest saving the axial slice that best visualizes it.

Temporomandibular Joints[23]:- Both coronal and sagittal sections of the TMJ are included in the 3-D orthodontic analysis, along with axial views to help orient the coronal and sagittal sections (Fig.6). These joint views can be correlated with the occlusal views because they are all produced from one volume. Functional shifts can occasionally be detected as differences between the left and right TMJ views.

Uses in orthodontics**:**

- It permits three-dimensional visualization of the airway[14] in obstructive sleep apnea cases where excellent segmentation of airway, minimum cross-sectional area and volumetric assessment can be made. Also, the use of Digital Imaging and Communications in Medicine (DICOM) multifile data with CBVI sets to produce a colour-contrasted blended view of the airway changes.
- It can be a useful tool for evaluating mesiodistal root angulations.[15]
- Is more sensitive than conventional radiography to detect simulated external root resorption cavities.[16] early diagnosis is important, because the presence or absence of root resorption

will determine the treatment strategy. Furthermore, advanced root resorption can make treatment impossible. Improvement of diagnostic measures for early detection and prevention is therefore essential for ensuring correct treatment, and it might also reduce treatment time, complexity, complications, and costs.

- Three-dimensional localization of the impacted teeth and determination of the type of impaction can be performed using the multiplanar reformats of the CBCT data, as well as three-dimensional reconstruction to give the clinician a sense of the position of the teeth in the bone and their relationship to their adjacent structures. Impaction is usually diagnosed during a routine clinical examination. Mismanagement and failure to diagnose can cause additional problems during the development and eruption of the impacted teeth. In the event of planning for extraction, the location of vital structures can be determined accurately around the impacted teeth.[17]
- It can be used to determine the thickness and morphology of bone at sites including where mini-implants may be placed or in patients for whom rapid maxillary expansion is being considered.[18]
- It provides the opportunity to examine facial asymmetries, soft tissues in three dimensions.[19]
- It offers improved means for assessing treatment outcomes and different patterns of bone remodeling following orthognathic surgery.[20] This is particularly important when the deformities are complex involving both function and esthetics such as those in the dentofacial area and with orthognathic surgery. Image fusion involves combining images from different imaging modalities to create a virtual record of an individual called a patient-specific anatomical reconstruction (PSAR). This can then be used to perform virtual surgery and establish a definitive and objective treatment plan for correction of the facial deformity. Face can be evaluated in three dimensions and an orthodontist can evaluate which face is the "best face" and which orthodontic and surgical treatment can best suitable for the individual patient.

The Future**:-**CBVI images can now be merged with photographs for treatment planning. Additional enhancements to the interactive software might include the ability to measure the volume of root structure for each tooth and the quantity and density of surrounding bone, which would allow this information to be used to position teeth.

Force systems are becoming more complex as the underlying engineering is better understood, and their determination is further complicated by contacting teeth, opposing teeth, mastication, and parafunction.[21] CBVI software might be able to determine the appropriate moment-to-force ratios needed to shift teeth into orthodontist-determined positions without moving them beyond their alveolar boundaries. Teeth would be placed efficiently in ideal positions that would cause the least discomfort to the patient.

CBVI provides a quantum leap in diagnostic capability, as well as the potential for integrating treatment and designing interactive clinical setups with other doctors. But the end result is that the orthodontist will be able to quickly glean the required diagnostic information and correlate it with findings from the clinical examination for precise, predictable treatment planning.

Conclusion:

The advent of Cone Beam Computed Tomography (CBCT) has been a monumental event for improving the diagnostic options and capabilities of the orthodontist. Familiarity and full utilization of its many options can provide the dentist with a valuable treatment planning tool, which can make diagnosis of increased precision that can excel an orthodontist in his/her day to day clinical practice.

Figures:

Fig. 1 A. Typical panoramic image from CBVI with teeth in occlusion. Toggling between images can help pinpoint suspicious areas for additional review.

B. Embossed panoramic view

C. Maximum intensity projection (MIP) panoramic view. (These and following images were created with Dolphin 3D software unless otherwise noted.)

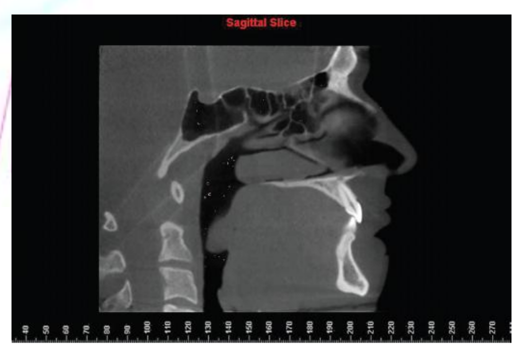
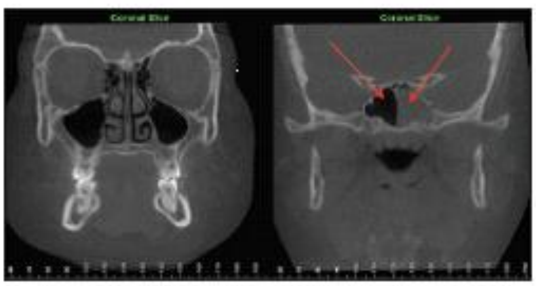
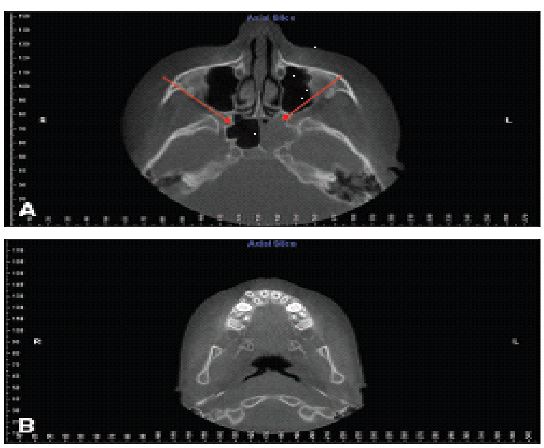


Fig. 3 Left side figure represents sagittal view of lower central incisor identifies position of tooth relative to available bone. Upper central incisor is not in focus, requiring second slice.

Right side figure represents sagittal view of upper central incisor allows visualization of realistic boundaries of tooth movement.





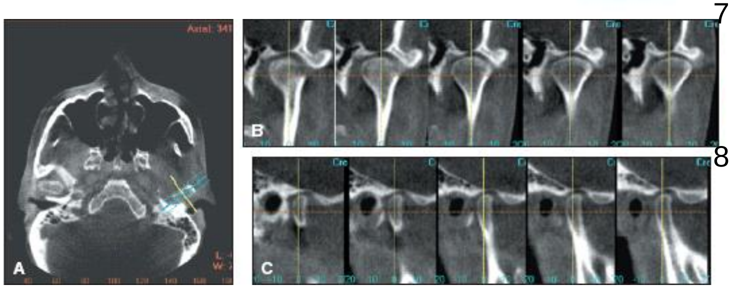


Fig.6 Temporomandibular joints. A.Axial view. B.Coronal sections. C. Sagittal sections.

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Conflict Of Interest - None