Why using CBCT in orthodontics is necessary

Author: Dr Andrei Iacob, Romania

Cone-beam computed tomography (CBCT) should be the imaging technique elected for comprehensive orthodontic assessment. With the progresses made in the field of CBCT imaging, clinicians can perform exact measurements without the errors induced by radiographic projection and landmark identification or location. The most important argument for the use of CBCT on a daily basis in orthodontics is the accuracy of image geometry. In contrast to 2-D images, CBCT achieves a 1:1 ratio of image geometry, which allows adequate linear and angular measurements.\(^1\)

The quality of CBCT images allows the orthodontist to analyse bone, teeth (even unerupted teeth) and soft tissue three-dimensionally. The accuracy of the measurements of the hard and soft tissue on CBCT images permits more comprehensive and precise diagnostic and treatment planning. It has been proved that landmarks can be located reliably on cephalometric images generated from CBCT data.\(^2\)

CBCT images can and should be used in different areas of orthodontic interest. With the help of these 3-D images, it is simpler and more accurate to evaluate the cortical and alveolar bone, the periodontal status of the patient, the teeth (including unerupted and supernumerary teeth) and their relation to the adjacent structures, and the temporomandibular joint (TMJ). Furthermore, from CBCT images, it is easy to extract very precise 2-D images, such as panoramic radiographs or cephalograms.

Fig. 1. Narrow alveolar crest in a 23 agenesis site.

Fig. 2. Very thin symphysis with the mandibular anterior teeth in contact with the buccal and lingual cortical plates.

Fig. 3. Deep periodontal pockets around the maxillary and mandibular first molars.

Fig. 4. Bone fenestration and dehiscence.

Fig. 5. Anterior condyle–fossa luxation. The condyle passes anterior to the articular eminence on full opening of the mouth.

Fig. 6. Opened functional spaces in a TMJ with a flat condyle.
The position and volume of the alveolar bone

In order for orthodontic movement to be performed, the teeth have to be moved through the cancellous bone of the alveolar bone. The buccal and palatal cortical bone can reduce or block the tooth movement, and root resorption or bone dehiscences may occur when the root is pressed against the cortical bone.

This process can occur regardless of the direction of movement (mesiodistal or buccolingual direction) and even in the alignment phase of treatment if the volume of the cancellous alveolar bone is not taken into consideration (Fig. 1).

Fig. 3
An osteophyte.

Fig. 4
Panoramic image and cephalometric measurements extracted from CBCT data.

Fig. 5
Example of transversal analysis using CBCT.

Fig. 6
Horizontally impacted canine.
A discrepancy between tooth size and arch length is one of the most common problems in clinical orthodontics. This can be resolved by means of extractions, interproximal enamel reduction, distalisation of the posterior teeth, or expansion of the dental arches. In orthodontics, where non-extraction is becoming increasingly popular, the use of CBCT has become mandatory. Expansion of the dental arches is very often associated with root resorption and causes significant buccal tipping of the teeth. It is known that tipping of the teeth is associated with root resorption and buccal cortical bone dehiscences. CBCT allows the clinician to evaluate the volume of the cancellous alveolar bone and the position of the root in relation to the cortical plates (Fig. 2). This information helps the orthodontist establish the limitations in tooth movement, so that the treatment will not induce root resorption or the decline of the periodontal system.3

**Periodontal bone level**

The periodontal status of the patient should always be verified prior to orthodontic treatment. This should be done on a regular basis for patients diagnosed with periodontal disease, as well as for all adult patients and young people over the age of 18 years (in accordance with the American Board of Orthodontics’ requirements) who are about to undergo orthodontic treatment. Usually, periodontal status is checked using a panoramic radiograph or a full-mouth series of radiographs. With CBCT, this kind of radiograph is no longer necessary, because the information can be extracted from the 3-D volume. In addition, CBCT images have the advantage of being 3-D, allowing the clinician to observe and quantify the exact amount of bone surrounding each surface of the tooth, lingual and buccal, as well as interproximal defects (Figs. 3 & 4).1

**The state and condition of the TMJ**

Clinical examination alone is usually not able to establish the condition of the TMJ or diagnose temporomandibular joint dysfunction syndrome. For this reason, images of the TMJ are essential for evaluating the condyle–fossa relationship (Fig. 5) and the functional joint spaces (Fig. 6) to determine the morphological changes in the osseous structures of the joint and to assess their severity. The morphological changes associated with temporomandibular joint dysfunction syndrome include wear, loss of cortical bone, flattening of the articular surfaces (Fig. 6) and osteophytes (Fig. 7).1,4 Recent studies recommend CBCT as the most appropriate radiographic investigation tool for evaluation of TMJ morphological changes.5

**Cephalometric analysis**

Cephalograms can be extracted from CBCT images (Fig. 8) and the measurements performed on CBCT synthetic cephalograms have proved to be on average similar to those on conventional cephalograms.2

**Transversal discrepancy between the maxillae and mandible**

Owing to the accuracy with which the landmarks representing the widths of the maxillae and mandible can be identified on CBCT images, it is far
more precise for the orthodontist to assess transversal plane discrepancy using 3-D data. For this purpose, one simple method is the University of Pennsylvania’s CBCT transversal analysis (Fig. 9). This transversal analysis uses CBCT to locate the points that define the maxillary and mandibular skeletal base width. For the transversal dimension of the mandible, the measurement is taken at the level of the furcation of the roots of the first molars. For the maxillae, the measurements are done from Mx to Mx points. The ideal difference between the width of the jaws should be 5 mm.6

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The size and position of impacted teeth

In clinical practice, the predictability and the quality of the orthodontic treatment outcome are uncertain with an impacted tooth. This is because it is very difficult for the orthodontist to assess clinically the correct position of the impacted tooth, both the crown and the root, and proximity to the roots of the adjacent teeth (Fig. 10). The 3-D images allow the orthodontist to analyse those aspects, as well as the eventual morphological anomalies, pathology of the impacted tooth, and resorption of the root of an adjacent tooth, and to determine the direction of the necessary orthodontic forces that will permit the recovery of the impacted tooth (extrusion, rotation, tipping, or root uprighting; Fig. 11).1

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Root resorption

With CBCT images, the orthodontist can determine whether root resorption has been caused by ectopia, or by orthodontic treatment. Figure 12 shows the external root resorption of a crowded central incisor.

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Localisation of teeth

The location of ectopic or supernumerary teeth can be determined with CBCT images. Figure 13 shows a third premolar impacted between the roots of the first and second premolars.

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Sinuses and teeth–sinus relationship

In many clinical cases, the close proximity of the roots of the posterior teeth and the maxillary sinus cortical bone cannot be properly assessed on 2-D images. When the roots are blocked by the sinus cortical bone, movements such as intrusion or mesialisation of the posterior teeth cannot be performed, or may cause external root resorption. With CBCT images, this shortcoming of 2-D images is easily overcome.7 Various incidental sinus findings on CBCT images may be made, including polyps, sinusitis and complete opacification of the maxillary sinuses (Fig. 14).8

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Airway assessment

On CBCT images, it is possible to measure the airway volume of the patient because the clinician can trace and analyse the contours and form of the airway.
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Changes in the hard and soft tissue with more accuracy than with 2-D radiographs. CBCT images allow the surgeon to perform virtual surgical osteotomies and to translate the bone segments to the desired position for better control and predictability of the results.9

**Various endodontic findings**

Occasionally various endodontic findings, such as internal or external root resorption, apical periodontitis or retained root tips, can be observed based on the CBCT data taken for the orthodontic diagnosis and treatment planning (Fig. 17). These are important findings in the diagnostic phase of treatment because they can influence the treatment plan.1

**Conclusion**

It is now easy to accept the advantages that CBCT has over 2-D images. In the context of new technological achievements, 3-D images give the clinician information that is more detailed compared with that of 2-D radiographs and at a lower dose of radiation. Because of its lower radiation dose and growing availability, CBCT is likely to become the modality of choice for the evaluation of, diagnosis of and treatment planning for orthodontic patients.9

**Placement sites for temporary skeletal anchorage devices**

Cortical bone thickness and bone depth are the criteria usually used to assess sites for the placement of temporary anchorage devices. Based on these criteria, various studies suggest various placement sites.9, 11 For an individualised and patient-oriented approach, the bone quality and the distances between adjacent teeth can be determined based on the patient’s initial CBCT data, with no need for any further radiographic investigations (Figs. 15 & 16).

**Surgical treatment planning for orthodontic surgical cases**

Another important clinical application of CBCT in orthodontics concerns surgical predictability with 3-D. Orthodontic surgical cases are very challenging, and 3-D images allow the clinician to plan the treatment virtually and to predict the

**Editorial note:** A complete list of references is available from the publisher.

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**Dr Andrei Iacob** graduated from the Faculty of Dentistry of the Grigore T. Popa University of Medicine and Pharmacy in Iași in Romania. He is a specialist in orthodontics and dentofacial orthopaedics. Dr Iacob has participated in numerous postgraduate training programmes in Romania and abroad. He is a member of the Roth Williams International Society of Orthodontists, Charles H. Tweed International Foundation for Orthodontic Research and Education, and Society of Esthetic Dentistry in Romania.

TRIDENT DENTAL CLINIC
Dr. Leonte 8
050465 Bucharest
Romania

andrei.iacob@clinicatrident.ro