Dr. Deepak Gupta completed his post graduation in oral medicine and maxillofacial radiology in 2011. He is currently an Associate Professor/Reader in the Department of Oral Medicine and Radiology, in M.M. College of Dental Sciences and Research, in Mullana, India. He teaches both graduate and post-graduate students. He serves on the editorial boards and scientific review committees of various international dental journals and professional committees with a particular interest in oral medicine and maxillofacial radiology.

The Role of Imaging

by Deepak Gupta, MDS
Abstract

In the past, the field of dentistry was precise and dental professionals were grossly involved with only treating dentition. Nowadays, dentistry has become more focused and specialized. Maxillofacial radiology is one of the specialties considered dentistry’s backbone in terms of investigation, treatment planning and follow up.

Although cone-beam computed tomography (CBCT) was a dream 20 years ago, today it has become a very important diagnostic tool. The recent introduction of CBCT has further upgraded the field of maxillofacial radiology; its role in oral and maxillofacial surgery, orthodontics, airway assessment, temporomandibular joint disorders, endodontics and periodontics is widely described in the literature.

Although precise and accurate measurements in the maxillofacial region for dental implants and for other maxillofacial lesions are achievable with conventional CT, CBCT provides more accurate measurements at lower dosages. Furthermore, CBCT enables the assessment of bone quality and quantity.

In this article I will highlight CBCT usage and application in dental practices, the importance of artifact reduction, and radiation risks.

Introduction

The maxillofacial region extends from the base of the skull to the hyoid bone and is considered one of the most anatomically complex regions of the body.

This region can be affected by a variety of diseases and disorders, and diagnostic maxillofacial radiology and imaging has assumed a lead role in its evaluation.

Just a few decades ago, oral radiology was practiced solely with the help of conventional radiographs. Although conventional radiographs revealed the anatomic structure of interest in only two dimensions, the procedure was considered vital for diagnosis, treatment planning and follow up. As soon as digital radiology came into existence and CBCT was introduced, it led to improved image quality, and three-dimensional visualization of the anatomical structure with minimal distortion and overlap.

In the past, literature has highlighted the emergence of CBCT as a radiological instrument that has expanded the field of oral and maxillofacial radiology.

Since CBCT imaging provides three-dimensional volumetric data reconstruction of dental and associated maxillofacial structures with isotropic resolution and high dimensional accuracy, the dental professional must
be well aware of the technique, its advantages and disadvantages, and cases in which this technology can be recommended.

A CBCT scanner is configured with a collimated X-ray source, leading to the production of a cone- or pyramid-shaped beam of X-radiation. Just a single full (or even partial) circular revolution around the patient is sufficient to capture enough data by the machine's digital detector. This data is then reconstructed into three-dimensional volumetric information in contrast to conventional CT scanners, which have a fan-beam approach.

CBCT requires reconstructing the object slice by slice, and then stacking the slices to obtain a 3D representation of the object. Thus, the time required to acquire an anatomical region by cone-beam projection is less than that required by a fan-beam projection.

Advantages

CBCT provides a number of potential advantages for maxillofacial imaging when compared with conventional CT, as follows:

• Isotropic voxel resolution
• Rapid scan time
• Significantly low radiation dosage.

CBCT can provide an optimum field of view (FOV) for each patient based on the region of interest and the suspected

CBCT requires reconstructing the object slice by slice, and then stacking the slices to obtain a 3D representation of the object. Thus, the time required to acquire an anatomical region by cone-beam projection is less than that required by a fan-beam projection.
CBCT utilizes a cone beam, which creates “noise,” thus reducing the image clarity in comparison to conventional CT and Dentascan. Current CBCT doesn’t appreciate soft tissue of the maxillofacial region.

disease.9, 10 Exposing the patient to CBCT for a particular maxillofacial lesion may reduce the effective dose of radiation by 90-98 percent as compared to a fan-beam CT system.2

Disadvantages
While CBCT offers several advantages, the dental professional must also consider its disadvantages.

CBCT utilizes a cone beam, which creates “noise,” thus reducing the image clarity in comparison to conventional CT and Dentascan. Current CBCT doesn’t appreciate soft tissue of the maxillofacial region. Another factor that impairs CBCT image quality is image artifacts, such as streaking, shading, rings and distortion. Streaking and shading artifacts, which appear due to high areas of attenuation (such as metallic restorations) and inherent spatial resolution, may limit adequate visualization of structures in the dento-alveolar region.2, 4, 5

Radiation risk
CBCT renders the patient with lower radiation risk as compared to the conventional CT, however, low dosage is important; one must take the ALARA principle into consideration.

The European guidelines for CBCT use indicate that CBCT interpretation should be done by a trained dentist or by an oral and maxillofacial radiologist.2

Literature has revealed that a per-capita annual U.S. dose is estimated at 6200μSv. Approximately 3000μSv are attributed to diagnostic procedures. Maxillofacial radiologists must keep the FOV as small as possible because the smaller FOV normally generates lower radiation doses.11-13

Lorenzoni and others reviewed the literature to disclose the radiation doses associated with CBCT, conventional CT, and conventional two-dimensional radiography.3 They revealed that the effective dose generated by CT is generally higher than that of CBCT. CT produces high radiation doses ranging between 534μSv and 860μSv for the maxilla and mandible.3 They also found that mandibular exposures lead to larger radiation risk than the maxillary14, 15 because the salivary glands, thyroid, and esophagus are more irradiated in the mandibular exam.

Artifacts
Artifacts contribute to image degradation and can lead to inaccurate or false diagnoses.

Some of these artifacts are more pronounced in CBCT units than their CT counterparts. Literature has revealed that CT images are more prone to artifacts than conventional radiographs.4, 16
Those considering installing CBCT devices should consult a health physicist (or other qualified expert) to perform a shielding analysis based on NCRP reports. Evaluation of the performance must also be completed every year.

Physical-based artifacts occur due to the physical processes involved in the acquisition of CT data, including noise and beam hardening.

Jaju defines noise as an unwanted, randomly or non-randomly distributed disturbance of a signal that tends to obscure the signal’s information. Literature highlights that the source of noise in computed tomography is scattered radiation, which arises from interactions of the primary radiation beam with the object’s atoms. This can be reduced by increased milliamperage (mA). Conventional CT machines produce less noise because of the high mA used, along with effective patient collimation, which reduces the scattered radiation. CBCT machines produce more noise, due to a lower mA. Since noise is a major determinant of contrast resolution, CBCT images have lower contrast resolution than conventional CT.

Beam hardening can result in cupping artifacts and the appearance of dark bands or streaks between dense objects in the image. By definition, cupping artifacts occur when X-rays passing through the center of a large object become harder than those passing through the edges of the object, due to the greater amount of material the beam has to penetrate. Dark streaks and bands between dense objects in an image are seen between two implants located in the same jaw that are in close proximity to each other. Jaju says this occurs because the portion of the beam that passes through both objects at certain tube positions becomes harder than when it passes through only one of the objects at other tube positions.

Brooks and Di Chiro used filtration to decrease beam hardening. They demonstrated a reduction of beam-hardening effects from 9.2 percent in 20cm of water using a 4.5mm aluminum pre-filter to 1.5 percent using a 3.5cm aluminum pre-filter. Their findings showed that using high-atomic-number materials such as copper or tin filters could produce even better results.

Antiscatter grids can also reduce beam hardening with the help of lead leaves. Beam-hardening-correction software may also be used. The software is an iterative correction algorithm that can be applied when images of bony regions are being reconstructed.
Partial-volume artifacts include a truncated-view artifact, which is a shading artifact that may arise if the object is not completely covered by the detector. In conventional CT units this is not a problem, as the entire object is always within the unit’s FOV; however, it does affect CBCT units due to their limited FOV.6, 16, 17 In addition, metal objects such as dental restorations can lead to streaking artifacts.18 Streaking caused by over ranging can be greatly reduced by means of special software corrections. Metal artifact reduction software can improve the image’s quality.

**Principles for use**

Various organizations like the National Council on Radiation Protection and Measurements (NCRP) have stressed that CBCT should only be used when the potential clinical benefits of the scan outweigh the risks associated with exposure to ionizing radiation.

NCRP’s guidelines also stress upon the fact that the operators must use the radiation safety equipment like thyroid collars and lead aprons when they will not interfere with the examination. CBCT must be performed if structures of interest cannot be captured by conventional techniques.6, 16

Those considering installing CBCT devices should consult a health physicist (or other qualified expert) to perform a shielding analysis based on NCRP reports. Evaluation of the performance must also be completed every year.6, 18

**Conclusion**

CBCT usage has evolved over the decades. While this may be better than conventional CT imaging, the clinician must be aware of the disadvantages and potential risks when utilizing CBCT. By understanding the risks, and staying up to date, clinicians can reap the benefits of CBCT and all it has to offer.