PACIFIC JOURNAL OF MEDICAL SCIENCES

{Formerly: Medical Sciences Bulletin}

ISSN: 2072 – 1625

Pac. J. Med. Sci. (PJMS)

www.pacjmedsci1625.com. Email: managingeditorpjms1625@gmail.com.

SHORT COMMUNICATION:

ROLE OF CONE BEAM COMPUTED TOMOGRAPHY IN IMPLANTOLOGY

[1*]VIJAYENDRANATH NAYAK S., [2] SUNIL KUMAR NETTEMU, [3] KARTHIK KANNAIYAN & [4] SAPTARSHI BHOWAL

1. Department of Oral Medicine and Oral Radiology, Faculty of Dentistry, Manipal University College Malaysia, Melaka, Malaysia.
2. Department of Periodontology and Implantology, Faculty of Dentistry, Manipal University College Malaysia, Melaka, Malaysia.
3. Department of Prosthodontics, Faculty of Dentistry, Manipal University College Malaysia, Melaka, Malaysia.
4. Faculty of Dentistry, Manipal University College Malaysia, Melaka, Malaysia

*Corresponding Author: drnayakomr@gmail.com

SHORT COMMUNICATION:

ROLE OF CONE BEAM COMPUTED TOMOGRAPHY IN IMPLANTOLOGY

[1*]VIJAYENDRANATH NAYAK S., [2] SUNIL KUMAR NETTEMU,
[3] KARTHIK KANNAIYAN & [4] SAPTARSHI BHOWAL

5. Department of Oral Medicine and Oral Radiology, Faculty of Dentistry, Manipal University College Malaysia, Melaka, Malaysia.
6. Department of Periodontology and Implantology, Faculty of Dentistry, Manipal University College Malaysia, Melaka, Malaysia.
7. Department of Prosthodontics, Faculty of Dentistry, Manipal University College Malaysia, Melaka, Malaysia.
8. Faculty of Dentistry, Manipal University College Malaysia, Melaka, Malaysia

*Corresponding Author: drnayakomr@gmail.com

ABSTRACT:
Imaging of the dental implant site has become a mandatory protocol, to determine whether the patient can tolerate the surgical procedure. Prior to the invention of Cone Beam Computed Tomography (CBCT), dentists used orthopantomogram (OPG), but it had its limitations. CBCT offers improved accuracy and reduced distortion. The identification of underlying bony pathologies, assessment of bone density, proximity of vital anatomical structures, and prognosis of the implant to be inserted became easier with CBCT.

Keywords: implant, bone density, radiology, tomography, cone beam computed tomography

Diagnostic imaging plays a crucial role in formulating a suitable and precise treatment plan for patients receiving dental implants. The anatomical aspects of the implant placement site should determine the choice of radiological techniques. To achieve the most comprehensive presurgical assessment of the implant site, the use of Cone Beam Computed Tomography (CBCT) imaging is highly recommended [1]. CBCT scanners offer user-friendly operation and generate a three-dimensional image volume that can be customized for anatomical visualization using software. Specific protocols have been established to enhance the quality of images for evaluating the implant site [2]. This review aims to emphasize the nature of CBCT usage in imaging for placement of dental implants.

CBCT scanners vary in capabilities, and achieving high-quality diagnostic information depends on patient-specific factors and the operator's skills. Oral radiologist selects the scanner, field of view, and voxel parameters based on clinical indications for individual patients and optimizing exposure for maximum diagnostic value. CBCT's multiplanar reconstruction capability has revolutionized implant dentistry by enabling clear visualization of structures without superimposition.

This ability to view structures from multiple angles enhances the precise evaluation of bone architecture, dimensions, contour, visual density, cortex, trabeculae pattern, and adjacent anatomical structures [3].

Imaging modalities for various treatment stages are presented in Table 1 [4].

Table 1: Imaging modalities used for various treatment stages [4].

Stage of treatment	Time (months)	Radiographic procedures
Treatment planning	-1	Periapical, Orthopantograph, tomo, CT, ceph
Surgery (placement)	0	Periapical, Orthopantograph, tomo, CT, ceph for correction of problems
Healing	0 to 3	Periapical, Orthopantograph, tomo, CT, ceph for correction of problems
Remodelling	4 to 12	Periapical, Orthopantograph
Maintenance	13+	Periapical, Orthopantograph
Complications	anytime	Periapical, Orthopantograph, CT (as indicated)

Abbreviations: tomo= conventional tomography; CT=reformatted computed tomography; Ceph= lateral cephalometric radiograph

IMAGING PROTOCOLS FOR IMPLANT PLACEMENT: CBCT imaging protocols for implant placement includes:

- Imaging the region of interest (ROI) and selecting the field of view (FOV),
- View the ROI at least in two planes right angle to each other,
- Evaluate bone height and width (bone dimensions),
- Determine quality of bone (Table 2),
- Determine long axis of alveolar bone,
- Identify and localize internal anatomy,
- Detection of bony pathology.

Table 2: Misch bone density classification [1]

Bone Density	Description	Tactile analogue	Typical anatomic location	Hounsfield units
D1	Dense cortical	Oak/maple	Anterior mandible	>1250
D2	Porous cortical and coarse trabecular	White pine/spruce	Anterior and posterior mandible, anterior maxilla	850-1250
D3	Porous cortical (thin) and fine trabecular	Balsa wood	Posterior mandible, anterior and posterior maxilla	350-850
D4	Fine trabecular	Styrofoam	Posterior maxilla	150-350

Anatomical structures and boundaries of those structures that are directly relevant to the area in which the implants are to be placed need to be identified and evaluated (Table 3) [5].

Table 3: Anatomical structures that needs to be considered prior to implant placement [5]

Anterior maxilla: • Nasal floor • Naso-palatine canal • Anterior superior alveolar canal	Posterior maxilla: • Maxillary sinus and related structures. • Posterior superior alveolar canal • Maxillary tuberosity • Pterygoid plates
Anterior mandible: • Lingual foramen • Incisive canal • Genial tubercles	Posterior mandible: • Inferior alveolar nerve canal • Mental foramina • Retromolar foramen • Sublingual fossa (lingual undercut) • Mylohyoid undercut • Lingula of ascending ramus
Zygomatic region: • Orbital floor • Infraorbital foramen • Zygomatic bone	

DATA TRANSFER

Stereolithographic models, which are computer-generated surgical guides, can be produced from Digital Imaging and Communications in Medicine (DICOM) data, effectively eliminating potential inaccuracies associated with conventional guide stent fabrication. The pre-implantation software planning aids surgeons in achieving more precise and safer implant placements. This technology enables minimally invasive surgery without the need to raise a flap, resulting in reduced surgical time, postoperative discomfort, swelling, and recovery period. The data obtained from the scan can be used in advance to create a master cast, and provisional restorations can be immediately placed following surgery (e.g., Teeth-in-an-Hour™ by Nobel Biocare in Kloten, Switzerland) [6 – 9].

POST SURGICAL APPLICATIONS OF CBCT

There are various indications described in guidelines and other scientific reports [5,10–12].

Indications for postsurgical use of CBCT in literature	Needed 3D info	Drawback CBCT
Postsurgical complications (e.g. neurovascular trauma)	Evaluate location and severity of problem and how to approach	Artefact by implant may mask neurovascular bundle CBCT fails to visualize neurovascular bundle
Healing follow-up of complex surgical procedures	Check bone healing and volumetric outcome	Detrimental artefacts of implants in borderline case (pneumatized maxillary sinus with inadequate bone)
Maxillofacial trauma with suspected complications at the implant level	Check mechanical failure implant or superstructure	Diagnostic failure to spot trauma caused by metal artefacts
Retrieval of Osseo integrated implants (infectious or mechanical failure etiology)		Blooming of implant masking neurovascular structures

ARTIFACTS

CBCT images often suffer from artifacts, especially when dense materials like metals are present, resulting in various artifact types. The most common artifacts among them are beam hardening, extinction, and exponential edge gradient effects [1].

These artifacts impact image quality in several ways, including bright streaks emanating from the metallic object, dark areas nearby, and even complete information loss between adjacent dense objects, collectively referred to as "metal artifacts." The presence of such artifacts in CBCT images compromises diagnostic accuracy and surgical planning. Material density and exposure parameters significantly influence artifact manifestation. Pauwels et al. quantified the impact of different CBCT devices and exposure protocols on the expression of metal artifacts caused by titanium implants, offering guidance on the development of optimized exposure protocols for effective metal artifact reduction [13]. Due to the clinical relevance of this matter, several efforts were made to reduce metal artefacts in CBCT images. A recent study conducted by Kuusisto et al. [14] demonstrated that composite materials give less artefacts, finding the cut-off point of artefacts at 20% radio-opaque filling material in composite implants.

CONCLUSION

In conclusion, the role of Cone Beam Computed Tomography (CBCT) in implantology is undeniably transformative and indispensable. CBCT technology has ushered in a new era of precision and efficiency in implant planning and placement, offering clinicians an unprecedented level of insight into the patient's anatomy. The ability to visualize critical structures, assess bone quality, and plan with meticulous detail has revolutionized the field, enhanced the success rates of implant procedures while minimizing risks. As we move forward in implantology, the significance of CBCT in optimizing patient outcomes cannot be overstated. However, it is essential that clinicians continue to stay updated on the latest developments in CBCT technology and best practices to ensure its effective utilization in dental implant procedures. With its promising future and the potential for further advancements, CBCT stands as a cornerstone in the evolution of implantology, empowering professionals to provide the highest standard of care to their patients.

REFERENCES

1. Karjodkar FR. 2nd ed. New Delhi (IND): Jaypee; 2011. Implant Radiology. Text book of dental and maxillofacial radiology; pp. 881–928.
2. Hatcher DC, Dial C, Mayorga C. Cone beam CT for pre-surgical assessment of implant sites. J Calif Dent Assoc. 2003;31(11):825–833.
3. Haiderali Z. The role of CBCT in implant dentistry: uses, benefits and limitations. Br Dent J 2020;228(7):560–1.
4. Gupta S, Patil N, Solanki J, Singh R, Laller S. Oral Implant Imaging: A Review. Malays J Med Sci. 2015 May-Jun;22(3):7-17.
5. Harris D, Horner K, Gröndahl K, Jacobs R, Helmrot E, Benic GI, Bornstein MM, Dawood A, Quirynen M. Guidelines for the use of diagnostic imaging in implant dentistry 2011: update of the E.A.O. A consensus workshop organized by the European Association for Osseointegration in the Medical University of Warsaw, Poland. Clin Oral Implants Res. 2012;23:1243–1253. doi: 10.1111/j.1600-0501.2012.02441.x
6. Deeb G, Antonos L, Tack S, Carrico C, Laskin D, Deeb JG. Is cone-beam computed tomography always necessary for dental implant placement? J Oral Maxillofac Surg. 2017;75:285–289.
7. Spector L. Computer-aided dental implant planning. Dent Clin North Am. 2008;52:761–775.
8. Loubele M, Maes F, Schutyser F, Marchal G, Jacobs R, Suetens P. Assessment of bone segmentation quality of cone-beam CT versus multislice spiral CT: a pilot study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006;102:225–234.
9. Ferreira MC, Garib DG, Cotrim-Ferreira F. Methodology standardization for measuring buccal and lingual alveolar bone plates using cone beam computed tomography. Dental Press J Orthod. 2010;15:49–52.
10. Bornstein MM, Scarfe WC, Vaughn VM, Jacobs R. Cone beam computed tomography in implant dentistry: a systematic review focusing on guidelines, indications, and radiation dose risks. Int J Oral Maxillofac Implants. 2014;29(Suppl):55–77. doi: 10.11607/jomi.2014suppl.g1.4.
11. Tyndall DA, Price JB, Tetradis S, Ganz SD, Hildebolt C, Scarfe WC, American Academy of Oral and Maxillofacial Radiology Position statement of the American Academy of oral and maxillofacial radiology on selection criteria for the use of radiology in dental implantology with emphasis on cone beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol. 2012;113:817–826. doi: 10.1016/j.oooo.2012.03.005.
12. Brown J, Jacobs R, Levring Jäghagen E, Lindh C, Baksi G, Schulze D, Schulze R, European Academy of DentoMaxilloFacial Radiology Basic training requirements for the use of dental CBCT by dentists: a position paper prepared by the European Academy of DentoMaxilloFacial Radiology. Dentomaxillofac Radiol. 2014;43:20130291. doi: 10.1259/dmfr.20130291.
13. Pauwels R, Stamatakis H, Bosmans H, Bogaerts R, Jacobs R, Horner K, Tsiklakis K, SEDENTEXCT Project Consortium Quantification of metal artefacts on cone beam computed tomography images. Clin Oral Implants Res. 2013;100(Suppl):94–99. doi: 10.1111/j.1600-0501.2011.02382.x.
14. Kuusisto N, Vallittu PK, Lassila LVJ, Huumonen S. Evaluation of intensity of artefacts in CBCT by radio-opacity of composite simulation models of implants in vitro. Dentomaxillofacial Radiol. 2015;44:20140157. doi: 10.1259/dmfr.20140157.