Review Article

Role of Cone Beam Computed Tomography in Diagnosis and Treatment Planning in Dentistry: An Update

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Abstract

Accurate diagnosis and treatment planning are the backbone of any medical therapy; for this reason, cone beam computed tomography (CBCT) was introduced and has been widely used. CBCT technology provides a three-dimensional image viewing, enabling exact location and extent of lesions or any anatomical region. For the very same reason, CBCT can not only be used for surgical fields but also for fields such as endodontics, prosthodontics, and orthodontics for appropriate treatment planning and effective dental care. The aim and clinical significance of this review are to update dental clinicians on the CBCT applications in each dental specialty for an appropriate diagnosis and more predictable treatment.

Keywords: *Anatomical variation, cone beam computed tomography, dental technology, pathology, radiology, three-dimensional, X-ray*

Introduction

Wilhelm C. Röntgen discovered electromagnetism in 1895 in a wavelength range (the X-rays) which became a very important diagnostic tool.[1] This discovery unleashed a great source of knowledge of the human body breaking the constraints of medical science and enabling doctors to diagnose and treat pathologies accurately. It was after 14 years that X-rays were recognized in dentistry by Dr. Walkhoff, a dentist in Braunschweig, Germany. The discovery of X-rays was the basis for improved methods of scientific evaluation such as the cone beam computed tomography (CBCT). Interestingly, this technology took almost 40 years to evolve and become available for clinicians.

CBCT has evolved from CT scan; a technique invented in 1967 by the British engineer Godfrey Hounsfield.[2] The first prototype of clinical CBCT scanner was originally devised as a cost-effective and efficient method for obtaining cross-sectional three-dimensional (3D) images for radiotherapy and later (1982) for angiography.[3] CBCT's commercial availability was delayed for a decade and was first introduced in Europe in 1998 and the US in 2001.[3] Columbia Scientific Inc., introduced 3D dental software in dentistry in 1988, and 2 years later, CBCT started to appear in dental research publications.[4] With CBCT's introduction in dentistry, dental clinicians could not only have profound knowledge of oral pathology but could also enhance the access to a detailed view of the underlying structures and their relations. This 3D image was groundbreaking since the process of decision-making became simpler and the recognition of the bony defects from different angles became easier.

The aim of this manuscript is to describe the CBCT function concept and its application in dental and maxillofacial conditions.

Materials and Methods

This narrative review gathered literature from peer-reviewed articles published in indexed journals available in PubMed and other web-based resources. The article and literature used for this publication has been summarized in Table 1.

Applications in Dentistry

Oral surgery

An oral surgeon can analyze the size, extent, and location of a tumor or cyst, its penetration into surrounding structures, and relation to vital structures such as nerves

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Table 1: Summary of literature used for this publication

Author	Year	Study design	Sample size	Method summary	Conclusion
Filler AG	2009	Review	-	A steady series of advances in physics, mathematics, computers, and clinical imaging science have progressively transformed diagnosis and treatment of neurological and neurosurgical disorders in the 115 years between the discovery of the X-ray and the advent of high-resolution diffusion-based functional MRI	Overall, the competitive arenas of the academic, intellectual property, and corporate aspects of these historical developments appear to have acted to spur on the advance of technology
Bhattacharyya KB	2016	Review	-	A review article focusing on the work of Godfrey Newbold Hounsfield	Informative article regarding the work of Godfrey Newbold Hounsfield and his contributions to the field of medicine
Liguori C *et al*.	2015	Review	-	Article focusing on the history, components, and functioning of CBCT	The introduction of CT is one of the most important milestones achieved in the last 40 years of clinical and biomedical research making imaging more robust and reliable as an evaluation technique for patients in all clinical settings
Orentlicher G *et al*.	2012	Review	-	The introduction of new 3D diagnostic and treatment planning technologies in implant dentistry shows an accurate and predictable placement of implants as virtual treatment plan is now a reality. Such techniques have revolutionized dental implant diagnosis and treatment	New 3D technologies for dental implants have opened new avenues to clinicians for accurate and predictable diagnosis, planning, and treatment Knowledge of CT scans, proprietary treatment planning software, the complete treatment process protocols, and guided surgery instrumentation and techniques are instrumental to successful treatment outcomes
Ogawa T *et al*.	2007	Case series	10-OSA 10-non-OSA	Ten patients with OSA and ten non-OSA control individuals were imaged using CBCT (Newtom QR-DVT9000) to compare their upper airway structure	The OSA group presented a concave- or elliptic-shaped airway and the non-OSA group presented a concave-, round-, or square-shaped airway, showing characteristics of OSA airway that may contribute to distinguishing OSA cases from non-OSA cases
Araki M *et al*.	2007	Case report	-	A case of odontogenic myxoma showing a cyst-like pattern with a partially thick but vague and unclear radiopaque border between the left mandibular second premolar and first molar on rotational panoramic radiography	CBCT may prove extremely useful in clarifying detailed internal structure and the state of margins
Nair MK *et al*.	2007	Case report	-	Incidental finding of a potentially life-threatening large fusiform aneurysm of the internal carotid artery at the level of the posterior communicating artery in a patient	This report assumes significance in the light of widespread use of CBCT by dental clinicians for routine diagnostic tasks without a formal interpretation being carried out on all such studies

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Author	Year	Study design	Sample size	Method summary	Conclusion
Bianchi A *et al*.	2010	Case series	10	Ten patients with craniomaxillofacial deformations underwent CBCT before surgery. Using the SurgiCase CMF software, the data were reconstructed in 3D, and various osteotomies were simulated in a 3D virtual environment by applying different surgical procedures. At 6 months after surgery, the patients underwent repeat CBCT	Simulations in orthognathic surgery for skull-maxillofacial deformities using CBCT acquisition are reliable, in addition to the low radiation exposure, and could become the reference standard to plan surgical treatment
Swennen GR *et al*.	2009	Case series	10	A double CBCT scan procedure with a modified wax bite wafer to augment the 3D virtual skull model with a detailed dental surface was used. The impressions of the dental arches and the wax bite wafer were scanned using a high-resolution standardized CBCT scanning protocol. Surface-based rigid registration using ICPs was used to fit the virtual models on the wax bite wafer. Automatic rigid point-based registration of the wax bite wafer on the patient scan was performed to implement the digital virtual dental arches into the patient's skull model	The results show the potential for a double CBCT scan procedure with a modified wax bite wafer to set up a 3D virtual augmented model of the skull with detailed dental surface
Uchida Y *et al*.	2009	Case study	Cadavers for: CBCT - 4, anatomy - 71	ALL for the mandibular canal and the mandibular ICD at its origin was measured and compared in cadavers using anatomy and CBCT to safely install endosseous implants in the most distal area of the interforaminal region	Large variations in measurements were observed, both for ALL and ICD, no fixed distance mesially from the mental foramen should be considered safe. The ALL and the ICD can be estimated from the CBCT measurement
Worthington P *et al*.	2010			The authors outline clinical goals for implant planning and placement and describe the anatomical and prosthetic requirements for successful implant placement. They also present imaging solutions, including CBCT scanning and software analysis, to the clinical goals	Virtual implant planning using CBCT data allows the clinicians to create and visualize the end result before initiating treatment. CBCT scans are accurate and cost-effective and can be used to achieve the desired clinical outcome
Alqerban A *et al*.	2013	Case study	Test - 32	2D and 3D preoperative radiographic diagnostic sets were subsequently analyzed by 6 observers. Preoperative evaluations were conducted by the treating surgeon. McNemar tests, hierarchical logistic regression, and linear mixed models were used to explore the difference between 2D and 3D	Surgical treatment planning of impacted maxillary canines was not significantly different between panoramic and CBCT images

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Author	Year	Study design	Sample size	Method summary	Conclusion
Dang V	2009	Review	-	From PubMed and other related data sources, review regarding functioning and advantages of CBCT	CBCT is a better tool in assessing and treating complex dental problems
Bittencourt LP *et al*.	2011	Case study	12 patients	Using CT images from mean interradicular distance and standard deviation values were obtained at heights of 2, 5, 8, and 11 mm from the alveolar bone crest. The means were compared with mean data from the literature	The safest interradicular site for miniscrew insertion in the mandible was between the first and second molars, whereas in the maxilla, between the canines and first premolars
Tyndall DA *et al*.	2008	Review	-	This article focuses on applications of CBCT to dentoalveolar disease and conditions, as applied in the practice of general dentistry, periodontics, and endodontics	Only a modest amount of research has been undertaken in the field of CBCT and dentoalveolar applications More *in vitro* and *in vitro* studies are needed 3. More clinical studies preferably random double blind clinical trials CBCT and caries research results are mixed for proximal caries and few data exist for occlusal and pit and fissure caries at this time CBCT imaging for caries should be limited to nonrestored teeth For periodontal disease, CBCT is superior to 2D imaging but no more accurate than 2D for bone height CBCT for endodontic purposes appears to be the most promising use of CBCT
Scarfe WC *et al*.	2009	Review	-	CBCT is a diagnostic imaging modality that provides high-quality, accurate 3D representations of the osseous elements of the maxillofacial skeleton. CBCT systems are available that provide small field of view images at low dose with sufficient spatial resolution for applications in endodontic diagnosis, treatment guidance, and posttreatment evaluation	Specific situations, both pre- and post-operatively, where the understanding of spatial relationships afforded by CBCT facilitates diagnosis and influences treatment. CBCT is a useful task-specific imaging modality and an important technology in comprehensive endodontic evaluation
Cohenca N *et al*.	2007	Review	3	The purpose of this review is to describe the advantages and disadvantages of each technique and the clinical application for dentoalveolar trauma. Three clinical cases are described to illustrate the potential use of the NewTom 3G for diagnosis and treatment plan of dentoalveolar traumatic injuries	The NewTom 3G DVT 9000 provided valuable information that helps to determine the type and severity of the injury to establish appropriate treatment plan and its implementation

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Author	Year	Study design	Sample size	Method summary	Conclusion
Cotton TP *et al.*	2007	Review	-	CBVT (CT) imaging captures a cylindrical volume of data in one acquisition and thus offers distinct advantages over conventional medical CT, including increased accuracy, higher resolution, scan-time reduction, and dose reduction	CBVT has great potential to become a valuable tool in the modern endodontic practice
John V	2008	Case report	-	This paper reports on the conservative nonsurgical endodontic management of an upper right lateral incisor diagnosed with infected dens invaginatus (Oehlers' Type III) and associated acute apical abscess, while maintaining vitality of the surrounding pulp. The use of contemporary endodontic techniques in the diagnosis, treatment planning, and management of the case is highlighted	Advances in contemporary endodontic practice allow the clinician to meet the technical and biological goals of endodontic treatment of a wide range of clinical situations. A thorough examination is needed to identify and manage such anomalies earlier to facilitate predictable conservative management
Tsurumachi T *et al.*	2007	Case report	-	Value of the 3DX cone beam computerized radiography system is illustrated by the case of a fractured endodontic instrument protruding into the maxillary sinus	This case illustrates successful application of 3DX cone beam computerized radiography system in planning endodontic surgery
Young GR	2007	Case report	-	A clinical case is reported where labial postperforation in a maxillary central incisor occurring 15 years previously presented with a sinus tract and radiolucent lesion. Nonsurgical retreatment and perforation repair using mineral trioxide aggregate were performed with the aid of an operating microscope	The sinus tract resolved with radiographic evidence of healing at 1-year recall
Patil S *et al.*	2015	Review	-	Article is to review the history and evolution of CBCT, its advantages over conventional radiography and to discuss the literature validating its application in endodontics	The American Association of Endodontics and the American Academy of Oral and Maxillofacial Radiology jointly suggested that CBCT imaging should be considered when 2D imaging fails to provide adequate information. Every patient does not require 3D imaging, and it should not be used for screening purposes
Mohan R *et al.*	2011	Review	-	This review discusses all the finer details of CBCT which not only reveals 3D architecture of the periodontium but also helps to reconstruct it	CBCT with its high spatial resolution, affordability, smaller size, lower acquisition, and maintenance have made it as a natural fit in periodontal imaging

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Author	Year	Study design	Sample size	Method summary	Conclusion
Afrashtehfar KI	2012	Comparative study	10 (women - 5, men - 5)	CT images and lateral cephalometric radiographs of ten patients were used in this study. Raw CT data of the patients were converted to 3D images with a 3D simulation program (Mimics 9.0, Leuven, Belgium). Lateral cephalometric radiographs were used manually for 2D measurements. The comparisons of the two methods were made using 14 cephalometric angular measurements. The Wilcoxon matched-pairs signed-ranks test (a 50.05) was used to determine the difference between the two methods. To assess the intra- and interobserver reproducibility, two sets of recordings made by each observer, in each modality, were used. Dahlberg's formula was used to determine the intraobserver reproducibility, and the Wilcoxon matched-pairs signed-rank test (a 50.05) was used to assess the interobserver reproducibility	The 3D angular cephalometric analysis is a fairly reliable method, like the traditional 2D cephalometric analysis. Currently, the 3D system is likely to be more suitable for the diagnosis of cases with complex orthodontic anomalies. However, with the decrease in radiation exposure and costs in the future, 3D cephalometrics can be a suitable alternative method to 2D cephalometry
Afrashtehfar KI *et al*.	2013	Review and a case report	-	This article briefly addresses various aspects to be considered such as CT, surgical guides, implant considerations for the edentulous patient, and considerations for immediate implant placement and loading. In this clinical case, immediate postextraction implant placement with immediate loading was performed accurately because of the planning done with the CT scan. The use of a stereolithographic model and a surgical guide prevented technical difficulties and improved the predictability during the prosthetically driven surgery	Immediate postextraction endosseous implant placement with immediate loading could be performed accurately because of the planning done using the CT. The manufacture and design of a surgical guide prevented technical difficulties during the prosthetically guided surgery. A proper diagnosis and a careful treatment planning will continue to be the key to success within the principles of complex oral rehabilitation
Bérgamo AL *et al*.	2015	Review	-	The database searched was PubMed, and the terms used were "dental age estimation methods" and "forensic dentistry". Just papers about dental age estimation methods written in English between 2012 and 2015 were selected	The most dental age estimation methods were based on developmental stages of the teeth through radiographs and they were applied in children and subadults in countries of the different continents

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Author	Year	Study design	Sample size	Method summary	Conclusion
Nodehi D *et al*.	2015	Review	-	The present article evaluates various clinical applications of CBCT. Among scientific articles, research was conducted by PubMed on the dental application of CBCT, containing many articles; in general, among which most of them were clinically about dentistry and its related analyses. Different functionalities of CBCT including oral and maxillofacial surgery, root treatment, implantology, orthodontics, temporomandibular joint dysfunction, periodontics, and forensic dentistry have been indicated in the study	CBCT test should not be taken unless it is necessary and do more good than harm. While using this method, the whole image dataset should be assessed completely to maximize the resultant clinical data and make sure that every significant implicit finding was reported. Further evaluations are required for better determination of CBCT applications in forensic dentistry
European commission, 2012	2012	Evidence-based guidelines	-	A multidisciplinary team was formed from the SedentexCT project academic institutions, consisting of nationally and internationally recognized experts, including dentists, dental radiologists, medical physicists, and other dental specialists, including oral and maxillofacial surgery, orthodontics, periodontology, and restorative dentistry	Guidelines regarding CBCT, its use, and ALARA were created, according to different fields
White SC	2014	Review	-	Book on oral radiology	To accurately read a soft tissue phenomenon, a 24-bit contrast resolution is needed
Shaibah WI *et al*.	2014			A physical method to assess the accuracy of measurements obtained from an i-CAT CBCT dental radiography unit used to appraise the effect of voxel size on the accuracy of measurement by an i-CAT CBCT unit	Not significant difference was found between the physical and CBCT measurements for all the samples. The linear measurements from i-CAT CBCT unit are accurate, and the adjustment of the scan parameters such as the FOV and voxel size will not significantly affect this accuracy
Adibi S *et al*.	2012	Review	-	Authors conducted PubMed, Google, and Cochrane library searches using the key words "CBCT and dentistry" resulting in over 26,900 entries in >700 articles including 41 reviews recently published in national and international journals. This article is based on existing publications and studies	CBCT is important in the diagnostic process; thus, oral and maxillofacial radiologists should take the leadership role and facilitate the training and education of dental students and residents
Gupta R *et al*.	2015	Review	-	Authors described the role of CBCT in dentistry and how much it can affect the tissue density of various structures	Hounsfield units of tissue density are not calibrated on CBCT, which making it unreliable to compare tissue density based on CT numbers generated from different CBCT units

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Author	Year	Study design	Sample size	Method summary	Conclusion
MacDonald-Jankowski DS *et al*.	2007	Review	-	The legal impact of using digital monitors and CBCT on dental practice have been described. The recent emergence of CBCT, which is changing current approaches to imaging for preimplant planning, has provoked a number of legal dilemmas, such as an accompanying responsibility for reading and interpreting large fields of view that include extragnathic	The recent emergence of CBCTs has provoked a number of legal dilemmas such as an accompanying responsibility for reading and interpreting large fields of view that include extragnathic areas that are ordinarily outside the dentist's purview
Scarfe WC *et al*.	2009	Review	-	CBCT can be utilized in various fields of dentistry and can be used to observe successfully before and after treatment improvement of the patient especially in the cases of OSA	It can be successfully used for analysis of soft tissue airway constrictions and obstructions for patients suffering from sleep apnea, other soft tissue evaluations for orthodontic treatment, and periodontal treatment
Orhan K *et al*.	2010	Case report	-	Utilization of CBCT in the detection of possible cervical or internal resorption secondary to a midhorizontal fracture in a 36-year-old male patient. The fractured teeth spontaneously healed and were diagnosed radiographically after 28 years. Because of possible invasive cervical resorption and doubt over internal resorption in the conventional images, it was decided to examine the teeth with CBCT with 3D reconstructions	It was concluded that CBCT images should be obtained for root fractures, especially those in which cervical or internal resorption is suspected from routine conventional radiographs

CBCT=Cone beam CT, MRI=Magnetic resonance imaging, 3D=Three-dimensional, OSA=Obstructive sleep apnea, ICPs=Iterative closest points, ALL=Anterior loop length, ICD=Incisive canal diameter, 2D=Two-dimensional, CBVT=Cone-beam volumetric tomography, ALARA=As low as reasonably achievable, CT=Computed tomography, FOV=Field of view

and blood vessels [Figure 1]. CBCT also helps in the assessment of impacted teeth and supernumerary in terms of its location and relation to vital structures.[5] The clinician can also detect changes in the bony deformities related to bisphosphonate-associated osteonecrosis of the jaw, bone grafts, and paranasal sinuses; in cases of obstructive sleep apnea, it helps to form a volume surface rendering of the windpipe.[5] CBCT has the ability to provide attention to details, thus, becomes the technology of choice for midface fracture cases e.g., gunshot wounds, orbital fracture management, interoperative visualization of the facial bones after fracture [Figure 2], and intraoperative navigation during surgical procedures.[6-8]

In cases of temporomandibular joint disorders and dysfunctioning related to trauma, pain, dysfunction, fibro-osseous ankylosis, detecting condylar cortical erosion, cysts, and visualization of soft tissue (ST), CBCT becomes the imaging device of choice.[9]

Implantology

CBCT provides a higher degree of predictability of implant placement because of its accuracy for evaluation. The clinician can evaluate the height and width of the bone present to place an implant [Table 2 and Figure 3]. In peri-implantitis cases, the amount of bone surrounding the implant can be assessed previous to probing, providing such important information as radiolucency.[10,11]

Orthodontics

An orthodontist can use CBCT for the assessment of the position of unerupted teeth, particularly for impacted ones, especially in cases of maxillary impacted canines where knowing exactly the tooth position results in accurate treatment planning [Figure 4]. The angulation is appreciated well in these 3D images, which would be difficult to appreciate on conventional radiographs even when taken in two different planes. It also

Figure 1: Destruction of the body – parasymphysis left mandibular region due to an intrabony tumor

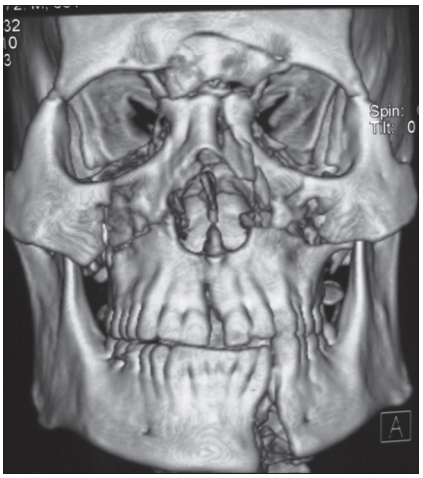

Figure 2: Multiple fractures involving the naso-orbitoethmoidal region, bilateral Le Fort 2 and 3 levels and a bilateral high Le Fort 1 fracture along with a left parasymphysis fracture of the mandible

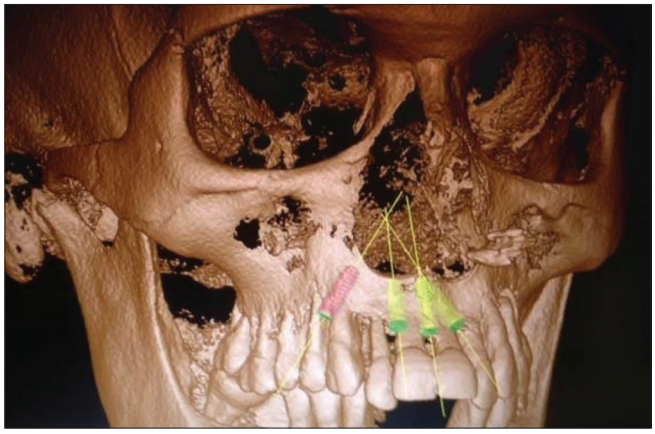

Figure 3: Use of cone beam computed tomography in planning the tridimensional placement of four implants in the anterior zone

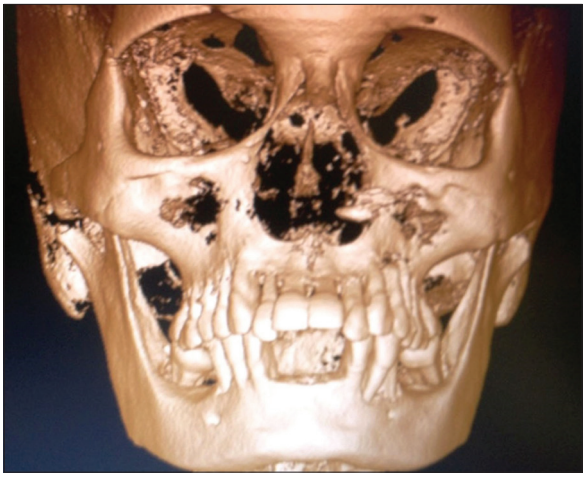

Figure 4: Three-dimensional view of both maxillary and mandibular arches depicting amount of bone present, craters, furcation, and crestal bone loss

helps in identification of any resorption of adjacent teeth (i.e., where maxillary canines are ectopic and incisor roots are suspected of having undergone resorption).[12]

Other applications of CBCT in orthodontics are cleft palate assessment, resorption related to impacted teeth, rapid maxillary expansion, 3D cephalometry, surface imaging integration, airway assessment, age assessment, and investigation of orthodontic-associated paraesthesia.[13] In cases where mini-screw implants are placed for anchorage, CBCT is used to analyze bone dimensions and precise location of placement to minimize complications.[14]

Endodontics

CBCT can also be used for caries diagnosis since caries detection and depth evaluation in approximal and occlusal lesions are improved considerably. However, its application in endodontic-metallic restoration would produce artifacts reducing diagnostic accuracy.[15] CBCT imaging for caries should be limited to nonrestored teeth.

Table 2: Cone beam computed tomography used in the treatment of implantology

Planning of exact implant position
Sinus lift
Intra-alveolar distraction osteogenesis
Reduced vertical bone height
Reduced horizontal bone width
Anatomical variations of the alveolar nerve
Preparation of templates

Sensitivity may increase with CBCT but it should not be at the cost of specificity.[15] CBCT in endodontics can be used for identification and measurement of the extent of periapical lesions[16] and it also differentiates solid from fluid-filled lesions (e.g., periapical granulomas from cysts) using grayscale values in the lesions.[15] CBCT plays an important role in establishing successful endodontic therapy by identification of all root canals

so that they can be accessed, cleaned, shaped, and obturated.[16] It helps in identification of prevalence of a second mesiobuccal canal (MB2) in maxillary first molars and also multiple and accessory canals (aberrant pulpal anatomy, e.g., dens invaginatus) in any other teeth.[15] It also helps in differentiation of pathosis from normal anatomy and relationships with important anatomical structures. CBCT also plays an important role in the diagnosis and management of root fractures, luxation and/or displacement, and alveolar fracture.[17-22]

Periodontics

In periodontics, CBCT detects the amount of bone present, craters, furcation, crestal bone loss, fenestrations, and dehiscences [Figure 5]. In spite of its usefulness in this field, CBCT is not indicated as a routine method of imaging periodontal bone support. However, limited volume, high-resolution CBCT may be indicated in selected cases of infrabony defects and furcation lesions, where clinical and conventional radiographic examinations do not provide the information needed for management; thus, it may have a role to play in the management of complex periodontal defects for which surgery is the treatment option.[13,15] CBCT can also be used within a period of 1 month for postoperative defect fill or bone density evaluation, which cannot be detected through normal radiographs, and it can also replace subtraction radiography.[15]

CBCT can help in identifying bone defect size and early signs of periodontitis by assessing periodontal ligament space, measurement of gingival tissue, and the dimensions of the dentogingival unit.[23] This method is called ST-CBCT and helps to visualize and measure precisely distances corresponding to the hard and STs of the periodontium and dentogingival attachment apparatus. With ST-CBCT, gingival margin and the facial bone crest, gingival margin and the cementoenamel junction (CEJ), and CEJ and facial bone crest can be determined.[23-25]

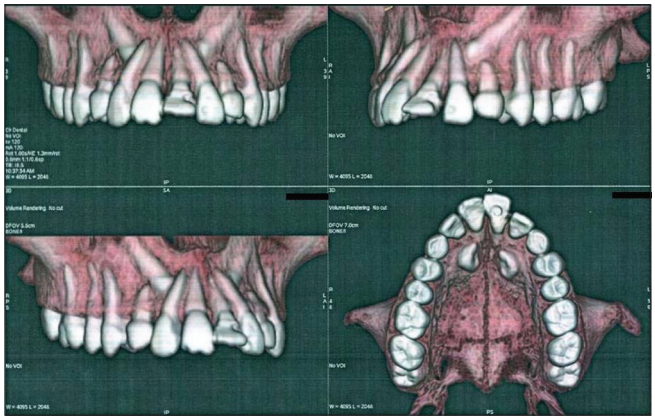

Figure 5: Both permanent upper canines are impacted with the crown facing toward the palatal aspect and the roots more toward the buccal aspect

Forensic dentistry

CBCT can also be applied in the field of forensic dentistry for accurate age estimation for every person of the legal system (including those who have passed away). To estimate accurate age, tooth has to be sectioned to identify morphological changes; as with age, internal layers of the tooth (dentin, cementum, and pulp) illustrate physiological and pathological changes.[26] However, with CBCT, such aggressive methods are not required.[27]

Safety concerns

It is paramount that as low as reasonably achievable (ALARA) principle is followed during diagnosis, as far as the radiation dose of CBCT imaging is concerned.[28] Use of CBCT for examination must be justified for each patient as the examination is dose dependent; i.e., higher doses of radiation may also be applied depending on the lesion to be examined, but higher radiation increases risks. Thus, CBCT should only be used when the question for which imaging is required cannot be answered adequately by lower dose conventional (traditional) radiography.[28] Therefore, it is necessary to ensure that patient doses are monitored on a regular basis and compared to agreed standards. Standard dose levels are normally referred to as diagnostic reference levels, and a dose of 4 mGy of SRL is recommended as the absorbed dose in air measured at the end of the spacer cone for a standard maxillary molar projection.[28]

By 1897, Kells reported that long exposures to X-rays caused a mild skin irritation, similar to sunburn, and early X-ray machines needed adjustment for each use so that the operator placed his hand between the actively radiating tube and the film plate. Kells took radiographs in this manner for 12 years, after which he developed cancerous tumors on his fingers. Thus, concerns about radiation exposure, especially when it is done once in a lifetime are inconsequential; furthermore, beyond 80 years of age, the risk becomes negligible because the latent period between X-ray exposure and the clinical presentation of a tumor would probably exceed the lifespan of a patient.[29] In contrast, the tissues of younger people are more radiosensitive and their prospective lifespan is likely to exceed the latent period. However, the ALARA principle should be kept in mind and should be followed with each exposure.

Limitations of cone beam computed tomography imaging

While there has been enormous interest on CBCT, this technology currently has limitations too related to the

"cone beam" projection geometry, detector sensitivity, and contrast resolution.[30] These parameters create an inherent image (known as noise) that reduces image clarity in such a way that current systems are unable to record ST contrast at the relatively low dosages applied for maxillofacial imaging; however, with advanced systems, it can be achieved.[30] Another factor that impairs CBCT image quality is image artifacts, such as streaking, shading, rings, and distortion.[31] Streaking and shading artifacts due to high areas of attenuation and inherent spatial resolution may limit adequate visualization of structures in the oral and maxillofacial region.[31]

Another limitation is the cost of the equipment and investment in the area where it is to be installed, as CBCT causes scattering of the radiation, especially when larger tissue is being evaluated, causing polydirectional Compton scattering. Thus, it needs lead barriers to be placed, adding to the investment.[31]

Another disadvantage is the poor quality in ST assessment.[13] The dynamic range of CBCT for contrast resolution can reach only 14-bit maximally.[32] To accurately read a ST phenomenon, a 24-bit contrast resolution is needed.[29] In addition, unlike multidetector CT, the Hounsfield units of tissue density are not calibrated on CBCT, which makes it unreliable to compare tissue density based on CT numbers generated from different CBCT units.[32]

Conclusion

From the aforementioned literature review, along with the advantages and disadvantages of CBCT, it seems that CBCT may not be the best imaging modality to evaluate STs; however, there are situations in which CBCT can help such as analysis of ST airway constrictions and obstructions for patients suffering from sleep apnea, other ST evaluations for orthodontic treatment and periodontal treatment,[33,34] and detection of healed root fractures.[35] The development and rapid commercialization of CBCT technology has undoubtedly increased practitioners' use of CBCT, as it is capable of providing accurate, submillimeter resolution images in formats enabling 3D visualization of the complexity of the maxillofacial region. It also provides clinicians with a modality that extends maxillofacial imaging from diagnosis to image guidance for operative and surgical procedures. Today, Wilhelm C. Röntgen's discovery through its evolution is providing diagnostic efficacy that can result in improved therapeutic efficiency in the medical and dental fields.

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Conflicts of interest

There are no conflicts of interest.

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