The Use of CBCT in Dentistry Represents the Future of the Profession

Rajiv Ahluwalia,[1*] Nishant Gupta,[2] Neeti Mittal,[3] Chetna Arora,[4] Priyanka Thukral,[5] Amit B Lall[6]

[1]Professor & HOD, Department of Orthodontics & Dentofacial Orthopedics, Santosh Dental College & Hospital, Santosh Deemed to be University, Ghaziabad, Delhi NCR

[2]Professor, Department of Orthodontics & Dentofacial Orthopedics, Santosh Dental College & Hospital, Santosh Deemed to be University, Ghaziabad, Delhi NCR

[3]Professor, Department of Pediatric & Preventive Dentistry, Santosh Dental College & Hospital, Santosh Deemed to be University, Ghaziabad, Delhi NCR

[4]Professor, Department of Conservative Dentistry and Endodontics, Santosh Dental College & Hospital, Santosh Deemed to be University, Ghaziabad, Delhi NCR

[5]Professor, Department of Prosthodontics and Crown & Bridge, Santosh Dental College & Hospital, Santosh Deemed to be University, Ghaziabad, Delhi NCR

[6]Professor & HOD, Department of Oral & Maxillofacial Surgery, Santosh Dental College & Hospital, Santosh Deemed to be University, Ghaziabad, Delhi NCR

*Corresponding author: Rajiv Ahluwalia

ABSTRACT

Cone beam computed tomography, often known as CBCT, is likely one of the most game-changing developments to take place in the area of dentistry over the course of the last ten years. Additionally, it offers an innovative platform for the orthodontic diagnosis and treatment planning processes. The currently available imaging techniques are simply representations of three-dimensional objects in two dimensions, and they have a number of drawbacks.

As a result, just a portion of the optimal imaging goals have been achieved. Radiographs that are in two dimensions are insufficient, particularly in complex cases such as those involving impacted teeth, supernumerary teeth, and orthognathic operations. CBCT images are user friendly and provide information that is significantly more detailed than that provided by standard 2D radiographs. On CBCT pictures, soft tissues, the skull, the airway, and the teeth may all be observed and measured in a 1:1 ratio. This is the case for all of these structures. The CBCT is an amazing tool that helps with accurate diagnosis, more predictable treatment planning, more efficient patient management and education, improved treatment outcomes, and increased patient satisfaction. The numerous applications of cone beam CT technology in the field of orthodontics are the primary subject of this essay.

Keywords: CBCT, 3D imaging technology, Virtual models, Orthodontic diagnosis.

INTRODUCTION

In orthodontic imaging, one of the primary objectives has always been to achieve comprehensive visualisation as well as recordings of the craniofacial complex. Plaster models, pictures, and radiography have traditionally been utilised in order to carry out these responsibilities. The imaging techniques that are now used in dental offices are essentially representations of three-dimensional things in two dimensions. These two-dimensional projections have a number of drawbacks, including the problems of magnification, distortion, superimposition, and inaccurate portrayal of structures. Cone-beam computed tomography (CBCT), on the other hand, has received a great deal of recognition in recent years all around the world as a feasible 3D imaging technique.

A genuine shift in perspective is being heralded by the advent of CBCT technology that is tailored solely for the imaging of the craniofacial region. It has caused a revolution in maxillofacial imaging by expanding the role of imaging beyond just diagnosis into image guidance of operational and surgical procedures using a variety of software programmes. This has allowed imaging to go beyond its traditional role as a diagnostic tool.

In dentistry, cone beam computed tomography (CBCT) refers to high-resolution, low-distortion computerised imaging of the head's hard tissues. Voxels are used as the unit of measurement rather than pixels, and the resolution is typically sharper than that of a standard CT. Conventional CT employs a fan-shaped beam to create several thin slices, but cone-beam CT uses an X-ray beam in the shape of a cone to create those slices. When the data is reformatted in a volume, the panorex and cephalometric projections that are produced by CBCT transform into three-dimensional images. When using CBCT technology, the taking of any and all radiographs can be accomplished in under a minute. The diagnostic capabilities of periapicals, panoramic, cephalograms, occlusal radiographs, and TMJ series are now at the orthodontist's disposal. In addition, the orthodontist has access to views that are not produced by standard radiographic machines, such as axial views, as well as separate cephalograms for the right and left sides of the head.

Obtaining conventional pictures might be difficult due to the complexity of the craniofacial complex, teeth, and airway. When compared to traditional imaging, CBCT provides advantages in terms of image-fidelity, which can lead to improved visualisation. CBCT is transforming orthodontics in terms of clinically assessing patients and is developing in terms of diagnosis, clinical procedures, and outcomes. These changes are occurring simultaneously.

This article explores the use of cone beam computed tomography (CBCT) in a variety of orthodontic procedures, from the most basic to the most complex. To understand how CBCT might develop into a routine component of high-tech orthodontic therapy in the future, one must also look into the distant past.

Orthodontic Applications of Cone Beam Computed Tomography (CBCT)

Impacted Tooth Position: The examination of impacted canines is generally acknowledged to be the most pressing requirement for CBCT imaging in orthodontics. CBCT imaging is accurate not only in establishing the relationship between the labial and lingual surfaces but also in providing a more precise angulation of the impacted canine [1, 2]. These 3D photos are helpful in detecting the proximity of neighbouring incisor and premolar roots, which can be invaluable in estimating the ease of uncovering and bonding. The proximity of adjacent incisor and premolar roots can be determined by clicking on the image and rotating it. It is also helpful in determining the vector of force that should be utilised to move the tooth into the arch with a reduced risk of root resorption in the surrounding teeth [3].

Root Resorption: Routinely In order to see root resorption, orthopantomograms and intraoral periapical radiographs are utilised; nevertheless, these radiographs have specific limitations as a result of which they are unable to provide information that is acceptable [4]. Root resorption is easily observable in CBCT pictures, and the clarity of the images enables clinicians to categorise the many types of root resorption that are present. When it comes to teeth that have more than one root, resorption can be confined to a particular root.

Fractured Roots: When viewing root fractures using radiography, it might be challenging if the fracture is angled in a direction that is not vertical. Because the tooth of interest can be visualised in all three planes of space with CBCT, it is much simpler to pinpoint the location of the root fracture and the degree of displacement [5].

Orthodontic Implants Placement: The understanding of the root alignment can significantly improve the chances of successful orthodontic implant insertion and placement in the correct location [6]. Images obtained with CBCT can provide views of the inter-radicular relationships that are more precise and reliable than those obtained using panoramic radiography [7]. Computed tomography (CBCT) data can be utilised in the construction of placement guides for the purpose of putting mini-implants between the roots of neighbouring teeth in anatomically challenging areas [8]. Before inserting the mini-implants, it is possible to do an assessment to determine both the quantity and quality of the bone in the potential locations for placement [9,10].

Location of Anatomic Structures: When using CBCT, anatomical structures including the mental foramen, inferior alveolar nerve, maxillary sinus, and neighbouring roots are all very easy to see. CBCT scans also enable for the accurate assessment of distance, area, and volume, which assists doctors in treatment planning for procedures such as sinus lifts, ridge augmentations, extractions, and implant placements.

Asymmetry Evaluation: The patient can be visualised in three dimensions, which enables a more accurate assessment of any skeletal or dental irregularities that may exist. When evaluating and measuring the maxillary and mandibular bones in three dimensions, it is possible to evaluate with more ease whether a true unilateral crossbite is present or whether it is one that has developed subsequent to a shift of the mandible into centric occlusion [11].

Temporomandibular Joint Assessment: Conventional tomography has seen widespread application in the evaluation of the TMJ; however, the sensitivity of the technology and the length of the tests have made it a less appealing diagnostic tool for dental practitioners. When it comes to detecting condylar erosions, it has been demonstrated that CBCT pictures of the TMJ provide a higher level of reliability and accuracy than either tomographic or panoramic views [12,13]. The presence of temporomandibular dysfunction can make orthodontic treatment more difficult, and as a result, the anatomy of the TMJ needs to be carefully assessed prior to, during, and after orthodontic treatment. In order for the orthodontist to properly evaluate the possible progression of any degenerative changes, it may be necessary to take follow-up CBCT scans at regular intervals over a prolonged period of time.

Airway Analysis: Traditionally, lateral cephalograms have been utilised during the process of doing airway analysis. The CBCT technology offers a significant advancement in the examination of the airways by making it possible to do 3D and volumetric analysis. The identification and treatment of complex clinical problems such as sleep apnea and enlarged adenoids would benefit greatly from the utilisation of three-dimensional airway analysis as a diagnostic tool [14,15].

Cleft Lip and Palate: It is difficult to acquire accurate estimations of the size (dimensions) of the osseous defects and the spatial connection of the defect to other critical anatomic structures using only 2D images. CBCT is able to provide information regarding the specific anatomic relationships of the cleft as well as the bone thickness surrounding the teeth that are located in close proximity to the cleft or clefts. This information is extremely helpful for the grafting treatments that are now being planned, as well as for any potential tooth movement in the existing dentition [16,17].

CBCT generated Cephalograms: It is possible to reformat the CBCT data set in order to build a CBCTreconstructed lateral cephalogram. This will allow standard measures to be taken and compared with previously established 2D standards. 18-20 These CBCT reconstructed lateral cephalograms give the benefit of the capacity to digitally realign the head position in instances in which the patient did not receive scanning with the appropriate head position.

Pathologies of Jaws: On panoramic radiographs, the presence of radiopaque lesions near the apexes of teeth, such as enostosis, condensing osteitis, thick bone island, and focal apical osteopetrosis, is not easily visible [21,22]. They do not appear to be the cause of the condition, but they can impede the mobility of teeth. CBCT pictures make it simple to identify and evaluate certain types of lesions.

Orthognathic Surgery: There have been multiple uses of CBCT created in the field of orthognathic surgery, including treatment simulation, guiding, and outcome assessment. In patients who have suffered traumas or skeletal abnormalities, preoperative CBCT 3D surface reconstructions of the jawbones are utilised for the purposes of surgical planning and simulation. Simulations of virtual repositioning of the jaws, osteotomies, distraction osteogenesis, and other procedures can now be successfully conducted. These simulations are made possible with the assistance of specialised software tools.

Superimpositions: Traditional lateral cephalometric superimposition can lead to a number of inaccuracies, but the advent of CBCT has made it possible for physicians to perform superimpositions in three dimensions. This has helped to eradicate a number of these errors. These 3D superimpositions contribute to a more accurate evaluation of the results of treatment.

Future uses for CBCT

The state of technology is in a state of perpetual flux, and practically daily, new applications are developed. The following CBCT applications provide a sneak peek at what might be attainable in the not-too-distant future.

Virtual Models: Without the requirement for alginate impressions, CBCT data can be used to build three-dimensional digital study models. It prevents the patient from being uncomfortable while also saving the orthodontist important chair time. Because these models include not only the tooth crowns but also the roots, impactions, developing teeth, and alveolar bone as well, the diagnostic value of these models is far higher than that of other digital models.

Invisalign Aligner: It is likely that in the not too distant future, the CBCT digital data could be used to carry out the entirety of the aligner construction process [11]. Because the CBCT images could be utilised to generate the virtual models, there would be no need to take impressions and mail them in, nor there be a requirement to register the bite. This information can be electronically communicated to laboratories, and the necessary virtual tooth movement can be performed by the orthodontist and the laboratory communicating with each other via e-mail. Even the retainers themselves could be made using the information included in the computer database of the laboratory, which contained the final tooth locations.

Indirect Bonding of Brackets: It is possible to employ the CBCT picture in the construction of "hardcopy" models, which can then be used for laboratory processes necessary for indirect bonding [11].

Custom-made Brackets and Wires: Data from a CBCT scan can be used to precisely create orthodontic brackets and wires that are tailored to the needs of a particular patient [11].

CONCLUSION

A new era of dynamic CBCT imaging has begun thanks to advancements in three-dimensional CBCT-based hard and soft tissue models, as well as photographic integrations and superimpositions. In the not-too-distant future, innovations in this area hold the promise of bringing orthodontic diagnosis and treatment an even wider range of advantages. The long-awaited addition of three-dimensional information to our radiography data is getting closer and closer to becoming a reality. The use of CBCT in orthodontics is the wave of the future, and the possibilities for its use in the field are practically endless.

REFERENCES

1. Walker L, Enciso R, Mah J. Three-dimensional localization of maxillary canines with cone-beam computed tomography. Am J Orthod Dentofacial Orthop 2005;128(4):418-23.
2. Chaushu S, Chaushu G, Becker A. The role of digital volume tomography in the imaging of impacted teeth. World J Orthod 2004;5:120-32.
3. Ericson S, Kurol J. Resorption of maxillary lateral incisors caused by ectopic eruption of the canines. A clinical and radiographic analysis of predisposing factors. Am J Orthod Dentofacial Orthop 1988;94(6):503-13.
4. Heimisdottir K, Bosshardt D, Ruf S, Can the severity of root resorption be accurately judged by means of radiographs? A case report with histology. Am J Orthod 2005;128(1):106-09.
5. Melo SL, Bortoluzzi EA, Abrea MJ, et al. Diagnostic ability of a cone beam computed tomography scan to assess longitudinal root fractures in prosthetically treated teeth. J Endod 2010 Nov; 36(11):1879-82.
6. Kuroda S, Yamada K, Deguchi T, et al. Root proximity is a major factor for screw failure in orthodontic anchorage. Am J Orthod Dentofacial Orthop 2007;131(4 Suppl):S68-73.
7. Peck J, Sameshima G, Miller A, et al. Mesiodistal root angulation using panoramic and cone beam CT. Angle Orthod 2007;77(2): 206-13.
8. Kim S, Choi Y, Hwang E, et al. Surgical positioning of orthodontic mini-implants with guides fabricated on models replicated with cone-beam computed tomography. Am J Orthod Dentofacial Orthop 2007;131(4 Suppl):S82-89.

9. Macchi A, Carrafiello G, Cacciafesta V, et al. Three-dimensional digital modeling and set up. Am J Orthod Dentofacial Orthop 2006;129(5):605-10.
10. Wong B. Invisalign A to Z. Am J Orthod Dentofacial Orthop 2002;121(5):540-41.
11. Hechler SL. Cone beam CT: Applications in orthodontics, Dent Clin N Am 52(2008):809-23.
12. Honey O, Scarfe W, Hilgers M, et al. Accuracy of the cone-beam computed tomography imaging of the temporomandibular joint: Comparisons with panoramic radiology and linear tomography. Am J Orthod Dentofacial Orthop 2007;132(4):429-38.
13. Tsiklakis K, Syriopoulos K, Stamatakis H. Radiographic examination of temporomandibular Joint using cone beam computed tomography. Dentomaxillofacial Radiol 2004;33:196- 201.
14. Sforza E, Bacon W, Weiss T, Thibault A, Petiau C, Krieger J. Upper airway collapsibility and cephalometric variables in patients with obstructive sleep apnea. Am J Respir Crit Care Med 2000;161(2, pt 1):347-52.
15. Ghoneima A, Kula K. Accuracy and reliability of cone beam computed tomography for airway volume analysis. Eur J Orthod 2011 Aug 10.
16. Hamada Y, Kondoh T, Noguchi K, et al. Application of cone beam computed tomography to clinical assessment of alveolar bone grafting: A preliminary report. Cleft Palate Craniofac J 2005;42:128-37.
17. Wortche R, Hassfeld S, Lux CJ, et al. Clinical applications of cone beam digital volume tomography in children with cleft lip and palate. Dentomaxillofacial Radiol 2006:35;88-94.
18. James KM, John CH, Hyeran C. Practical applications of cone beam computed tomography in orthodontics. J Am DA 2010;141(3):7S-13S.
19. Zamora N, Llamas JM, Cibrian R, et al. Cephalometric measurements from 3D reconstructed images compared with conventional 2D images. Angle Orthod 2011 Sept;81(5):856-64.
20. Gribel BF, et al. Accuracy and reliability of craniometric measurements on lateral cephalometry and 3D measurements on CBCT scans. Angle Orthod 2011 Jan;81(1):26-35.
21. Yonetsu K, Yuasa K, Kanda S. Idiopathic osteosclerosis of the jaws: Panoramic radiographic and computed tomographic findings. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;83(4):517-21.
22. Bsoul SA, Alborz S, Terezhalmy GT, Moore WS. Idiopathic osteosclerosis (enostosis, dense bone silands, focal periapical osteopetrosis). Quintessence Int 2004;35(7):590-91.