ISSN NO : 0970-4167 OCTOBER TO DECEMBER 2021

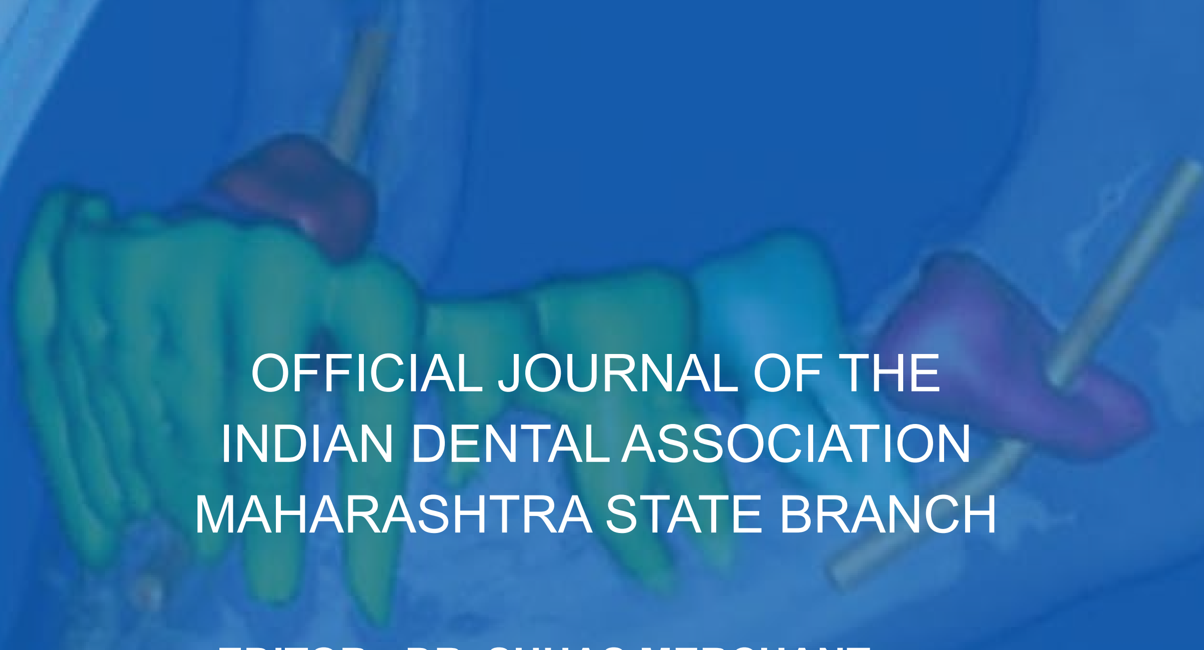
Volume xxxxv No. 6

ida®
Indian Dental Association
Committed to Dental Excellence

A Glimpse in to Digital Dentistry

Dental Dialogue

INSPIRING DENTISTRY AHEAD



OFFICIAL JOURNAL OF THE
INDIAN DENTAL ASSOCIATION
MAHARASHTRA STATE BRANCH

EDITOR : DR. SUHAS MERCHANT

GUEST EDITOR : DR. PRASHANT JAJU

ASSISTANT EDITOR: DR RIKIN MERCHANT

Indian Dental Association
Maharashtra State Branch

Office Bearers

Editorial Office :

Dr. Suhas Merchant
105, First Floor, Ronak Heights, Near
Soni Paithani, Kulkarni Colony,
Sharanpur Road, Nashik - 422002
Contact: +91 9823154068

Email : editoridamsb@gmail.com
drsuhasmerchant@gmail.com

EDITOR`S NOTE

Dr. Suhas Merchant
B. A. (Mass Comuniction & Journalism)
Diploma In Yog Techer
Yog Instructer (YCB Level II)
Yog Therapist

D ear Colleagues,

The black clouds of Covid-19 are fading away. After a long time we are gathering at this IDA MSB Conference. Learning and Technology is a continuous process, We learn to gain Knowledge. The quest for knowledge never ends. This quest adds newer technologies to mankind.This quest and technology go hand in hand. The technology benefits to new researches. The technology paved new way in all fields and in all walks of life. Be it Medical Sciences, Space , War fares, Telecommunications etc. The Telecommunication has changed our life The mobile phones are integeral part of our life.

In the field of Dental Sciences the Digital Technology has opened new horizons. A new branch of Digital Dentistry has evolved. The CBCT machines helps to diagnose the diseases, placement of implants, Digital prints, CAD-CAM etc.

This issue of Dental Dialogue is dedicated to the subject of Digital Dentistry. This will help to understand the subject well and update the knowledge.

I Thank Dr. Nitin Barve President & Dr. Vikas Patil Secretory for encouraging & helping to publish this journal.

I Thank Dr. Prashant Jaju for accepting the invitation to be the Guest editor of this issue on Digital Dentistry.

Happy Reading

Stay safe

Try to take some Digital holiday from social media also.

Dr Suhas Merchant

Editor in chief

President and Secretary's Desk

First of all,Congratulations to our Editor Dr Suhas Marchant ,for coming out the Last issue of Dental Dialogue for this year 2021

Upgradation in the Dental Profession is very essential to everyone ,to give benefits to our own Patients .

With this frame of mind ,this issue of Dental Dialogue , containing Digital Dentistry, very important topic in current situation ,has been reformed for every member .

- To understand the new trends and the need for customized strategies for success
- To understand the challenges of a real digitalization and how to overcome them
- To understand your patients and improving your message
- To understand the real impact of digital on clinical procedures
- To understand what makes artistic CAD/CAM
- To understand the new structure and roles of a Modern Smile Rehabilitation Clinics
- This issue of the magazine will help the clinicians and student to understand the subject of digital dentistry.

Dr. Nitin Barve

President

Dr. Vikas Patil

Secretary

DR NITIN BARVE

PRESIDENT

DR VIKAS PATIL

SECRETARY

Dental Dialogue

EDITORIAL OFFICE :

DR. SUHAS MERCHANT
105, First Floor, Ronak Heights,
Near Soni Paithani, Kulkarni Colony,
Sharanpur Road, Nashik - 422002
Contact: +91 9823154068

Email : editoridamsb@gmail.com
drsuhasmerchant@gmail.com

CONTENTS

FUTURE OF ARTIFICIAL INTELLIGENCE IN DIGITAL DENTISTRY

Dr Prashant P Jaju
BDS,MDS
Oral Medicine and Radiology
Officer on Special Duty(OSD), Professor,
Head of Dept & Guide

Prashant P Jaju, is a graduate from MGV Dental College and Hospital ,Nashik,Maharashtra. He completed his post graduation in Oral Medicine Radiology from reputed Dr DY Patil Dental College and Hospital, Pune, India . He is an gold medalist from Pune University. Currently serving as Professor , Head of the Department and Administrative Head in Rishiraj College of Dental Sciences and Research Centre, Bhopal. He is practicing exclusive Oral Radiology since 2011 and has 5 CBCT centers pan India. He is also the director of Oral Imaging Solutions, a tele radiology company associated with more than 15 CBCT centres across India for reporting .He is Key opinion leader of Dentsply Sirona for Imaging in India .He has trained oral maxillofacial radiologists and dentists for CBCT in India, Nepal, South Africa, Dubai, Iran ,Turkey.He is an certified CBCT trainer and an expert in digital dentistry. He is also collaborator for developing radiology softwares for Xelis and 3diagnosys. He has authored to two books on CBCT and is Editor in Chief of CBCT Magazine. He is also appointed as Oral Radiology section editor of European Oral Research . He has numerous International and National Research publications .

He is life member for Indian Association of Oral Medicine Radiology, active member of Computer Aided Implantology society(Italy), associate member of AAOMR,EADMFR and AAOMFR. He is recipient of IDA Profile of the Month and Year Awards.

Artificial intelligence (AI) the GenX word has entered in every aspects of our lives . Medical and Dental world is witnessing an upsurge in the applications of AI in diagnosis and treatment planning . Algorithms, enormous mathematical calculations, computerised data collection methods and reproduction of data are the basis of machine learning, an subset of AI which is helping to improve the dental treatment in an unimaginable way..

The term "artificial intelligence" (AI) was coined in the 1950s and refers to the idea of building machines that are capable of performing tasks that are normally performed by humans.

Machine learning (ML) is a subfield of AI, in which algorithms are applied to learn the intrinsic statistical patterns and structures in data, which allows for predictions of unseen data . A popular type of ML model are neural networks (NNs), which outperform more classical ML algorithms in particular on complex data structures such as imagery or language.

The Covid-19 pandemic has had devastating effects on health, economics, and society as a whole. Perhaps one of the most affected areas has been in the dental industry, where dentists had to limit patient care to emergency procedures only.

This limitation has had a negative impact on dental offices and patients who had to put off necessary dental procedures. No time has ever been more appropriate to incorporate digital technology than now, as Covid-19 will likely be with us for the foreseeable future.

AI computing allows the input of the patient's history, complaint and clinical findings, and it can then offer the most probable diagnosis based on evidence. Several studies have shown that using AI has led to more specificity and sensitivity in usage when compared with results offered by a dental professional. Using this model of AI reduces human errors, helps to simplify complicated presentations of an oral condition and enables proper and targeted patient care. AI is also being used as the gold standard for identifying the risk development of oral cancers, even in their pre-stages.

To assist with early diagnosis, mobile applications have been developed and used for image capture of oral lesions for remote diagnosing. Likewise, developments within these applications are being integrated in which deep learning will be used for the system to differentiate between pictures with and without signs of oral cancer. In fact, the algorithm will have the ability to classify different oral lesions into one of three categories: benign, malignant, and potentially malignant. Theoretically, the use of this type of AI in early detection of oral lesions could provide a higher quality of care as patients could receive the appropriate care at the appropriate time.

The refinement of this application of AI could lead to a proper and precise method for diagnosing cancers before they are even confirmed or visible to the eye. AI can leverage surgical and clinical data to make suggestions on the appropriate treatment plan in relation to the condition, history, and input of the patient. Taking a que from thousands of data sets models and analysis ,AI can offer a valuable second opinion on how a surgery should be performed and the potential treatment outcomes.

Dental imaging plays a pivotal role in dental diagnosis and forms a cornerstone of most patients' dental voyage, from screening to treatment planning and conduct. Dental imaging is taken multiple times for the same patients over a period of time and such data is useful for AI based software to arrive at an proper diagnosis

Patient's dental radiographs can be scanned using AI software to identify patterns that can reveal certain conditions like bone loss and caries. AI and digital technologies will be able to identify the following correctly and more effectively:

- Bone loss
- Tooth Decay
- Natural anatomy of the patient
- Other previous dental work that may have been done

The implication here is that this technology will be able to identify pathologies faster and with a greater degree of accuracy.

Also, AI has the potential to significantly enhance the patient's trust, which is essential to their agreeing to treatment. Many patients will more likely accept the data conclusions created by a computer program. It also allows for more time interacting with patients and focusing on treatment. The clinician can see more patients leading to an increase in productivity.

A dentist or dental office that embraces technology can stay ahead of the game and advance quicker when addressing problems and challenges that their practice may face. In these unprecedented times, with disasters such as Covid-19 changing our world, it is imperative to find ways to stay productive, adhere to regulations, and implement ways to keep safe.

With the use of digital dentistry tools like CAD CAM technology , AI methods are able to design the prosthetic components with greater accuracy, and design considerations can be customized to each particular case depending upon the clinical scenario.

Orthodontics is next big development in the field of AI .With introduction of digital smile design , aligners , digital segmentation of teeth . Virtual models and 3D scans are exceptionally useful tools in assessing dental abnormalities and even craniofacial abnormalities, allowing devices such as aligners to be precise and treatment approach to be customized, the combination of these aids is revolutionizing orthodontic treatment.

Teledentistry applications has revamped in this post Covid -19 pandemic. Scheduling and rescheduling appointments and follow-ups, managing insurance and reimbursement claims, taking a detailed medical history, dental history and history of habits—these can all be taken care of before seeing the dental professional. This allows dental experts to have the full picture before they even see the patient, reduces time and is a more streamlined approach to patient care.

The next decade will prove if this time the expectations for tangible AI applications are met by actual outcomes .In particular in healthcare, the stakes are high. There is reasonable concern

about data protection and data security and about handing over critical medical decisions to computers. However, AI has the potential to revolutionize healthcare and, with it, dentistry; AI

may assist in addressing the weaknesses harshly criticized in conventional dental care . Dentistry and, specifically, dental research, has a role to ensure that AI will make dental care better, at lower costs, to the benefit of patients, providers, and the wider society.

A brief overview of the current standards & future trends of digital guidance in implant surgery

Senem Yildirimturk
DDS, PhD, Yigit Sirin DDS, Phd, Assoc.Prof.
Istanbul University, Faculty of Dentistry,
Department of Oral and Maxillofacial Surgery,
Istanbul, Turkey

Corresponding author

Dr. Yigit Sirin
Postal address:Istanbul Universitesi Dishekimligi Fakultesi Agiz Dis Cene Cerrahisi Anabilim Dalı Beyazıt Vezneciler Istanbul/Turkey
e-mail:ysirin@istanbul.edu.tr
phone:+902124142020

Abstract

The invention of the dental implants and the cone beam computed tomography have revolutionized the daily clinical routine of dentistry. Further advancements in the processing of the tomographic data with dedicated software platforms allow the virtual planning and guided surgery, which provides better prosthetic outcome in terms of function and esthetics. In addition, the guided surgery protocols alleviate the need of extensive flap design thereby reducing the post-operative discomfort. Maximum efficiency and achieving zero error-margin in the digital as well as physical replicas of the anatomical structures in the least amount of time by using the lowest possible dose of ionizing radiation has become the current standard of digital implant surgery, which, in turn, paved the way for static and dynamic navigation, virtual reality, artificial intelligence and robotic technology. The aim of this article is to provide a brief overview of the current status and future trends in the surgical navigation of dental implants.

Key words

Dental implant, cone beam computed tomography, navigation, guided surgery, digital dentistry

Introduction

In the last two decades, rapid advances in the technological innovations have had a significant impact in dentistry, as in all aspects of daily life. The dental profession by its very nature is closely related to material science, new device designs and software-driven systems. However, no invention ever caused such a significant change in the daily clinical routine of modern dentistry as the cone beam computed tomography and implantology did. The digital transformation in the dental settings has started with the transfer of patients' records such as intraoral images and two- and three-dimensional (3D) imaging studies to the computer environment and recently evolved into the processing and overlapping of the anatomical data in 3D printers. Maximum efficiency and achieving zero error-margin in the solid modeling of anatomical structures in the least amount of time by using the lowest possible dose of ionizing radiation has become the current goal of digital dentistry, which, in turn, paved the way for virtual reality, artificial intelligence and robotic technology. Advanced techniques have started to be used more widely in restorative and esthetic dentistry, endodontics, orthodontics and especially in implantology (1). The aim of this article is to provide a brief overview of the current status and future trends regarding the surgical navigation of dental implants.

Background of the digital transformation

In the early years of dental implant surgery, methods borrowed from the engineering field dominated the rationale behind the insertion procedures, which reflected themselves as using long and wide implants having bicortical anchorage inserted parallel to each other, since the concepts of implant supported prosthetic occlusion and biomechanics were still in the infancy period. However, clinicians were soon to discover that the "radiologically perfect" implants did not perform as well as expected. Therefore, even when the implant placement has been mainly performed based on the diagnostic data acquired from two-dimensional radiographic images and by using freehand surgical techniques, the need for an accurate prosthetic guidance was evident. This was especially true for completely edentulous patients for which no reliable reference points could be determined. As early attempts of rudimentary navigation, the radiopaque materials such as barium sulfate fillings or gutta-percha were embedded in the existing or temporary dentures and the implants were inserted to predetermined positions. This procedure was time consuming, expensive, and yet it was not effective in terms of accuracy. Consequently, the deviations from the original diagnostic plan had had to be compensated at the prosthetic stage by using specialized equipment, which negatively affected the load distribution around the implants and thus, their survival rate.

Even though the importance of multi-planar imaging had already been recognized and the medical computed tomography devices had been available when the dental implants were first introduced, the dental professionals had limited access to that imaging modality mainly due to its high cost, availability, large footprint and high ionizing radiation dose. The introduction of cone beam computed tomography in the early 2000s was a viable solution to these problems and this imaging modality caused a true paradigm shift in the implant surgery as well as in other fields of dentistry (2). Based on the tomographic data, the design and planning of dental implants has evolved into a workflow of digital events that include image acquisition, digital planning, computer aided manufacturing and design, surgical navigation and probably the robot-assisted surgery in the near future. Among those, the navigation protocols seem to be the key step in the success of the whole process.

Types of navigation

The tomography guided implant surgery could be divided into two main categories defined as the static navigation which consists of surgical templates, and the dynamic navigation. Both techniques have advantages over each other as well as over free hand surgery, but some distinct disadvantages also exist.

Static navigation

Surgical stents used in CBCT- guided surgery are fabricated by either conventional laboratory techniques or by stereolithography (SLA) methods. With both techniques, a static guide is fabricated to transfer the original treatment plan based on CBCT data to the patient's mouth. Regardless of the fabrication method, there are three main types of surgical guides; bone-, tooth-, and mucosa-supported (2, 3).

The laboratory technique starts with the fabrication of an initial denture which represents the one the patient will wear in the final phase. After the try-in stages are completed, a copy of this denture with acrylic teeth is produced and used as the scan template. A prefabricated acrylic cube is attached to the denture to ensure the accuracy of the data transfer. The patient, wearing the same template, is scanned with CBCT. After virtual planning is done by using the dedicated CBCT software, the scan prosthesis and the cube are mounted on the drill machine and the guide cavities are prepared on the denture.

The surgical guides prepared with SLA techniques have become more popular in recent years. The denture prepared with acrylic resin teeth or gutta percha markers is dual-scanned; once in the patient's mouth and once by itself. The obtained images are overlapped and presurgical implant treatment planning is performed in the CBCT software. The data is then transferred digitally to a device that produces surgical stents by means of computer aided manufacturing technology. In the SLA technique, the liquid resin polymer is deployed in layers and the polymerization is achieved via ultraviolet light. Immediately after the polymerization is completed, the implant holes for sequential drilling are prepared. In order to provide anchorage for the positioning of the guide in the patient's mouth during surgery, additional holes for stabilization screws are created on the buccal side. Thus, SLA-fabricated surgical guides could transfer the CBCT-based treatment plans accurately and safely to the patient's mouth (4).

Compared to the conventional free hand surgery, using the static surgical guides shortens the duration of the surgery, provides a less-stressful procedure and let the clinician to position the implants more accurately. Consequently, they lower the rate of postoperative complications and discomfort. On the other hand, the static surgical guides do not allow momentary changes in the treatment plans as they will have to be refabricated. The bone-supported guides may not be seated properly, especially in the edentulous cases and they may hamper the visibility of the surgical site. Similarly, the amount of irrigation solution that reaches to the drill tip may be limited because of the obstruction. Positioning and stabilizing the guide can be very difficult in cases with limited mouth opening. Even when stabilized correctly, the vibrations of the surgical hand piece and minor contacts may slightly change the position of the guide. Small deviations from the original treatment plan could not be detected immediately. Finally, the procedure for static navigation is relatively more expensive compared to the freehand technique (3, 5) (Figure 1, 2 and 3).

Dynamic navigation

Dynamic navigation systems, e.g., the virtual surgery techniques, have been used in craniomaxillofacial surgery, neurosurgery, and spine surgery for some time. In dentistry, the dynamic navigation-guided implant surgery can be used to insert zygomatic, pterygoid and alveolar implants. It is becoming a widespread technique in which the positioning between the jaw and the tip of the implant drill can be monitored in real time through motion tracking technology. The real-time mapping of the drill tip to the patient's pre-acquired CBCT scan is of utmost importance in the dynamic navigation system. Therefore, accurate recording, calibration and tracking are considered as the main steps, all of which provide precise implant placement as per to pre-planned angulation and fixture dimensions during surgery (6). Since the system has the ability of providing instant feedback, the surgeon may modify his/her initial treatment plan momentarily. Moreover, preoperative planning and surgical procedure can be completed on the same day. The dynamic navigation protocol does not necessitate specific intraoral measurements and does not require the involvement of a laboratory technician (3, 7). The system consists of four major components. First step is to prepare a scan template. The thermoplastic impression material is placed in the patient's mouth. A thermoplastic retainer involving a CT marker and a fixation screw is mounted on this impression. Following the CBCT scan, DICOM data is exported to the navigation system in which the treatment plan will be decided. The final stage of the navigation system is positioning and calibration. A custom made thermoplastic stent is fixed to an optical marker placed in the jaw. A second optical marker is fixed to the contra-angle and the implant drills are calibrated. These optical sensors detect the markers on the implant drill and stent, providing real-time monitoring. Thus, the operator can see the target position as marked, compare the positions of the contra-angle and drill tip in terms of angulation and distance (3). Recently, dynamic navigation systems working with trace registration (TR) technology have been used instead of thermoplastic stents or retainers with metal markers. In the TR system, at least three intact structures in the mouth are selected as reference points such as natural teeth or existing implants for CBCT scan recording. Thus, the deviations or errors caused by the potential movement of radiological markers are reduced (3, 7). Pellegrino et al. (5) have reported that there is no significant difference between dynamic navigation and static computed guided implantology in terms of implant placement errors. However, compared to the conventional free hand surgery, it has been observed that the implants could be placed with higher accuracy and with lower error rate in dynamic navigation. Besides, there are fewer complications and lower rate of implant failures in patients treated with digital navigation compared to the conventional method. Jorba-Garcia et al. (7) have conducted a meta-analysis in which they evaluated the accuracy of dynamic computer aided implant surgery system (dCAIS) and compare static computer aided implant surgery system (sCAIS) with conventional free hand surgery technique. According to the results of this research, particularly for in-vitro studies, dCAIS reveals an average angular deviation of less than 4 degrees which means that angular deviations are reduced in comparison with sCAIS. However, since deviations more than 1 mm in terms of distance had been reported regarding dCAIS, it is of utmost importance to maintain the 2 mm safety zone, especially when inserting implants adjacent to vulnerable anatomical structures. Despite the advantages of dynamic computer aided systems, they can significantly increase the duration of surgery especially in edentulous patients (5, 7) (Figure 4 & 5).

Augmented reality-guided navigation

The AR-guided navigation system is currently in use in some medical specialties such as; neurosurgery, thoracic, vascular, urological, gynecological and cardiac surgery as well as in the field of oral and maxillofacial surgery; traumatology, reconstructive and orthognathic surgery. Nevertheless, dental implant placement through this technology still needs further validation and verification (8, 9).

In the AR-guided navigation system, patient data and 3D implant planning can be visualized in real-time. There are various types of systems in AR-guided navigation, among which the most interesting one is the 3D image overlay-based surgical visualization system that uses integral videography (IV) technology. This system consists of a computer, optical tracker, recorder and 3D image overlay device. There are 4 fiducial points and a patient marker in the recording device. The transfer of the CBCT data to the patient is performed according to these markers and coordinates. At first, the recording device is fixed to the patient's mouth with a dental retainer. Then, the data in the CBCT and optical tracker are transferred to the computer, where an IV image is created over the data and displayed on the 3D image overlay device, which superimposes the mandible, mandibular nerve, implants planning as well as drills. An optical drill marker is located on the contra-angle in order to track drill movements in real-time (10). Even though AR-guided navigation technology currently has some limitations such as additional software requirements, emerging technological demands, connection and battery problems, orientation difficulties, those can be overcome through developments in special software programs and further in vitro/clinical research studies (9).

Robotic-assisted surgery

Robotic-assisted dental surgery (RADS) is a system that provides dental implant planning, surgical site preparation and implant placement with haptic guidance accompanying visual guidance in dynamic navigation. In the 2010s, research studies on robotic-assisted dental surgery (RADS) reported successful results (11, 12). The first commercial robotic-assisted dental implant application approved by the FDA (2017) was performed by Rawal et al. (13). The robots used in RADS technology are generally industrial serial robots that have low rigidity and inverse kinematics which are among the main factors that reduce safety and success rate of RDAS technique. Parallel robots have more rigid and inverse kinematics compared to serial robots. On the other hand, as parallel robots could not meet all the surgical needs, hybrid robots that incorporate the features of serial and parallel variants have been designed. Today, the brand-new technology in digital dentistry is robotic-assisted dental implant surgery with hybrid robot systems (14).

Conclusion

It can be stated that the dynamic navigation as well as robot-assisted techniques will become new standards for implant surgery in the near future. Therefore, clinicians should take necessary steps for integrating their practice as soon as possible, which will require a significant level of technological knowledge.

Conflict of interest

The authors declared no conflict of interest.

Financial aid

The authors declared that they received no financial support of any kind.

References

1. Vandenberghe B. The digital patient - Imaging science in dentistry. J Dent. 2018;74 Suppl 1:S21-S6.
2. Turbush SK, Turkyilmaz I. Accuracy of three different types of stereolithographic surgical guide in implant placement: an in vitro study. J

Prosthet Dent. 2012;108(3):181-8.

3. Mandelaris GA, Stefanelli LV, DeGroot BS. Dynamic Navigation for Surgical Implant Placement: Overview of Technology, Key Concepts, & a Case Report. Compend Contin Educ Dent. 2018;39(9):614-21; quiz 22.

4. Vercruyssen M, Fortin T, Widmann G, Jacobs R, Quirynen M. Different techniques of static/dynamic guided implant surgery: modalities and indications. Periodontol 2000. 2014;66(1):214-27.

5. Pellegrino G, Ferri A, Del Fabbro M, Prati C, Gandolfi MG, Marchetti C. Dynamic Navigation in Implant Dentistry: A Systematic Review and Meta-analysis. Int J Oral Maxillofac Implants. 2021;36(5):e121-e40.

6. Panchal N, Mahmood L, Retana A, Emery R, 3rd. Dynamic Navigation for Dental Implant Surgery. Oral Maxillofac Surg Clin North Am. 2019;31(4):539-47.

7. Jorba-Garcia A, Gonzalez-Barnadas A, Camps-Font O, Figueiredo R, Valmaseda-Castellon E. Accuracy assessment of dynamic computer-aided implant placement: a systematic review and meta-analysis. Clin Oral Investig. 2021;25(5):2479-94.

8. Jarvinen S, Suojanen J, Suomalainen A, Stoor P. Virtual Surgical Planning Combined With Intraoperative Navigation in Mandibular Bilateral Sagittal Split Osteotomy for Accurate Placement of Patient Specific Implants. J Craniofac Surg. 2021;32(8):2666-70.

9. Pellegrino G, Mangano C, Mangano R, Ferri A, Taraschi V, Marchetti C. Augmented reality for dental implantology: a pilot clinical report of two cases. BMC Oral Health. 2019;19(1):158.

10. Ma L, Jiang W, Zhang B, Qu X, Ning G, Zhang X, et al. Augmented reality surgical navigation with accurate CBCT-patient registration for dental implant placement. Med Biol Eng Comput. 2019;57(1):47-57.

11. Sun X, McKenzie FD, Bawab S, Li J, Yoon Y, Huang JK. Automated dental implantation using image-guided robotics: registration results. Int J Comput Assist Radiol Surg. 2011;6(5):627-34.

12. Sun X, Yoon Y, Li J, McKenzie FD. Automated image-guided surgery for common and complex dental implants. J Med Eng Technol. 2014;38(5):251-9.

13. Rawal S, Tillery DE, Jr., Brewer P. Robotic-Assisted Prosthetically Driven Planning and Immediate Placement of a Dental Implant. Compend Contin Educ Dent. 2020;41(1):26-30; quiz 1.

14. Feng Y, Fan J, Tao B, Wang S, Mo J, Wu Y, et al. An image-guided hybrid robot system for dental implant surgery. Int J Comput Assist Radiol Surg. 2021.

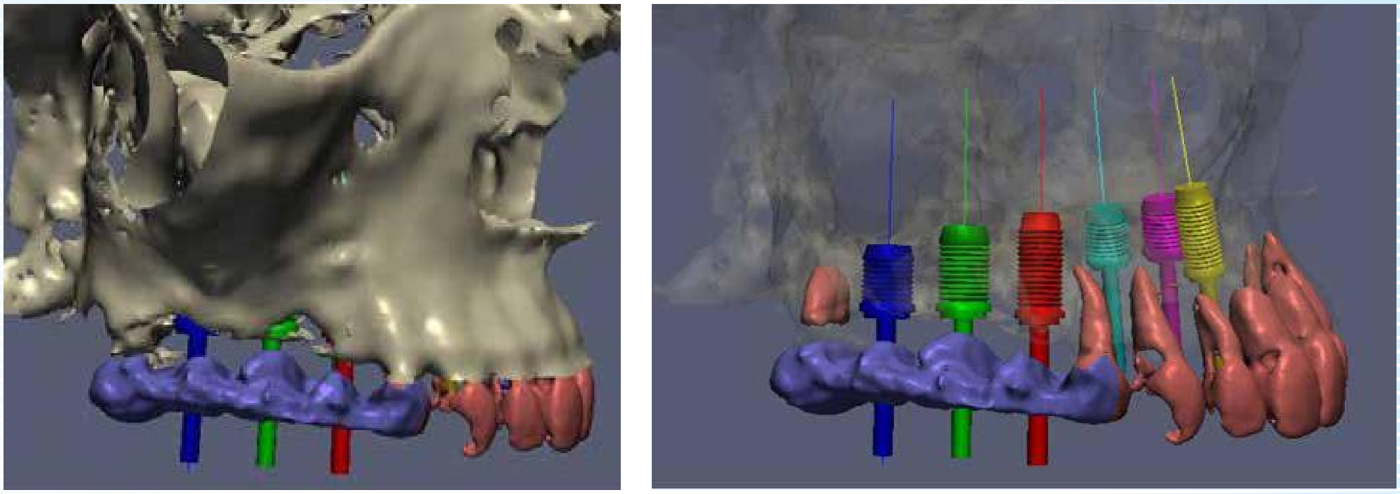


Figure 1. Three-dimensional reconstructed view of the prosthetic-driven virtual planning in the maxilla by using cone beam computed tomography data.

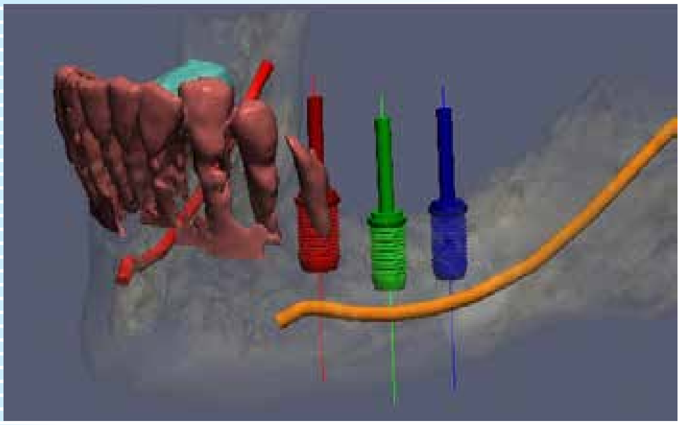


Figure 2. Dental implant planning in the mandible for the reconstruction of the static guide, note the position of the inferior alveolar nerve and the residual root which will be removed during the surgery.

Figure 3. Guide for static navigation in the edentulous mandible, note the accessory holes prepared for screw stabilization.

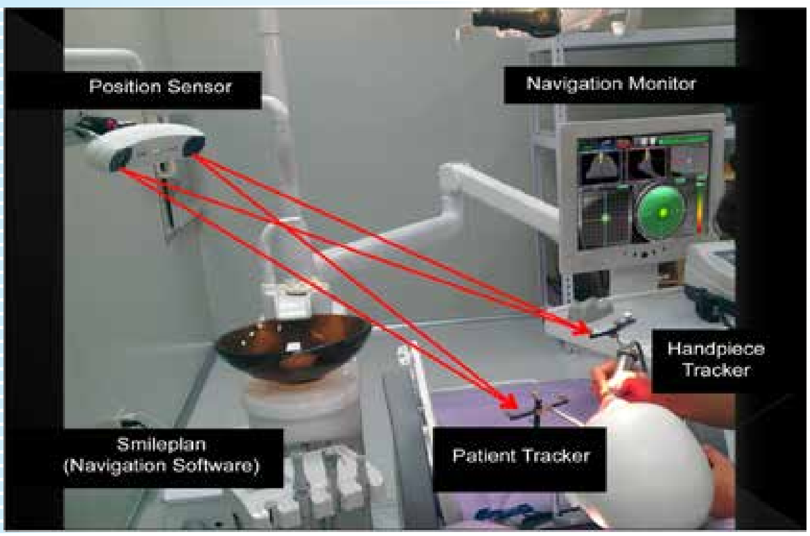


Figure 4. Dynamic navigation setup for implant placement (reprinted from Sun TM, Lee HE, Lan TH. The influence of dental experience on a dental implant navigation system. BMC Oral Health. 2019 Oct 17;19(1):222. doi: 10.1186/s12903-019-0914-2. PMID: 31623636; PMCID: PMC6798373 under creative commons CC-BY-4.0 license).

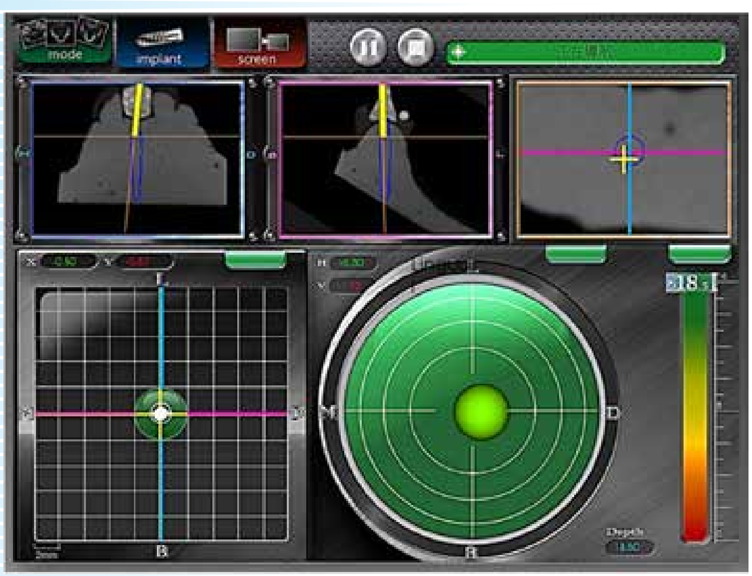


Figure 5. Real time drilling of the recipient site (reprinted from Sun TM, Lee HE, Lan TH. The influence of dental experience on a dental implant navigation system. BMC Oral Health. 2019 Oct 17;19(1):222. doi: 10.1186/s12903-019-0914-2. PMID: 31623636; PMCID: PMC6798373 under creative commons CC-BY-4.0 license).

Role of 3D Printing in Maxillofacial Surgery

DR ANUJ S .DADHICH
BDS.MDS,FIBOMS

Dr Anuj Dadhich is a maxillofacial reconstructive surgeon from Nashik. He has completed his graduation from MGV Dental College and Hospital, Nashik in 2004 and his post graduation from college of dental sciences , Davangere in 2009. He awarded the pretigious fellowship of Indian Board of Oral Maxillofacial Surgery in the year 2014. He is the project director for Smile Train and Director of Dadhich Centre for Maxillofacial and reconstructive surgery, Nashik . Currently working as an Associate professor and PG GUIDE in the department of maxillofacial and reconstructive surgery, Rural DentalCollege, Loni

His areas of interest are Orthognathic surgery, cleft lip and palate, head and neck oncology and reconstruction and aesthetic facial surgeries.

Abstract

Although application of three-dimensional (3D) printing in oral and maxillofacial surgery was first reported almost 30 years back, reduction in its manufacturing cost and availability of affordable 3D printing devices have popularized its use over the past few years.The 3D printed objects include anatomical models, occlusal splints, drilling or cutting guides and patient specific implants (custom made plates and reconstruction devices). The anatomical model not only assists the surgeon in better understanding of the deformity or pathology but alsoaids in explaining the same to the patient and relatives. Mock surgery carried out on these models improve precision and thereby reducethe operating time. The guiding splints provide an exact design and fit for the graft, thus replicating form and function of the jawbone. The patient specific implants manufactured through computer assisted designing help in superior replication of original anatomical form. This article intends to highlight the current applications of 3D printing in field of maxillofacial surgery in management of facial deformity.

Introduction

The field of Oral and Maxillofacial surgery has witnessed numerous breakthrough innovations in every aspect of clinical practice ranging from evaluation, diagnosis to treatment of the patients.The last decadehas emphasized on the use of newer diagnostic tools, virtual treatment planning techniques, minimally invasive surgeries, regeneration techniquesand precise reconstruction of hard and soft tissues.Three-dimensional (3D) printing technology, also referred as additive manufacturing or rapid prototyping or solid-freeform technology, was first demonstrated in 1986.since then this innovative technique has attracted significant attention, especially within the head and neck surgical specialties; maxillofacial, otorhinolaryngology and plastic surgery, owning to its incredible ability to create complex constructs with high precision.

The concept behind 3D printing in the medical field is to capture anatomical scans using imaging techniques such as magnetic resonance imaging (MRI) and computed tomography (CT) scans. The image from these modalities will be saved in a standard format such as Digital Imaging and Communications in Medicine (DICOM) format and later with the help of computer-aided design (CAD) software will create a virtual 3D prototype with Standard Tessellation Language (STL) format to allow 3D printing and deposition of the material layer by layer to achieve the final structure. Depending on the application, appropriate printing technique is selected, for example, fused deposition modelling (FDM), stereolithography (SLA), selective laser sintering (SLS), inkjet bioprinting, extrusion bioprinting and laser-assisted bioprinting. Finally, the printed object will go through a post-printing modification to obtain the final printed object.

Use of 3D printing in Oral & Maxillofacial surgery:

the basic form of 3D printing has been very commonly applied by using computed tomography (CT) guided stent fabrication for precise drilling and placement of dental implants. As we move forward,there is a need to incorporate this technique in other dental aspects as well as the different OMFS procedures.Use of 3D-printed models inablative and orthognathic surgeries for treatment planning and simulation has become more popular over the past few years.2It can be used in patients with facial bone fractures to prepare diagnostic models and for fabrication of patient specific implants, which can improve the reduction of fractures. In orthognathic surgeries, it can be used for performing mock surgeries and for fabrication of cutting guides and occlusal splints to improve accuracy of outcome. In reconstructive surgeries, it can be used for fabrication of cutting guides, which allow three-dimensional accuracy in reconstruction of defects of face and jaw. It can also be used in manufacturing facial prosthesis especially the jawbone, temporomandibular joint, ear and eye.

Case report:

A 21year old male patient was referred by fellow Orthodontist with the chief complaint of progressivefacial asymmetry. On clinical examination an obvious facial asymmetry was noticed with mandible and chin deviated to the right side. (Figure

1a) Patient had normal inter incisal opening of approx. 40 mm. On intra oral examination it was noticed that the entire mandibular occlusal table was shifted on right side with Maxillary & Mandibular dental midlines not coinciding with each other and with facial midline.

There was Angles class III molar relationship on Lt side and class I molar relationship on Rt side with posterior cross bite & occlusal cant

Fig. 1(a): Extra oral appearance of patient showing deviation of mandible & chin on Rt. side.

Orthopantomogram, Lateral cephalogram & PA cephalograms were advised for further evaluation. OPG revealed elongation of Lt mandibular condyle as compared to Rt condyle. A CT scan was performed which revealed enlargement of condylar head & there was elongation of Lt ramus of mandible compared to Rt. (Figure 1b, c)Based on the clinical and radiographic findings, diagnosis of left condylar hyperplasia was made. Bone scan was performed to study the activity of rightcondyle, showed no significant changes.

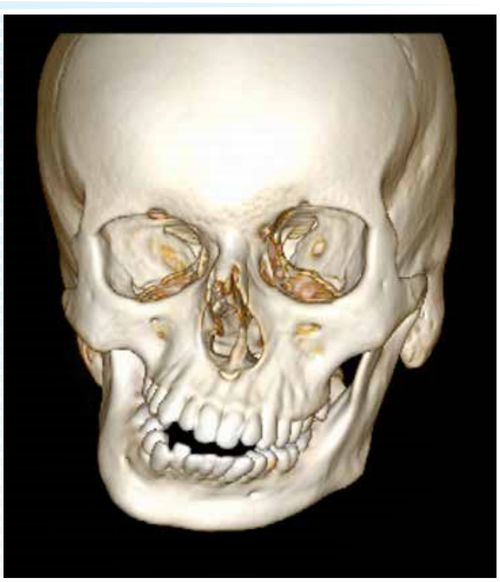


Fig. 1(b & c): CT scan showing enlargement of Lt ramus of mandible suggesting possibility of Lt. Condylar hyperplasia.

A 3D printed anatomical model of facial skeleton was prepared based on the data available from the CT scan. (Figure 1d)

Fig.1(d): 3D printed anatomical model.

Fig. 1(e): Intraoperative steps involving high condylar shave

Fig. 1(f)Lefort I osteotomy with maxillary impaction

Fig. 1(g) Sagittal split ramus osteotomy with differential mandibular setback

Anatomical model was used to evaluate the facial deformity and explain the extent of the skeletal problem to the patient.Treatment plan for management of left condylar hyperplasia with associated skeletal and occlusal discrepancy included; high condylar shave on Lt side to remove the hyperplastic area, Lefort I osteotomy with unilateral (Lt) maxillary impaction (5mm) to correct the occlusal cant and sagittal split ramus osteotomy with differential mandibular setback to correct the chin deviation. Mock surgery was performedas per the treatment plan and the outcome was evaluated. The3D modelafter mock surgery was used to pre-bend and adapt the miniplates after the osteotomy cuts were designed and the desired movements were achieved.These plates were used as patient specific implants intra-operatively. The surgical procedure was carried out as planned and executed during the mock surgery. (Figure 1e-h) Patient had uneventful postoperative healing with correction of facial asymmetry and occlusal discrepancy on follow-up (Figure 1i)

Discussion:

The aim of any reconstructive surgery is not just restoration or improvement of the preoperative form and function but also reduction in the intraoperative time and post-operative morbidity. Due to the complex anatomy of maxillofacial region,correction of complex developmental/acquired deformities anddefects from ablative surgeries becomes a challenging task. In the past few decades advanced imaging modalities, sophisticated instrumentation, advances in anesthesia and refined surgical tecnniques have resulted in better surgical outcome with lesser morbidity. 3D printing in OMFS has further improved preoperive assesment, intraoperative execution and postoperative outcome of surgical procedures.

Technique of 3D Printing:

The concept behind 3D printing is to capture the anatomical scans using imaging techniques such as magnetic resonance imaging and CT scans. These images arethen saved in a standard Digital Imaging and Communications in Medicine (DICOM) format. Subsequently with the help of computer-aided design (CAD) software,a virtual 3D prototype is created with Standard Tessellation Language (STL) format to allow 3D printing and deposition of the material layer by layer to achieve the final structure. Printing of the final anatomical structure can be achieved by various techniques including; stereolithography (SLA), fused deposition modelling (FDM), inkjet bioprinting, extrusion bioprinting, selective laser sintering (SLS), and laser-assisted bioprinting.6 The choice of a technique depends on the required application. In the final step, the 3D print goes through minor modifications to obtain the final printed object.

Use of 3D Printing in Maxillifacial Surgery:

One of themost traditional and common

application of 3D printing in dentistry and OMFS is the use of surgical guidesin implantsurgeries. These guides are designed to aid in correctly angulatingthe drills and subsequently placingthe dental implants as per preoperative plan. 3D printed device/object can be broadly classified into five categories, based on its use in OMFS; 3D anatomic models, surgical guides (cutting/drilling/positioning), occlusal splints, patient specific implants (osteosynthesis plates, skeletal reconstruction) and facial prosthesis. A systematic review in 2017, identified 297 articles (2,889 patients) describing use of 3D printed devices in OMFS.5The most commonly printed objects included surgical guides (59%), anatomic models (34%) andpatient specific implants(23%), followed by occlusal splints (8%) and prosthesis (4%).5

3D printing helps in obtaining the accurate anatomical models, allows thorough understanding of the defects and help in restoration of post-operative symmetry and form. It helps the clinician to understand the complex anatomical structures like orbit, maxilla and mandible accurately and assists the surgeon in minimizing the intra-operative time and morbidity. In the present case the 3D anatomical modelshelped in preoperative assesment and patient motivation. Theywere used topractice the procedure preoperatively (mock surgey) and for prebending of bone platesfor fixation of osteotomized jaw bone. Recently conducted comparative clinical study showed that 3D printing technology allowed better functional restoration of mandible in comparison to the traditional method.7Surgical guides have also been used in orthognathic surgery for correct placement of the osteotomies (cutting guides), insertion of screws at predefined sites on the model (drilling guide) and in final positioning and fixation of the osteotomized bone acording to preoperative plan (positioning guide).8

Computer-aided simulation significantly increases the efficiency and accuracy of correction of the dentofacial deformities by orthognathic surgery.

Use of patient specific implants and prosthesis have been frequently used for temperomandibular joint (TMJ) replacement. Mandibular printed implants are only second to TMJ prosthesis in frequency of use in maxillofacial reconstruction surgery.10Manufacturing and processing of these implants have to follow strict guidelines as compared to 3D printed anatomical models, as these are implanted within the human body. Various material have been used depending on area of application. Jawbone and joint replacement implants are usually made of high grade metal meant for medical use, including titanium, molybedenum and cobalt-chrome alloys. Recently Polyetheretherketone (PEEK) which is a polyaromatic linear polymerhas emerged as a upcomming material for medical implants due to its high strength, stiffness, durability and biocompatibility.

Current Limitation for Use of 3D Printing:

The major limitation for application of this 3D technology in routine clinical practice is the cost involved. However,improvement in software development and manufacturing over the past few years have led to reduction in cost of manufacturing. It is expected that the cost will continue to go down as the number of manufactures go up. Another drawback of 3D printing is time taken for manufacturing. Based on its manufacturing, the 3D print can be hospital based or industry based (professional). Although simple anatomical model can be printed in health care facility, more complex implants like custom made plates and reconstruction models are more demanding and required professional manufacturing units, increasing its cost and time for fabrication. Need of advanced computer based skills and regulatory limitations are other hindrances in its development. The accuracy of the 3D printed modelsand precision in replicating the complex maxillofacial structures areother challengesfor manufacturers. Although 3D printed patient specific implants have advantages of exact anatomic fit and reduced surgical time, complication like implant rejection, loosening and infection have been infrequently reported.14 Most of the evidence of use of 3D printed objects is through case report and series. In terms of scientific study, there is a need to perform more randomized controlled trials to prove its superiority over the conventional surgical approaches.

Future Application:

3D printing in maxillofacial surgery has a promising role in future, beyond its current use in preparation of study models, surgical planning, training, use of guide splints and manufacturing custom fit implants. Higher resolution of printing, faster manufacturing time and reduced costs would significantly popularize its application. There is a need to be able to print materials with greater biocompatibility to reduce risk of infection and graft rejection. Materials used for patient specific implants should match the flexibility and stiffness of normal bone. Manufacturing of 3D printed scaffold with internal channel networks for cell proliferation and eventually bone in-growth will further improve the outcome.

Conclusion:

3D printing has an emerging role in maxillofacial surgery.The current applications include manufacturing of anatomical models, surgical guides/splints, patient specific implants and prosthesis. 3D printing allows for better preoperative evaluation of facial defect/deformity. It is a useful tool for teaching purpose and for patient education. It allows better preoperative planning and training of the procedure, thus reducing surgical time and post-operative morbidity and in turn improving the surgical outcomes. The major disadvantagesof 3D printing are the cost involved and time required for the manufacturing, which can be significantly reduced with the everimproving technology and increased incorporation of advanced materials in day-to-day clinical practice.

DIGITAL DENTISTRY AN OVERVIEW

DR ROHIT GUPTA
BDS

Abstract

Digital Dentistry has changed the way we practice. Intraoral scanning, with chair side designing and processing has brought about the concept of 'SIngle Visit Dentistry'. Designing and delivering a single tooth restoration or a quadrant dentistry can be performed in a matter of hours or minutes. As more dentists adapt to these innovations in technologies more and more materials are being launched by companies to cater to this new demand, from modified glass ceramics with better strength to Zirconia which has better translucency and is more esthetic.

Digital dentistry is the use of computer assisted manufacturing or designing of the dental prosthrsis. The dental ailments affect a huge group of people psychologically and physically, inducing how they look, speak, and chew, accommodate in the social life. Dental medicine is observing remarkable revolutions, remodeling people's lives and smiles with each and every technique. "Prosthodontic dentistry" serves as the art and science of reinstating teeth, both esthetically and functionally. The restoration of missing teeth with prosthetic instruments might occasionally be problematic for the dentists, because of the artistic requests. There are many options of techniques offered for an appropriate restoration but among them the "CAD/CAM: Computer aided design/ computer aided manufacturing" techniques characterize a foolproof and least painful solution for the dental patient with effectiveness and robustness [1]. The digital systems are now offering the opportunities to circumvent conventional, analog impressions, as well as the typical impression materials, treatment limitations and time related with traditional methods [2]. Depending upon the production concept in digital dentistry using CAM/CAD, there are three concepts available which are:

- **Chairside production:** In this process, without involving the laboratory procedure, the construction of the dental restorations takes place at chairside. The instrument consists of an intra-oral camera which substitutes for a conventional impression in dental situations. It helps to save time and provides fabricated restorations incidentally to the patient at one appointment. .CEREC ("Chairside Economical Restoration of Esthetic Ceramics") system provides this possibility. This was the first system consisting of CAM/CAD in dentistry [3, 4]. Recently other systems are available which can provide similar solutions.
- **Laboratory production:** This process of production is similar to the conventional series of working which

takes place between dentist and laboratory. The dental surgeon makes the impression and sends to the laboratory where the impression cast is manufactured first. The other steps of CAD/CAM process are executed totally in the laboratory. Through the help of a scanner, the 3-D data are generated and designing is done on software. After this (CAD) procedure the data are directed towards a distinct milling device which generates the actual geometry of tooth in laboratory. In the end, the precise fit of the restoration is ensured.

- **Centralized production:** In this process, the scanners in the dental laboratory are connected with a manufacturing center through the Internet. The data produced in the laboratory are forwarded to the manufacturing center for the restorations to be shaped with the help of CAD/CAM system. Lastly, the construction center sends the constructed restoration to the laboratory. Therefore, the first two production steps occur in the dental laboratory, while the third step takes place in the production center [7, 8].

The components of CAD/CAM system include: optical and mechanical scanners, design software, milling and printing devices, furnaces to crystallize/sinter/finish and glaze prosthesis . The materials used in CAM/CAD process are vast amd being updated regularly including metals, resin materials,Glass ceramics Lithium disilicates and , and Zirconia[9].

The "intraoral scanners" help to make correct visual impression of the dental structures, with the aid of only a beam of light. . The evidence about the dento-gingival tissues attained from the impression could not only be used to make a diagnosis, but also to reconstruct prosthetic restorations. Certainly, the data from optical impression could efficiently be sent into the software for designing artificial restorations. In simple cases for example the temporary restorations, all the procedures could be directly executed without involving the dental technician in the dental office, with the help of "chairside" procedure. In the complex cases for example, copings or long span bridges, complex implant restorations association with the dental technician may be required.[10].

3-D Printing Technologies in Dentistry

Following are some 3-D printing Technologies used in dentistry:

Selective Laser Melting

This SLM technique involves layer by layer accumulation of powdered material which generates 3-D parts by firming up of the consecutive layers. The addition of layers one above the other use the heat produced by the laser-radiation which is computer controlled [11]. The SLM is an appropriate technology to produce the dental parts. The optimal results could be obtained when the material databases work out distinctly for each material. Moreover, an improved structure and scanning approach has to be employed. The SLM could process any metal powder commercially available and even the powder mixtures [12].

Stereolithography

Stereolithography (SLA) is most extensively used technology involving rapid prototyping. It uses an extremely focused UV laser to make the footprints by consecutive cross-sections of a 3-D item in a container of liquid "photosensitive polymer". When the laser traces a layer, the polymer is solidified and the additional parts are remained as melted. After one layer is finished, a levelling blade proceeds across the exterior surface to make it smooth prior to deposition of next layer. The display place is then dropped by a space equal to the thickness of layer and then the successive layer is established over the formerly completed layers. The tracing and smoothing processes are repeated till the restoration is completed. After completion, the constructed part is raised above the vat and evacuated [13].

Fused deposition modelling

In this method the 3-D printers are used which are computer aided models and scan the information from the surfaces. Then the "melted thermoplastic polycarbonate" is deposited in a layer-by-layer fashion which generates the objects from top to bottom. The layers are then combined with each other thus producing the complex materials [14]. The quality of parts made by this method mostly be subjected to careful choice of the parameters' variables in the process. Therefore, description of these process parameters could meaningfully influence the quality of processed parts. These parameters include: thickness of layers, breaks between the framing tools on the same layer, angle of the framework pattern, width of the raster etc. [15].

Digital light processing (DLP)

In this technique, the projected light source develops the liquid layer of resin layer by layer and the layers are created upside down. When the layers of polymer are formed the object is constructed and the remaining liquid polymer is cleared out [16]. Many factors affect the accuracy and precision of this method, particularly the resolution of the "digital mirroring device" which is a component of the DLP printer and the conformation of the ceramic photopolymer [17].

The 3-D printing is also known as additive manufacturing and has obtained a lot of attention in the field of dentistry because of its wide-range abilities regarding production of temporary restorations, surgical guides, occlusal splints, scaffolds, bite-guards and orthodontic appliances. It provides certain benefits including: Decreases the waste material and less energy consumption, minimizing the number of steps to obtain the ultimate product and involves less human interference and likelihood for error, producing intricated details with less cost [18]. Apart from all the advantages, there are certain disadvantages associated with the 3-D printing technology in the dentistry. The drawbacks of DLP and stereolithography are that they are obtainable only with light treatable polymers liquids. Likewise, they display a limited life span and could not be sterilized with heat, and is a high-cost technology. The drawback of SLM is that it is an tremendously costly technology and a slow procedure [19].

In conclusion, the digital inventions in field of dentistry have significantly improved the restoration processes and dental problems. With the help of digitalization, the patients' experiences have improved. A lot of restoration choices are offered which bring extended lifetimes, and improved aesthetics. These methods are delivering greater effectiveness, precision and capabilities to the Dentists.

References

1. M. TATARCIUC, D. DIACONU-POPA, and A. VITALARIU, "Digital dentistry," The Medical-Surgical Journal, vol. 123, no. 4, pp. 735-738, 2019.
2. D. J. Fasbinder, "Digital dentistry: innovation for restorative treatment," Compendium of continuing education in dentistry (Jamesburg, NJ: 1995), vol. 31, pp. 2-11; quiz 12, 2010.
3. B. Reiss, "Clinical results of Cerec inlays in a dental practice over a period of 18 years,"

International journal of computerized dentistry, vol. 9, no. 1, pp. 11-22, 2006.

4. T. Otto and S. De Nisco, “Computer-aided direct ceramic restorations: A 10-year prospective clinical study of Cerec CAD/CAM inlays and onlays,” International Journal of Prosthodontics, vol. 15, no. 2, 2002.

5. A. J. Raigrodski and G. J. Chiche, “The safety

Fig1 : Initial clinical picture

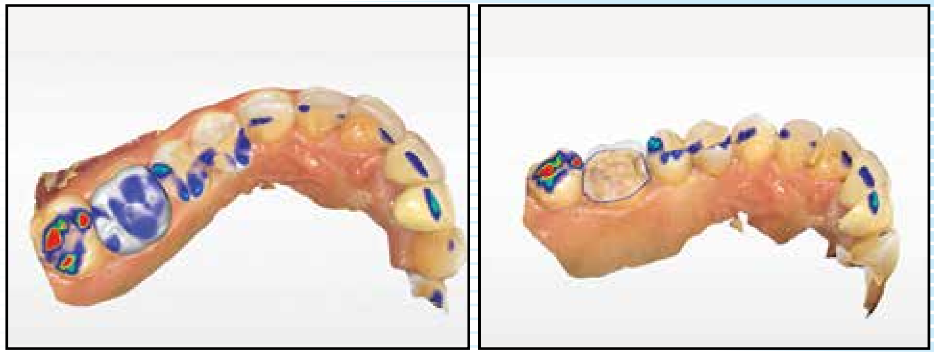


Fig 2: Digital design on Cerec software

Fig 2: Digital design on Cerec software

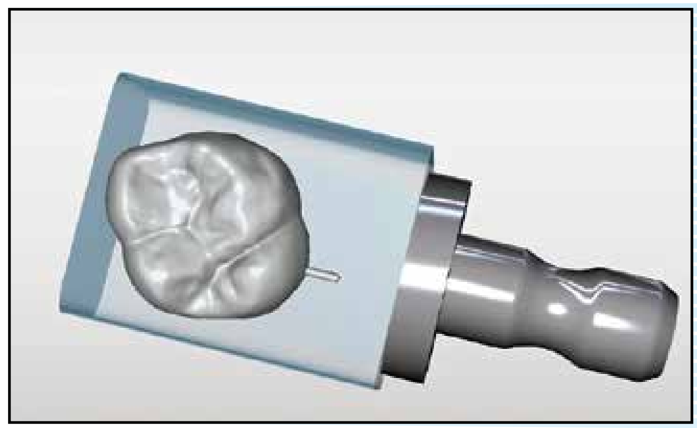


Fig 3: Milling preview

Fig 4: Final prosthesis

Fig 5: Post cementation radiograph

and efficacy of anterior ceramic fixed partial dentures: a review of the literature," The journal of prosthetic dentistry, vol. 86, no. 5, pp. 520-525, 2001.

6. A. J. Raigrodski, "All-ceramic full-coverage restorations: concepts and guidelines for material selection," Practical procedures & aesthetic dentistry: PPAD, vol. 17, no. 4, pp. 249-56; quiz 258, 2005.

7. S. Reich, M. Wichmann, E. Nkenke, and P. Proeschel, "Clinical fit of all-ceramic three-unit fixed partial dentures, generated with three different CAD/CAM systems," European journal of oral sciences, vol. 113, no. 2, pp. 174-179, 2005.

8. S. Reich, K. Kappe, H. Teschner, and J. Schmitt, "Clinical fit of four-unit zirconia posterior fixed dental prostheses," European journal of oral sciences, vol. 116, no. 6, pp. 579-584, 2008.

9. F. Beuer, J. Schweiger, and D. Edelhoff, "Digital dentistry: an overview of recent developments for CAD/CAM generated restorations," British Dental Journal, vol. 204, no. 9, pp. 505-511, 2008/05/01 2008, doi: 10.1038/sj.bdj.2008.350.

10. F. Mangano, J. A. Shibli, and T. Fortin, "Digital dentistry: new materials and techniques," ed: Hindawi, 2016.

11. J.-P. Kruth, B. Vandenbroucke, J. Van Vaerenbergh, and I. Naert, "Digital manufacturing of biocompatible metal frameworks for complex dental prostheses by means of SLS/SLM," in Proc. of 2nd Int. Conf. on Advanced Research in Virtual and Rapid Prototyping, Leiria, 2005, pp. 139-145.

12. A. Gebhardt, F.-M. Schmidt, J.-S. Hötter, W. Sokalla, and P. Sokalla, "Additive manufacturing by selective laser melting the realizer desktop machine and its application for the dental industry," Physics Procedia, vol. 5, pp. 543-549, 2010.

13. S. S. Bammani, P. R. Birajdar, and S. Metan, "Dental crown manufacturing using stereolithography method," in Proceedings of international conference on advances in industrial and production engineering, 2012: Citeseer.

14. A. Dawood, B. M. Marti, V. Sauret-Jackson, and A. Darwood, "3D printing in dentistry," British dental journal, vol. 219, no. 11, pp. 521-529, 2015.

15. O. A. Mohamed, S. H. Masood, and J. L. Bhowmik, "Optimization of fused deposition modeling process parameters: a review of current research and future prospects," Advances in Manufacturing, vol. 3, no. 1, pp. 42-53, 2015.

16. R. Masri and C. F. Driscoll, Clinical applications of digital dental technology. John Wiley & Sons, 2015.

17. D. Anssari Moin, B. Hassan, and D. Wismeijer, "A novel approach for custom three-dimensional printing of a zirconia root analogue implant by digital light processing," Clinical oral implants research, vol. 28, no. 6, pp. 668-670, 2017.

18. T. A. Sulaiman, "Materials in digital dentistry—A review," Journal of Esthetic and Restorative Dentistry, vol. 32, no. 2, pp. 171-181, 2020.

19. C. Zaharia et al., "Digital dentistry-3D printing applications," Journal of Interdisciplinary Medicine, vol. 2, no. 1, pp. 50-53, 2017.

Fundamentals of Maxillofacial Radiology in the Digital Workflow

Dra. Monica Piña D'Abreu
Oral and maxillofacial radiologist
Master in Digital Dentistry.
San Leopoldo Mandic University. Brazil
PhD in Dentistry, Universidad del Zulia.
Venezuela

Dra. Beatriz Gómez Bonilla
Oral and maxillofacial radiologist
Master of Education in Health Sciences.
San SebastianUniversity. Chile
General Manager of Centro Radiologico
BEGMAX. Chile

Keywords: cone beam tomography, digital dentistry, workflow, virtual planning, digital impression

Abstract

Simplified, fully digital workflows are the latest trend in all dental specialties, allowing the digital dental team to work with greater precision and predictability, offering safer treatments, and with less clinical time. To achieve this workflow, one of the main tools to simulate and project dental treatments are maxillofacial images. Cone beam tomography images and optical scan images play a crucial role when integrating with digital design software that incorporates 3D printing into practice. Therefore, the purpose of the article is to briefly describe the role of images in this digital workflow, and to propose acquisition guide protocols conducive to minimizing errors and inaccuracies.

Innovation and technological development continue to mark the continuous evolution in which Dentistry is immersed. And it is that concepts such as digital flow, guided surgery or 3D printing are already part of the daily routine of more and more professionals in the dental sector, both clinical and technical.(1-5)

Digital Dentistry is something more than the present and most of the professionals in the dental sector familiar with technology agree on this. Despite its progressive implantation and, although there may still be some distrust of its adaptation, most dentists are attracted to the digital world.(6-8)

The objective is to integrate transversally all clinical and laboratory equipment in the digital flow. This is how you can really get the most out of all the new tools emerging in the dental environment.(9)(Fig. 1)

FIG.1 : Digital workflow in dentistry, has as fundamental pillars, the tomographic registration and the scanning that supports the diagnosis, planning (CAD) with design software, and manufacturing (CAM) in 3D printers

Imaging being one of the fundamental pillars of digital dentistry, we cannot put aside training in this area, an imaging record is needed to achieve a virtual patient, and the management of tomographic software allows us to go through the volume acquired first. carry out an imaging diagnosis, before proposing the planning of a treatment.(Fig.2)

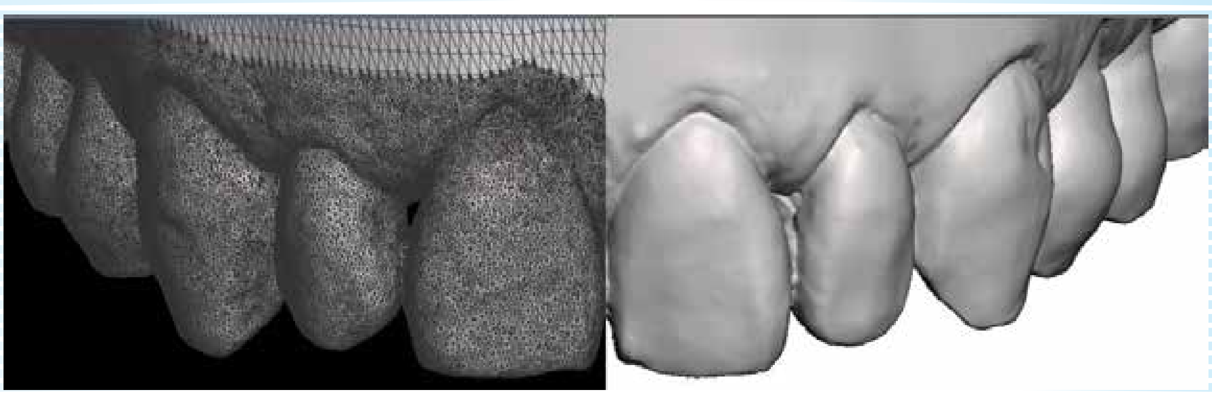


FIG. 2 : Integration of three-dimensional files consists of the union of STL, ONJ, PLY, JPG files with cone beam tomography, to have a virtual patient where to plan treatments such as digital smile design

In this sense, training is essential given the constant updating of the needs and applications of the technology used in this type of digital process. A permanent update in which all team members must be involved, so the oral and maxillofacial radiologist must understand the protocols for acquisition and management of images to be an optimal initial record to integrate with the three-dimensional systems that make up the flow digital work and cad cam procedures; computer-aided design and planning in dentistry.

Since cone-beam computed tomography (CBCT) was incorporated into dentistry, its use has increased rapidly. Numerous CBCT equipments have been developed with different configurations, currently there are about 50 different models.

Imaging from CBCT equipment requires lower radiation doses to the patient compared to medical computed tomography (CT). However, radiation doses with CBCT equipment are usually higher than with conventional radiology. It is important to bear in mind that any exposure to X-rays implies a potential risk for the patient, so every time a radiographic examination is indicated, the principles of radiation protection must be considered. The principle of justification weighs the possible benefits of a certain exposure to ionizing radiation versus the potential risk that such exposure implies. (5-7)

Due to the fact that CBCT is a relatively recently introduced technology, a high number of publications are observed in the literature, mainly reporting the experience of its use, based mainly on clinical cases. In recent years there has been a tendency to search for scientific evidence to support the uses of CBCT and numerous guidelines have been published around the world, mainly in the United States and Europe. These guidelines tend to guide the rational use of ionizing radiation in dentistry, including the use of CBCT.

Currently there is a trend towards consensus in general aspects of the use of CBCT. There is agreement that CBCT is not a routine imaging method, the field of view (FOV) must be adjusted to the area of interest, and the exposure parameters must be adjusted depending on the clinical indication and the size / age of the patient. However, there is still a lack of scientific evidence to support specific indications. Indications in digital dentistry are no exception, and different indications for their use are observed depending on the purpose and orientation of the study.

The purpose of developing image selection criteria for digital planning in dentistry is to identify the most appropriate imaging technology for each patient treatment design. In this way, it aims to provide recommendations that guarantee the obtaining of appropriate images applicable to each clinical situation, complying with the justification principle. Through the development of criteria for the selection of images, an attempt is made to call attention to the responsibilities, training, and knowledge of both the person taking X-rays and the radiology specialist. These criteria are considered a prerequisite for CBCT imaging and conventional radiographic techniques. (13-15)

Although there are currently numerous guidelines on the use of CBCT for each clinical specialty, to date no review has been published that consolidates the different positions on tomography for digital dentistry. The objective of this review is to analyze the various guidelines developed by organizations worldwide in relation to the use of CBCT and to propose a general basic protocol for its use as a basic registry of digital dentistry.

Cone Beam Tomography Protocol in Digital Dentistry

Cone beam computed tomography (CBCT) has replaced traditional 2D radiographs for a large number of dental indications. Thanks to its low dose and excellent spatial resolution, clinicians can now improve diagnosis and use the 3D environment for planning purposes. However, numerous parameters can play a role in the desired precision and its associated radiation dose and therefore can also lead to differences in the diagnoses obtained. A carefully chosen one Therefore, the exposure protocol should always be used based on the need for diagnosis. In addition, most of the large number of CBCT units on the market have different configurations with a full list of proprietary exposure parameters and their associated reconstruction parameters. The most important parameters are scan field size or field of view (FOV), scan time and often associated voxel size, mA or beam intensity, and kV of tube potential. In this initial stage of the digital workflow the first difficulty arises that can contribute to errors in the workflow. (7)

CBCT unit, its technical parameters will not only influence the radiation dose attributed to the patient, but will also influence the spatial resolution or the thickness of the reconstructed slice (voxel size), or in other words, the acquired image detail. This is exactly where the difficulty lies in finding the right balance between the dose to which the patient will be exposed and the dose, detail that will be needed for the diagnosis and subsequent steps in the digital workflow. Unfortunately, many dentists are still not fully aware of this technical information even though it is so critical and even waiting to be known since the ALARA principle must always be respected by every radiologist.

In order to meet the technical needs of digital dentistry, the protocol must include the use of the necessary image acquisition and enhancement filters, as well as noise and artifact reduction tools, included in the tomographic acquisition and processing software, with mathematical algorithms to remove low-quality images generated by motion, high-density foreign bodies. (Figure 3)

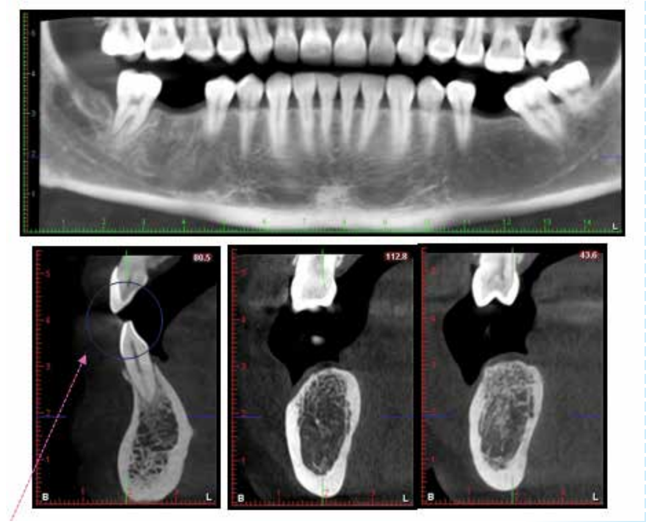


FIG. 3 : Panoramic and transversal tomographic section image where the patient's disocclusion is observed in his tomographic record, to facilitate segmentation in the design and planning software with other three-dimensional files

The tomographic records of a patient that will be incorporated into a digital workflow must be acquired in de-occlusion, with a minimum separation of 3mm, to facilitate segmentation and pairing with other three-dimensional files. (Figure4)

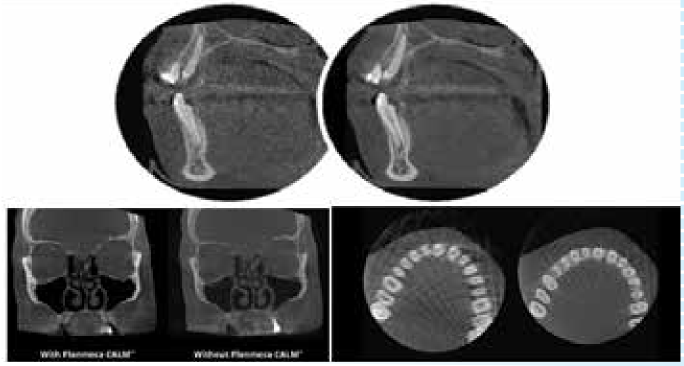


FIG. 4 : In cone beam tomography for digital dentistry, it is necessary to use image enhancement tools, such as noise, artifact and motion acquisition and reduction filters. image courtesy of Planmeca_ Romexis.

The patient must follow the instruction to place the tongue on the palate, or posterior area so as not to contact the teeth with it.

The use of soft tissue separators is also suggested, such as lip separators for orthodontics or at least the placement of cotton swabs for isolation. (Figure 5)

FIG. 5 : In digital dentistry, the use of lip and soft tissue retractors is suggested as a cone beam tomography acquisition protocol, for the best visualization of structures

The standardization of acquisition protocol guides conditions the reduction of errors in the initial steps of a digital workflow

Conclusion

The digital dental workflow comprises fundamental pillars in which imaging plays a primary role. Essentially the acquisition of images at the beginning of the digital workflow is a decisive stage that will influence the next steps and therefore can generate cumulative errors. For the successful execution of novel digital technology techniques in dentistry, it is crucial that the oral maxillofacial radiologist is aware of the entire process and the many difficulties it presents in this workflow. However, when properly executed, digitizing the workflow will lead to more efficient, secure, and predictable work.

Disclosure statement

The authors declare that they have no conflict of interest.

Bibliographicreferences

1. De Vos W, Casselman J, Swennen J. Cone-beam computerized tomography (CBCT) imaging of the oral

and maxillofacial region: A systematic review of the literature. Int J Oral Maxillofac Surg 2009;38:609-25.

2. FDI WORLD DENTAL FEDERATION. FDI policy statement on radiation safety in dentistry: adopted by the FDI General Assembly: 13 September 2014, New Delhi, India. Int Dent J 2014;64:289-90.

3. BC Centre for Disease Control. Guidelines on radiation protection & quality assurance applicable to dental cone beam computed tomography (CBCT).2014 [citado 13 de nov. 2017]

4. AMERICAN ACADEMY OF ORAL AND MAXILLOFACIAL RADIOLOGY. Clinical recommendations regarding use of cone beam computed tomography in orthodontics. Position statement by the American Academy of Oral and Maxillofacial Radiology. Oral Surg Oral Med Oral Pathol Oral Radiol 2013;116:238-57.

5. Bornstein M, Scarfe W, Vaughn V, 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;29:55-77.

6. Tyndall DA, Price JB, Tetradis S, Ganz SD, Hildebolt C, Scarfe WC. 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 RadiolEndod 2012;113(6):817-26.

7. Bart Vandenberghe. The crucial role of imaging in digital dentistry. The academy of dental materials. Elsevier 2020.

8. Harris D, Horner K, Gröndahl K, Jacobs R, Helmrot E, Benic GI et al. E.A.O. Guidelines for the use of diagnostic imaging in implant dentistry 2011. A consensus workshop organized by the European Association for Osseointegration at the Medical University of Warsaw. Clin Oral Implants Res 2012;23:1243-53.

9. Hatcher DC, Dal C, Mayorga C. Cone Beam Ct for pre-surgical assessment of implant sites. J Calif Dent Assoc 2003;31:825-33.

10. MacDonald D. Cone-beam computed tomography and the dentist. J Investig Clin Dent 2015;0:1-6 doi: 10.1111/jicd.12178.

11. Arai Y, Tammisalo E, Iwai K, Hashimoto K, Shinoda K. Development of a compact computed tomographic apparatus for dental use. DentomaxillofacRadiol 1999; 28: 245-8.

12. Mozzo P, Procacci C, Tacconi A, Martini PT, Andreis IA. A new volumetric CT machine for dental imaging based on the cone-beam technique: preliminary results. Eur Radiol 1998; 8:1558-64.

13. Pauwels R. Cone beam CT for dental and maxillofacial imaging: dose matters. RadiatProt Dosimetry 2015;165:156-61.

14. Suomalainen A, Esmaeili E, Robinson, S. Dentomaxillofacial imaging with panoramic views and cone beam CT. Insights Imaging 2015;6:1-16.doi: 10.1007/s13244-014-0379-4.

15. EUROPEAN COMMISSION. Radiation protection Nº 172: Cone beam CT for dental and maxillofacial radiology. Evidence based guidelines. 2012.

DIGITAL ADVANCEMENT IN ORAL SURGERY: A 2021 UPDATE

Dr. Hemant Baonerkar
MDS OMF Surgery*
Ph.D. Research Scholar*
Oral Maxillofacial surgeon*
Director: Ora Face Maxillofacial Hospital
Mumbai

INTRODUCTION

The roots of Oral and facial surgery found in past around 800BC. Complex procedures like rhinoplasty and incision drainage was introduced by Shushruta. He was introduced more than 250 surgical instruments and more than 80 surgical procedures in his grand book of 'Sushrut Smhita'. Shushruta was consider as Father of all surgery.

Dentistry is relatively newer branch but still evolved so much in last 100 years compare to Oral surgery. In dentistry many new dental materials, new engineered machines, new instruments and newer treatment protocols arrived, but in oral surgery very few advances happened.

In this article we are going to discuss recent digital advancements in oral and maxillofacial surgery.

Digital advancement

Digital electronic technology is all about collection of accurate anatomical data and its accurate implication for treatment planning.

- Radiovisiography (RVG)
- Cone Beam computerized tomography (CBCT)
- CBCT IN impacted tooth localization
- CT Guided Dental implantology
- Maxillofacial Sonography
- CAD CAM in surgery planning
- Navigation in oral maxillofacial surgery Endoscopy
- maxillofacial reconstruction and prothesis
- Digital planning in facial aesthetics
- Robotics in Head and neck surgery

Radiovisiography (RVG)

In dentistry in past we were using conventional 2D intraoral periapical radiographs. Conventional IOPA Xrays has many developing and manual errors result into less diagnostic properties. Then first direct digital imaging system (Radiovisiography) in dentistry was invented by Dr Frances Mouyens and manifectured by trophy radiology (France) in 1984. Digital radiography generally allows for a dose-dependent reduction

in radiation. Using digital imaging, image acquisition is easier and faster allowing for amore rapid and accurate diagnosis. the use of digital imaging eliminates the need for a dark room and regular maintenance of chemical fixation and developing solutions. importantly, various image analysis and enhancement tools may allow for better interpretation of images. Image processing tools allow for manipulation of brightness,contrast, density, magnification, sharpness, and inversion. (image no 1)

For oral surgeons, imaging plays an important role in risk assessment prior to third molar extractions. Risk factors predictive of higher rates of inferior alveolar nerve paresthesia include interruption, narrowing, or diversion of the cortical canal wall and deflection or darkening of the third molar roots.

Cone Beam computerized tomography (CBCT)

CBCT was invented by Sir Godfrey N. Hounsefield in 1967. It was initially developed for angiography in 1982, subsequently applied to maxillofacial imaging. Only since late 1990s that it has been possible to produce clinical sys- tems that is both inexpensive and small enough to be used in dental office.

CBCT is actually boon for dental surgeons and oral surgeons. It play vital role to diagnose pathology, fractures and implant planning. (image no 3) It makes all three dimensional analysis of jaw and skull bone in axial, coronal and sagittal section and then represent it as 3D Reconstruction.(image no 4) 3D Reconstruction helps to accurately localize the interested area.

Image 3: 3D Diagnosis of mandible fracture with CBCT

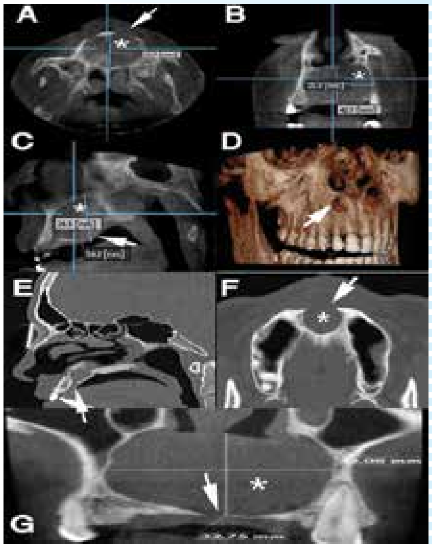


Image 4: Localization of maxillary cyst with axial, coronal and sagittal sections.

CBCT IN impacted tooth localization

CBCT has gold standard diagnostic method for localization for impacted wisdom tooth or any impacted tooth in maxilla and mandible. It also shows close relation ship with adjacent vital structures. (image no 5)

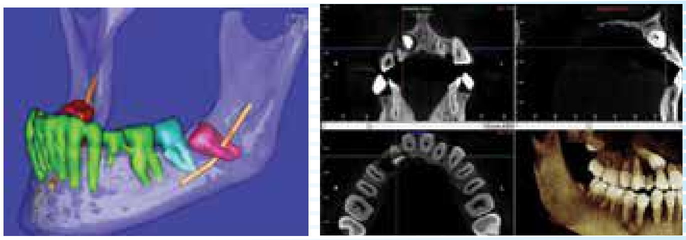


Image no 5: Localization of impacted wisdom tooth & canine

CT Guided Dental implantology

Digital imaging helps to place accurate dental implants and zygomatic implants in oral surgery. It is important to place implant in correct direction were maximum anatomical bone is available and it will do not injure vital structure like inferior alveolar nerve in case of posterior mandibular implants (image no 7) and avoid orbital Flore perforation in zygomatic implant placements. (image no 6)

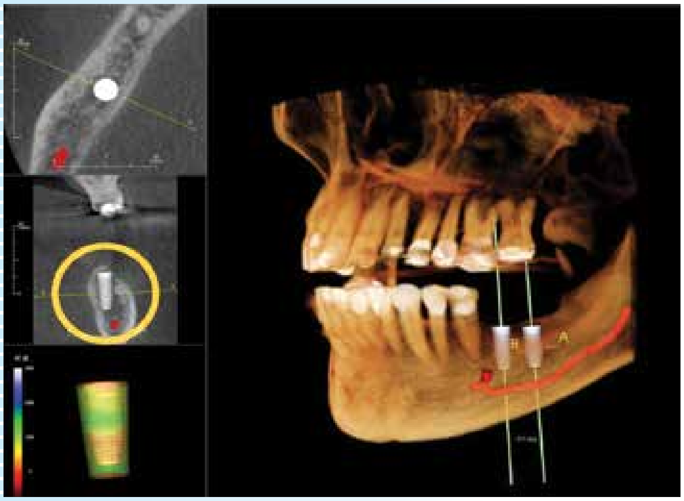


Image no 7: 3D Implant surgery planning

Maxillofacial sonography

Maxillofacial surgery, like any other surgical specialty is greatly dependent on the discipline of radiology. This poses a greater challenge because of the complex anatomy of this region. Various investigation modalities have been applied in diagnosing various diseases which are found in the maxillofacial region, including IOPA, PET, USG, CT, MRI and panoramic radiographs. Of these, USG can easily diagnose non invasive and soft tissue diseases. It is very useful in diagnosing the diseases which are not usually evident on a conventional radiograph. However; many of the dentists are not aware of the benefits of USG in diagnosis of oral diseases. Its most helpful for diagnosis of infectious oral and facial lesions like space infections. (image no 8)

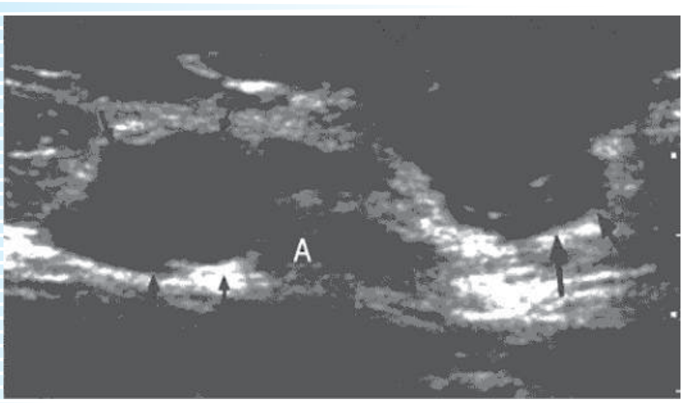


Image no 8 : Ultrasonographic image showing abscess with well demarcated margins of hypo echoic area

CAD CAM in surgery planning

CAD/CAM technology allows for the creation of customized tools to be used to assist with or plan for surgery in an efficient manner. These surgical tools include the following: customized anatomical dental replicas (image no 9), cutting guides for osteotomy design,

implant placement guides. Anatomical replicas and templates may be used in the pre-operative bending of reconstruction plates, design of customized

bone appliances (distraction devices), or fabrication of customized implants.

The initial step in customized design involves patient imaging. The manufacturing varies greatly particularly with the type of material used. Both liquid and solid based materials are used and both additive and subtractive methods can be employed, and sterolithographic model made for treatment planning. (image no 10)

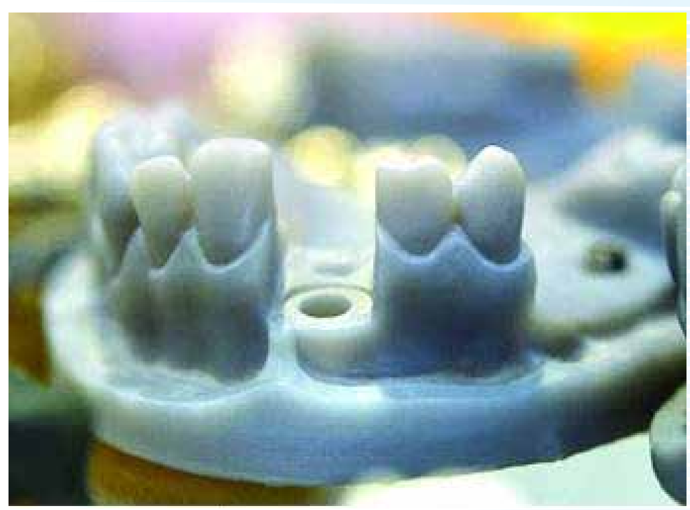


Image no 9: CAD CAM anatomical Dental Replicas

Image 10: A stereolithographic model has been constructed using the DICOM data from the CBCT for mandibular pathology

Navigation in oral maxillofacial surgery

Computer assisted surgery includes template guided approaches (obtained via CAD/CAM technology) as well as surgical navigation (Figure no 11). Navigation utilizes data obtained from 3D imaging to provide directional and spatial assistance to surgeons intraoperatively. Most importantly, the image guidance is provided in real time.

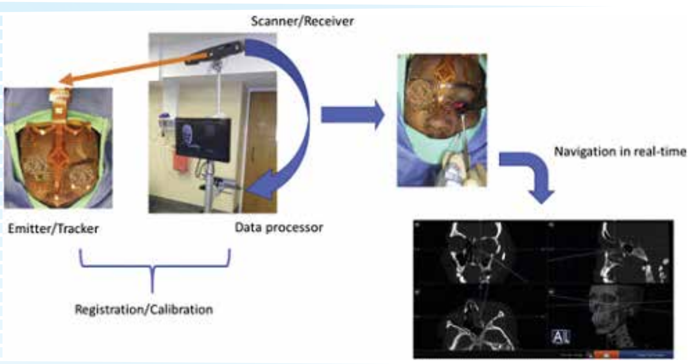


Figure no 11: Real time Digital Navigation technology in poly trauma correction

Endoscopy

Sialo endoscopy and FESS (Functional endoscopy sinus surgery) are main apex endoscopic methods which use in oral maxillofacial surgery for minimal invasive complex surgery for sialolith removal and maxillary sinus procedures. Both are real time navigation assisted digital technologies. (image no 12 and 13)

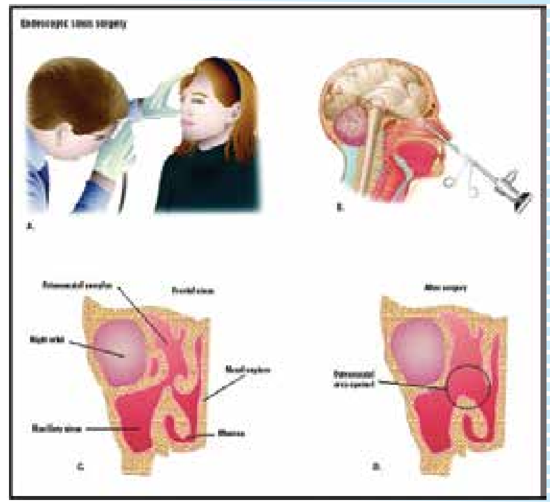


Image no 12: Functional endoscopy sinus surgery

Image no 13: Sialoendoscopy for salivary grand stone removal Maxillofacial reconstruction and prothesis

CAD/CAM technologies applied to reconstruction allow for more efficient use of

intraoperative time by pre-planning osteotomies and segment positioning. CT scans and MRI data use for bone reconstruction strategies and face prosthesis in cancer patients. (Image 14 and 15)

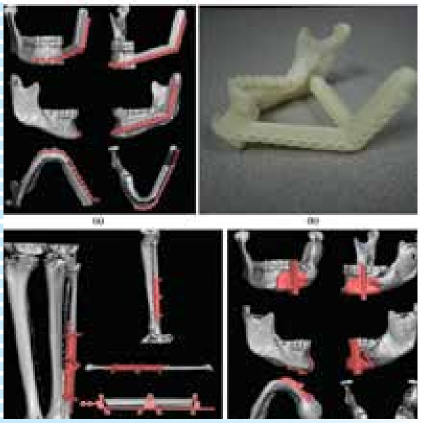


Image 14 : 3D model for mandible reconstruction

Image 15: Digital reconstructed model for facial prosthesi

Digital planning in facial aesthetics

Esthetic enhancement of deficiencies in facial contour can be performed with implants. While stock implants exist, they commonly require modification prior to placement in order to minimize contour irregularities. This prolongs operative time and minor irregularities may persist. Pre-operative assessment using 3D CT scan imaging allows for a better assessment of the hypoplastic regions while CAD/CAM technology allows for the fabrication of a custom implant with more predictable improvements of enhancement.(image 16 and 17)

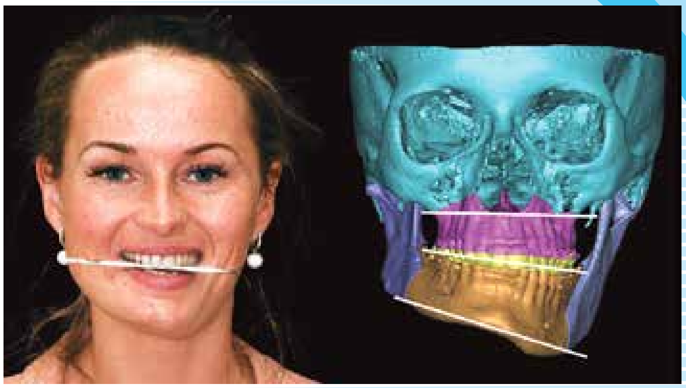


Image 16: orthognathic surgery planning for facial asymmetry correction

Image 17: CAD CAM for facial aesthetic planning

Robotics in Head and neck surgery

The first robotic surgical system developed was the Puma 560, which was used in 1985 to perform neurosurgical biopsies with increased precision. Since this time, a series of robots have been developed. However, the only FDA approved and actively marketed system (2009, for Transoral Robotic Surgery for head and neck surgery is the da Vinci Surgical Robot. (Image 18)

Image 18: robotic surgery unit in head & neck Conclusion

the digitization of patient data can be used for generation of 3D normative data sets to be used for surgical predictions. Predicting the soft tissue response to skeletal manipulation has both functional (bimaxillary advancement) as well as esthetic (orthognathic surgery) implications.

Applications of CBCT in Dental Practice

Om Kharat, BDS,
Easwaran Ramaswami, MDS,
Nimma Vijayalaxmi, MDS,
Rashmi Ingle, BDS

1. II year Post-graduate, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai, India.
2. Associate Professor and Head of Department, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai, India.
3. Associate Professor(academic), Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai, India.
4. I year Post-graduate, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai, India.

Abstract:

Cone Beam Computed Tomography (CBCT) is an exciting variety of digital imaging modality which provides outstanding images which help us to improve the accuracy in dental diagnosis and treatment planning. It has got varied applications in the field of dentistry mostly includes implantology, orthodontics, oral and maxillofacial surgery, periodontics, location of inferior alveolar canal, diagnosis of oral and maxillofacial pathologies and to lesser extent in fields of endodontics. A relatively low patient dose when compared to CT (Computed Tomography) and 3-dimensional visualization of structures are potentially attractive features of CBCT imaging. Its use in diagnosis and treatment planning of sleep apnoea and 3-D reconstruction, virtual imaging are promising areas in dentistry. Thus, CBCT can be considered as promising tool for future dentistry.

Key words: Advanced imaging, cone beam CT, dentistry.

Introduction:

The dental practice is revolutionized with the advent of Dental Cone Beam Computed Tomography, popularly known as Cone Beam Computed Tomography (CBCT)1. CBCT has applications in all fields of dentistry facilitating the dental diagnosis from 2D to 3D images and increasing the role of imaging from diagnosis to image management of operative procedures by using digital imaging and communications in medicine (DICOM) files. The most common indication for cone-beam imaging in dentistry are evaluation of the jaws for placement of dental implants, examination of teeth and facial structures for orthodontic treatment planning, assessment of temporomandibular joints (TMJs) for osseous degenerative changes, estimation of the proximity of the lower wisdom teeth to the mandibular nerve before surgical procedure, evaluation of teeth for root fracture or periapical disease, and assessment of bone for signs of infections, cysts, or tumour's2.

More recent advances in digital diagnostic imaging have resulted in lower radiation doses and faster processing times without hampering the diagnostic quality of the intraoral or panoramic images. However, 2D images possess inherent limitations which include magnification, distortion, and superimposition that can lead to misinterpretations of radiographs3.

Every dentist should be equipped with the knowledge of how they can utilize this advanced imaging modality for their patient care.

Applications of CBCT in the different dental departments:

1. Cone-beam computed tomography in implantology:

The application of CBCT has left a great impact in the implantology more than any other areas in dentistry.

CBCT images helps to locate and determine the distance to vital anatomic structures. It provides cross-sectional images in various planes of the alveolar bone height, width and angulation and accurately locates the vital structures such as inferior alveolar canal in mandible and the sinus in the maxilla3. the quality of bone can also be detected to certain extent which is important in implant placements.

- It measures alveolar bone width and visualize bone contours [figure 1 (a)]
- Aids in Selection of the most suitable implant size and type
- Optimize the implant location and angulations.
- Virtual implant planning [figure 1 (b)] [selection of implants dimensions, surgical guide preparation and placements strategies]

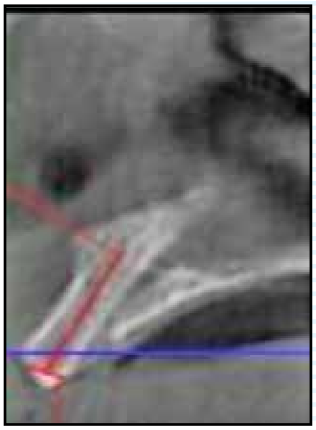


Figure 1 (a): Cross sectional images showing alveolar ridge width and height measurement in anterior maxillary region.

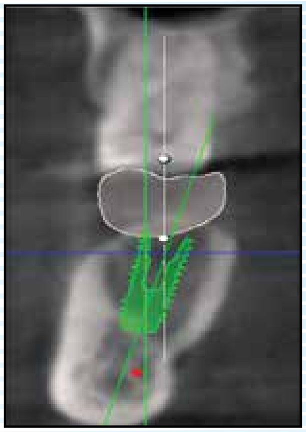


Figure 1 (b): Cross sectional images showing alveolar ridge width and height measurement in anterior maxillary region.

2. Cone-beam computed tomography in Orthodontics:

Since years we are using the 2D imaging modalities for orthodontic evaluation and planning, due to recent advance in the digital imaging like CBCT treatment planning and patient wellbeing is improved markedly. CBCT offers a 3D image that can be used to aid in orthodontic tooth movement in all three planes of space.

- Aids in 3D evaluation of impacted tooth position and anatomy [figure 2(a)]
- TMJ assessments of condylar anatomy in three dimensions

- Airway assessment is outstanding [figure 2 (b)]
- Orthognathic growth assessments and treatment planning is in true 1:1 imaging
- Assessment of skeletal symmetry
- Planning for placement of dental implants for tooth restoration or orthodontic anchorage and for placement of temporary anchorage devices.
- Allows 3D views of vital structure and 3 D cephalometric analysis [figure 2 (c)]
- CBCT helps to visualize the source of obstruction in Sleep apnoea.
- Aid in appliance fabrication.

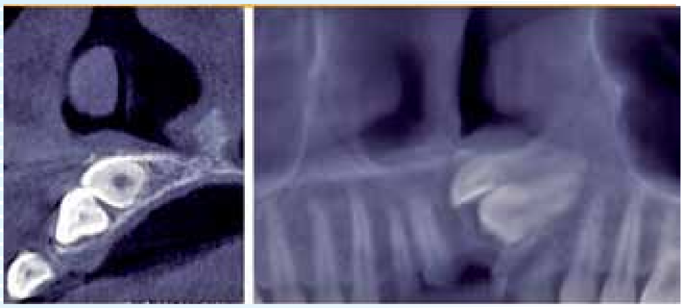


Figure 2 (a) Sagittal CBCT section showing impacted left maxillary canine and central incisor.

3. CBCT applications in Oral and maxillofacial pathology:

Figure 2 b) Sagittal CBCT section showing constricted airway space

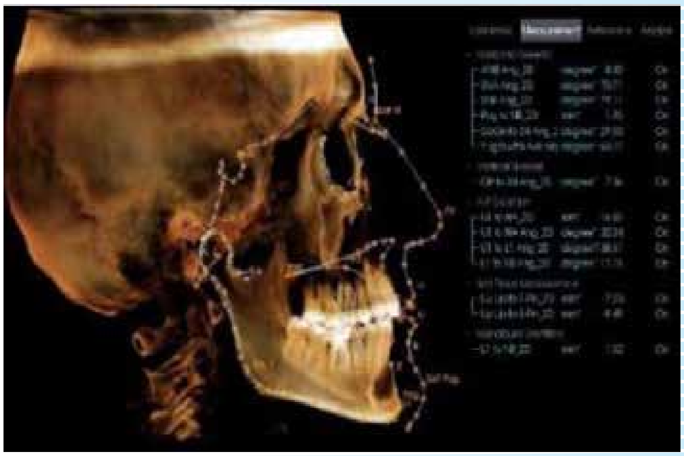


Figure 2 (c)3D reconstructed image showing virtual 3D cephalometric analysis.

It provides more accurate information related to size, extent, location, and the relation to effect on nearby anatomical structures.

The pathologies whose internal structure and margins were not distinctly appreciated using the 2D imaging are now been evaluated in more precise way [figure 3 a]

Appreciation of involvement of structure of maxillofacial skeleton like nasal cavity, para nasal structures, orbits etc is now possible with use of CBCT.

Helps to monitor the progression of the pathology as well as the success of treatment. Example dens in dente case. [figure 3 b]

Figure 3 a) Axial CBCT section showing a large expansile lesion in the mandible with perforation of cortical plates.

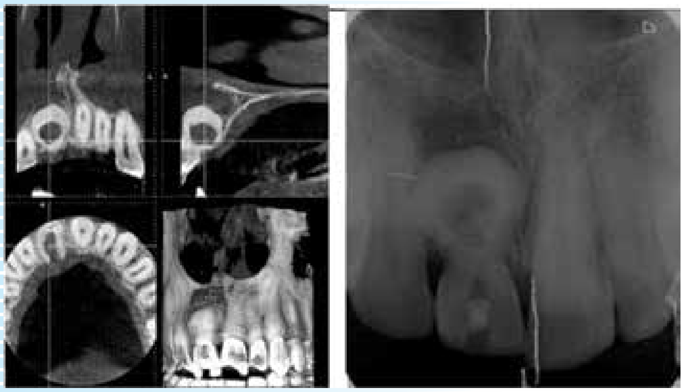


Figure 3 b) Multi-planar CBCT Scan of anterior maxillary region at root level with 3D reconstruction showing Dens in Dente with dilated root and a periapical lesion.

4. Cone-beam computed tomography in oral and maxillofacial surgery:

In the areas of oral surgery and oral pathology, the data from the CBCT can have a profound impact on decision making. The location and root configuration of impacted and erupted teeth can be seen with exceptional clarity, thus aiding in precise surgical planning.

In patients with facial trauma, it is used to characterize the kind of fracture its effect on adjoining structures and related complications. [figure 4 (a)]

The accurate assessment of the position of the inferior alveolar canal to the roots of mandibular third molar, mental foramen and their variations can be detected. [figure 4 (c)]

Morphologic changes of the TMJ depicted with CBCT imaging are useful in diagnosing pathologic processes such as degenerative changes and ankylosis, joint remodelling after diskectomy, malocclusion, and congenital and developmental malformations. [figure 4 (b)]

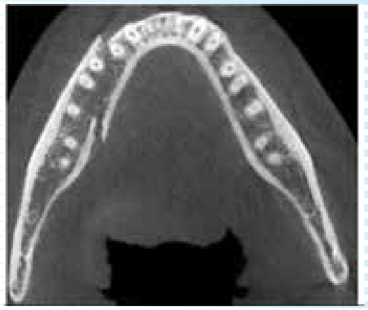


Figure 4 (a) Axial CBCT section showing fracture of body of mandible

Figure 4 (b) Coronal CBCT section showing TMJ ankylosis preoperative and postoperative condylectomy performed

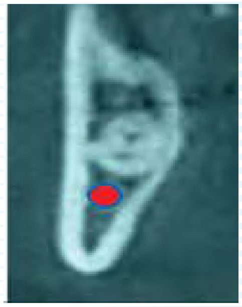


Figure 4 (c) Cross-sectional image showing Inferior alveolar nerve canal tracing and its proximity to the third molar root.

5. Cone-beam computed tomography Endodontics:

The three-dimensional scanning of all the roots of a tooth during endodontic treatment to detect perforation or aberrant canals is useful. Applications would include apical lesions, root fractures, canal identification, [figure 5 (a)] and characterization of internal and external root resorption. Evaluation of periapical lesion before after difficult endodontic surgeries has gained popularity.

Figure 5 (a) Sagittal CBCT section in mandibular left second premolar showing bifurcated root with periapical abscess.

6. Cone-beam computed tomography Periodontics:

The conventional method for monitoring periodontal bone loss has been through the use of a periodontal probe and bitewing radiographs.

visualization with CBCT images, most software includes tools for evaluating and monitoring bone density, which may help assess the effectiveness of treatment, predict the results of treatment, or identify areas of future concern.

CBCT imaging offers specific advantages for periodontal diagnosis with the ability to accurately assess alveolar bone on the facial/buccal and lingual/palatal surfaces of all teeth as well as the mesial and distal aspects. [figure 6 (a)] Similar to panoramic radiography, image acquisition is extraoral, rapid, and technically easy to perform4.

- Helps in molar furcation assessment
- In the localization of periodontal abscess.
- To locate lateral periodontal cyst.
- Bone mapping
- Sinus lift procedure before implant
- Graft site assessment [figure 6 (b)]

Figure 6 (a) Cross sectional image showing alveolar bone loss in the maxillary & mandibular incisor region.

Figure 6 (b) cross sectional image showing bone graft fitted with screw in the maxillary anterior region.

8. Cone-beam computed tomography Pedodontics:

Unerupted tooth localisation Complex cases of skeletal abnormality in orthodontics, particularly those patients requiring combined orthodontic/surgical management

- External root resorption in relation to unerupted teeth
- Cleft palate [figure 7 (a)]
- Periodontal assessment
- Assessment of periapical disease paediatric Endodontics
- Dentoalveolar trauma.
- Skeletal growth evaluation.

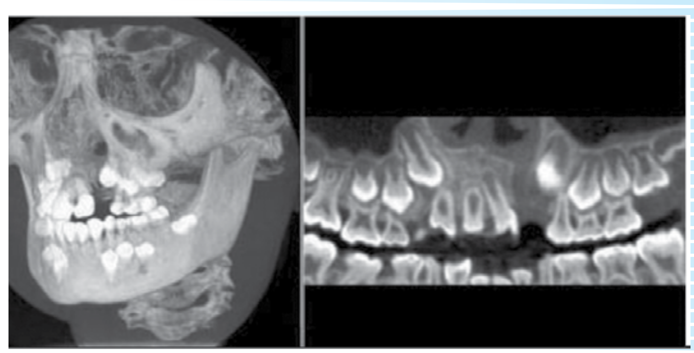


Figure 7 (a) 3D reconstructed section showing cleft palate in left maxilla.

Limitations:

All the newer imaging modalities including CBCT are definite advantage to dentist in providing dental care to the patient but a word of caution should always be remembered that CBCT is not replacement for conventional imaging modalities, which are less hazardous to the patients. We have seen what CBCT can advantageously use for but there are few limitations as well

Example:

- It cannot Differentiate the intralesional contents (e.g., fluid vs. tumor)
- Lesional extension through cortical perforation
- Adjacent soft tissue reaction (e.g., cellulitis associated with osteomyelitis)
- Intra-articular disorders (e.g., temporomandibular disc position, synovitis)4.
- CBCT is superior to 2D imaging for the visualization of bone topography and lesion architecture but no more accurate than 2D for bone height measurement.
- Resolution for CBCT is lower than intraoral periapical radiographs.

Future prospects of CBCT IN DENTAL PRACTICE:

CBCT is the area around which major research is taking place, 3Dprinting has been one of them. Use of this advanced imaging modality in virtual treatment planning, combination of cbct with sialography and nuclear imaging modalities are in full swing.

CONCLUSION:

CBCT is wonderful imaging modality but not an alternative to clinical expertise of the dentist. Its use should always be done cautiously, weighing the advantages over the disadvantages.

REFERENCE:

1. Makhija PG, Makhija P. Integrating cone beam computed tomography (CBCT) in dentistry-Review. Bhavnagar Univ J Dent. 2013;3(1):49-55.
2. Ghali SR, Katti G, Shahbaz S, Katti C. Cone beam computed tomography: A boon for maxillofacial imaging. Journal of Indian Academy of Oral Medicine and Radiology. 2017 Jan 1;29(1):30.
3. Vyas T. APPLICATIONS OF CBCT IN SPECIAL REFRENCE TO DENTISTRY. Journal of Advanced Medical and Dental Sciences Research. 2017 Apr 1;5(4):67.
4. Scarfe WC, Angelopoulos C, editors. Maxillofacial cone beam computed tomography: principles, techniques and clinical applications. Springer; 2018 Jan 4.
5. Rivas JA. Aspects of Dental Cone-Beam Computed Tomography in Children and Young People. The University of Manchester (United Kingdom); 2014.