Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 5s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Digital Dentistry and Oncology: A Revolutionary Era

Dr. Nisha Garg[*1], Dr. Sumit Singh Phukela[2], Dr. Akansha Srivastava[3], Dr. Jaiveer Yadav[4], Yash[5], Dr. Ananya Kothe[6]

[*1]Private Practitioner, BDS, MDS PROSTHODONTICS, Ex Pg Faculty Of Dental Sciences, SGT University, Gurugram, Haryana.

[2]Professor, Department of Prosthodontics and Associate Dean, Faculty Of Dental Sciences, SGT University, Gurugram Haryana.

Email ID: sumit.phukela@sgtuniversity.org

[3]Private Practitioner, Ex Student of Hazaribag college of dental science and hospital, Jharkhand.

Email ID: doctornishagarg@gmail.com

[4]Reader, Department of Prosthodontics, Faculty Of Dental Sciences, SGT University, Gurugram, Haryana.

Email ID: jaiveer.yadav38@gmail.com

[5]BDS Final year student, Faculty Of Dental Sciences, SGT University, Gurugram, Haryana.

Email ID: yashsingh0059@gmail.com

[6]Senior Lecturer Faculty Of Dental Sciences, SGT University, Gurugram, Haryana.

Email ID: ananya_fds@sgtuniversity.org

***Corresponding Author**

Email ID: doctornishagarg@gmail.com

Cite this paper as: Dr. Nisha Garg, Dr. Sumit Singh Phukela, Dr. Akansha Srivastava, Dr. Jaiveer Yadav, Yash, Dr. Ananya Kothe, (2025) Digital Dentistry and Oncology: A Revolutionary Era. *Journal of Neonatal Surgery*, 14 (5s), 42-52.

ABSTRACT

Over the past years the use of technology had a great impact on many fields. There are ongoing development which has colossal effect on field of dentistry. New advances in the field of dentistry has taken over many procedures. Advancements has changed all the aspects of dentistry even altered the flow of traditional treatment processes. Workflow between the different parties involved (dentists, surgeons and dental laboratories) has been affected drastically. The fully digital workflow consists of a direct digitization of the oral cavity utilizing intraoral scanning devices. The digitized file is then utilized as a virtual model by a Computer-Aided Designer (CAD) to virtually design the intended reconstruction. The designed file is then manufactured utilizing computer-aided manufacturing (CAM). Advancements also made a significant contribution to Dental diagnosis in capturing of images from equipment such as RVG, CT Scans, MRI, ECO, EMG etc. Digital dentistry and oncology are two distinct yet increasingly interconnected fields, as advancements in digital technology are significantly transforming both areas.

1. INTRODUCTION

Digitalization refers to the use of dental technologies or devices that incorporates digital or computer-controlled components to carry out dental procedures rather than using mechanical or electrical tool. Advancements in technology enable patients to receive modern solutions of conventional dental problems. Although conventional techniques in dental care have worked excellently for decades, digital technology have improved workflow efficiency and accuracy.

There are many recent areas of dentistry available, and many more are being researched. Some of them are as follow.

Laser

Computer-aided design computer-aided manufacturing (CAD CAM)

Virtual articulator and facebow

Digital occlusal analysis -T scan

Cone beam computed tomography

Digital Smile Design

Digital Shade Selection

Nanotechnology

2. LASER

Laser is an acronym which stands for "Light Amplification by Stimulated Emission of Radiation", utilised in many fields. Named by GORDO GOULD in 1957.

The use of Lasers in dentistry provides a new standard of care. The application and role of Lasers in prosthodontics in providing fixed dental prosthesis improves the standard of care for both the patients as well as the dentist due to its precise excision, a shortened period of wound healing and their benefits of coagulation, which increases tissue response to provided surgeries.[1-3]

Uses and application of lasers

Crown lengthening

The uses of Lasers provide precise control during surgery and enhance gingival outline. It also provides dry surgical field for better visualization, reduction in bacteria, faster healing with less chair side time (FIGURE 1).

Figure 1 Aesthetic gingival contouring

Laser troughing

Laser minimizes most of the difficult works and makes everything easy and concise; thus, the use of retraction cord is decreased by creating a trough by Laser before taking impression. It also seals the blood vessels thus providing coagulation and lessens the use of hemostatic agents[4-5].

Modification of soft tissues around laminates

The use of argon laser helps in recontouring and removal of the remaining gingival tissues around laminates easier.

Management of soft tissues around abutment

Gingivectomy, gingivoplasty (i.e.,) removal and contouring of soft tissues around abutment tooth are best done using Ar Laser. The management of soft tissues around abutment provides better finish line, adequate crown length.

Osseous crown lengthening

Tooth is made of hydroxyapatite crystals, which is a mineralized bone matrix. Er:YAG laser absorbs water content of mineralized matrix content Thus, encouraging for bone ablation.

Altered passive eruption management

The altered passive eruption of teeth with uneven margins can be managed using lasers which removes and recontour the soft tissues such as margins of gingiva with minimal complication thus enhancing esthetics.

Formation of ovate pontic site

RE contouring both hard and soft tissues provides and enhance the pontic design. Soft-tissue re contouring and removal are done using Er lasers. In osseointegrated implant placement, granulation tissue should be removed and is done using lasers.

Removal of veneer

Dislodgement of restoration without cutting is done by using Lasers. Laser energy passes through porcelain glass which is unaffected and is absorbed by water molecule at the adhesive. Debonding occurs between silane and resin without damaging the underlying tooth. Lasers such as Er, Cr:YSGG are used for removal of unwanted or failed veneers.

Bleaching

To improve esthetics and smile diode lasers are commonly used to improve the shade of the teeth without causing sensitivity and much alteration to the tooth complex.

To treat dentinal hypersensitivity

Nd:YAG laser for the treatment of dentinal hypersensitivity. Many lasers can induce thermal effect, if their parameters are used under controlled conditions, thermal damage to temperature sensitive pulpal tissues can be minimized.

Lasers in maxillofacial prosthesis:

This new approach can generate the wax pattern directly and reduce labour-intensive laboratory procedures. So the manufacturer time is reduced and more precision can be achieved.

Lasers in the dental laboratory

Lasers are used for deposition of hydroxyapatite (HA) thin films on titanium implants. Pulsed laser deposition (PLD) is a proven method to produce pure, crystalline and adherent HA coatings which show no dissolution in a simulated body fluid. Lasers can be used for surface treatment of titanium castings for ceramic bonding and have shown improved bond strength when compared to acid etching techniques. Lasers can also be used for welding.

3. COMPUTER-AIDED DESIGN (CAD)/COMPUTER-AIDED MANUFACTURING (CAM)

Computer-aided design (CAD) and computer-aided manufacturing (CAM) have become an increasingly popular part of dentistry over the past 25 years. The technology is used in both the dental laboratory and the dental office, can be applied to inlays, onlays, veneers, crowns, fixed partial dentures, implant abutments, and even full-mouth reconstruction.

All CAD/CAM systems consist of three components:

1. A digitalization tool/scanner that transforms geometry into digital data that can be processed by the computer.
2. Software that processes data and, depending on the application, produces a data set for the product to be fabricated [6-8].
3. A production technology that transforms the data set into the desired product (FIGURE 2).

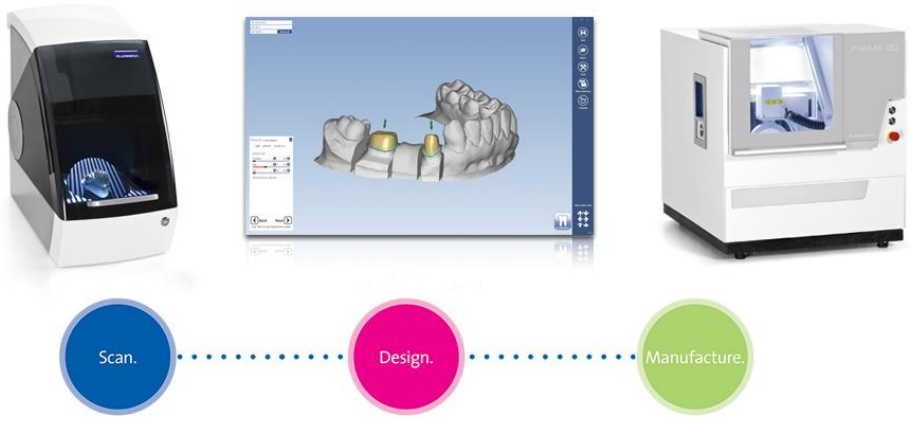

Figure 2 CAD CAM SYSTEM

4. USES OF CAD CAM IN DENTISTRY

CAD CAM is being used in almost every field of dentistry these days. Following are its some of the uses in different specialties of dentistry:

1. a) Removable Complete Dentures: Many researches have been proposed regarding fabrication of removable complete dentures through CAD CAM but no clinical reports or trials have been published yet. Only 2 of the manufacturers claim that they manufacture RCD through CAD CAM [9,10].

b) Removable Partial Dentures: Partial denture framework can be produced through CAD CAM by using additive prototyping technique.

c) Crowns / Bridges: Zirconia is the widely used material for the fabrication of crown and bridge through CAD CAM. However, metal & porcelain crown & bridge can also be fabricated through CAD CAM.

d) Inlay, Onlay & Veneers: These restorations are also being produced through CAD CAM. A study says that inlays & onlays, produced through CAD CAM, have a higher survival rate.

2. In orthodontics, clear aligners have gained so much popularity due to esthetics. Now patients don't have to show metallic brackets and wires. The credit goes to CAD CAM again. Also lingual bracket system is in demand due to its invisibility. The wires and bracket system for the lingual bracket system is fabricated through CAD CAM. Orthodontic mini implants can also be positioned using CAD CAM technology.

3. Implant abutments and surgical guides for the placement of implants are being produced through CAD CAM these days.

4. Maxillo-Facial Prosthetics:A study shows the difference in between the outcome of the artificial ear prosthesis carved by hand & fabricated through CAD CAM. The latter is superior over the hand carved prosthesis. So artificial ear, artificial nasal prosthesis are being produced through CAD CAM.

5. VIRTUAL ARTICULATOR AND FACEBOW

In the field of prosthetic and restorative dentistry, the virtual dental articulator analyse complex static and dynamic occlusal relations. The virtual articulator requires digital 3D representations of the jaws and patient specific data on jaw movements. It then simulates jaw movements and provides a dynamic visualization of the occlusal contacts(FIGURE 3). The Virtual articulator can be defined as a software tool for improved clinical outcome based on virtual reality technology [11-13].

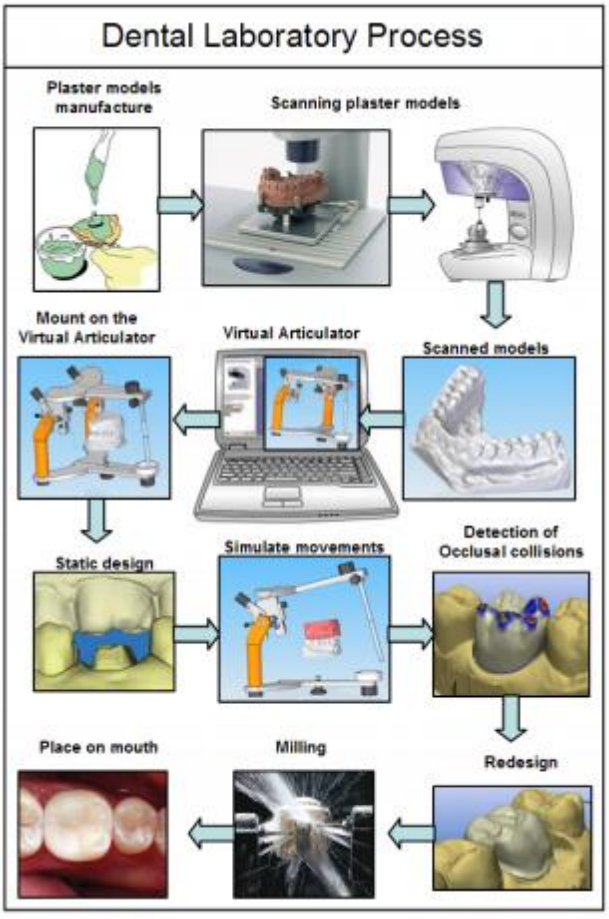

Figure 3 Virtual Articulation

Advantages of Virtual Articulator

Provides best quality of communication between the dentist and dental technician

Simulating real patient specific data

Analyses both static and dynamic occlusions

Analyses ganathic and joint conditions

Acts as a 3D navigator [14,15].

6. DIGITAL OCCLUSAL ANALYSIS

Normal occlusal and articulation relations between the jaws ensure balanced distribution of the generated forces in them during mastication. Any premature occlusal contacts and occlusal-articulating blockages cause occlusal traumas which induces changes in the tooth-supporting tissues (the mucosa, periodontal tissues, and bone), in the masticatory muscles and the temporomandibular joint.

In dental practice articulating paper has been established as the most commonly used diagnostic tool to identify contact points between the maxillary and mandibular teeth. The paper can readily highlight occlusal contacts, but cannot accurately quantify their intensity and measure the magnitude of the generated occlusal forces[16-18].

Figure 4 T SCAN

T scan aimed to register the patient occlusion on a thin patented 60 µ thickness disposable sensor to record instantaneously the patient bite in terms of location, timing, and force of every tooth in contact (FIGURE 4). This record is transferred to a computing system which can make an actual simulation of the patient occlusion on a monitor, assuming the different situations possible during centric, eccentric, and functional movements. This provides both qualitative and quantitative assessment of occlusion.

Clinical Applications of T-scan in different fields of dentistry

Orthodontics: The use of T-scan before and after orthodontic treatment for every patient helps to attain the goal of correcting malocclusion and maintaining the proper bite force.

Implant: The biocompatible implants do not have shock absorption and cannot adapt according to the need of occlusal forces. T-Scan occlusal analysis system is helpful to meet the needs of patients for reliable measurement of occlusal biting forces [19,20].

Restorative dentistry: Improperly restored tooth can cause several problems like headache, TMD related problem. T-Scan has played an important role to rule out overly/underly restored tooth and has saved the time of finishing of restoration and recall visits

Temporomandibular Disorder: The application of T-Scan and kinesi graphic techniques in combination with electromyography is of great value to the clinician for substantiating certain clinically hard-to- evidence factors, such as chronology and strength of contact points, muscular activity, or certain mandibular movements

Oral and maxillofacial surgery: The T-scan can play a major role in the evaluation of occlusion after post-surgical treatment and was found to be the effective to judge the precision of the new appliance. It also plays a major role in determining the accuracy of occlusion after orthognathic surgery.

Prosthodontics: Replacement of single or multiple teeth with crown, bridge, complete or partial denture is routinely performed in dentistry to attain proper function and esthetics. Improper occlusion is a major challenge. The T-Scan system was found to be clinically useful as a diagnostic screening method for occlusal stability of intercuspal position.

7. CONE BEAM COMPUTED TOMOGRAPHY

PRINCIPLE OF CONE-BEAM COMPUTED TOMOGRAPHY

The CBCT imaging employs the principle of Tomo synthesis. A CBCT machine, uses a cone-shaped beam and a

reciprocating solid state flat panel detector, which rotates around the patient, 180-360 degrees, covering the defined anatomical volume. This single scan (rotation) captures planned data, further reducing the absorbed x-ray dose from 6 to 15 times in comparison to CT. Depending upon manufacturers, the scanning time of CBCT equipment varies from nearly 5 to 40 seconds. The captured 2D images are instantaneously conveyed to the computer, which reconstructs them.These reconstructed views, consecutively interpreted, judged, and measured for diagnostic and treatment-planning purposes[21,22].

APPLICATION IN DENTISTRY

The success of dental implant restorations depends, in part, on adequate diagnostic information about bony structures of the oral region.

Implant planning can be done with CBCT by assessing the presence of some kind of pathology, location of anatomic features, location of osseous morphology and amount of bone available.

Anatomic structures such as the inferior alveolar nerve, maxillary sinus, mental foramen, and adjacent roots are easily viewed using CBCT (FIGURE 5). In addition, these specific CBCT images also permit precise measurement of distance, area, and volume.

It has been related to find application in pre-surgical imaging, as well as surgical-intra-operative and postsurgical evaluation (for assessment of osseointegration).

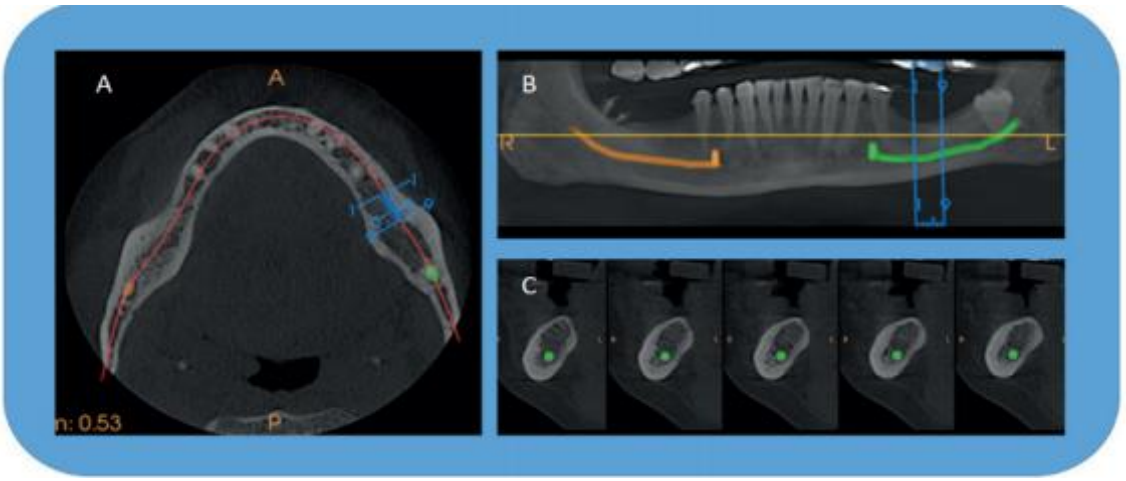

Figure 5 cbct scan of mandible

Furthermore, the availability of newer software to construct surgical guides has further reduced the possibility of structural damage. To locate the final tooth position under "prosthetically driven implant" technique, a radiopaque marker can be utilized. This data, when arranged on CBCT, can be utilized to create a surgical guide for precise implant placement, which ensures final prosthesis to fit accordingly with the implant alignment.

CBCT has various uses in areas of inadequate bone to support dental implants. This will help in predicting the volume and type of graft material needed prior to surgery. It assists in gaining valuable information about sinus membrane thickening and perforations, patency of the osteomeatal complex and also in gaining surgical access into the sinus.

The images provide the appearance of ridge patterns, such as irregular ridges, narrow crestal ridge form or knife shaped ridges. The loss of cortical bone and associated concavities can be seen.

Mc Ginvney et al and Schwartz et al concluded that the 3D images more accurately showed true osseous topography, and considered it a valuable diagnostic aid [23].

8. DIGITAL SMILE DESIGN

It is a practical multiuse clinical tool with relevant advantages: it can strengthen esthetic diagnostic abilities, improve the communication between team members, create predictable systems throughout the treatment phases, enhance the patient's education and motivation, and increase the effectiveness of case presentation. It is an effective digital treatment protocol which utilizes 2D clinical and lab images of the patient and the proposed treatment plan including planes of reference, facial and dental midlines, incisal edge position, lip dynamics, basic tooth arrangement, and the incisal plane (FIGURE 6)[24-26].

Figure 6 digital smile design

ADVANTAGES OF DIGITAL SMILE DESIGN

Accurate esthetic analysis

The DSD allows a careful esthetic analysis of the patient's facial and dental features and a gradual discovery of many critical factors that might have been overlooked during the clinical, photographic, or study models evaluation [27-29].

Increased communication among the interdisciplinary team

Team members can identify and highlight discrepancies in soft or hard tissue morphology, discussing over high-quality images on the computer screen the best possible solutions for the case [30-31].

Feedback at each phase of treatment

At any time any team member can access the slide presentation and check what was done until that moment.

Patient understanding and marketing tool

The DSD is an important marketing tool to motivate the patient, making him or her understand the issues and treatment options, compare before and after pictures, and value all the work that was done.

Dynamic and effective treatment planning presentation

The DSD makes the treatment planning presentation more effective and clear because it allows patients to see and better understand the combined multiple factors that are responsible for their oral-facial issues.

Educational tool

The DSD can increase the impact of the presentations because it adds visual elements into the slides that will improve the educational aspects of the lecture. The audience can understand better the issues that were previously highlighted and the presenter can minimize the use of the laser pointer [32-34].

9. DIGITAL SHADE SELECTION

The interest in color research in dentistry has increased significantly over the past several decades. Shade determination for direct and indirect restorations has always been a challenge for the esthetic dentist. During the past half-decade, the dental profession has experienced the growth of a new generation (FIGURE 7) of technologies devoted to the analysis, communication and verification of shade.

INSTRUMENTS FOR DIGITAL SHADE-MATCHING

Colorimeters

Spectrophotometers,

Imaging systems

Figure 7 digital shade guide

10. CHARACTERISTICS AND CLINICAL APPLICATION

COLORIMETERS

Colorimeters measure tristimulus values and filter light in red, green and blue areas of the visible spectrum. Colorimeters are not registering spectral reflectance and can be less accurate than spectrophotometers (aging of the filters can additionally affect accuracy)[35-37].

SPECTROPHOTOMETERS

Spectrophotometers are among the most accurate, useful, and flexible instruments for color matching. A spectrophotometer functions by measuring the spectral reflectance or transmittance curve of a specimen. They are useful in the measurement of surface Color.

A prism disperses white light from a tungsten filament bulb in the spectrophotometer into a spectrum of wavelength bands between 5 and 20 nm (FIGURE 8). The amount of light reflected from a specimen is measured for each wavelength in the visible spectrum The measurements obtained by the instruments are frequently keyed to dental shade guides and converted to shade tab equivalent.

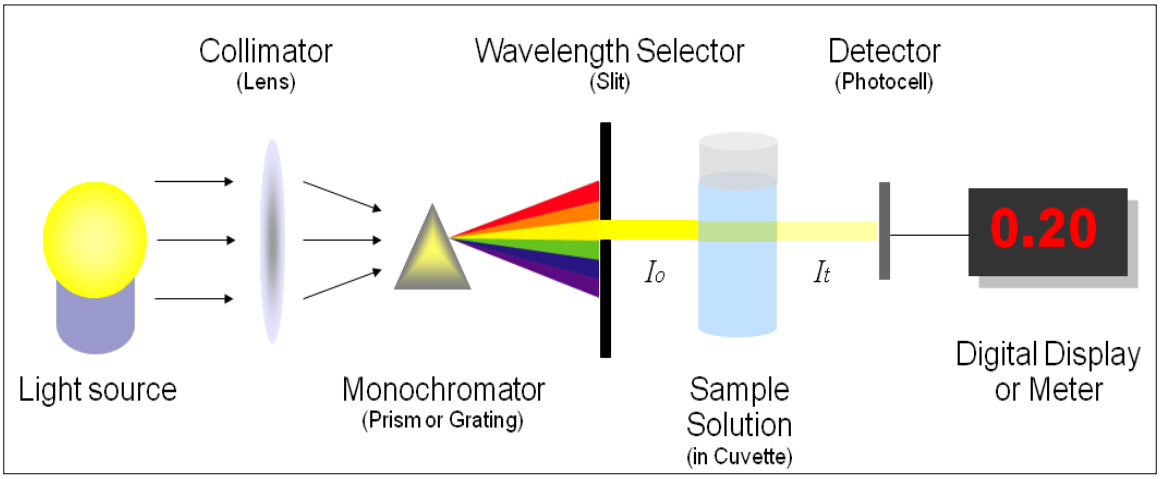

Figure 8 principle of Spectrophotometer

Compared with observations by the human eye, or conventional techniques, it was found that spectrophotometers offered a 33% increase in accuracy and a more objective match in 93.3% of cases[38,39].

11. NANOTECHNOLOGY

'Nano' is derived from the Greek word which means Dwarf. Nanotechnology is the art and science of material engineering at the Nano scale size (1-100nm).Nanotechnology is one of the most popular areas of current research and has developed in multiple disciplines.

NANOMATERIALS IN PROSTHODONTIC APPLICATION

In implants: TiO2 nanotubes on Ti improved the production of alkaline phosphatase (AkP) activity by osteoblastic cells. Bone morphogenetic protein (BMP) has been also immobilized on the surface of dental implants to enhance bioactivity and hence bone formation [40-41].

Restorations: Nano fillers of 1-100nm have been incorporated into the resin matrix to produce Nano composites. Since the dimensions of these filler particles are below that of visible light, it is impossible for them to either scatter or absorb visible light. This phenomenon plays a key role in getting excellent aesthetic properties and can be used for anterior teeth restorations.

Nanocomposite denture teeth: have homogenously distributed nanofillers and polymethyl methacrylate (FIGURE 9). They have shown high durability and polish ability, increased shear strength, superior esthetics and higher abrasion resistance.

Figure 9 Nanocomposite denture teeth

Self-healing adhesives: capable of closing micro- or Nano cracks have been also introduced. They contain healing agent-filled nano capsules; the rupture of the nano capsules and the release of their content is usually initiated by the presence of a crack in the resin matrix.

TISSUE CONDITIONERS AND SOFT LINERS: Addition of silver Nano-particles in these materials have displayed antimicrobial properties against S.mutans and S.aureus at 0.1% and C. albicans at 0.5% after 24 hours incubation period.

DENTAL CEMENTS: Nano-HA and Nano-FA were added to Fuji II glass ionomer. Glass ionomer cement with up to 5% w/w TiO2 nano particles have shown increased fracture toughness, flexural strength, compressive strength and antibacterial activity.

IMPRESSION MATERIALS: Nano fillers in Poly Vinyl Siloxane (PVS) have shown good flow, improved hydrophilic properties and superior detail precision. Trade name Nano Tech Elite HD+. These nano filled silicone impression materials have shown a high degree of fluidity compared to from the original viscosity.

MAXILLO-FACIAL PROSTHESIS: Addition of surface treated Silicone dioxide nano particles in 3% concentration have improved the mechanical properties, especially the tear strength [42,43]

.Digital Oncology:

In oncology, digital technologies have revolutionized how cancer is detected, diagnosed, and treated, providing more personalized and efficient care. Key advancements include:

AI and Machine Learning: These technologies help analyze vast amounts of data from medical imaging, pathology reports, and genetic information to identify cancer earlier and predict treatment responses.

Precision Medicine: Advances in genomics, supported by digital tools, allow oncologists to develop tailored treatment plans based on a patient's genetic profile, optimizing therapy.

Digital Pathology: Allows for more efficient and precise diagnosis by digitizing tissue samples, enabling remote consultations, and enhancing data storage and retrieval for future analysis.

Radiomics: Involves the extraction of large amounts of data from medical images to uncover patterns that may be overlooked, improving tumor characterization and treatment response predictions.

12. SUMMARY AND CONCLUSION

Sophisticated new technologies are continually being introduced to dentistry because of the rapid scientific progress occurring today. Dentists seem to have an innate love for new technologies. Today, more than ever, there is a need for such expanding technology. While we are seeing a decline in dental disease among young patients we also are facing an aging population. People are living longer, keeping their dentitions longer and want to maintain their dentitions throughout their lives. They need and demand services that are often complex. Technology needs to evolve to respond the shift in dental concerns. These advances should make consistently successful treatment of increasingly complex conditions possible.

In turn, new technologies challenge the current paradigms of dental practice and will lead to significant shifts in future treatment modes. However, in the future, not only will dentists recommend more sophisticated preventive measures, but also they will be able to detect incipient caries at a point where remineralization, rather than restoration, can achieved. **In both fields of Digital Dentistry and Oncology, the integration of digital tools improves not only accuracy and outcomes but also enhances the overall patient experience, providing faster, more precise treatments and diagnoses.**

REFERENCES

[1] Gupta C, Mittal A. Role of digital technology in prosthodontics: A step toward improving dental care. Indian J Oral Health Res 2018;4:35-41.

[2] Paul L, Child JR. Digital dentistry. Is this the future of dentistry? Dent Econ 2011;101:10.

[3] Jayachandran S. Digital imaging in dentistry: A Review. Contemp Clin Dent 2017;8:193-4.

[4] Devi N, Kumar PA, Rakshna M, Rameshkumar KR. Application of lasers in prosthodontics: A review. J Indian Acad Dent Spec Res 2018;5:42-5.

[5] Gosawi S, Kumar S, Lakhyani R, Bacha S, Wangadangi S. Lasers in prosthodontics – A review. J Evol Med Dent Sci 2012;1:624-33.

[6] *The use of CAD/CAM in dentistry. Davidowitz G, Kotick PG. Dent Clin North Am. 2011;55:559-70.*

[7] *CAD/CAM dental technology. McLaren E.Compend Contin Educ Dent. 2011;32:73-6, 78-80.*

[8] *Talking with patients. Chairside CAD/CAM in dentistry. Ritter AV. J Esthet Restor Dent. 2003;15:127.*

[9] *A review of dental CAD/CAM: current status and future perspectives from 20 years of experience. Miyazaki T, Hotta Y, Kunii J, Kuriyama S, Tamaki Y. Dent Mater J. 2009;28:44–56.*

[10] *Computer-aided design and manufacturing in dentistry: a review of the state of the art. Rekow D. J Prosthet Dent. 1987;58:512–516.*

[11] Bisler A, Bockholt U, Kordass B, Suchan M, Voss G. The virtual articulator. Int J Comput Dent. 2002;5:101-06.

[12] Kordass B, Gartner CH, Gesch D. The virtual articulator - a new tool to analyze the dysfunction and dysmorphology of dental occlusion. Aspects of Teratology. 2000;2:243–47.

[13] Kordass B, Gartner CH. Virtual articulator: usage of virtual reality tools in the dental technology. Quintessence of Dent Tech. 2000;12:75-80.

[14] Solaberrieta E, Etxaniz O, Minguez R, Muniozguren J, Arias A. Design of a virtual articulator for the simulation and analysis of mandibular movements in dental CAD/CAM. Cranfield, England: Proceedings of the 19th CIRP Design Conference – Competitive Design; Cranfield University; 2009. p. 323.

[15] Kordass B, Gartner C, Sohnel A, Bisler A, Voss G, Bockholt U, et al. The virtual articulator in dentistry: concept and development. Dent Clin North Am. 2002;46:493-506.

[16] Yamamura M, Takahashi A, Aoki H, et al. [A study on display and accuracy of occlusal contacts by means of T-Scan system.] Kanagawa Shigaku 1990;25(2):236-241.

[17] Lyons MF, Sharkey SW, Lamey PJ. An evaluation of the T-Scan computerised occlusal analysis system. Int J Prosthodont 1992;5(2):166.

[18] Throckmorton GS, Rasmussen J, Caloss R. Calibration of T-Scan® sensors for recording bite forces in denture patients. J Oral Rehabil 2009;36(9):636-43.

[19] Gözler S, Vanlioglu B, Evren B, Gözneli R, Yildiz C, Özkan YK. The effect of temporary hydrostatic splint on occlusion with computerized occlusal analysis system. Indian J Dent Res 2012;23(5):617-22.

[20] Kerstein RB. Current applications of computerized occlusal analysis in dental medicine. Gen Dent 2001;49(5):521-30.

[21] Palomo L, Palomo JM. Cone beam ct for diagnosis and treatment planning in trauma cases. Dent Clin North Am 2009;53(4):717-727, vi-vii.

[22] Razavi T, Palmer RM, Davies J, Wilson R, Palmer PJ. Accuracy of measuring the cortical bone thickness adjacent to dental implants using cone beam computed tomography. Clin Oral Implants Res 2010;21(7):718-725.

[23] Scarfe WC, Farman AG, Sukovic P. Clinical applications of cone-beam computed tomography in dental practice. J Can Dent Assoc 2006;72(1):75-80.

[24] Galante DL. History and current use of clinical photography in orthodontics. J Calif Dent Assoc 2009;37:173-4.

[25] Yoo A. 10 reasons why dental photography should be an essential part of your practice. Dent Econ 2014;104:1-7.

[26] Geissberger M. Esthetic Dentistry in clinical practice. WileyBlackwell Publishers; 2010.

[27] Desai V, Bumb D. Digital dental photography: A contemporary revolution. Int J Clin Pediatr Dent 2013;6:193-6.

[28] Sreevatsan R, Philip K. Digital photography in general and clinical dentistry-technical aspects and accessories. Int Dent J Stud Res 2015;3:17-24.

[29] Coachman C, Calamita M. Digital smile design: a tool for treatment planning and communication in aesthetic dentistry. Quintessence Dent Technol. 2012;35:103–111.

[30] Daher R, Ardu S, Vjero O, Krejci I. 3D digital smile design with a mobile phone and intraoral optical scanner. Comp Cont Educ Dent. 2018;39(6):5–8.

[31] Aragón ML, Pontes L, Bichara L, Flores-Mir C, Normando D. Validity and reliability of intraoral scanners compared to conventional gypsum models measurements: a systematic review. Eur J Orthod. 2016;38:429–434.

[32] Zanardi PR, Zanardi RL, Stegun RC, Sesma N, Costa BN, Laganá DC. The use of the digital smile design concept as an auxiliary tool in aesthetic rehabilitation: a case report. Open Dent J. 2016;10:28.

[33] Coachman C, Calamita MA, Sesma N. Dynamic documentation of the smile and the 2D/3D digital smile design process. Int J Periodontics Restor Dent. 2017;37(2):183–193.

[34] Miller LL. Shade matching. Journal of Esthetic Dentistry 1993;5:143–53.

[35] Yamamoto M. The value conversion a new concept for expressing the shades of natural teeth. Quintessence of Dental Technology 1992;19:9–13.

[36] Evolution of materials. Journal of Dental Technology 2000;3:9–10.

[37] Goldstein GR, Schmitt GW. Repeatability of a specially designed intraoral colorimeter. Journal of Prosthetic Dentistry 1993;69:616–9.

[38] Yamamoto M. Development of the vintage halo computer color search system. Quintessence of Dental Technology 1998;21:9–26.

[39] Advances in Nanotechnology for Restorative DentistryZohaib Khurshid, Muhammad Zafar, Saad Qasim, Sana Shahab, Mustafa Naseem, Ammar AbuReqaibaMaterials (Basel) 2015 Feb; 8(2): 717–731

[40] Role of Nanotechnology in Dental implants Dr. Umesh Y. Pai ,JIMD2015; 2(3): 186-203

[41] Nanomaterials and their application in prosthodontics: a reviewIvy Fernandes Coutinho1, Meena Ajay Aras1, Kathleen Manuela D'souza1Journal of Research in Dentistry 2018, 6(6):124-131

[42] Kanaparthy R, Kanaparthy R The changing face of dentistry: nanotechnology Int J Nanomedicine. 2011; 6: 2799–2804

[43] Ensanya Ali Abou Neel,Laurent Bozec, Roman A Perez, Hae-Won Kim,Jonathan C Knowles Nanotechnology in dentistry: prevention, diagnosis, and therapyInternational Journal of Nanomedicine 2015:10(1) ;6371—6394