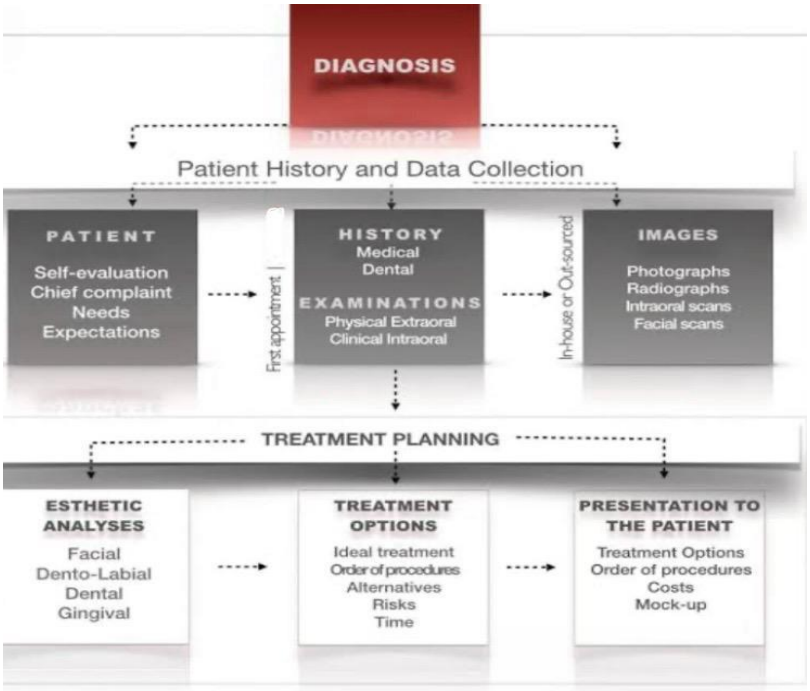
NAVIGATING THE DIGITAL FRONTIER IN DENTISTRY

1. Introduction

Today, digital dentistry has revolutionized the way dental professionals provide patient care. It refers to the use of digital technologies in all aspects of dentistry, including diagnosis, treatment planning, and restoration; encompassing a range of technologies, including computer-aided design/computer-aided manufacturing (CAD/CAM), three-dimensional (3D) printing, artificial intelligence (AI), augmented reality (AR), and teledentistry, a rapidly evolving and transformative field.

Digital dentistry is the term used to describe the different modalities of dental treatment workflow that are mostly performed with the use of digital technologies. Several digital methods have been incorporated into dental practice to replace conventional methods and techniques in order to enhance treatment planning and predictability of execution. Nowadays, digital dentistry is considered a whole field of study within dentistry. As with any other field of study, digital dentistry involves a learning curve to be mastered and used in the clinical routine. Ultimately, the dental professional is responsible for using existing digital tools appropriately for patient treatment.



2. Importance of digital dentistry

[1] Better Patient Experience: Digital dentistry provides a more comfortable experience for patients. The use of digital tools like intraoral cameras eliminates the need for uncomfortable and bulky dental trays, providing a more pleasant experience for patients.

[2] Improved Communication: Digital dentistry allows for better communication between dentists and patients. Using 3D imaging and digital treatment plans, dentists can show patients exactly what their treatment will entail, making it easier for patients to understand and participate in their dental care.

[3] More Accurate Restorations: With digital dentistry, dental restorations can be precisely designed and manufactured using CAD/CAM technology. This results in restorations that are more accurate and natural-looking than traditional methods.

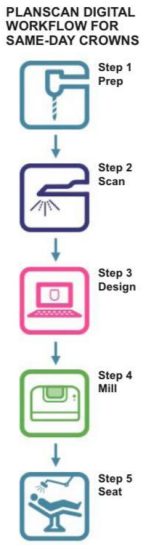
[4] Reduced Radiation Exposure: Digital X-rays emit significantly less radiation than traditional X-rays, making them a safer and more environmentally friendly option for dental care.

[5] Increased Efficiency: Digital dentistry streamlines the dental care process, reducing the time and resources needed to perform many procedures. This can result in cost savings for both dentists and patients.

3. History of digital dentistry

The history of digital dentistry can be traced back to the 1970s, when the first computerized tomography (CT) scanners were introduced. In 1971, the first computer-controlled dental drill was developed by Robert Ledley, a physicist and dentist at the National Institutes of Health. Later, in the 1980s, the first CAD/CAM system was introduced for dental restorations, allowing the computer-aided design of dental restorations, which could then be milled out of a block of material using a CAM system. The first 3D printer for dental use was introduced in the 1990s. Furthermore, one of the early pioneers of digital dentistry was CEREC (Chairside Economical Restoration of Esthetic Ceramics), a system developed in the early 1990s by German company Sirona, which uses digital imaging and CAD/CAM technology to create custom restorations, such as crowns and bridges, in a single visit.

4. Current state of digital dentistry



Chairside digital dentistry, aided by tremendous advancements in technologies, equipment, and materials, has seen a rapid increase in popularity, particularly over the past few years and even months. One possible reason for this recent boost could be a surge in online continuing education, with clinicians gaining increased knowledge in this field. A second, perhaps more compelling, reason may be the COVID-19-related quest to complete more dental treatment in one patient appointment rather than following a "quick patient turnover" scheduling approach. With its ability to provide patients definitive indirect restoration from virtually any material in one appointment-thereby reducing in-office patient traffic and the need for more frequent dental chair cleaning and heightened personal protective equipment usage-chairside digital dentistry has become increasingly appealing, and its numerous advantages are now more obvious than ever before. The number of intraoral scanners (IOSs), milling machines, sintering furnaces, 3D printers, and other CAD/CAM equipment specifically designed for chairside application is increasing exponentially. Several manufacturers offer various components of the chairside digital workflow individually, such as scanners, chairside milling machines, and ceramic furnaces with small, office-friendly footprints.

5. Real-life examples of recent advancements in the application of digital dentistry

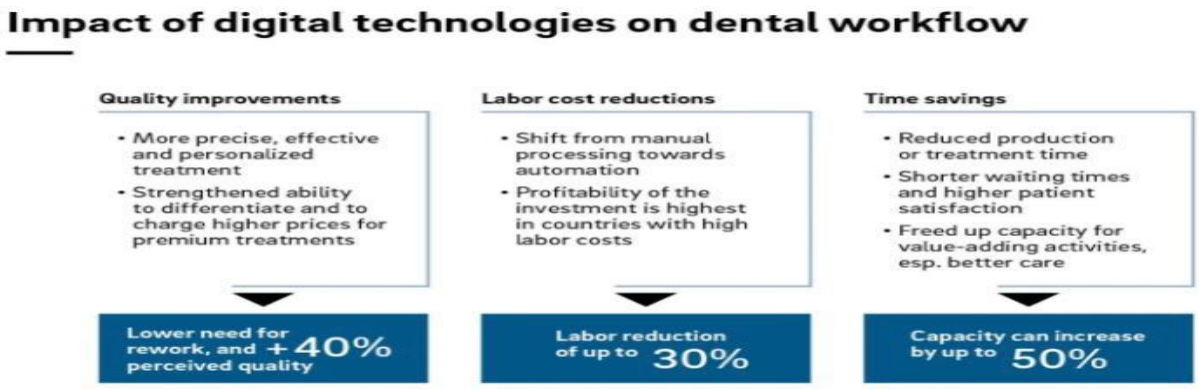
DIGITAL DENTISTRY APPLICATION	*APPLICATION*	*CRITICAL TECHNOLOGIES*	*REAL-LIFE EXAMPLES*
PAST			
Digital impressions	Dental restorations	CAD/CAM, intraoral scanners	This technology captured detailed digital images of the patient's teeth and surrounding oral structures, which were then used for dental restorations such as crowns and bridges. Real-life examples include 3M True Definition Scanner and iTero Element Scanner.
Computer-aided implant placement	Implant dentistry	CBCT Imaging, CAD/CAM	Computer-aided implant placement involved the use of cone-beam computed tomography (CBCT) imaging to create 3D models of the patient's oral structures. Real-life examples include SimPlant and Blue Sky Plan.
PRESENT			

3D printed dental models	Prosthodontics, orthodontics	3D printing, CAD/CAM	3D printing technology is used to create physical models of the patient's teeth and jaw structures from digital scans. Real-life examples include Formlabs Form 2 and Stratasys Objet30 Dental Prime.
AI-based caries detection	Diagnostics	Artificial intelligence, image processing	Artificial intelligence (AI) algorithms analyze dental images, such as X-rays and intraoral scans, to detect and diagnose dental caries (cavities) accurately. Real-life examples include Denti.AI and Dentulu.
Augmented reallity dental stimulations	Patient education	Augmented reality, 3D imaging	Augmented reality (AR) applications allow patients to visualize potential treatment outcomes by overlaying virtual dental restorations onto real-world images of their mouths. Real-life examples include DentalAR and DentalViewer.
Personalized prosthodontics	Prosthodontics.	Digital scanning, CAD/CAM, 3D printing	Digital scanning of the patient oral structures combined with CAD/CAM software and 3D printing technology will enable the fabrication of highly personalized and precise dental prostheses with improved function and esthetics.

FUTURE

AI-powered treatment planning	Oral surgery	Artificial intelligence, image analysis	Artificial intelligence algorithms will analyze patient data, such as dental images, medical history, and genetic information, to create personalized treatment plans which will improve treatment efficiency and predictability.
3D printed biocompatible implants	Implant dentistry	3D printing, CAD/CAM, biomaterials	3D printing technology will advance to fabricate biocompatible dental implants directly from digital designs. Customized implants with optimal fit and aesthetics will be created using CAD/CAM software and specialized biocompatible materials.

Teledentistry consultations	Remote dental care	Telecommunication, imaging technology	Teledentistry enables remote consultations and diagnosis through video conferencing, image sharing, and patient monitoring. Real-life examples include MouthWatch TeleDent and Denteractive.



5.1. Digital radiography

Digital radiography is the use of optical face scanners to produce a clear map of teeth and dental impressions. These scans can be viewed, printed or assessed by the dentist while you are in the chair.

In addition, digital radiographs emit up to 70 percent less radiation than traditional X-rays and are more environmentally friendly. At Coastal Dental Care, our practices use several types of 3D intra-oral scanners including CEREC Omnicam, 3Shape TRIOS, and iTero.

5.2. Cone-beam computed tomography imaging (CBCT)

A Cone-beam CT is a rotating X-ray machine which provides a three-dimensional view of teeth and the oral anatomy. Additionally, this imaging technique identifies oral conditions which are not detectable by regular X-ray screenings. A CBCT can also determine the exact position of teeth and their roots.

5.3. Intra-oral cameras

Intra-oral cameras allow dental practitioners to see clear, accurate images of the mouth. Shaped like a wand, the camera can magnify images on a computer screen in real time. This enables patients to clearly see what the dentist is doing or referring to. In addition, the intra-oral camera can provide a detailed view of hard to see areas in the mouth. This helps to accurately identify problems such as a fractured tooth.

5.4. Computer aided design or computer aided manufacturing (CAD/CAM) and 3D printing

Computer aided design and 3D printing have made it more efficient for practitioners to design and manufacture dental restorations. Such restorations may include porcelain crowns, bridges, or veneers.Computer aided dentistry allows dentists to design, fabricate and insert dental restorations on the same day. Traditionally, a dental laboratory would make the restoration. This process could take up to 3 weeks. The new technology, however, means that the patient can receive the final restoration within a day.

5.5. Digital smile designing

The digital smile design is a multiuse tool that can assist the restorative team throughout treatment, improving the dental team's understanding of the esthetic issues and increasing patient acceptance of the final result. The placement of references lines and other shapes over extra- and intra-oral digital photographs widens the dental team's diagnostic vision and helps to evaluate the limitations, risk factors, and esthetic principles of a given case. These critical data will lead to improved results in all phases of treatment.

Various software available such as Smile Designer Pro, Visagismile, Digital Smile Design, Planmeca Romexis® Smile Design, 3Shape Smile Design, Photoshop CS6 (Adobe Systems Incorporated), Keynote (Apple Inc.), Smile Designer Pro (Tasty Tech Ltd),

5.6. Shade matching

Visual shade matching is now being overrun with automatic shade selection devices such as colorimeters, spectrophotometers, and digital imaging devices which give more consistent shade and a near-life effect with color

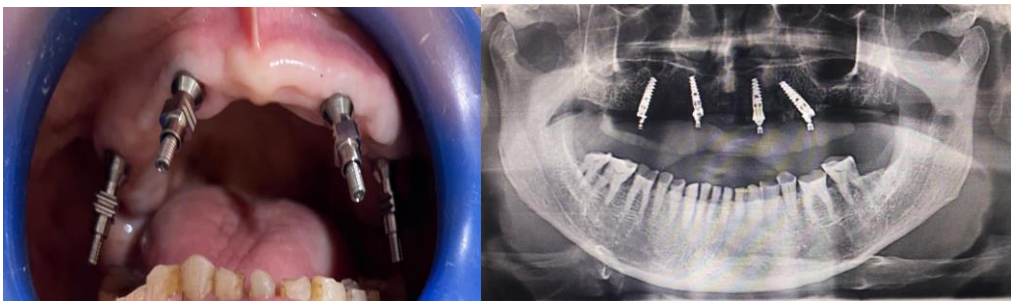
mapping of tooth selected. Digital imaging and shade matching decrease the interoperator and intraoperator variability and also ease the communication with the laboratory.

Colorimeters measure the tristimulus values in the red, green, and blue areas of the visual color spectrum. The ShadeVison® (X-Rite, Grandville, MI, USA) and ShadeEye NCC® (Shofu, Menlo Park, CA, USA) are two of these colorimeters.

Shade vision system can send the shade information to the dental laboratory via e-mail, disk or printout.

5.7. 3D printing technology

A relatively new addition to digital dentistry, involving the use of a CAD file to produce physical models, custom surgical guides, implant abutments, and even dental restorations. 3D printing technology (additive manufacturing) revolutionized the fabrication process of dental prostheses, reducing the time and cost of production.



Intra oral picture Radiographic picture

Figure shows "real life example of additive manufacturing by 3D printing technology "

5.8. Virtual articulators and digital facebow

The virtual facebow is developed to provide an alternative to the conventional facebow for the mounting of casts to an articulator. The virtual facebow implements several design features:

1. To prevent and minimize errors.

2.To provide accurate mounting and reinforce the anatomical considerations associated with articulators

5.9. AI in dentistry

AI has found its way into dentistry and has the potential to improve diagnosis, treatment planning, and patient outcomes. AI algorithms can analyze large amounts of data, including radiographic images and clinical records, to assist in the *early* detection of oral and dental diseases and help provide personalized treatment plans.

6. Challenges, limitations and future directions

Digital dentistry brings many challenges for dentists and dental technicians as well as society. Cost is the major limitation of most areas of digital dentistry because a higher capital investment generally needed to adopt new technology. Other limitations are as follows.

1. Large digital gap between dentists and dental technicians

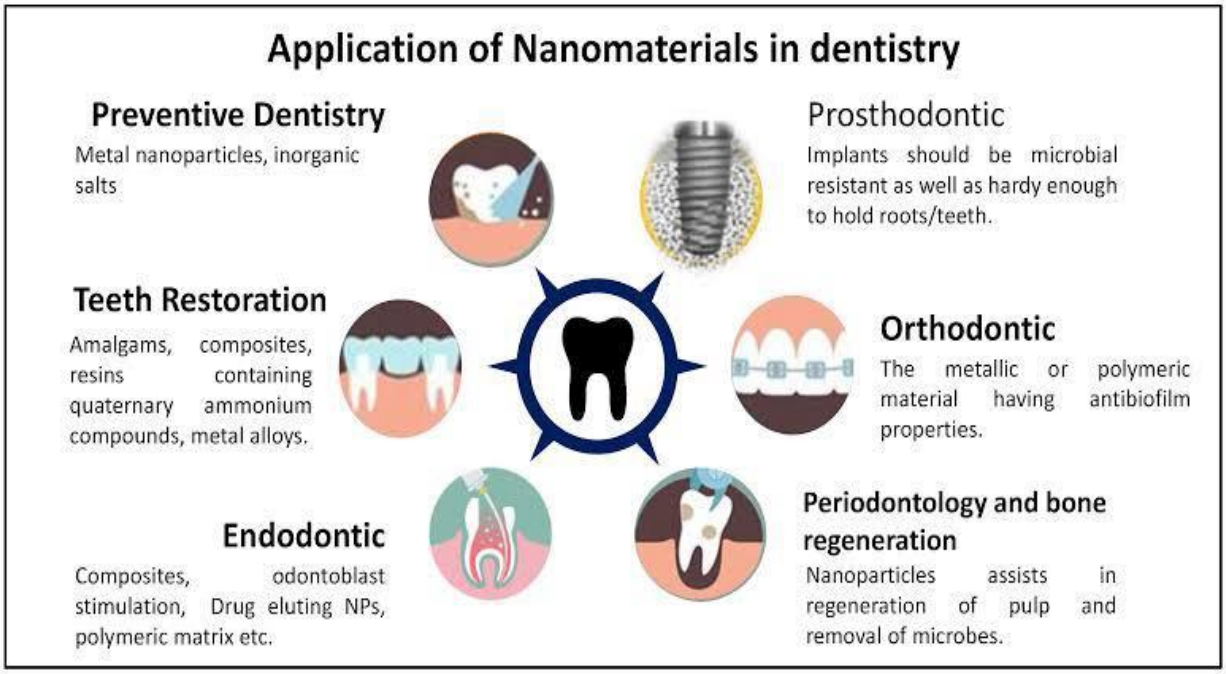
Technicians are steps ahead of the dentists in terms of digitalization. receiving digital impressions, designing the models in computer software, and sending the digital information to milling machines that create the prosthetic restorations. On the other hand, many of the dentists are still using conventional techniques, taking molded impressions of their patients' teeth, and physically transporting the impressions to the dental labs.

2. Maintaining a balance between simplicity, speed, and reliability.

Digitalization demands speed with simplicity and reliability. As technology develops rapidly, the manufacturing companies also grow too fast to provide speed and simplicity. Along with this, they need to stabilize their hardware and software so that the digital techniques also maintain their reliability. So, it is a responsibility of manufacturing companies to make sure about quality of their products.

NanoDentistry

Today, *nanoDentistry* or the application of nanotechnology (use of materials and devices at the nano-scale — one billionth of a meter — to create new materials and devices with unique properties) in dentistry involves the employment of nanomaterials and nanorobots for diagnosis, treatment, and prevention of dental diseases.



7. Conclusions

Digitalisation is one of the most important parts of modern dentistry. If digitalization is implemented in clinical dentistry with proper knowledge, then it can increase the joy of practicing dentistry and better care for patients. To achieve a fully digitalized workflow in dental care, prosthodontist should start using the digital techniques to the same large extent as the technicians. They should keep knowledge of all ongoing advancement in dentistry and use judicially in their practice to meet today's patient's needs and improve their own workflow.

Digitalisation dentistry has transformed the field of dentistry, improving the precision, accuracy, and efficiency of dental procedures, as well as patient outcomes. Advancements in imaging, CAD/CAM technology, 3D printing, and regenerative dentistry have transformed the dental industry. Current and future applications of digital dentistry, such as AI, AR, and teledentistry, have the potential to further enhance the capabilities of digital dentistry. Indeed, it can be stated and expected that the future of digital dentistry is exciting and promising, with new technologies and innovations emerging and progressing all the time.

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