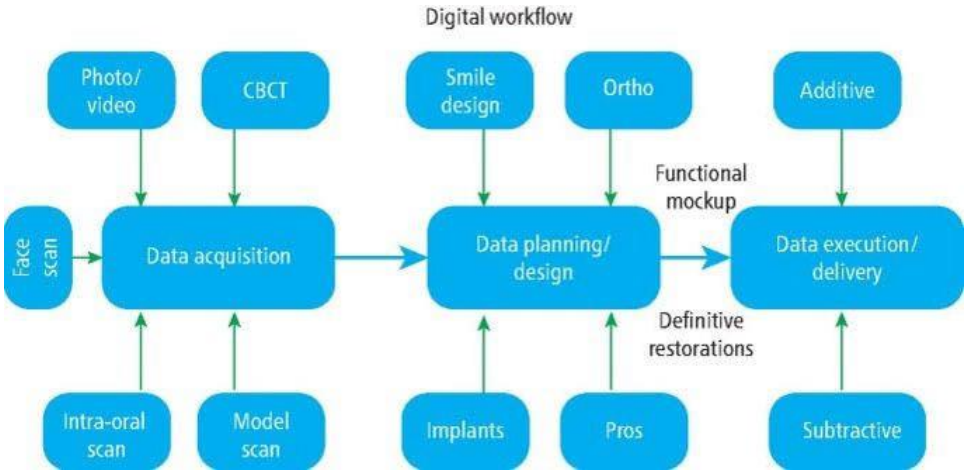
NAVIGATING THE DIGITAL FRONTIER IN DENTISTRY

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 refers to the use of advanced digital technologies in dental practices and laboratories which are designed to enhance the accuracy, efficiency, and overall quality of dental treatments and procedures. These technologies can be used in a variety of dental fields, including restorative dentistry, orthodontics, implant dentistry, and cosmetic dentistry, enhancing our abilities to create highly accurate and personalized treatment plans for each patient.



2. Importance of digital dentistry

[1] The use of AI and machine learning (ML) in digital dentistry is increasing, allowing for personalized treatment recommendations based on patient data analysis.

[2]. Develop intelligent systems that can assist in diagnosis and treatment planning.

[3]. Systems can analyze large volumes of patient data to provide personalized treatment recommendations.

[4]. 3D printing allows for more precise and accurate fabrication of dental structures, reducing treatment time and improving outcomes.

[5]. The socioeconomic impact(s) of digital dentistry research can be significant, improving access to care, reducing costs, improving patient outcomes, and creating new job opportunities.

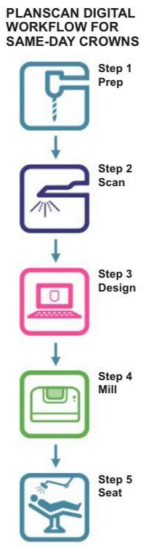
[6]. Digital technologies such as 3D printing can help reduce the cost of dental treatment by allowing for more precise and accurate fabrication of dental structures.

[7]. This leads to improved overall health and quality of life for patients. Therefore, as digital technologies become more prevalent in dentistry, there will be a growing need for dental specialists and professionals with expertise and training in these areas. In turn, this can lead to further job and employment creation in fields such as dental technology, digital dentistry, and tele dentistry, amongst others

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



Digital dentistry is now an integral part of modern dentistry. CAD/CAM systems are used for the design and fabrication of dental restorations, while 3D printing technology is used for the fabrication of prosthetic and surgical guides, models, and orthodontic appliances. AR technology is being used to improve patient education and treatment planning, while teledentistry is being used to improve access to dental care for patients in remote or underserved areas. Such technologies can help us to analyze patient data, make more accurate diagnoses, and develop personalized treatment plans. Artificial intelligence and Machine learning algorithms are also being used to control robotic dental systems. For example, a robotic arm can be programmed to perform specific dental procedures with greater precision and accuracy, thereby greatly reducing the risk of human error.

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 implant treatment planning

Modern oral implantology and implant prosthetics depend on comprehensive diagnostics and precise planning to ensure the desired outcome and meet the patient's and the dentist's expectations. Digital implant planning involves

the use of cone beam computed tomography (CBCT) scans and CAD/CAM software to design and place dental implants with greater precision and accuracy. For example implant prosthesis metal prototype fabricated by powder bed fusion.

5.2. Digital smile design

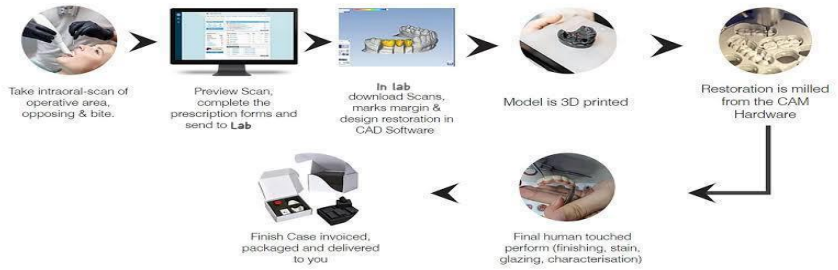
DSD or digital smile design, basically, involves the use of digital imaging software to create a virtual 3D model of the teeth and gums of a patient. This model is then used to design a custom treatment plan to improve the appearance of the smile. This technology can also be used to show patients what their smile will look like post-treatment, thus helping them make informed decisions about their dental care.

5.3. Teledentistry

Teledentistry, as aforementioned, is a form of telemedicine, involving digital technologies to provide dental care and consultation remotely, where patients can receive dental consultations, screenings, and even some treatments without needing to visit a physical dental office (so, increasing convenience and reducing costs). It is particularly useful for patients in isolated, distant, or underserved areas who may not have access to dental care.

5.4. Digital occlusal analysis and prosthetic design

Digital occlusal analysis involves the use of digital sensors to analyze a patient's bite and occlusion. This technology can identify areas of high pressure or wear on the teeth, which can help dental professionals diagnose and do treatment by fabrication of accurate prosthesis.



5.5. Intraoral scanning technology

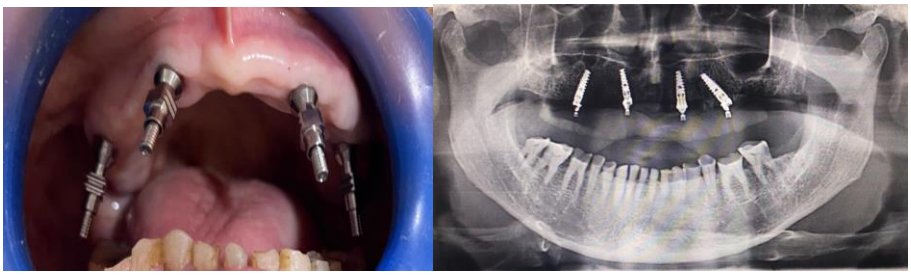
Hand-held intraoral scanners have become an integral part of dental treatment. These scanners use optical or laser technology to capture highly detailed digital impressions (and create virtual models) of the teeth and gingiva, eliminating the need for traditional impressions.

5.6. Digital radiography

A modern alternative to traditional film-based radiography that involves capturing radiographs using digital sensors that produce high-quality images with less radiation exposure. The images can be stored digitally and then easily shared with other dental/medical professionals for joint diagnosis, treatment planning, and follow-up.

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. Regenerative dentistry

Using stem cells, growth factors, and other biologic materials to regenerate damaged or missing tissues in the oral cavity is another area that has been impacted by digital technologies. Tissue engineering and 3D printing have the potential to revolutionize the way dental professional approach dental regenerative procedures. Indeed, digital images and models can help design customized scaffolds and implants and then 3D printing using biocompatible materials such as ceramic or polymer help create them for use to regenerate damaged or missing tissues.

5.9. AI in dentistry

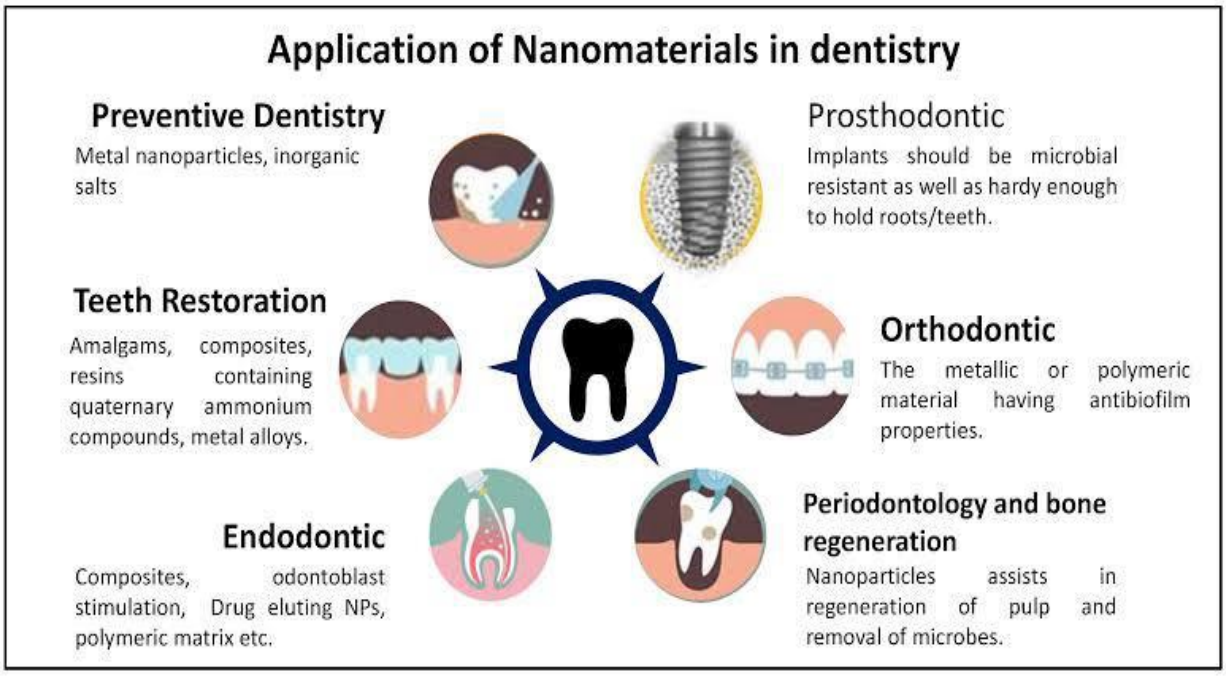
AI has found its way into dentistry and has the potential to improve diagnosis, treatment planning, and patient outcomes. AI algorithms can analyze large amounts of data, including radiographic images and clinical records, to assist in the *early* detection of oral and dental diseases and help provide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

6. Challenges, limitations and future directions

Despite the many advantages of digital dentistry, there are also challenges and limitations. These include the cost of technology, the need for specialized training, and the potential for technological errors or failures. Another potential limitation of digital dentistry is the risk of cybersecurity breaches and patient privacy violations. Digital images and patient data are vulnerable to cyber-attacks, and dental professionals must ensure that they have adequate security measures in place to protect patient information. Finally, some dental professionals may be hesitant to adopt digital technologies due to concerns about job loss and automation. However, it is important to recognize that programmed dentistry is not intended to replace dental professionals but rather to enhance their capabilities and improve patient care.

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 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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