



## **Emerging Dental Practices in a Technology Driven Era**

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### **ABSTRACT**

*Technology and digitalization are profoundly changing the shape of the world today, impacting every industry and consumers around the globe. Digital transformation is not only about the evolution of devices but also about the integration of intelligent data into everything that we do. So, in these digital times, like any other industry, dentistry has also undergone a major breakthrough. Although the basic principles of diagnosis, treatment planning and management remain almost similar, but an array of computerized and digitalized devices based on Artificial Intelligence have completely revolutionized the dental practices, thus leaving little room for error. This article aims to review many such upcoming advancements in dentistry encompassing the use of artificial intelligence in dentistry, 3D printing materials, smart toothbrush, tooth regeneration; robotics in dentistry, teledentistry etc.*

**Keywords:** Artificial intelligence; smart toothbrush; regenerative dentistry; 3D printing; Robotic-assisted dentistry

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### **INTRODUCTION**

The history of dentistry is almost as ancient as the history of humanity and civilization itself. The journey of dental practice from the crude tools of the historic era to the sophisticated computerized equipment in the 21st century is indeed remarkable. The past two decades have offered quantum leaps in the practice of dentistry, witnessing its evolution from a humble mechanical form to a completely digitalized model.

Technological innovations are just like software updates, very important for the advancement of any industry. And just like any other branch, the Dental technology has also continued to advance and introduce new technologies that improve the existing workflows. An array of computerized and digitalized devices based on Artificial Intelligence have completely revolutionized the dental practices, thus leaving little room for error. These innovations and advancements have proven to be beneficial for both the Dentists and the patients. Besides the advancements in the dental clinics, the home care dental products have also undergone a major revolution. The article gives a glimpse of much such upcoming advancement in dentistry and dental care.

### **ARTIFICIAL Intelligence**

Artificial intelligence or AI refers to the genesis of human intelligence in machines. Hence, it applies that machines are programmed to mimic human brain like the ability to think, learn, reason and do problem solving and decision making like humans.

AI is being checked and used in the healthcare industry from diagnosis to treatment planning and even performing surgical procedures in the operating room.

Not surprisingly, Artificial Intelligence has carved its path towards the dental arena also from diagnostic methodologies to detect the unnoticed lesions of oral cavity to developing a precise prosthesis using a computerized methods and technology. Thus, System based on Artificial Intelligence have replaced the conventional methods of casting inlays, onlays, crowns and bridges and more prosthesis thus reducing time and adding precision.

Application of Artificial Intelligence in dentistry broadly includes three methodologies namely artificial neural networks, genetic algorithms, and fuzzy logic. A model build by Kim et al. based on the principle of Artificial Neural Network can indicate any tooth related discomfort or tenderness by generating its association with everyday tooth brushing time and frequency, dental floss usage, toothbrush replacement routine, oral prophylaxis procedures experiences and other factors like dietary habits and daily exercise [1]. This prototype also takes into account prevention of stress or stress related factors, proper eating habits, and oral hygiene maintenance practices as the most important factors in preventing

toothaches.<sup>1</sup>On the other hand, Genetic algorithms are used to reduce mechanical fracture and provide durable strength to the implant by the augmentation of dental implant systems [1]. And thirdly, fuzzy logic that aims to mimic human reasoning ability [1]. A system based on fuzzy logic was designed by *Ambara and colleagues*, which is time-saving and economical, and an instrument-free consultation can be done that reduces fear and anxiety of the patient [1].

### **Smart Toothbrush**

From smartphones to smart watches, smart devices have overruled mankind. Manual brushes are the choice for routine use by the individuals but it's the addition of the brilliant technology that makes it effective in plaque control. An electric smart toothbrush along with its app makes sure that brushing of teeth by the individual is carried the right way and offers fun games for toddlers and children to keep up the good habit of regularly cleaning their teeth and the built-in 3D sensors inserted in these toothbrushes gather and evaluate data about duration, accuracy and frequency of tooth brushing, detecting correct position of the toothbrush and orientation across different brushing zones in the oral cavity. Also the device with the help of algorithms based on artificial intelligence (AI), tracks of all the missed out areas and proposes customized recommendations to improve oral health care [2].

### **Regenerative Dentistry**

With advancing times, tooth replacement has travelled its journey from removable prosthesis to fixed ones to dental implants and now to tissue engineered bio tooth. Regenerative tooth repair therapy and recovery of a whole functional tooth is currently aspired for an unprecedented therapeutic notion with the complete restoration of physiological functions of the tooth.<sup>3</sup> Dental stem cells when seeded on scaffolds combined with cell-activating cytokines have the ability of differentiation into tooth tissues in vitro and in vivo and hence, considered to be a captivating approach for tooth regeneration [3]. Whole tooth replacement therapy appeals to be a fascinating option for future regenerative procedures as a form of bioengineered organ replacement.<sup>3</sup> The "organ germ method", an advanced three-dimensional cell manipulation method which involves compartmentalization of epithelial and mesenchymal cells at a high cell density to mimic multicellular set-up conditions and epithelial-mesenchymal interactions in organogenesis was developed for whole tooth regeneration [3]. The bioengineered tooth germ produces an anatomically correct tooth in vitro, and when grafted back into the oral cavity erupts successfully, with correct morphology, restored tooth functions such as mastication, response to noxious stimuli and functions of the periodontal ligament [3].

### **Clustered Regularly Interspaced Short Palindromic Repeats**

Clustered Regularly Interspaced Short Palindromic Repeats or CRISPR is the first-ever genome editing method in which a programmable protein can edit, eliminate and activate the genome or turn it off.<sup>4</sup> It alters a patient's own cells at gene level to fight cancer and in addition to combat cancer this technology has numerous potential uses in dentistry as it can diagnose and identify causative organisms or faulty genes and manipulate genes therefore treating various oral pathologies for instance dental caries.<sup>5</sup> The main causative agent for dental caries is streptococcus mutans.<sup>6</sup> Researchers to produce antimicrobials use RNA-guided nucleases (RGNs) CRISPR/Cas technology, whose field of action is selected by design.<sup>7</sup> RGNs causes selective destruction of targeted strains primarily based on genetic signatures additionally allow the modulation of complex bacterial populations. Other than dental caries, CRISPR technology can also prevent periodontitis by preventing dental plaque formation as it is observed that nearly 95% of clinical strains of *P. gingivalis* hold-up CRISPR arrays [8].

### **3D printing materials**

In the printing type technology, the effectiveness of any printer is directly proportional to the righteous materials they use. And for dentistry, the materials on the horizon are going to be revolutionary before insertion. To promote guided tissue regeneration, the permit for the cell population, adhesion and differentiation and initial mechanical support is provided by scaffolds produced by the biomaterials which are used to obtain the 3D print of the oral tissues [9]. Based on whether they are used for bone and for soft tissue regeneration, these biomaterials can be broadly divided into inorganic and organic respectively. The prerequisites for inorganic biomaterials are that they are mechanically stable, undergo slow resorption and do not trigger an inflammatory reaction. Due to stoichiometric similarity or biocompatibility between hydroxyapatite and natural bone's mineral phase has ensured reduction in the mechanical resistance and a prolonged resorption time [9]. With calcium phosphate binding chemically to the bone, manufacturing of desiderated shapes and forms gets easier, and resorption faster compared to hydroxyapatite. On the other hand, Organic biomaterials are polymers made from alginate, collagen, gelatin, agarose, fibrin, chitosan, which are of natural origin or synthetic origin, namely polylactide (PLA), polyglycolic acid (PGA), poly-lactic-co-glycolic acid (PLGA), or polycaprolactone (PCL). Hydrogels are either curable polymers which upon solidification produce mechanically solid scaffolds, or injectable soft hydrogels for soft tissue regeneration combination of both with cells; in the former case, the cells are

sown after curing to avoid roughcuring circumstances or coarse printing; on the contrary in the second, during printing, the cells nest within the bio-ink. 3D printing with hydrogels has another prime advantage that these bioactive agents can be incorporated effortlessly. Also an extremely versatile composition along with tissue revascularization, a controlled resorption rate and modulation of cell migration is achieved by the production of bioglass [9].

### **Tooth Remineralization**

Tooth remineralization, a process which one amongst the foremost captivating dental breakthroughs on the horizon. Dentists at King's College in London have developed a system called Electrically Assisted Enhanced Remineralization (EAER) which can remineralize a decaying tooth. This technique, uses a small electrical pulse to drive well mineralizes deep into the tooth to repair the demineralization that occurs from daily life [10]

EAER is a technique that aims at enhancing the uptake of the various remineralization factors towards the damaged tooth, which results in shifting of the equilibrium from demineralization state to remineralization state and the mechanism behind this process involves various steps – Cleaning and conditioning for the removal of all decayed material from the lesion, followed by Activation which includes optimization of lesion surface for remineralization. Then, the actual remineralization process takes place by increasing the concentration of all the natural minerals at the site which is to be repaired, with the help of electric field from a custom-made dental device. Therefore, the tooth structure is repaired naturally without any drill and fill [10].

### **Virtual Reality**

VR training can restructure dental education, both in dental school and in continuing education courses for the forthcoming dental professionals. Virtual Reality creates a highly detailed virtual model of the human anatomy which enables the clinicians and the students to have a better view of the patient's oral cavity and can make use of the concept of virtual reality to acuminate their skills and experiment with completely different ergonomic techniques without a real patient being present [11]. It lays out an accurate projection of a radiographic image in a virtual environment like a real-world situation, a visual representation of implants, bridge, crown, and orthodontics. It can take a visual scan of the patient mouth to improve the patient experience.

### **Robotics and Dentistry**

Robotics have continued to contribute to the medical field with assistance in the cardiac space, orthopedics, and within neurosurgery.<sup>12</sup> Robotics, microbots, and nanotechnology have the potentiality to support dentists and positively impact the sector of dentistry [12]. Robotics-assisted dentistry has evolved from traditional navigational surgery to more convoluted systems that will prove to be essential in the repair of oral lesions and maintenance of oral health using nanomaterials, nanorobots, and constructing of new diagnostic and therapeutic modalities [13].

Taking into account that endodontic procedures demands extreme precision and accuracy, endodontic microrobots can upgrade the authenticity and the quality of endodontic therapy.<sup>14</sup> Various procedures like automated probing, drilling, shaping and cleaning and filling of the root canal can be performed by this robot under e-monitoring and rational management [14].

Also talking about robotics in maxillofacial surgery- surgical robotics, a surgical robotic system has been developed through which the robot can conduct all the preprogrammed tasks throughout the surgery as programmed by the surgeon.<sup>14</sup> Some of the preprogrammed tasks can be drilling holes, deep saw osteotomy cuts, milling of bone surfaces, planning orthognathic surgery, osteosynthesis plates selection and bending and intraoperative positioning in defined position. Robotics is a world of perfection and precision and is yet to be introduced in many areas of dentistry [15].

### **Teledentistry**

Visiting a dentist for toddlers, children, and individuals with special needs or elderly in nursing homes or people living in distant rural areas is rare and somewhat back-breaking. Interpreted as the as the conduction of realistic and physical dental care along with diagnosis, treatment planning, consultation and follow-up through e-transmission from different sites, teledentistry is a combination of telecommunications and dentistry which has the potential to address many of these issues [16].

Teledentistry is split in two protocols: (a) realistic or real-time consultation and (b) store and forward. Real-time consultation comprises of an online video recording conference between the dental professionals and their patients, at different places and setting can communicate virtually with each other using advanced wireless technology and ultra-high bandwidth LAN connectivity. The store and forward protocol however collects and stores the exchanged clinical information and static images are within the telecommunication system.<sup>16</sup> Here, the dentist constructs the treatment planning through the established networks or the internet by gathering all the essential demographic and clinical data including the intraoral and extraoral images and digital or scanned radiographs of the patient [16].

## CONCLUSION

One of the noteworthy things about dentistry is that it is evolving every minute with the upcoming technologies. Each year brings new technologies in the dental world and further mutate with the approaching needs thus enhancing current workflows. While a few innovations are unvarying in nature like software updates or slight tugging in the direction of progressed and faster usability while some of the new procedures are so substantial that the promised drastic development is felt instantaneously. The overall intention of dental care is to provide optimal patient treatment; and in the forthcoming years, dentistry is poised to introduce many new eye-popping technologies that will revolutionize dental care and change modern day dentistry as a whole.

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