



## Virtual Reality: An Arsenal For Modern Dentistry In The Era Of COVID-19

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### Abstract

In the wake of the COVID-19 pandemic, the use of different digital imaging technologies is increasing that is revolutionizing health and healthcare for patients. Virtual Reality (VR) is one such promising tool which till date has been underutilized in dentistry. VR can be described as “a computer generated, three-dimensional world that creates a simulated environment in which the user interacts with virtual object or characters”. VR seems to have extensive application for planning, training, therapeutic treatments, pain management, behaviour modification and acclimatisation in dentistry. Thus, it helps enhance the clinical practice and dental education. Trainee dentist can learn and practice different dental techniques to keep their skill up to date. This technology is helpful in identifying new disease without causing any harm to the patient. Oral and maxillofacial surgery is the primary area of application, dental implantology, orthognathic surgery and paediatric dentistry are the other specialities that frequently use this application. Recently it is enabling the applications in restorative dentistry, orthodontics and endodontics. This review briefly summarizes the evolution of modern imaging technology and the advent of virtual reality technology as an essential tool that can be used efficiently in dentistry to combat the challenges innovatively and over the course of years may help us move towards the new era of technology and patient care in dentistry.

**Keywords:** Digital Imaging, Virtual Reality, Dentistry

### Introduction

In recent decades, different epidemics and pandemics have shown that human beings are still very vulnerable to infectious diseases. In December 2019, the new disease that had spread to many countries around the world, the COVID-19 pandemic, has been a situation that has generated a global health and economic crisis [1]. After announcing the need to assume “social distancing” and reducing all contact, education and training programs were deeply affected. The COVID-19 pandemic hit dental education hard, the rapid and forced change to virtual

teaching has affected dental practice and the training of professionals, who have always relied on face-to-face interaction to teach preclinical and clinical classes [2]. The cessation of preclinical and clinical activities has limited clinical skills learning opportunities for students. Likewise, it has not been possible to continue many of the treatments started [3]. The rapid advancement in the field of digital imaging has gradually challenged both traditional dental clinical practices and dental education learning methods. Nowadays, there are a lot of skills about the progress in the computer-based technologies such as

Virtual Reality (VR) and Augmented Reality (AR). VR refers to a non-conventional computer graphics system that creates a simulated environment having a virtual sense of reality or surrounding in which display technologies are developed in such a way that human mind perceives it as an absolute reality depending on the methods used which bring human to other world. The term 'augmented reality' have been coined by Caudell and Mizell, who worked for Boeing in the 1990s. In contrast to VR system, which provides only a computer-generated environment that elicits a user's sense of being present, Augmented Reality (AR) is a type of technology in which an environment is enhanced through the process of superimposing computer-generated virtual content over real structure, enhancing the sensory perception of reality. In a sense, AR can be considered as a subcategory of VR [4]. Virtual Reality (VR) can be described as the combination of multiple technologies allowing users to interact with virtual entities in real time [5]. The two main features of VR are immersion and interaction [6]. Immersion refers to the sense of presence in a virtual environment, while interaction refers to the user's power of modification [7]. VR helps enhance the clinical practice and dental education. Thus, it seems to have extensive application for treatment planning, training, therapeutic procedures and pain management in dentistry. It has an excellent capability to connect personalized service to the individual patient. This technology has a high clinical impact on dentistry and is more flexible for learning rather than two-dimensional images. Thus, it seems to be a proper technique for teaching and learning of dental professionals and students. VR technology, familiarizes the doctor with the patient's oral anatomy so that the dentist can gain much experience and feel free while performing the actual procedure. Virtual reality provides an innovative path for research and development in dentistry. The main limitation of this technology is the cost and lack of awareness amongst professionals [8]. This technology creates a highly realistic simulation for the dental patient. It opens up new avenues for dental professionals to communicate and treat patients from rural areas and at remote locations. In upcoming days, VR will remarkably provide positive patient experience, improve patient satisfaction and treatment. The aim of the current review is to

enlighten the value of virtual reality in the current dental practice with special emphasis during covid era.

### **Mechanism Of Virtual Reality:**

Virtual reality (VR) uses computer generated simulation of a 3D environment in which humans can interact with the help of specially designed electrical instruments such as gloves, helmet, treadmills, body trackers, and external sensors. It is an immersive and multisensory participative synthetic environment in which the user acts as an external observer which can improve the quality of life in an uncomfortable and hazardous situation and even in medical fields [9].

### **Discussion:**

The approach of teaching dental anatomy is changing worldwide and is moving away from dissection and lectures to a more integrated course, where basic science and clinical skills are taught simultaneously. There are considerable financial, ethical and administrative limitations associated with the use of cadavers which are considered as the gold standard for teaching anatomy to medical and dental science students. Dental students have reported a lack of confidence in their basic science knowledge, especially concerning anatomy. The continuous advancement in technology have successfully developed several new learning experiences that enables student to explore three-dimensional views of the human body without the limitations of traditionally used cadaveric teaching. Recent introduced technologies include augmented reality (AR) and virtual reality (VR). VR and AR are comprehensive technologies that are made up of many components: computation machines, operating software, display devices and tracking sensors. AR is an education tool that combines aspects of VR and AR by superimposing digital 3D holograms and 360 degree spatial sound onto the real world. Currently, VR still lacks true realism, although immersion is a basic feature of both VR and AR [4]. There have been multiple VR and AR anatomical tools that have been introduced to provide dental education. Most AR and VR devices include a head-mounted display, where an ergonomically assembled headset provides a viewable display for human-computer interaction. The HoloHuman is one recent entrant into the range of commercially available trainers that use VR-based technology. Other is the Microsoft HoloLens which

is a wearable headset that projects a visible image for the users. Many softwares such as HoloHuman, HoloPatient and HoloChemistry have been developed for these devices in order to be implemented for educational training [1]. Though there is very limited information on this innovative teaching system and its implementation into the dental anatomy curriculum. It enables dental students and teachers to accurately examine the process of learning and gain knowledge. VR enables 3D models for training to learn about the oral anatomy of the patient. Huang *et al* stated that VR technology will become an important tool in future dentistry. Roy *et al* used VR as the best education tool when compared with other traditional methods. It continually provides different benefits such as improving skill, coordination and training. By adopting this technology, there is a better experience and it proves to be an essential part of modern education. Thus, it has extensive application in education, clinical treatment and development. It creates a safe environment to reduce the risk during surgery [4,6]. Virtual online simulators, representing advances in technology and telecommunications, are presented as an opportunity in dental education before a student is faced with real situations in the clinic. The implementation of virtual reality simulators is increasing in areas of preoperative assessments, preclinical training, therapeutic training for less advanced students, and external accreditation of professional licenses. The phantom head simulator (mannequin) has been the iconic and leading device for dental education since its inception decades ago. Virtual haptic simulation (simulation of tactile, auditory and visual sensations) in education is innovative and can be implemented in preclinical practices. Their use in dentistry is associated with its various advantages such as reinforcement of learned dental concepts, correct ergonomic positioning, learning of psychomotor skills, correct use of dental instruments, faster acquisition of skills, positive student perception, availability after hours, opportunity for self-evaluation and standardized evaluation [9]. Technological advancements in virtual and augmented reality are enabling its application in the field of dentistry. Oral and maxillofacial surgery is the primary area of application, dental implantology, orthognathic surgery and paediatric dentistry are the other specialities that frequently use this application. Most

of the publications are on the assessment of the accuracy of virtual planning for orthognathic surgery. Three dimensional virtual surgery and mandibular reconstruction after cancer resection and reconstruction are the main applications of virtual reality. When it comes to Pediatric dentistry, the visual and audio stimuli that most commonly trigger anxiety are averted as the patient's attention is focused on the VR scenario. VR is also indicated for cognitive and behavioral therapies based on progressive exposition to different stimuli such as the dental anesthesia needle. VR could be used to distract patients during local anesthesia injections before dental procedures. Atzori *et al* applied VR for five pediatric dental patients between 13-20 years of age using this technology. After 1 week of controlled treatment satisfactory results were obtained. It significantly decreased the pain without any side effects. Therefore, the clinician preferred this technology for pediatric patients. The greatest total analgesia will likely be achieved when immersive interactive virtual reality and traditional pain medications are used simultaneously [7,10]. The reduction in fear for pediatric needle procedure is significant while using VR compared with standard methods of behavioral management or distraction techniques. The physiological response in children who received virtual reality devices during dental procedures have been investigated in two recent meta-analysis. The first one concluded that children with VR have a significant lower heart rate during local dental anesthesia. This result is based on 352 participants across 6 studies. However, there was no significant change in the oxygen saturation levels. Unlike the first meta-analysis, the second shows no significant improvement linked to VR use during the administration of local anesthetic at the placement of the surgical site. They concluded, however, that VR audiovisual distraction may reduce pain perception and improve child behavior during caries excavation followed with restoration. Psychological preparation for a surgical intervention by virtual visit of the operating room is possible and allows a reduction in preoperative anxiety scores. The main objective and interest of VR, in these cases, is the cognitive reprogramming of anxious patients. Moreover patients who are intolerant to pharmacological conscious sedations such as inhalation of nitrous oxide and oxygen or who cannot benefit from an

administration of benzodiazepines (midazolam) may also be treated under virtual reality. With growing interest in non-pharmacological techniques for anxiety and pain management, VR analgesia is a promising direction for future clinical research. Technology is advancing and has been driven lately by the COVID-19 pandemic. In addition to VR simulators that are used as an alternative teaching modality, the experience of using virtual reality has been identified as a more pleasant and enjoyable learning experience. As stated by Gallagher *et al* the medicolegal and economic impact of simulation training prior to certification in certain specialties or for “high risk” techniques is now well-recognized [11]. Moreover, patients may feel reassured to know that their surgeon has been trained on a simulator before performing an invasive procedure on their body as mentioned by Graber *et al* [12]. The reviews on the application of virtual reality and augmented reality in dentistry are mentioned (Table 1). Nevertheless, the incorporation of such simulators with virtual reality in the curriculum seems to be well justified today, it is still necessary to carry out studies to confirm their reliability, validity, precision of the different procedures and the evaluation of learning process. New simulators with different functions, 3D softwares and special programs for each speciality will continue to progress each day. They will be useful for virtual dental education and practical learning from home or elsewhere. Various systems and devices used in different specialities of dentistry are listed (Table 2). However, the precise adoption of these newer advancements in daily clinical practice will depend on the individual's ability and willingness to adapt themselves with the technology.

### Conclusion:

Simulation in dentistry is evolving, providing a safe environment with the possibility of better feedback and which emphasizes the importance of mentoring throughout the teaching-learning process. Virtual haptic simulation seek solutions to real-world challenges. Virtual simulation in dentistry is not a substitute for clinical practice with real patients, but improves students ability to perform dental procedures and develop preclinical manual skills. Thus, it seems to have extensive application for planning, training, therapeutic treatment and pain management in dentistry. It is interesting to see that a variety of training strategies can be implemented with

existing VR simulators to make most out of this new technology. Strong results may help improve the acceptance of VR training for skills and problem solving in dentistry and medicine.

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**Tables**

**Table 1: Recent reviews on the application of Virtual Reality and Augmented Reality in dentistry**

Author	Year	Aim	Conclusions
1. S. Zafar	2021	Investigated dental student’s perception of dental local anesthesia, virtual reality simulation on a paediatric patient and to determine whether this can improve students learning experience.	It was concluded that the use of virtual reality simulation can enhance students engagement and learning experience in paediatric dentistry settings and can be used as an additional means of local anesthesia training.
2. A. Al-Khaled	2021	This literature review discusses augmented reality systems and provide an update on the most recent technological developments and applications in the dental field.	Augmented reality systems are still being tested as there are still some limitations that limit the adoption of this technology in the dental sector. Literature suggestive of devices appropriate for clinical use, yet no regular clinical application was recorded.
3. Gökhan Ozdemir	2021	This article reviews the requirements for virtual articulators and occlusal recordings and assesses their advantages and disadvantages in various aspects.	When combined with additional software, virtual articulators can enhance education and practice, allow for quicker and more precise individualized diagnoses and enable discussions of dental treatment planning options with patients. In particular, virtual articulators have allows for a full analysis of occlusion with dental models that can simulate all mandibular movements in static and dynamic positions.
4. Sobia Zafar	2020	To investigate dental student's perception of the augmented reality (AR), head and neck anatomy application and to determine whether the learning environment was beneficial for students compared with traditional	AR has the potential to be used as an adjunct tool in the learning of dental head and neck anatomy as it has demonstrated increased student engagement and enjoyment.

		cadaver learning.	
5. Sobia Zafar	2020	This cross-sectional questionnaire-based study compared students' perception of the pre-clinical paediatric dentistry training gained in Simodont® and conventional simulation environment.	The study suggests that Simodont® could be used as an adjunct in training dental students for pre-clinical paediatric dentistry restorative exercises.
6. Rasa Mladenovic	2020	The aim of the study was to evaluate the impact of augmented reality (AR) simulator on the perception of learning and acute stress level in students administering local anaesthesia to paediatric patients relative to standard teaching methods.	The AR concept may influence better manipulation and control of the syringe in students administering their first anaesthetic injection to paediatric patients, but may not reduce acute stress.
7. Mahmoud E Elbashti	2020	To introduce an augmented reality (AR) application for students, patients, and practitioners to use to visualize a maxillectomy defect, the associated obturator prosthesis, and the eventual effects on the patient's facial appearance.	An AR application for visualizing maxillofacial prosthetic data could interestingly be developed as a pedagogic tool to explain prosthetic treatments.
8. Ashley Towers	2019	A scoping review of the use and application of virtual reality in pre-clinical dental education.	This paper summarises and draws out themes from the current areas of inquiry in the literature, uncovering a number of weaknesses and assumptions. It recommends areas where additional investigation is required in order to form a better evidence base for the utility of VR in dental education, as well as to inform its future development.
9. Ashraf Ayoub	2019	The aim of this study was to provide an overview of the literature on the application of virtual and augmented reality in oral & maxillofacial surgery.	Virtual and augmented reality have contributed to the planning of maxillofacial procedures and surgery training. Literature highlights the importance of this technology in improving the quality of patients' care. There are limited prospective randomized studies comparing the impact of virtual reality with the standard methods in delivering oral surgery education.
10. Ho-Beom Kwon	2018	This review briefly summarizes the history, definitions, features, and components of augmented reality technology and discusses its applications and future perspectives in	Augmented reality (AR) technology has also expanded to other areas of dentistry, such as restorative dentistry, orthodontics and endodontics. Simulators for

		dentistry.	education or training are well-suited to AR technology, especially in anatomy, surgery and restorative dentistry. With other state of the art technologies, such as haptics and robotics, AR applications in dentistry are expected to become more prevalent in the near future.
11. Marco Farronato	2018	The aim of this systematic review was to screen the literature and to describe current applications of augmented reality.	Customized software for augmented reality seems promising to help routinely procedures, complicate or specific interventions, education and learning.

**Table 2: The list of systems/devices used according to the dental specialities**

Systems/ Devices	Treatment/ Application	Dental Speciality
DenSim	The virtual reality simulators (VR) combined with force - feedback used as a tool for manual dexterity training and preclinical exposure.	Dental Education
MOOG Simodont		
Microscopic Assist Guided Intervention (MAGI)	Outlining the extent of a poorly differentiated squamous cell carcinoma	Oral Surgery
Head Mounted Display system (ARTMA Biomedical Inc.)	Secondary reconstruction of post-traumatic deformities of the zygoma	
“Wearable Augmented Reality For Medicine” (WARM)	LeFort 1 Osteotomy procedure	
Sony HMZ-T1 personal 3D viewer	Implant placement	
Microsoft HoloLens	Implant placement	
X-Scope	Maxillary positioning	
I-plan CMF Software	Bimaxillary osteotomy	
3D integral imaging technique with usage of half silver mirror	Implant placement	
ARToolKit software	Mandibular angle oblique split osteotomy (MASO)	
Video see-through AR system for OMFS	Navigational guide for surgeons	
Light-weight monocular video see-through AR system	Brackets placement	Orthodontics
C++, Qt, Optimized video system for AR	Detection of root canals	Endodontics

IvoSmile Kapanu, Ivoclar-Vivadent	Educational tool to explain to the patient the different smile possibilities	Prosthodontics
Magic Leap One AR HMD	Detecting early dental decay and monitoring	Restorative
Serious game (immersive virtual environment using AR), An interactive interface, Kinect for Windows SDK 2.0 (Microsoft Corp)	Oral hygiene education for children	Pedodontics