Virtual Reality Applications in Dentistry: A World to be Unveiled

Eby Aluckal[1], Gopika Renjith[2], Anoopa Paulose[3]

From,[1]Professor and Head of The Department, [2]Intern, Department of Public Health Dentistry,[3] Associate Professor, Department of Prosthodontics, Mar Baselios Dental College, Kothamangalam, Kerala, India.

Correspondence to: Dr. Eby Aluckal. Professor and Head, Department of Public Health Dentistry, Mar Baselios Dental College, Kothamangalam - 686673, Kerala, India. Email ID: draluckal@gmail.com

ABSTRACT

Virtual Reality is a collection of technological devices which creates a simulated environment of real world based on graphics, which is a 3D world in which people interact virtually with others, connect with them and are subjected to different procedures and so on. It plays a vital role in pain reduction and thereby the anxiety of patients by distracting patients from the pain processing signals. In medical professionals, they provide a trial and practice opportunity before the actual procedure is done in patients. With wide range of treatment modalities and better hope for treatment, this innovative technology augments traditional training methodologies and thereby enhances patient compliance by enabling a personalized service to individual patients.

Key words: Augmented reality, Dental Simulation, Virtual Reality.

Virtual reality (VR) is a technique of creating a simulated environment with the use of computer technology where in humans with the help of specially designed electrical instruments such as gloves, smart glasses, helmet, hand/body trackers, and external sensors are placed inside an experience by interacting with 3D world.[1] This detach them from the real world to a partially or entirely different virtual world.[2-4] This computer generated new environment can be explored by each person with the help of these instruments.

In dentistry, virtual reality provides visual instruction to dentists, so as to make the procedure at ease with the use of smart glasses. [1, 5] A complete VR system consists of a motion tracking device, an input device, a stereo display device and a computing platform. It takes the patient into a different world and helps them in reducing the pain, fear and anxiety towards treatment as they can view the scenes which bring them to a relaxed state. [2] When patients are at ease, treatment can be carried out efficiently in minimal time, thus enabling more no of patients to be treated.

VR technique displays the 3D picture of the tooth and head and thereby help the doctor to understand the anatomy of the teeth to plan the treatment beforehand. [1] This technology enables the doctor to zoom through the patients' teeth and thereby helps patient in the alignment of teeth and treatment of cavities. It also enables to rotate the tooth image which enables to visualize the underlying structure as shown in figure 1.

Figure 1: Using VR technology to display the 3D effects

APPLICATION IN ENDODONTICS

Integration of VR simulation to Endodontics has been greatly appreciated by student population [6,7]. When compared with 3 dimensional reconstructions and 2 dimensional radiographs, VR has markable advantages.

A successful good quality root canals treatment is possible only when there is an indepth knowledge about the root canal anatomy. Learning and negotiating the number of root canal is the prime step in root canal treatment. The 3D view along with clinical photographs, schematic drawings and radiographs are considered as passive approach at present [7]. Software virtual programs such as the 3D Tooth Atlas (eHuman, Fremont, CA, USA) provide students with an interactive data set whereby the students are able to select the desired model and analyze the tooth from the direction which they wish to, thus making it an active session of learning and treating [7]. Traditionally, new dentists felt pressure using a drill but now with the advent of virtual reality, they were provided with ideas of drilling using a virtual drill which enhanced their confidence and capability before the actual procedure.

APPLICATION IN PEDODONTICS

In Pedodontics, Virtual Reality distraction in behavior management is considered as budding distraction tool [8]. The virtual reality analgesia has gained popularity as an effective mode of pain distraction technique thereby increasing fun experienced by children during painful dental procedures [2,5]. Here, the child enters into an illusion of going inside a 3D world [9]. Being in a virtual world, the patient pays less attention or gets distracted to process pain signals generated.

Figure 2: VR technology usage to distract patients while treatment.

A Head Mounted Display allows the computer-generated visual images and sound effects thereby substituting and separating the patient from the real world [4,9]. It is also helpful to distract patients as shown in figure 2, which will be helpful during painful injections in the gums. This makes them more cooperative due to the additive effect of local anesthesia and for the reason that they remain in the virtual world.

APPLICATION IN PERIODONTICS

University of Illinois at Chicago developed 'Periosim' and 'periodontal simulator' wherein the VR application simulates three dental instruments, a periodontal probe, a scaler and an explorer, which are used for training in different aspects of Periodontology [10].

Virtual reality is applied in procedures like training of scaling, differentiating between pathological and normal conditions, periodontal probing, ultrasonic scaling, calculus detection and removal [11]. Periodontal probing and assessment of attachment loss are the main methods of diagnosing a periodontal disease. Variations in angulations, force and pressure results in different values for different examiners.

Virtual periodontal probe is used to teach correct probing technique and measure the correct probing depth thus reaching a proper diagnosis. Subgingival calculus is difficult to remove using scalers, as it mainly depends on tactile sensation. So, for this a virtual periodontal scaler with two models of gingiva, transparent and opaque, could be used for this purpose. With the opaque model where the tooth surface is covered by gingiva, the haptic device will provide the tactile sensation to evaluate virtual calculus present on the root surface, and with the transparent gingiva, calculus can be concomitantly seen under the gingival line. Further, virtual explorer will be helpful to evaluate that the calculus has been fully removed, which could be performed with both a transparent and an opaque gingiva. [12,13]

APPLICATION IN ORAL AND MAXILLOFACIAL SURGERY

Oral and maxillofacial surgery is the prime area of application of technological advances in virtual and augmented reality. Areas of frequent application are oral Implantology and Orthognathic surgery, restoration of

orbital floor following blow out fracture. Mandibular reconstruction after cancer respective and reconstructive surgery is the prime example for this [14] and the main use of it is for the visualization of masked structures.

In dental Implantology, virtual reality is applied by CBCT taken preoperatively to detect the implant position, size, direction, proximities and so on, thus enabling its best and accurate functional position. Based on the virtual designing, the static transfer of surgical plan is carried out followed by fabrication of a surgical guide using computer-aided design/computer aided- manufacturing (CAD/CAM) thereby aiding in placement of dental implants [14].

Virtual reality has mainly found its significance in management of cases with complex fractures in the bone or where the jaw bones anatomy has been completely altered due to any pathologies or trauma. Minimally invasive surgeries required in case of patients with blood dyscrasias and bone related jaw damage also benefited at a greater range with the advent of virtual reality [14].

USE AS A LEARNING TOOL

Flexibility for scheduling activities, the high motivational potential and ability to provide adequate and safe instructions without violating ethical principles for interaction with patients makes virtual reality simulation more advantageous even in the field of dental education. Traditional ways of training preclinical skills with the use of phantom head, extracted teeth and other models is irreversible and inaccurate. But dental simulators used in virtual reality makes the procedures repeatable, reversible and environment friendly [15].

In addition to this, different layers of teeth enamel, dentin and pulp can be modelled using virtual reality unlike resin models which prevents unintentional pulpal exposure when dealing on patients. [10] Also different tooth can be viewed in different directions and can be displayed in 3D on a computer screen for feedback from trainers.

DENTAL SIMULATORS

Dental simulator is an assimilation of dental technology and computer, replicating both hard and soft tissues thus making the clinical diagnosis and treatment much perfect and easier. Major dental simulators include: [6,15]

Dentsim: The DentSim TM units comprise of a phantom head, a set of dental instruments, infrared sensors, monitor, two computers assisting an overhead infrared camera.

Individual Dental Education Assistant (IDEA): The IDEA offers a stylus, with six degrees of freedom, attached to a stand and provides 3D image on screen and provides the trainee with haptic feedback.

Periosim: PerioSim consisting of a haptic device, stereoscopic display and a computer which allows students to visualize and detect caries and periodontal diseases in a haptic environment with use of virtual instruments.

Simodont Dental Trainer: It is a widely used dental simulator in dental schools. It is a haptic 3D Virtual simulator and provides with instant feedback.

ADVANTAGES

Dental simulators offer a better learning experience compared to phantom based study model learning. It can be used both as a tool for distraction and acclimatization [16]. Theoretical knowledge is also offered by the simulators besides the operating skills enabling repeatable and reversible training which helps to improve the skills of the students or dentists. It reduces the risk and increases the safety of the treatment as different procedures and their possible consequences is revealed beforehand the actual treatment. In patients, it reduces the pain and anxiety by distracting the patient's conscious attention. Their use in dentistry is not an easy task. The reason can be sought in complexity of dental instruments in type, shape and speed, and the diversity of oral tissues which include gingiva, multilayer teeth and bone [8].

DISADVANTAGES

Lowered resolution and lack of stereo vision of display, absence of stable finger rest and lack of bimanual cooperative operation are the major disadvantages with the use of virtual reality. Majority of the 3D Displays are smart glasses which may sometimes interfere with the color of oral tissues and might cause nausea and vertigo as side effects. Precise dental operations and small intraoral space requires a stable finger rest, thus lack or absence of finger rest may cause accidental injury to hard or soft tissues or surrounding tissues near the operative procedure. So, use of finger rest is very significant in dental skills training and

should be provided for optimal dental simulation. Optimal simulation also requires training by bimanual operation where the operator handles the odontoscope, stretching the soft tissues from the operative field, adjusts the light etc with the left hand for perfect instrumentation by the instrument held in the right hand [6].

CONCLUSION

Virtual Reality helps to enhance the dental education and clinical practice process. It augments the traditional training techniques. This advanced technology provides dentistry with better hope for treatment and a wide range of treatment modalities and also enhance patient compliance and interest towards treatment.

REFERENCES

1. Haleem A, Javaid M, Khan IH. Virtual reality (VR) applications in dentistry: An innovative technology to embrace. Indian J Dent Res 2020; (31):666-7

2. Li A, Montano Z, Chen VJ et al. Virtual reality and pain management: current trends and future directions. Pain Manag 2011; 1(2):147-157.

3. Mallari B, Spaeth EK, Goh H et al. Virtual reality as an analgesic for acute and chronic pain in adults: a systematic review and meta-analysis. J Pain Res 2019; (12):2053–85.

4. Alauddin MS, Baharuddin AS, MohdGhazali MI. The Modern and Digital Transformation of Oral Health Care: A Mini Review. Healthcare (Basel) 2021; 9(2):118.

5. Koticha P, Katge F, Patil PD et al. Effectiveness of Virtual Reality Eyeglasses as a Distraction Aid to Reduce Anxiety among 6–10-year-old Children Undergoing Dental Extraction Procedure. Int J Clin Pediatr Dent 2019; 12(4):297–302.

6. Roy E, Bakr MM, George R. The need for virtual reality simulators in dental education: A review. Saudi Dent J 2017; 29(2):41-47.

7. Ayoub A, Pulijala Y. The application of virtual reality and augmented reality in Oral & Maxillofacial Surgery. BMC Oral Health 2019; 19:238.

8. Rao DG, Havale R, Nagaraj M et al. Assessment of Efficacy of Virtual Reality Distraction in Reducing Pain Perception and Anxiety in Children Aged 6-10 Years: A Behavioral Interventional Study, Int J Clin Pediatr Dent 2019;12(6):510-513.

9. Do NM, Graff D, Chauvin C et al. Indications and Therapeutic Potentials of Virtual Reality in Pediatric Dentistry. Sch J Psychol & Behav Sci 2020; 4(4):457-60.

10. Mallikarjun SA, Tiwari S, Sathyanarayana S et al. Haptics in periodontics. J Indian Soc Periodontol 2014; 18(1):112-3.

11. Albuha Al, Mussawi RM, Farid F. Computer-Based Technologies in Dentistry: Types and Applications. J Dent (Tehran) 2016; 13(3):215-222.

12. Steinberg AD, Banerjee P, Drummond J et al. Progress in the development of a haptic/virtual reality simulation program for scaling and root planning. J Dent Educ 2003; 67:161-5.

13. Luciano C, Banerjee P, DeFanti T. Haptics-based virtual reality periodontal training simulator. Virtual Real 2009; 2:69-85.

14. Joda T, Bornstein MM, Jung RE et al. Recent Trends and Future Direction of Dental Research in the Digital Era. Int J Environ Res Public Health 2020; 17(6):1987.

15. Li Y, Ye H, Ye F, et al. The Current Situation and Future Prospects of Simulators in Dental Education. J Med Internet Res 2021; 23(4):e23635.

16. Cunningham A, McPolin O, Fallis R et al. A systematic review of the use of virtual reality or dental smart phone applications as interventions for management of paediatric dental anxiety. BMC Oral Health 2021; 21:244.