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BOON OF VIRTUAL REALITY AND ITS APPLICATIONS AS AN EDUCATIONAL TOOL IN DENTISTRY: A REVIEW

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ABSTRACT

Various training methods are available in the field of dentistry to obtain psychomotor skills for the dental students, dental assistants and also for dentists themselves. Modern era poses various challenges to the dental schools ranging from increased cost of advanced equipments to unavailability of challenging cases. Virtual reality is a boon for dental schools, dentists and dental assistants in order to practice as many times they want and improve their skills to the next level. This paper discusses the strengths and weaknesses of the advanced virtual technologies available for the dental fraternity.

Keywords: virtual reality, surgery planning, surgery simulation, surgery training, trauma care.

INTRODUCTION

Dentistry has received relatively little attention from virtual reality researchers, yet it is one of the most common healthcare encounters. Virtual reality (VR) has been defined as electronic simulations of environments experienced via head mounted goggles and wired clothing, enabling the end-user to interact in realistic three-dimensional situations[1]. The development of attaining a skill requires mastery of two components: knowledge of the concepts of the procedure and the dexterity to perform it. However, the performance component requires a situation in which dentists can repeatedly practice the application of the knowledge and practices him to perform. In the past decades, educators have come to the realization that the clinical arena may not be an optimal environment for dental education. There are a number of reasons for this. Technical skills are increasingly complex due to advances in knowledge, materials, and technology. In parallel with the technological advances, financial restraints have increased the pressure for high patient turnover at dental school clinics, leaving less teaching time available to instructors and students. Finally, concerns over patient safety have led to a decrease in the acceptance of having practice new skills on patients.

New technology-based approaches to address these problems have emerged in recent years through the development of a wide range of computer-based tools and systems. These include intelligent tutoring systems, medical simulation and virtual reality techniques [2,3,4,5,6]. This has created revolution in developing many simulation techniques with the primary goal of minimizing patient's suffering, time and complexity of operation. The strength of these simulators is that it can record the outcome and data on how each methods of training are performed individually which cannot be monitored by the regular training methods. A virtual environment which approximates working on real patients serve as a tool to better train the dental professionals to evaluate and treat the patients in emergencies. Simulation of a wide variety of accident cases in VR will enhance the performance of the physicians and interns in trauma surgery. Integration of innovative systems, based on new technology, into dental curricula should be a goal to improve the quality in dental and medical education [7].These technologies are likely to change clinical training and encourage the use of reflective forms of assessment, which involve students in a self-assessment process to identify individual learning needs and self-directed learning. These innovations promise not only lower costs of the educational process, but also an increase in quality by providing a new set of pedagogical tools for dental schools. Hence virtual reality can be considered as an invaluable tool which has become a boon for dental field.

Virtual reality in simulation and planning of surgery

Evolution of Simulators in dentistry

Over the last decade there has been a marked increase in the use of technology in medical education[8, 9]. In 1990's, Ranta and Aviles introduced the concept design of a virtual reality dental training (VRDT) system to practice cavity preparation[10]. Thomas et al. developed a training system with Impulse2000 enabling the operator to practice the detection of carious lesions[11].Periosim was developed for periodontal simulation, which can simulate three typical operations including pocket probing, calculus detection, and calculus removal[12]. This system focused on probing the difference of different tissues around tooth, while cutting simulation was not considered. In hap-TEL, two generations of prototypes were developed based on feedback from user evaluation[13.] Several companies have been focusing on developing commercial dental training systems. Simodont was developed by MOOG, Inc., and can simulate drilling and mirror reflection[14]. Forsslund Dental system was developed to practice dental drilling and wisdom teeth extraction [15]

Dental simulations

Components of a simulator

The simulator system consists of a high-end computer workstation with appropriate software a haptic device and a stereoscopic computer monitor with stereo glasses. The computer renders three-dimensional (3D) graphics that can be viewed with the stereo glasses, and operates the haptic device that provides a realistic tactile sensation.

Dental surgery simulation requires the haptic device to provide force similar as that generated in the real operation. The performance of the haptic device determines the task that the device could be used for. Realistic haptic devices and graphical displays are the recent training systems used for dental simulation. A **haptic device** is one that involves physical contact between the computer and the user

Applications

a. Exploration
b. Tooth grinding/Preparation
c. Dental Implants

a. Exploration of oral cavity (i-feel 3)

Exploring the oral cavity of a dental patient requires oral screening visually with the help of diagnostic instruments. There is different stiffness of soft and hard tissues present in the oral cavity .To match this stiffness through a haptic device is a big task.

Swedish Royal Institute of Technology has developed a dental surgery simulation system with haptic device, which could simulate exploration[16].

Also iDental is used to simulate dental caries exploration with maximum stiffness of 2.4N/mm which is much lower than the stiffness of natural tooth[17].

iFeel 3 outputs a 3D force similar to the force created in real operation. The performance characteristics of the haptic device are decided based on the Degree of freedom (Dof), maximum output power, workspace, stiffness and resolution. Dof is the freedom to move freely in the oral cavity which is 6 degree. Maximum output power is the maximum exertable force on the device which is designed as 5N.Workspace is both translational and rotational workspace and the posture tool was created in the virtual tool named Phantom Omni. The size and posture of the virtual oral cavity are similar to the real tool (Fig.1) and the tools posture in virtual surgery can be recorded. The simulated device has maximum stiffness criteria of 14.5 N/mm [18.] All the above said characteristics are analyzed quantitatively and iFeel3 as a dental mirror is shown in (Fig. 2).

b. Tooth grinding/Preparation

Tooth preparation is ubiquitous in dental surgery. This process always involves grinding operation using high-speed rotating burs to modify the shape of the tooth for further treatment. During this operation, too much applied force will increase the rate of heat generation and thus damage the tooth tissues, while too little force may prolong the painful treatment procedure for the patient. Therefore, haptic sensation is very important for the surgeons to operate successfully. The feedback force is generated by the grinding interaction between the tooth and the dental bur (Fig.3) on the hand piece. The factors that affect the grinding force are the shape of the bur, behavior of the hand piece and different tooth sections and environment. In dental surgery, the tooth is static and the grinding tool undergoes rotational and translational velocities. The different forces acting are calculated using virtual coupling to retain stability. A voxel-based grinding simulator has also been developed to overcome the force discontinuity and the feedback force generated is shown to be consistent with the real grinding (Fig.4). These methods are implemented in Visual Studio 2005 with Open Haptics and OpenGL and have been integrated into a dental training system. These simulation platforms have been effective in creating better alternative for traditional training with plastic teeth or removed teeth from patients.

c. Dental Implants

In the field of oral Implantology, treatment planning has been based on the interpretation and mental reconstruction of cross sectional two-dimensional image data. Because the clinician concerned has to imagine how the two-dimensional images are in three dimensions, this is very difficult, and it hampers treatment planning treatment planning in oral Implantology that provides a three-dimensional view has been developed[19] .It enhances diagnosis and treatment planning as the true position and orientation of implants can be assessed in three dimensions. The virtual world in which treatment planning takes place allows the clinician to move and interact with the individual patient's anatomy simultaneously with three degrees of freedom. The design and placement of implants are interactively controlled by the clinician and are simulated in real-time. Thus the results of actions become immediately visible and provide feedback for interactive adjustment. In addition, the virtual reality environment for oral implant treatment planning enables the detection of inappropriate implant placement with regard to the quantity and quality of a patient's bone [20] VIP3 virtual implant placement developed by Bio horizons (USA) used to plan surgically and develop a surgical guide. A CAD-CAM surgical template can be made to follow the implant surgery. The screen layout has four options to provide the user with the preferred layout (Fig.5). VIP's default screen layout is divided into four sections which includes: panoramic projection, panoramic, axial, and cross section view[21]

Simulation in maxillofacial surgery

In head and neck surgery

In oral and maxillofacial surgery, Virtual surgical planning using computed tomographic imaging and virtual and augmented reality technology allow oral and maxillofacial surgeons to perform virtual surgery and generates templates and cutting guides that allow for the precise and expedient recreation of the planning surgeries [22].

Applications

A. Trauma B. Aesthetics

A. Trauma-(Computer-Assisted Planning in Cranio-Maxillofacial Surgery)

A computer assisted modeling, planning and simulation system to aid surgeons to effectively perform the surgical corrections on a 3D virtual model of the patient before actual surgery. The most important factor here is the anatomy and physiology of the patient's skull before any disproportions. This is accomplished by the studies on facial proportions and characterization of faces along with the database of healthy morphological anatomies. The 3D model of the deformed skull is obtained by the projection of 2D X-ray images[23]

B. Aesthetics-(The computer generated osteotomy)

Computer-assisted osteotomy planning is oriented by 'draw and cut' principle**,** the initial step is to draw the osteotomy lines and then to compute path to the surfaces to be cut. The transection of nerves, vessels and underlying teeth roots can be revealed by mapping the cut surfaces and the tomographic images. The mobilized parts of the model are made to be rotated and translated with single degree of freedom over a rotational axis[24].

SUMMARY AND CONCLUSION

The present article has discussed about the advancements in training along with the application of using virtual reality and its tremendous use in the dental field. **VR** helps in training dental surgeons, interns and students in minimal invasive surgery rather than using cadavers, plastic models etc. Skills learnt using simulators guide in reducing errors significantly. The efficacy of the virtual environment depends on the freedom of interaction between the user and the simulated environment. With adequate infrastructure and training, growing use of internet, multimedia and online interactions VR emerges as a lifesaving tool in trauma management also. Many systems that have been discussed are at preliminary stages and require in-depth long term evaluation. For a variety of reasons, several dental schools are reluctant to implement these systems in their academic and clinical training[25]. VR should be taken to the next level by enhanced collaborative research between research scholars and specialist dentists, dedicated entrepreneurs, scientists to reach to developing countries with low cost.

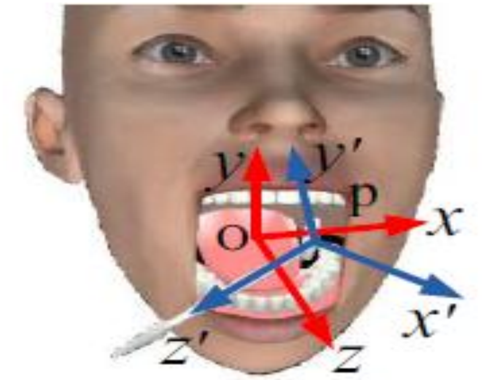

Figure 1- Virtual oral cavity

Figure 2- iFeel3 Simulator

Figure 3- Diamond tooth preparation burs

Figure 4- Voxel grinding simulator

Figure 5- CAD-CAM software

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CONFLICT OF INTEREST: NIL

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