



Research Article

VIRTUAL DENTAL SIMULATORS: A REVIEW

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ABSTRACT

Virtual reality is the human computer interface that facilitates visualization of three-dimensional images with details so as to evoke a real experience. The aim of this article is to emphasize the use of virtual dental simulators in dental education. There are different dental simulators available today in the market such as Voxel Man Dental, Moog Simodont Dental Trainer, Virteasy Dental Simulators etc. These devices provide 3D virtual tooth models and any dental procedure can be practiced on the screen, such as cavity preparation, access cavity preparation, root canal therapy as well as endodontic microsurgery. The concept is based on the premise that no patient should bear the brunt of learning curve and every patient is rendered the best treatment possible. Simulators improve the precision of students while performing clinical exercises. Their assets are far greater than their liabilities and hence they can act as a trump card in imparting quality dental education.

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INTRODUCTION

There was a time when acquiring skills was a tough task but nowadays skills can be acquired precisely. The era which we live in today is the era of digital dentistry. Virtual reality simulators are an important part of this digital dentistry¹. Simulation means imitating a procedure over time. The dental students must achieve a sufficient level of competence prior to actually performing exercises on patients as most of the procedures done on teeth such as root canal therapy, cavity preparation, endodontic surgeries, oral and periodontal surgeries are irreversible, and learning such skills solely on patient is not a good practice². Simulation allows student to practice the procedures as many times as possible till they become perfect in that procedure so that actual patients are not put at risk³. Virtual reality is the computer technology that uses software to generate realistic images, sounds and sensations that will replicate a real environment and simulate a user's physical presence in this environment². Virtual dental simulators have emerged from the technologies available in the field of aviation and medicine^{4,5}. The word 'haptics' is derived from Greek word 'haptikos' meaning 'sense of touch'⁶. Haptic devices are used with virtual simulators as they provide tactile sensations to the users. Haptic devices allow users to perform procedures such as pushing, pulling, and cutting of soft or hard tissues with the realistic force feedback³. The aim of this article is to provide a review of importance of simulators used in pre-clinical dental education to improve the skills of the students prior to working on actual patients.

Virtual Dental Simulators

The various simulators used in dental education are

- 1) Dentsim Simulator manufactured by DenX Ltd².
- 2) MOOG Simodont Dental Trainer by MOOG Industrial Group⁴.
- 3) Voxel Man Dental⁴.
- 4) Periosim⁴.
- 5) Iowa Dental surgical Simulator².
- 6) Individual Dental Education Assistant⁴.

Dent Sim

It is an augmented reality virtual dental training simulator. It tracks the movement of the student's handpiece and typhodont teeth while the student performs exercises on the mannequin. The head of the mannequin and handpiece of the simulator contain infrared emitters that allow the infrared camera to detect their orientation in space. As the student performs an exercise a virtual tooth model is been created on the computer and this model is compared with the ideal preparation approved by a faculty. It provides instantaneous feedback with regards to floor depth, outline, shape, handpiece positioning angles along with the floor and wall smoothness².

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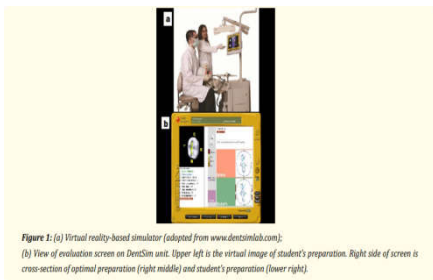


Figure 1: (a) Virtual reality-based simulator (adapted from www.dentsimlab.com); (b) View of evaluation screen on Dentsim unit. Upper left is the virtual image of student's preparation. Right side of screen is cross-section of optimal preparation (right middle) and student's preparation (lower right)

MOOG Simodont Dental Trainer

It is a haptic 3D virtual reality simulator manufactured by Moog Industrial Group, Amsterdam. This simodont software has modules for manual dexterity skills, cariology, crown and bridge exercises, clinical cases and full mouth simulation experience. It has a unique feature called as 'case editor' which allow users to scan their own instruments and clinical cases to create a new exercise⁴.



Figure 2: (a) MOOG Simodont Dental Trainer (adapted from www.moog.com); (b) A haptic tooth preparation exercise.

Voxel Man Dental

It is another 3D virtual training device which uses haptic devices to provide a real time force feedback. It allows the operator to use animated high and low speed burs of different shapes which are controlled by a foot pedal. The operator can inspect the teeth from all aspects using a virtual dental mirror. It allows for magnification of teeth as well as showing cross sectional images. This software allows students to get instant feedback, problem-based study and objective evaluation of their performance⁴.



Fig 3 (Voxel Man Dental Simulator)

Periosim

It is a virtual reality simulator developed by Luciano(2006) offers tactile sensation allowing students to use variety of dental instruments in visualizing, detecting and evaluating periodontal diseases or caries in a haptic environment. The device can be assessed by the students via internet and allows instructors to upload different dental procedures which can be saved and replayed by the student anytime⁴.

Individual Dental Education Assistant (IDEA)

It provides a 3D animated image on screen that allows the student to practice with tools while providing haptic feedback. For a given task, the simulator measures and records task time, percentage of the material removed, deviation from the task assigned, level of accuracy, and a score is displayed on the screen⁴.

Table no.1

ADVANTAGES	DISADVANTAGES
Tactile delicacy ²	High Cost ⁴
Biofeedback ²	Technical problems ⁴
Minimal invasiveness ³	
Customized learning ²	

DISCUSSION

Many studies have been conducted so far on virtual dental simulators. Sukhdeep Murbay (2019) demonstrated that performance of students in direct restorations was better among those who used Moog Simodont Dental trainer than those who performed it manually without the use of simulator¹. A study showed that students who used Dentsim simulator for class 1 cavity preparation improved their scores on an average from 78.26 to 90.47 between their first and fifth attempts and students who did not use the simulator showed a 2-point increase in their average scores². S. Suebnukarn (2011) concluded that post training performance had improved compared with pre training performance of access cavity preparation exercise. Virtual simulator group decreased the amount of hard tissue lost on post training exercise³. A study by Gal et al (2011) reported that both experienced academics and fifth year dental students perceived that IDEA simulators proved to be beneficial in enhancing dental education⁶. Ioannis Marras (2008) described a simulator that allows user to practice virtual tooth drilling for endodontic cavity preparation. If unexperienced users make an error during cavity preparation, they can undo their last drilling steps and continue to the right direction⁷. A study by S Suebnukarn (2010) showed that novices could learn to perform access opening tasks faster with more consistency, better bimanual dexterity, and better force utilization using haptic virtual reality⁸. Amirhosein Toosi (2014) reported a haptic virtual reality simulator for root canal treatment which used collision detection and collision response algorithms for the detection of change in the anatomy of endodontic file while performing root canal treatment⁹. Bogoni (2016) demonstrated a simulator for root canal treatment which stores all the actions taken by the user and allows the user to visualize these actions and check if the techniques were properly chosen for a particular clinical case¹⁰. Dangxiao Wang (2012) evaluated a haptic based dental simulator on quantitative and qualitative grounds to prove that most trainees show great interest for this new way of dental training¹¹. A study reported that virtual methods decreased the faculty time by five times when compared to traditional preclinical teaching methods¹². Premotor and motor neural cortices show significantly increased activity when working and observing tasks rather than acting as a passive observer, thus increasing the learning outcomes¹³. A study demonstrated that students exposed to virtual reality software before an apicoectomy procedure preserved neighboring structures such as soft tissue and bone six times more efficiently than students who were directly asked to do the exercise on pig cadavers¹⁴. Dalai Dr et al

described robotic patient which knows over 20 patterns of automatic dialogues along with body movement functions like eye blinks creating a realistic environment opening a new era in dental simulation training¹⁵.

CONCLUSION

Virtual dental simulators should be imparted in the pre-clinical dental curriculum so that students learn the skills precisely before performing any exercise on the patients. These simulators not only help in the ideal exercises but they can also simulate a particular difficult case so that it is practiced first and then it is performed on the patient. Every patient has the right for best possible treatment and no patient should bear the brunt of learning curve.

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