Haptics in Periodontics

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Abstract
Dental and medical education has utilized technology increasingly over the past few years for learning as well as training.Medical simulation has become a valuable tool for learning and acquiring skills. Webster's dictionary defines simulator as a training device that duplicates artificially the condition likely to be encountered in some operations.The simulation of clinical situations with the acquisition of fine motor skills is an essential component of the dental students learning experience. The traditional approach to dental skills training has drawbacks in terms of cost, availability, lack of real‑ world cases, with the restraints of time, clinical supervision, and the funding of raw materials such as real and plastic teeth. The introduction of dental haptics opens the door to a more realistic clinical experience which can be free from theprevious constraints.
Key words: *haptics, simulators.*

I. Introduction

The field of periodontics is that field of dentistry which requires dentists to depend primarily on their tactile sensations, for both diagnostic and surgical procedures. This makes haptics ideally suited for periodontal simulators. The word "haptics" is derived from the greek "haptikos," meaning able to grasp or perceive. It is a technology of tactile feedback that makes use of a user's sense of touch by applying vibrations, forces or motions to the user.[1]

Haptics (pronounced hap‑ tiks) is defined as the science of applying touch (tactile) sensation and controlto interaction with computer applications. Unlike manikin-based, haptics-based simulators are much more cost effective because no physical models need to be replaced. Simulators have become a standard in aerospace and aviation[2] and useful in a wide variety of

Medical fields for procedures such as laparoscopy,[3] sigmoidoscopy,[4] lung biopsy,[5] neurosurgery,[6] vascular access and cardiovascular catheterizations.[7]in addition, since the haptic device measures theforces applied by the trainee when touching the virtual patient's mouth, it is possible to detect when the trainee'saction is too aggressive. The followings are some of the most well-known haptics- based dental simulators previously developed:

- Virtual reality dental training system (vrdts) - novint technologies.
- Iowa dental surgical simulator (idss) - joint project between the college of dentistry at the university of iowa and the graphical representation of knowledge (grok) lab.
- 3d dental, commercialized by (simulife 2002).
- Haptically-enabled dental simulator (montgomery et al. 2005) .
- Volume-based dental simulator (kim and park 2006).

Currently, periodontal procedures are taught by time-consuming teaching process of instructor demonstration, use of practice manikins and finally, by actual work in the patient's mouth which requires excessive one-on-one instructor/student interaction. Haptics-based dental simulators could be beneficial for the training of dental and hygiene students as they aid in diminishing the instruction time period, enhance the learning curve, and provide for unlimited practice of these treatments.[8]by the use of virtual reality and haptics technology, the periodontal simulator allows trainees to learn performing diagnosis and treatment of periodontal diseases by visualizing a three-dimensional virtual human mouth and feeling real tactile sensations while

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touching the surface of teeth, gingiva, and calculi with virtual dental instruments. Since periodontics requires dentists to depend primarily on tactile sensations to perform diagnostic and surgical procedures, the use of haptics is crucial for a realistic periodontal simulator.

II. Literature Survey

- Wang et al.[9] worked on a simulator that allows probing and cutting a virtual tooth, but the virtual tool implementation was limited to a spherical shape for simplicity.
- Kim et al.[10] developed a dental training system with a multi-modal workbench providing visual, audio, and haptic feedback. This system is a volume-based haptic modeling which represents a tooth as a volumetric implicit surface. It allows burring and drilling on the tooth with a spherical tool.
- Yau et al.[11] proposed a dental training system utilizing material stiffness and spring force function. This simulation uses adaptive octree data structure for a tooth model and oriented bounding box for the boundary of the cutting tool. Different shapes of a cutting tool are introduced but details on how the forces are rendered for irregular-shaped cutting tools is missing as well as how to handle the torque that might occur in the case of nonspherical tool.
- Luciano[12] developed periosim, which allows trainee to practice diagnosing periodontal diseases that does not require deformation of tooth surface.

HAPTICS-BASED SIMULATORS

Theyconsist of a haptic device[fig 1] and virtual models of a human tooth or mouth which acts as a platform to facilitate dental practicing. It works on the principles of creating virtual environment, which replaces the reality, and user can interact to perform various motor and perceptual tasks.

Fig 1: Simulator setup and comparison between handling the real instrument and the haptic stylus

Hardware includes:
• Monitor and speakers
• Haptic interface device (stylus)
• Glasses and helmets for visualizing 2d videodisplay as 3d
• Gloves to feel the sensations.
The simulator allows the trainee to manipulate the position and the orientation of the virtual periodontal instrument by holding a haptic stylus, which has similar dimensions of the one of the real instruments.

APPROACH

Differentiating between pathological and normal conditions, diagnosing and treating periodontal diseases requires skill whichcan be achieved by employing one of the two visuo-haptic systems: periosim© and a periodontal simulator.[13,14]

DIAGNOSIS

Diagnosing the periodontal disease mainly depends on probing and measuring the clinical attachment loss. Virtual periodontal probe could be used to teach the correct probing technique, which will help in determining the health andseverity of disease of periodontal tissue and thus the correct diagnosis. [fig. 2]

TREATMENT

Main etiological factors of periodontal disease are plaque and calculus and thus the treatment of periodontaldisease revolves around complete elimination of these etiological factors. [fig. 3]
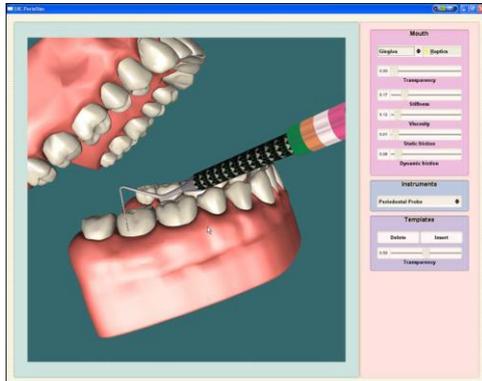

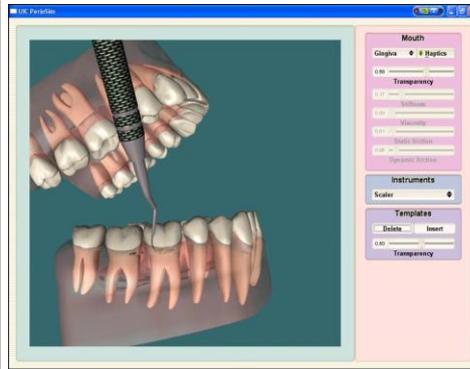**Fig. 2:** Measuring pocket depth with periodontal probe   **Fig. 3:** Calculi being removed with scaler

III. Operating A Periodontal Simulator

Instrument selection

Using the control panel, one of three periodontal instruments can be selected for onscreen use: aperiodontal probe, explorer, or scaler [fig. 4].
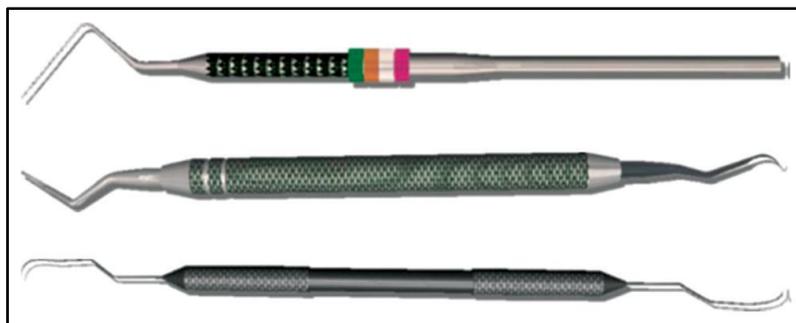

Fig. 4: Virtual periodontal probe, explorer, or scaler

Graphics control

In the main window of the simulator, the user can see the full‑ screen 3d model of area of interest in a dental arch along with the main control panel. The main control panel contains a variety of controls for navigation which include options to select and manipulate gingiva. The operator can induce varying degrees of transparency of the selected objects using a slider bar.

Haptics control

In the main window of the simulator, the user can control the haptic properties of the simulation process. This includes the basic ability to turn haptics on or off for each selected object. The haptic parameters such as stiffness, viscosity, static friction, dynamic friction can be controlled and altered separately for each object. By moving the haptic stylus, a trainee can move the virtual instrument on the tooth surface and feel the crevice or pocket area within the margin of the gingiva along the root surface of the tooth [figure 5]. The 3d virtual periodontal probe can be used to determine and measure crevice or pocket depths around the gingival margins of the teeth. The textural feel of pocket areas can be differentiated and regions of sub‑ gingival calculus can be located. Since the root surface is covered by gingiva, the trainee cannot see the area being probed or the

underlying calculus and must depend totally on haptic feedback to identify these areas. This situation corresponds to conditions encountered clinically. To assist visualization of what he/she is feeling, control panel adjustments can introduce varying degrees of gingival transparency. Graphical and haptic parameters can be altered by an instructor using control panel adjustments to provide the "feeling" or feedback he/she wishes to impart to the trainee. The system permits any instructor to generate a diagnostic and/or treatment procedure for student use.

Record and replay functionality

Recording of the haptic experiences involves the production of instructor‑ driven trajectories to definecorrect movements of the dental instrument when performing the periodontal procedure. These recordings can be stored in the system for future use by students and will guide their performance of a procedure. The methods used by an individual instructor to both diagnose and treat a particular procedure can be demonstrated while guiding students to perform the procedure in the same fashion.

Fig. 5: Comparison between handling the real instrument and the haptic stylus

ADVANTAGES
• Reinforcement of learned dental concepts
• Correct use of dental instruments
•Correct ergonomic positioning: incorrect operator or patient positioning can result in blocking the camera from reading the led sensors and prevents the user from continuing by warning signals. This encourages the students to practice good ergonomic habits
• Good psychomotor skills[15]
•Self-evaluation: students have immediate, unlimited and objective access to detailed feedback of their work
• Standardized evaluation
• Faster acquisition of skills: students attain a competency-based skill level at a faster rate than with traditional simulator units (phantom heads). This can result in changes in dental curriculum and earlier entrance into the pre-doctoral clinic
• Positive student perception.[16]

DISADVANTAGES
• Virtual of augmented reality dental simulators are at an early or experimental stage.
• A system limitation with the current design: the tactile perception for gingiva is not very real.
• The initial cost of this advanced technology simulation can be substantial.
• Difficult equipment to maintain and repair: technology-based systems require faculty/engineering staff to be available for training and supervision of the laboratory.

IV. Conclusion
The technologies of virtual reality innovate how clinical training takes place. Unlike existing systems for clinical courses, virtual reality systems overcome the limitations of phantom head systems and provide standardized case, objective assessment, and interactivity.

Haptic technology is a powerful educational methodology which improves the level of perception, sense of touch and feel and reduces the distance between the virtual and the real world. Haptics offer an excellent complementary means of training and could be a replacement for the existing ones.

FUTURE SCOPE

The introduction of haptics can lead to the simulation of other dental procedures beyond periodontics. Even medical procedures that require the simulation of tactile sensations could be developed based on the current implementation of the haptics-based periodontal simulator.

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