Teeth reduction dental preparation using virtual and augmented reality by Constanta dental medicine students through the VirDenT system

AMARIEI CORNELIU¹, DUTA MIHAELA¹, POPOVICI MIRCEA-DORIN², BOGDAN CRENGUTA², GRIGORIAN MIRCEA¹

¹ Faculty of Dental Medicine, Ovidius University Constanta, 7 Ilarie Voronca Str., 900684, Constanta
² Faculty of Mathematics and Informatics, Ovidius University Constanta, 124 B-dul Mamaia , 900527, Constanta

Abstract: The Faculty of Dental Medicine from Ovidius University in Constanta (project director Prof. Dr. C. Amariei) developed the VirDenT system. VirDenT uses technologies based on virtual and augmented reality for simulating unidental fixed prosthetic preparation. The purpose of the study was to bring into practice the VirDenT system in the Fixed Dental Prosthetics Course at the Faculty of Dentistry from the “Ovidius” University in Constanta, in order to find the optimal operation and use. The study’s objectives are: to test the quality of the VirDenT system within the Faculty of Dentistry of Constanta, in order for the teachers to correct any deficiencies and for the students to assess the possibilities for system use in Dentistry during the IIIrd year. The system’s use was studied and applied in the first phase by five teaching staff members. In the second stage the system was used by 10 students selected by teachers based on results from previous years. In the IIIrd phase the other 40 students of the IIIrd year of study practiced the reductional preparation of the 11 tooth. Due to problems encountered in using the system, we had to limit their use to the preparation of a single tooth (11). Teachers needed a double period of time for acquiring the ability to work with VirDenT system compared to the best three students. There are big differences between the skills demonstrated by students. The system implementation has raised more problems than anticipated, but they were gradually resolved. Although the application of the VirDenT system is in its infancy, the system presents an important potential for development of dental education. The project will end with the evaluation of the differences in the training of students through the VirDenT system as opposed to traditional methods.

Key-Words: - virtual reality, augmented, dental education, dental preparation reduction

1 Introduction
In Romania, since 1990, when the transition from centrally controlled economy to a market economy started, many dental schools have appeared which required a large number of staff members for teaching and for practical demonstrations, which was impossible to achieve in a short time; on the other hand, the privatization of dental offices has limited the opportunities to learn medicine on patients from state dental clinics. In order to facilitate skills gaining in clinical procedures, the safest solution is to use virtual and augmented reality.

The Faculty of Dental Medicine from Ovidius University in Constanta, developed the VirDenT system (project director Prof. Dr. C. Amariei). VirDenT uses technologies based on virtual and augmented reality for simulating unidental fixed prosthetic preparation. In designing this system, we relied on students openness to new technologies that offer the possibility to make an unlimited number of virtual procedures to appropriately learn the procedure / labor. The system envisioned by us does not use any dental turbine or burs, nor models; the patient as well as the teeth are virtual. VirDenT is a dental medicine e-learning system with a haptic interface that allows students in dental schools to practice dental procedures in a virtual environment. Intelligent training module allows a student to follow simultaneously and proactively the correct procedures shown by an intelligent tutorial [1-3].
Until now, virtual reality has been used in many universities around the world:
- DentSim was one of the first virtual reality systems used in dental higher education schools from Europe and North America since 2000; it allows students to perform clinical procedures on models with on-screen tracking, real time feedback and evaluation of their performance [4-8].
- Department of Cariology from the Faculty of Dentistry from Geneva (Geneva Project), has developed innovative concepts of 3D computer simulation for teaching dental anatomy. Currently, research is made to achieve a dental simulator using second generation virtual reality techniques with improved tactile features techniques for teaching cavity preparation [9].
- The AIIA Computer Vision and Image Processing Laboratory Group, Informatics Department of Aristotel University of Thessaloniki, Greece has developed the application "Virtual Dental Patient (VDP)" to help students in: familiarization with dental anatomy, handling dental preparation instruments and with the challenges associated with the endodontic drilling procedure [10]. VDP uses PHANToM™ haptic device (SensAble Technologies Inc) to control dental instruments [11].
- Virtual Reality Dental Training System (VRDTS) developed by the Novint Technologies in collaboration with Harvard School of Dental Medicine, is a simulator using virtual reality technology to prepare cavities [12]. VRDTS has the advantage of virtual possibilities of dental restoration (dental cavities fillings with amalgam).
- Iowa Dental Surgical Simulator /IDSS (College of Dentistry at the University of Iowa and Graphical Representation of Knowledge GROK Lab.) is composed of a computer, a monitor and a feedback force device with a software. Participants interact with the computer by holding a joystick or with force feedback device attached to it. The original development was focused on virtual simulation of the clinical evaluation of tooth decays using a probe, and then focus changed on haptic reality technology assessment of the marginal adaptation of unidental prosthodontic restorations (crowns) at prepared tooth [13].
- Luciano has developed PerioSim© a virtual reality and augmented simulator based on dental and periodontal diagnosis learning and scaling. PerioSim© has been validated by an experiment conducted by teachers and students of College of Dentistry at University of Illinois at Chicago (UIC) [14,15].
- The HapTEL system (King's College London Dental Institute and Reading University, UK) is a virtual haptic system for simulating cavity preparation, starting from simple decays to the complicated ones [16-18]. During 2 years, 300 students have used hapTEL system [19].
- Moog Simodont Dental Trainer is a virtual trainer for the preparation of cavities used by students of The Netherlands, the Academic Centre for Dentistry Amsterdam (ACTA) [20,21].

2 Problem formulation
Considering the fact that no system described above does not use virtual and augmented reality only in reduction of tooth preparation, we consider the VirDenT system implementation an important step in the development of modern techniques of dental medical education.

The VirDenT system conducted by the research team from the Faculty of Mathematics and Informatics of the „Ovidius” University of allows the reductive preparation of the teeth: upper right central incisor (11), left first upper premolar (24), left lower canine (33) and first lower molar right (46), representing one on each and every group of the dental hemiarch.

In the first phase was formulated the formal description based on domain ontology of the standard operator protocol for each of the four mentioned above teeth. This stage was achieved with prosthetics specialists from the Departments of Prosthetics of the Romanian faculties: Faculty of Dentistry, "Gr.T.Popa" University of Medicine and Pharmacy Iasi and the Faculty of Dentistry, "Victor Babes" University of Medicine and Pharmacy Timisoara.

In the next stage was achieved the VirDenT prototype followed by its testing and validating. It was created the user manual, then, within the discipline of Fixed Prosthodontics on Phantom the activity was divided into two distinct sections: half of the internships are made on phantom type simulators, the plastic models, and half with the tooth preparation technique using VirDenT virtual and augmented reality.

2.1. Aims and Objectives
The purpose of the study was the introduction into the practice of the Fixed Dental Prosthetics discipline of the Faculty of Dentistry, from the “Ovidius” University of Constanța of the VirDenT system, in order to find the optimal operation and
use, followed by validation system at the Faculty of Dentistry, "Gr.T.Popa" University of Medicine and Pharmacy Iasi and Faculty of Dentistry, "Victor Babes" University of Medicine and Pharmacy Timisoara.

Study’s objectives are:
- Testing the qualities of the VirDenT system to correct any deficiencies, by the teachers of the Faculty of Dentistry, Constanta
- Consider the use of the system by third year students of the Faculty of Dentistry, Constanta.

2.2. Material and method
The system’s use was studied and applied in the first phase by five teaching staff from the Faculty of Dentistry, „Ovidius” University Constanta, settling the issues to be improved, together with system developers. In the second stage the system was used by 10 students selected by teachers based on results from previous years in school. In the IIIrd phase the other 40 students of the IIIrd year of study (except the 10 enrolled in phase II) practiced the reductional preparation of the tooth 11.

Training courses were of 2 hours for each teacher or student; the basic unit of performance is the number of hours required for the skills aquisition by using the VirDenT system.

3 Results
Teachers, with one exception, had serious problems using the VirDenT system, always bringing criticism and giving up to improve themselves to achieve the proper preparation of the 4 teeth.

In these conditions, the three teeth reductional preparation were dropped for a moment; we concentrate the efforts only to the tooth 11 reductional preparation. After a week of testing, teachers needed a double time to acquire the ability to work with the VirDenT system compared with 3 students of the group who had the best results.

Regarding the 11 reductional preparation learning by students, the learning speed is represented by fig. 1. 3 students needed four simulations of 2 hours each one to properly perform the procedure (group 1), other 3 students required six simulations of 2 hours each one (group 2), and the last four students took at least 8 simulations of 2 hours each one (group 3). Stage III is still in progress because there are very large differences between the results obtained by different students in the preparation of the tooth (11).

![Fig. 1 The necessary time for abilities achievement](image)

3.1 Discussion
Using the system was more difficult than we expected. At each stage we have found so many shortcomings that need to be fixed by the IT person.

The tool used by students is very different than the turbine used in dental polishing which greatly difficult the skills development for the future professional. Add to this that is very high possibility of error by lack of support for the operator’s arm.

We failed to create a warning system for the mistakes committed by the student, leading to stop the performance of procedure, but the IT experts promise that this will be solved.

Analyzing the benefits of the systems described in Chapter 1 Introduction, we found that the VirDenT system has all the advantages described to the other systems. Advantages to the VirDenT system over the mentioned systems are: does not require simulation, plastic models, dental parts, turbines, dental drills and more, so costs are much reduced. Unfortunately, there are no relevant studies regarding the evaluation of these simulators for realism by the dental experts.

4 Conclusions
Although application VirDenT system is in its infancy, the system presents an important potential for development of dental education.

Implementation of the system raised more problems than anticipated, but they were gradually resolved. The project will end with evaluation of the differences in preparing students thru the VirDenT system compared to traditional methods.
Acknowledgements

This review was supported by the project VirDenT, which is funded by the Romanian National Center for Project Management in the competition in 2008 with the number PNII 12083.

References:

ISBN: 978-1-61804-055-8