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Publication date
2010
Document Version
Final published version
Published in
Bio-Algorithms and Med-Systems

BIO-ALGORITHMS AND MED-SYSTEMS
JOURNAL EDITED BY MEDICAL COLLEGE – JAGIELLONIAN UNIVERSITY
Vol. 6, No. 11, 2010, pp. 21–24

TRANSFER OF MANUAL DEXTERITY SKILLS ACQUIRED ON THE SIMODONT, A DENTAL HAPTIC TRAINER WITH A VIRTUAL ENVIRONMENT, TO REALITY. A PILOT STUDY

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Abstract: Introduction: Dental students invest many hours in manual dexterity training to prepare themselves for the clinics. Exercising on plastic has the advantage of learning within a standardized environment; continuing exercises on prefab teeth are unrealistic as plastic does not generate a training facility for clinical problem solving. Introducing a virtual learning environment with haptics and 3D models with realistic pathology (the Simodont) enables students to become competent before they enter clinics, assuming that the competences are easily transferred from virtual reality to reality. Therefore a study has been carried out to investigate if skills developed in virtual reality are transferred to reality. **Methodology:** Twenty-eight students participated in the study; 10 trained in the traditional phantom lab, 10 trained in the Simodont lab and 8 acted as a control group. Performance was tested before, during and after training. **Result:** It turned out that all students performed better after little or more training, independent of the training environment. **Conclusion:** Skills developed in virtual reality on the Simodont were transferred to reality.
Key words: dental education, preclinical training, haptics, virtual reality

Introduction

The goal of dental education is to guide students' development through different stages from novice to competent, eventually resulting in an expert clinician. Students traditionally devote several years to the acquisition of sufficiently fine manual skills to prepare them for entry-level dental practice. In the current simulation laboratory, training is restricted to non realistic procedures using phantom heads, often on plastic teeth. Dental education, of all the health professional schools, is the discipline that could benefit the most from virtual reality since a significant proportion of preclinical dental education is dedicated to teaching psychomotor skills (1, 2, 3).

A simulator, Simodont, (Moog, Nieuw Vennep, the Netherlands and ACTA, Academic Centre of Dentistry Amsterdam, Amsterdam, The Netherlands) consisting of a force feedback robot arm connected to software in such a way that every movement of the arm is visualized on a screen, has been developed to replace the traditional lab conditions by a realistic virtual learning environment (Figs. 1 and 2).

The haptics are based on the Moog patented admittance control paradigm for the HapticMaster (4, 5).The simulator

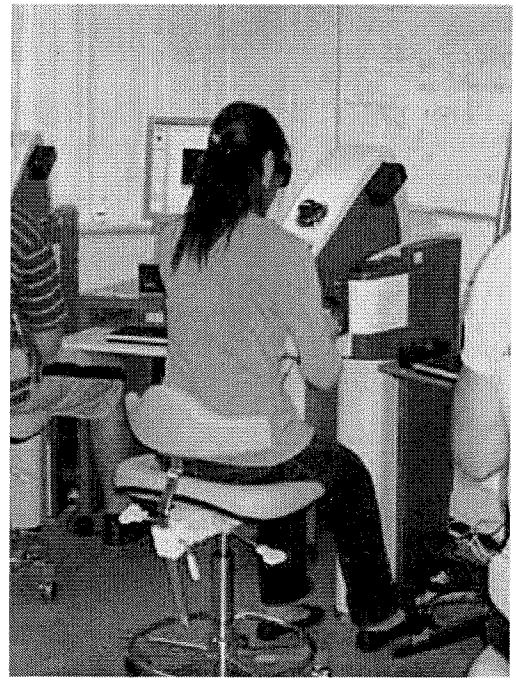

Fig. 1. Student working on the Simodont

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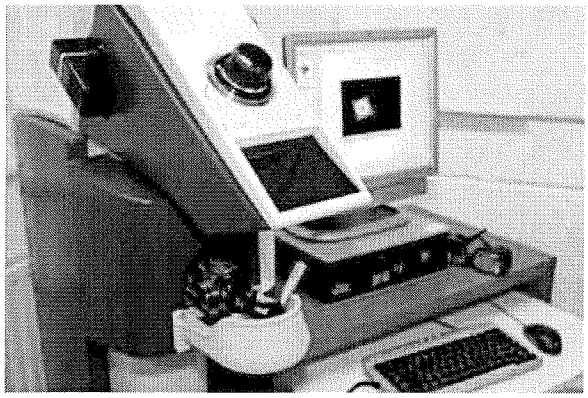

Fig. 2. Simodont unit with courseware

contains two separate loops (threads), namely a haptic loop and a graphics loop, running at different frequencies. A surface model is used to represent teeth and a tool for a better visual quality while maintaining a good performance of rendering in the graphics loop. The dental tool has six degrees of freedom positional sensing, generating 3 degrees of freedom force feedback and it moves relative to the position and orientation of a haptic probe. Collision detection and tooth cutting simulation are running along with the haptic loop in such a way that it allows computing realistic force feedback and simulating tooth cutting within only 1 millisecond. A high resolution stereo, real size co-located visual display approaches the acuity limits of the human eye. 3-D projection and mirror technology allow the full resolution, full stereo image to be seen "in" the physical workspace of the hand piece. A realistic model of the behavior of the drill speed, under the control of a foot pedal and the force exerted by the operator on the drill drives a built-in sound module which accurately renders the sound of a dental drill. Volumetric teeth data are acquired from extracted teeth using an I-CAT CBCT (120 KvP, 5 mA, Imaging Sciences, Pennsylvania, USA). A surface mesh is reconstructed from the segmented volumetric output of the segmentation tool using the marching cube algorithm (6).

Such a simulator offers the students the opportunity to develop from the beginning the required competencies in an almost realistic virtual learning environment.

Acceptance of such a simulator as a training tool is only possible if the skills developed on the simulator appear to be transferrable to the present reality in the preclinical laboratory. Therefore, prior to the introduction of the Simodont in dental education a pilot study has been carried out to investigate whether skills developed on the Simodont are transferred to reality.

Material and methods

Twenty eight 1st year students, who had no experience in using a dental bur, participated in the study. The group consisted of 18 female and 10 male students; 25 students were right-handed, 3-left handed. The average age was 19.5 yrs, with a range from 17 to 32 years.

All students started with a manual dexterity test at the phantom head lab. Thereafter, the students were randomly divided in 3 groups: 8 students acted as a control group (group 1), 10 students trained on the traditional phantom head, cutting plastic (group 2) and 10 on the Simodont simulator (group 3). Group 2 and 3 exercised for three hours and 35 minutes during 2 sessions (2 x 35 minutes exercise and 30 minutes break in between). At the beginning of the third session all three groups performed a second manual dexterity test. Thereafter, group 2 and 3 practiced again 2 x 35 minutes with 30 minutes break in between. In the fourth session, they first practiced for 2 x 35 minutes with a 30 minutes break in between. Thereafter, a third manual dexterity test was performed by all three groups after a break of 15 minutes after the last exercise (Table 1).

Table 1. Study design

Session	Control (gr 1)	Phantom head (gr 2)	Simodont (gr 3)
1	Test 1	Test 1	Test 1
		Exercise	Exercise
		Rest	Rest
		Exercise	Exercise
2		Exercise	Exercise
		Rest	Rest
		Exercise	Exercise
		Rest	Rest
		Exercise	Exercise
3	Test 2	Test 2	Test 2
		Exercise	Exercise
		Rest	Rest
		Exercise	Exercise
4		Exercise	Exercise
		Rest	Rest
		Exercise	Exercise
		Rest	Rest
	Test 3	Test 3	Test 3

The manual dexterity test was performed on a frasaco® A-PTSM mounted in a phantom head (Fig. 3, 4).

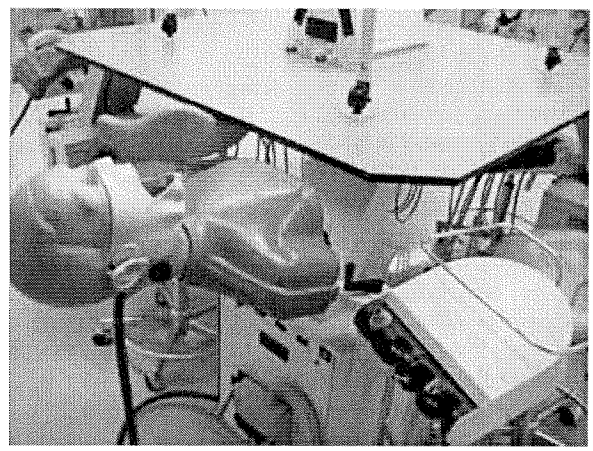

Fig. 3. The phantom head lab

The assignment was to cut away the inner circle without touching the outer circle and make the walls of the cut circle smooth and perpendicular to the bottom (Fig. 5)

The students used an airotor at 200.000 rpm with a diamond bur (FG109/010).

Two faculty members with more than five years of clinical and teaching experience performed the evaluation of the procedures. The preparations were graded anonymously and independently. The preparations were scored on two criteria: the size of the circle and the inclination of the wall, using a 4 point scale (<25%, 25-50%, 50-75%, > 75% correct) (Fig. 5). The scores of the criteria were summated. The inter-observer correlation was 0.78.

The data were analyzed using SPSS 17 by the Kruskal-Wallis test followed by Tukey tests for *post hoc* pairwise multiple comparisons at a significance level set at $\alpha = 0.05$.

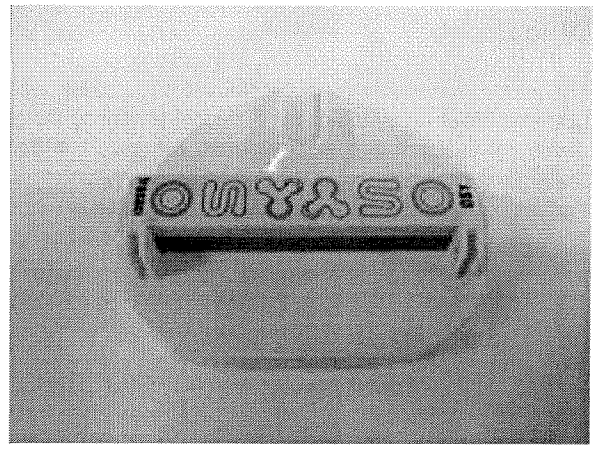

Fig. 4. Frasaco A-PTSM

Results

The results of the test at the specified time points after practicing on plastic or the Simodont at all three sessions are shown in figure 6.

It appeared that the control students did not improve during the three tests where the students that practiced on the Simodont performed significantly better after the second session than the control students, as those who practiced on the phantom heads did not show a significant improvement. After the fourth session during the third test the students who practiced on the Simodont produced similar results as after the second session, where as the students that practiced on the phantom heads now performed significantly better than the controls. At the third test no significant difference in performance was found between the students who practiced on the phantom head or the Simodont.

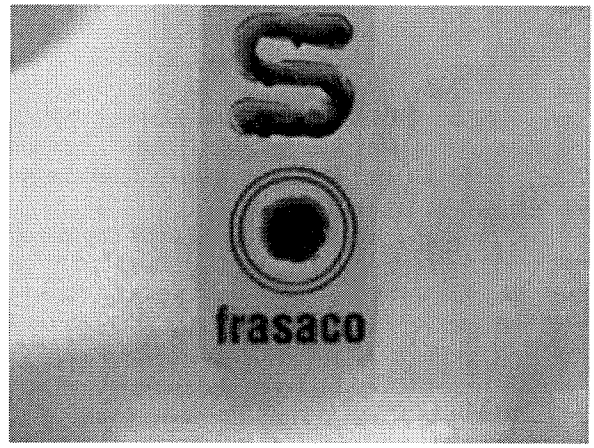

Fig. 5. Preparation performed by a student

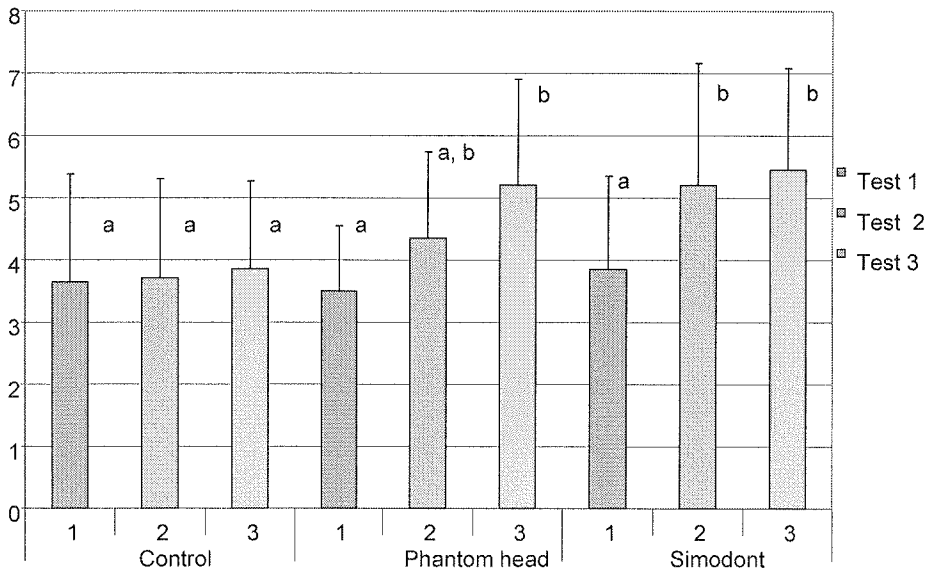

Fig. 6. The means of the summated scores of the criteria (maximum score = 8) of the tests of the students that served as controls, or practiced on phantom heads or the Simodont during the three sessions (1,2 and 3). Different letters between test results represent statistically significant differences. Identical letters indicate no statistically significant difference between the test results.

Discussion

The main observation seen in this study is that students who practiced either on plastic or the Simodont performed better during the final test than those who did not, indicating that the practicing was useful to reach the desired performance. Furthermore, at the end of the experiment the students who practiced on plastic and those who practiced on the Simodont performed equally well showing that apparently skills developed on the Simodont can be applied in reality, thus implying transfer of skills from virtual reality to reality. This result suggests that in this respect the Simodont may be a useful instrument for dental students to develop their manual dexterity during dental education.

In comparison to the traditional preclinical laboratory the Simodont offers several advantages. As all instruments and materials are virtually represented no costs are made for dental hand pieces, burs and plastic teeth to practice on. Also realistic pathology can be treated without risks for patient and student. Furthermore no water and suction are involved which eliminates Legionella threats. It was very convenient for students that in case they had to redo an exercise, they just had to click to get a new exercise model where in reality a plastic tooth has to be replaced in the phantom head which is a rather tedious procedure and continuously distracts the focus and concentration of the students.

An interesting observation during the study was that the majority of the students working on the Simodont had a more desired upright working position than students working in the phantom head lab. Further research should be carried out to find out if this also leads to improvement of clinical working positions.

Conclusion

Skills developed in virtual reality on the Simodont were transferred to reality thus the Simodont appeared to be a useful instrument for the development of manual dexterity of dental students.

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