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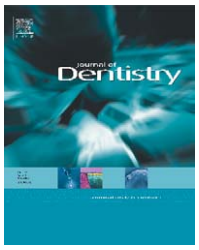

Effect of reducing frequency of augmented feedback on manual dexterity training and its retention

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ABSTRACT

Objective: The study addressed the impact of the frequency of tutorial-enriched augmented visual feedback, provided by a virtual simulation system (DentSim™), on the skill acquisition for a cavity preparation task in novice dental students.

Methods: Thirty-six subjects were assigned to two training groups and a control group. The task consisted of a geometrical cross preparation on the lower left first molar. All subjects performed a pre-test to assess their basic skill level. The training groups received simulation feedback, enriched with tutorial information, across acquisition. One group trained under continuous augmented feedback, while a second group trained under an intermittent (66% of the time) feedback. At both 1-day and 4-month interval, subjects performed a retention test to explore learning specific effects. Two transfer tests were added to assess the extrapolation of the learned skills to an adjacent molar. All tests were performed in the absence of feedback. A control group performed all the tests, without preceding training. All preparations were graded by the simulation system.

Results: The training groups performed similarly across acquisition and improved with practice (ANOVA, $P < 0.001$). After 1 day and 4 months of no practice, the training groups outperformed the control group on a retention test (ANOVA, $P < 0.001$) and transfer test (ANOVA, $P < 0.001$).

Conclusions: Performance and learning of a cavity preparation task on a simulation unit was independent of the frequency of tutorial-enriched augmented visual feedback within the range tested. Training sessions on a simulation unit could be alternated with training sessions in the traditional phantom head laboratory.

1. Introduction

In the field of motor learning it is well known that, aside from practice itself, information feedback about the performer's success is one of the most powerful variables affecting the acquisition of a new skill.[1,2] The augmented feedback information guides the learner to accurate performance.

In dentistry, one must acquire mastery in fine motor skills. This can be achieved by vigorous training on phantom teeth. Traditionally, a learner receives verbal feedback on

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performance by an external source, usually an instructor, when he has completed all or a portion of a cavity preparation task. More recently, a virtual reality (VR) simulation system (DentSim™, DenX, Jerusalem, Israel), providing continuous augmented feedback during performance has been introduced. Buchanan[3] and other researchers[4,5] reported that the use of this simulator accelerated skill acquisition when compared with traditional laboratory training. Whether this has a remaining effect in later clinical practice, remains unknown. The faster dexterity build-up may have a beneficial influence on the attitude of the dentist towards assimilation of new skills. Wierinck et al.[6] showed that manual dexterity training on such a simulator resulted in enhanced performance during acquisition. When feedback was withdrawn, however, performance deteriorated, indicative for feedback dependency. It also seemed that the subjects could not process the copious VR information properly. Thus in a subsequent study,[7] the same group of researchers enriched the simulation feedback with additional verbal information on the performance criteria, provided by an experienced tutor, more similar to a traditional learning setting. This was coined tutorial-enriched VR feedback. It appeared that this feedback mode was beneficial for long-term learning and transfer of a cavity preparation task. The question remained, however, whether this continuously provided tutorial-enriched VR information could be limited and would as such provoke enhanced performance during feedback-free test conditions. The purpose of the present study was therefore to evaluate the effect of reduced feedback frequency on the learning of skills in novice dental students. It was hypothesized that a feedback frequency of less than 100% could benefit the acquisition and retention of a cavity preparation task as compared to 100% feedback training.

2. Materials and methods

Thirty-six first year dental students, aged 18–22 (mean age = 19.14) participated in the present study. None of the participants had received any manual dexterity training or had any experience in using dental handpieces. All subjects gave their written informed consent. A proper motivation to score was achieved by considering the training phase as a preliminary part of the participants' preclinical course.

The task consisted of preparing a geometrical class 1 cavity on the lower left first molar, defined as the cross preparation (Fig. 1). All cavity preparation sessions were completed on the DentSim™ computerized training system, an advanced interactive simulation and navigation unit for training dental students in manual dexterity. The DentSim™ unit includes a simulated patient or manikin with head and dentoform, dental handpiece, light source, infrared camera and two computers.[8] The optic tracking device, consisting of the infrared camera and light emitting diodes on the manikin head and handpiece, allows detecting the orientation of the head and handpiece in space and produces a virtual three-dimensional image of the preparation in progress. The software compares the operator's performance to an ideally prepared tooth at any moment during preparation as well as after its completion, revealing consistent feedback information. All preparations were cut with a diamond cylindrical bur (Komet™ 835-010, Komet™ GmbH, Besigheim, Germany), used at ultra-high speed and with continuous water spray. Participants were supplied with a millimetre graduated periodontal probe and mouth mirror.

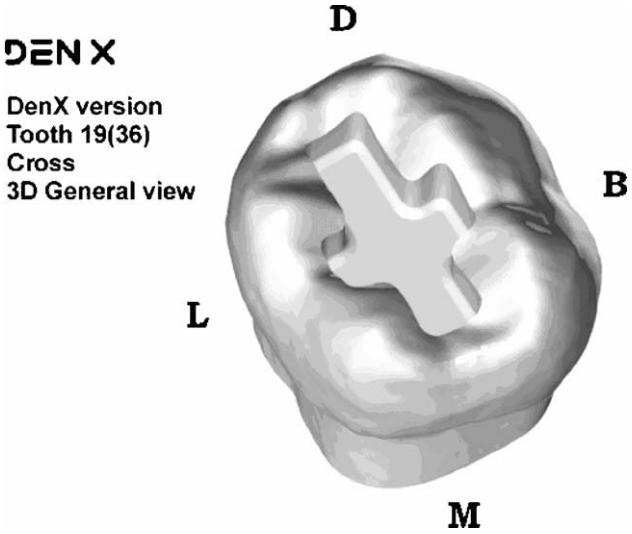

Fig. 1 – 3D-occlusal view of the cross preparation on tooth 36.

Subjects were randomly assigned to one of the training groups, the 100% feedback-plus (100% FB+) or 66% feedback-plus (66% FB+) group, or to a non-training control (CO) group, each consisting of 12 subjects. Both training groups received simulator feedback and evaluation information on performance, supplemented with tutorial input, enriching the VR information. The latter consisted of ten minutes of standardized expert advice on one or two specific evaluation issues prior to each training session (Table 1). Both FB+ groups differed from each other with respect to the frequency of feedback provided during training. The augmented feedback information was continuously (100%) or available at a reduced (66%) time span. All subjects had 1 h of introduction on the working of the VR system and the basic principles of cavity preparation. Each participant received a manual guide with information on the performance criteria. Subsequently, all groups performed one pre-test preparation (P) to assess the basic skill level of each group. During this test, the simulator did not provide any feedback (no augmented FB). Subsequently, in contrast to the CO group, the FB+ groups started their training sessions, according to their specific feedback frequency for 5 days (Tuesday = S1, Wednesday = S2, Thursday = S3, Monday = S4 and Tuesday = S5). Each day, they

Table 1 – Issues brought by tutorial information, prior to each training session (S1–S5)

S1	'Cross-sections' and 'centralization evaluation'
S2	'Outline shape' and 'floor depth'
S3	'Floor smoothness' and 'wall inclination'
S4	Review of an arbitrary chosen session
S5	Review of a previous performed training session