Training Device for Dental Students to Practice Mirror-Inverted Movements

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Abstract: The goal of this study was to explore whether the ability of precise mirror-inverted movements can be learned and improved with the device Mirroprep and whether practice success can be transferred to the clinical situation. Three groups of students at different levels of dental study and different achievement levels were asked to perform a drawing exercise with indirect vision using Mirroprep. Further, the group of most senior students were asked whether the motor skills learned with this device were helpful in clinical tooth preparations by use of the dental mirror. According to the test results, we were able to show that mirror-inverted motor functions can be learned and improved by practice and that it is also helpful for performing tooth preparations. Because of this, it is deemed reasonable for students to start practicing with the training device during their preclinical studies and to have their skills tested.

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There are some areas in dentition not accessible to direct vision. Therefore, tooth preparation has to be carried out by indirect vision with a dental mirror. Some areas can be worked on with direct vision, but only by physiologically adverse contortion and bending of the body. It has been shown that the ability to transfer indirect vision into mirror-inverted movements can be acquired and improved by motor practice and neurophysiological adaptation.1,2 Once acquired, motor skills seem to be permanent.3 Therefore, motor skill acquisition should occur early in the dental curriculum prior to patient contact. An important goal is that the dental students learn to perform the intended type of preparation confidently without affecting adjacent teeth.

We have developed a simple but highly practical training device to support dental students in transferring indirect vision into mirror-inverted movements. The goal of this study was to test the following hypotheses: 1) mirror-inverted motor functions relying on a mirror image can be learned and improved by practicing with the training device; and 2) the skills acquired with the device can be applied to clinical situations.

Methods

Seventy-eight dental students took part in the study. There were three groups of students at different points in the curriculum. The first group (which we will refer to as the first-year students) comprised twenty-nine students in their first preclinical semester. This group had had no previous experience in working with indirect vision. The second group comprised twenty-eight advanced students who had previously had one practice trial with the training device and had recently experienced indirect vision by working on the dental mannequin. The third group consisted of twenty-one graduate students in the last year of study. Prior to the test they had had self-defined practice sessions with Mirroprep in regards to time and frequency as well as clinical experience working on the patient.

Training devices for retracing lines have been described elsewhere.1,3 The training apparatus Mirroprep consists of a u-profile high-quality steel sheet with a mirror mounted to its rearmost wall and a replica of a dental drill holding a short pencil (Figure 1). Because of its screen, the object positioned on its base plate can be seen only through the mirror. There are several advantages to this newly developed training device. Because of its simple and open design, it is suitable for both right- and left-handed people. Furthermore, both two- and three-dimensional objects can be inserted for practice. The actual test sheet consisted of a curved track course, its track having a width of 4 mm, and three different outline forms in the shape of a circle, rectangle, and heart (height ranging from 4 to 5 mm and width ranging from 5 to 6 mm).
The task was to track the course on the pad marked by two lines with the pencil and to completely blacken various outline forms. The tracing course particularly was supposed to help the student practice the movement in the direction reflected by the mirror. The blackening of the forms was intended to simulate the preparation of geometric forms in dental cavities. The students were asked to trace the course and color the outline forms within the given time of six minutes without crossing the boundaries under close supervision. It was defined as an error when the boundary lines were exceeded in either the course or the outline forms and also when white areas remained in the outline forms bigger than 0.5 mm². After completing this practical test and then performing an inlay preparation on the patient, the twenty-one graduate students were asked to evaluate, on a scale from 1 to 6, how helpful this kind of practice had been in helping them master clinical situations with indirect vision using a dental mirror.

To determine whether there were statistically significant differences in the number of errors students in the three groups made in completing the course and the outline forms, we computed a univariate analysis of variance (ANOVA). Post-hoc Games-Howell tests were used to determine which group differences precisely were statistically significant.

**Results**

Consistent with our prediction, the number of errors students made decreased markedly from first-year students to graduates. On average, first-year students made 15.4 errors ($SD=7.9$; range 4–39), advanced students made 4.4 errors ($SD=5.7$; range 0–30), and graduates made only 1.8 errors ($SD=1.9$; range 0–5). Thus, univariate ANOVA for number of errors was highly significant, $F(2, 75)=38.26$, $p<0.001$, $\eta^2=.51$. Post-hoc Games-Howell tests showed that first-year students made significantly more errors than both advanced and graduate students (both $ps<0.001$). The difference in number of errors between advanced and graduate students...
was marginally significant, \( p=0.07 \). There was thus a statistical trend for graduates to make fewer errors than advanced students. Figures 2 and 3 show typical samples from groups 1 and 3, respectively.

Table 1 gives a frequency distribution of numbers of errors for the three groups of students. Its first column clearly illustrates how the substantial decrease in average number of errors from first-year through graduate students came about. While there was only a single first-year student who could perform the task with fewer than five errors, more than half of the advanced students fell into this category. For the graduates, a large majority of 90 percent performed the task with fewer than five errors.

After conducting clinical preparations, graduate students were asked to answer a question about the helpfulness of the device. Their responses are shown in Figure 4. Eighty percent considered practicing mirror-inverted movements with Mirroprep helpful in performing clinical preparation in the patient’s mouth (answer categories 4, 5, and 6 taken together). In addition to this practical relevance, students in all three groups stated that they had enjoyed working with the training device.

**Discussion**

Mirroprep was accepted with pleasure and as a kind of sporting challenge by the students. The high number of errors of 15.4 on average in the group of untrained dental students from the first preclinical semester is consistent with findings from other studies that have found the ability to perform mirror-inverted movements requires neurophysiological adaptation.\(^1,2,5\) The comparatively high standard deviation of 7.9 in this group is also consistent with previous results, which have found this ability to vary strongly between individuals.\(^1,2,5\)

With an average number of errors of 4.4 and 1.8, the clinical semesters of advanced dental students and graduate students achieved clearly better results. The group of first-year students had had no previous clinical experience with indirect preparations in the patient’s mouth nor had they had experience in working on the dental mannequin. It is therefore plausible to assume that the much reduced number of errors of the advanced students in comparison to that of the first-year students is at least partially attributable to the one-time practice with the device. Indeed, other studies\(^1,2,5\) have found that a single exercise alone results in a significant decrease of errors. This interpretation receives further support from our finding that number of errors only marginally decreased from advanced to graduate students. It should be noted, however, that the graduate students made less than half as many errors as the advanced students. The fact that this difference was statistically only marginally significant may largely be attributable to the relatively small number of subjects in the study. At first sight, the low number of errors of 1.8 on average in the group of graduate students seems

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![Figure 2. Typical sample of Mirroprep test results selected from the group of first-year students showing 15 mistakes (7 in the outline forms, 8 in the course)](image1)

![Figure 3. Sample with no mistakes selected from the group of graduate students](image2)
to allow for the conclusion that the tested ability can be improved and brought close to perfection by Mirroprep. However, in comparison to the other groups, these students have had more opportunity and time to practice. Furthermore, in comparison to the other two groups, the more positive results of this group may also have been influenced by advancing to higher level courses and consequently acquiring clinical experience. Therefore, a possible criticism of this study may be that it cannot definitively assess to what extent the advancement in the curriculum and the training device have a share in the learning results.

Despite these shortcomings, our study supports the conclusion that two-dimensional motor skills with indirect view can be improved by practicing with Mirroprep. However, the clinical situation in the patient’s mouth demands that movements are conducted three-dimensionally with the dental mirror held in various positions, different amounts of pressure to be applied, and possibly dealing with a mist settling on the dental mirror by the use of the water spray system. Thus,
some authors insist on training measures to always be conducted three-dimensionally. However, we argue that as soon as the bottom of a cavity is reached with a cutting bur, the necessary movements towards the margins of the cavity occur solely on one level. This important, mainly two-dimensional movement is simulated by the outline forms to be blackened in the Mirroprep device. The graduate students were asked whether they felt that prior motor practice had clinical relevance and a positive effect on working in the patient’s mouth. This group was allowed to conduct a clinical preparation only after they had passed the Mirroprep test with fewer than two errors. The predominantly positive answers allow for the conclusion that practice with Mirroprep is indeed helpful for clinical work in the patient’s mouth. Even though the results of Neumann’s study did not clearly confirm a positive practice effect, her students equally considered two-dimensional practice with mirror-inverted view at the dental mannequin beneficial for indirect cavity preparation.

Taking into account findings from previous studies as well as our own, we consider the procedure installed in Tübingen an effective teaching method: for students to begin practicing two-dimensionally by using Mirroprep in preclinical courses, to continue practicing three-dimensionally on the dental mannequin, and to finally take another test in the clinical course before starting to work on patients. In order to enhance the possibilities to practice, dental models mounted with either plastic or natural extracted teeth may be placed into the training device for tooth cavity preparation with cutting burs. Thanks to its open structure, our training device allows for the use of suction devices to eliminate spray mist and drilling debris. It is therefore also possible to practice three-dimensional cutting exercises using Mirroprep.

One point that might be criticized about our study is that practice success was measured solely by obtaining students’ evaluation of how helpful they considered the practice in mastering the actual clinical situation. Future studies using Mirroprep as a training tool in dental education should therefore measure practice success not only by asking students for self-evaluation but also by evaluating their skills at preparation of teeth.

Conclusion

Our study supports the idea that indirect motor skills can be practiced and improved by the use of Mirroprep. A significant improvement of the two-dimensional motor skills can be seen after a single practice session. Considering the students’ evaluation of the helpfulness of the training device for performing tooth preparations on the actual patient, it further can be said that these exercises make the transition to clinical work easier for the student.

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