EXTENDED REPORT

Advantage of three dimensional animated teaching over traditional surgical videos for teaching ophthalmic surgery: a randomised study

A Prinz, M Bolz, O Findl

Background/aim: Owing to the complex topographical aspects of ophthalmic surgery, teaching with conventional surgical videos has led to a poor understanding among medical students. A novel multimedia three dimensional (3D) computer animated program, called “Ophthalmic Operation Vienna” has been developed, where surgical videos are accompanied by 3D animated sequences of all surgical steps for five operations. The aim of the study was to assess the effect of 3D animations on the understanding of cataract and glaucoma surgery among medical students.

Method: Set in the Medical University of Vienna, Department of Ophthalmology, 172 students were randomised into two groups: a 3D group (n = 90), that saw the 3D animations and video sequences, and a control group (n = 82), that saw only the surgical videos. The narrated text was identical for both groups. After the presentation, students were questioned and tested using multiple choice questions.

Results: Students in the 3D group found the interactive multimedia teaching methods to be a valuable supplement to the conventional surgical videos. The 3D group outperformed the control group not only in topographical understanding by 16% (p < 0.0001), but also in theoretical understanding by 7% (p < 0.0003). Women in the 3D group gained most by 19% over the control group (p < 0.0001).

Conclusions: The use of 3D animations lead to a better understanding of difficult surgical topics among medical students, especially for female users. Gender related benefits of using multimedia should be further explored.
Study design
Through a period of 8 weeks, four regular practical courses in ophthalmology were held at the Medical University of Vienna. Within the course blocks of two consecutive weeks (10 working days) students were also attending lectures. Altogether, 172 medical students were included in this study. Because of the large number of students, each course block is subdivided into two parallel classes. During the course both classes were scheduled for a video presentation of cataract and glaucoma surgery: the A class in the first week (on the fourth day of the course) and the B class in the second week (on the eighth day of the course). Therefore, a class of approximately 25 students was included in our study per week. Each student class was randomly assigned to the 3D or control groups of the study, according to a randomisation list derived from a table of random numbers. A block randomisation was applied to ensure a balance between first and second weeks of courses. The presentations were presented over a PC beamer in the same lecture theatre. Before the presentation was started, students were informed about the study and given the choice to participate by anonymously answering a questionnaire following the presentation. The control group saw the surgeon’s view of the cataract and glaucoma procedures. The 3D group saw the director’s cut of the same procedures, which includes the 3D animations in addition to the surgeon’s view sequences identical to those in the control group. The narrated comments were identical in both groups. After the presentation of the cataract and glaucoma surgical procedures, the students evaluated the teaching project and, if applicable, the 3D animations, by using a questionnaire of five and 10 statements, respectively. A four level ordinal scale (1, fully agree, 4, disagree) was used for the statements in the questionnaire.

Additionally, a multiple choice test of 19 questions that focused on the topics of cataract and glaucoma surgery was presented. It consisted of two question parts: cataract (n = 9) and glaucoma (n = 10). For the statistical analysis, multiple choice questions (MCQ) that assessed spatial knowledge with allocation of each surgical step to the anatomical tissue involved were combined in the category of topographical understanding questions (n = 8). Questions that assessed more theoretical knowledge of the surgical procedures and why the surgical steps are performed were combined in the category of theoretical understanding questions (n = 11). The MCQs were aimed at specifically verifying the level of knowledge gained based on the same narrated information (shown in both groups) during the presentation. Therefore, the questionnaire was constructed considering all details in the surgical procedure from the wound construction, over exactly predefined anatomical structures, their removal with instruments and, finally, the type of wound adaptation. After completing and handing in the questionnaire, the students in the control groups received an opportunity to view the missed 3D animation sequences.

The reported relative (%) results refer to the differences in the correct scores on the different sections of the MCQs. For instance, students in the 3D group achieved 12% better test results considering the entire questionnaire, which means 2.6 items more correctly answered in 19 MCQs than in the control group.

Statistical analyses of data trends
The data are presented as means and 95% confidence intervals (CI). The two sided unpaired Student’s t test was applied to the data. Probability values of less then 0.05 were considered to be statistically significant. Reliability analysis of the multiple choice questionnaire was calculated with Cronbach’s alpha coefficient that measures the internal consistency. This coefficient of test scores is obtained from a single test and is a function of the number of test items and the average intercorrelation among the items. A coefficient of 0.7 to 1 indicates a high reliability.

RESULTS
The randomisation of groups resulted in 90 students in the 3D group (55 women/35 men) and 82 in the control group (50 women/32 men).

Concerning the general questions in the questionnaire, significant differences between the two groups were found for most criteria (see table 1).
The largest difference in rating was found for the improvement of the spatial ability, with a mean better grade of 0.3 for the 3D group.

The 3D animation was confirmed to be an important and useful supplement to conventional surgical videos and it was suggested to use similar 3D animations in teaching of various other topics in medicine (fig 2).

The results (percentage of correct answers) of both groups on the multiple choice test, testing the topographical and the theoretical understanding of the operations, are illustrated in figure 3. The 3D group outperformed the control group not only in the topographical understanding tasks ($p < 0.001$), but also in the theoretical understanding questions ($p < 0.001$). An acceptable reliability of the entire multiple choice questionnaire was found with a Cronbach’s alpha of 0.69.

The differences between mean results of the tests of both groups are presented in table 2. Female students in the 3D group achieved significantly better test results in all categories, than in the control (video) group. This was not the case with male students. No significant difference was found between the first and the second week within both groups.

**DISCUSSION**

The use of multimedia in e-learning is indispensable when one considers that a person usually retains only 10–15% of that which is read, 10–20% of what is heard, and 20–30% of what is seen, but when audio and video materials are presented side by side the retention of knowledge increases to 40–50%. In this study, we compared the results of two different approaches to teaching medical students about ophthalmic surgery. Videos supported with 3D computer animations resulted in a difference of approximately one more correct answered MCQs of students as well for cataract (14%) and for glaucoma (11%) surgery compared to the common surgical videos alone. This result confirms those of Glittenberg et al., that showed the effectiveness of computer assisted 3D animation in teaching neuro-ophthalmology to medical students.

Also, our study extended the findings of several studies, showing a great acceptance and support of multimedia assisted education among students.

To our knowledge, “Ophthalmic Operation Vienna” is the first teaching project and learning aid for ophthalmic surgery, which systematically presents each surgical step using 3D animation and multiple view videos.

Nevertheless, there may be some limitations to our study. With respect to the study design, the internal validity needs to be questioned as both groups may not be comparable (selection bias). One of the reasons for the absence of a
pretest was that we assumed a normal distribution of the students’ pre-knowledge. The students were grouped coincidentally, and these groups were randomly allocated to 3D or control. With respect to the possible “diffusion of treatment” no preventive measures were used, since the only access to the tested DVD was given to the control group only after collecting the questionnaire. With a Cronbach’s alpha of 0.69, the reliability of the multiple choice measure suggests an acceptable intercorrelation of the multiple choice questionnaire. Other important aspects of evaluating novel educational programs such as social applicability, social educative relevance (one more/less correct answer), and long time effects need to be further assessed.

Another limitation of this study may be that no standardized visual spatial tests such as mental rotation were used. There are different opinions as to how important and predictive the innate visual and spatial ability may be relating to success in learning. Considering the gender differences, some studies have found that men outperform women with regard to spatial ability. Several variables are assumed to be responsible, such as functional hemispheric asymmetry and the possible influence of the menstrual cycle phase on that asymmetry. Based on the theoretical and empirical principles of several evolutionary models, sexual selection generally leads to the evolution of sex differences. The range size hypothesis predicts the sex differences in spatial abilities only in polygynous species, since males are compelled to travel long distances in order to win in the male-male competition, rather than to hunt for food. In addition, sociocultural factors seem to be involved. However, in this study, there was no difference between male and females in either the 3D or the control groups. The implication of a meta-analysis suggested that large sex differences are found only on measures of mental rotation and smaller sex differences are found on measures of spatial perceptions. Our findings suggest that, mainly, women seem to benefit by improving their topographical and theoretical knowledge, after being taught with the 3D computer animation (3.6 more correct answers on 19 MCQ). Generally, the use of 3D animations seems to optimise the level of motivation and perception, so that students with less developed spatial ability achieve greater learning efficiency. Thus, gender related benefits of using multimedia as a teaching method may need to be considered in future studies.

CONCLUSION

Surgical videos supported with 3D computer animations resulted in an increase of spatial and theoretical understanding of ophthalmic surgery. Compared to the control group, there was a significant improvement of knowledge and a better acceptance of multimedia assisted teaching among students. Furthermore, women showed more benefit in being taught with a multimedia 3D animated program than men.

Table 2 Improvement of 3D versus control group for correctly answered multiple choice questions (MCQ) about cataract and glaucoma surgery and also separated according to gender

<table>
<thead>
<tr>
<th>Correctly answered MCQ (%)</th>
<th>All</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3D n = 90</td>
<td>3D n = 55</td>
<td>3D n = 35</td>
</tr>
<tr>
<td></td>
<td>control n = 82</td>
<td>control n = 50</td>
<td>control n = 32</td>
</tr>
<tr>
<td>All MCQ (n = 19)</td>
<td>12% (7 to 17)</td>
<td>19% (12 to 26)</td>
<td>8% (–1 to 17)</td>
</tr>
<tr>
<td>Cl (95%)</td>
<td>p = 0.0001</td>
<td>p = 0.0001</td>
<td>p = 0.08</td>
</tr>
<tr>
<td>Cataract MCQ (n = 9)</td>
<td>14% (7 to 21)</td>
<td>20% (12 to 28)</td>
<td>9% (–1 to 19)</td>
</tr>
<tr>
<td>Cl (95%)</td>
<td>p = 0.0001</td>
<td>p = 0.0001</td>
<td>p = 0.16</td>
</tr>
<tr>
<td>Glaucoma MCQ (n = 10)</td>
<td>11% (5 to 17)</td>
<td>14% (6 to 22)</td>
<td>7% (–1 to 15)</td>
</tr>
<tr>
<td>Cl (95%)</td>
<td>p = 0.0002</td>
<td>p = 0.0005</td>
<td>p = 0.12</td>
</tr>
<tr>
<td>Predominantly topographical understanding MCQ (n = 8)</td>
<td>16% (10 to 22)</td>
<td>19% (12 to 26)</td>
<td>10% (–1 to 21)</td>
</tr>
<tr>
<td>Cl (95%)</td>
<td>p = 0.0001</td>
<td>p = 0.0001</td>
<td>p = 0.03</td>
</tr>
<tr>
<td>Predominantly theoretical understanding MCQ (n = 11)</td>
<td>7% (1 to 13)</td>
<td>14% (7 to 21)</td>
<td>4% (–5 to 13)</td>
</tr>
<tr>
<td>Cl (95%)</td>
<td>p = 0.002</td>
<td>p = 0.0001</td>
<td>p = 0.38</td>
</tr>
</tbody>
</table>

Questions also grouped according to predominantly topographical and theoretical understanding. Mean relative difference (%) in correct answered MCQ (3D control), 95% confidence interval (Cl), p value of unpaired t test. Positive values indicate a better performance of the 3D group compared to the control group.

REFERENCES

3 Glittenberg CG, Binder S. Computer-assisted 3D design software for teaching neuro-ophthalmology of the ocular motor system and training new retinal surgery techniques. Proc SPIE 2004;5314:275–85
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