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Effect of Magnification on the Precision of Tooth Preparation in Dentistry

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Clinical Relevance

Magnification devices can improve the precision of tooth preparation by dentists.

SUMMARY

Objectives: To evaluate the impact of magnification aids on the precision of tooth preparation under simulated clinical conditions.

Methods and Materials: Two plastic blocks marked with a geometric shape were fixed in a dental phantom head: a circle as the distal surface of tooth 16 (UNS 3) and a y-shaped figure as the occlusal surface of tooth 36 (UNS 19). Sixteen dentists (mean age: 39 years; range: 26-67 years) prepared the geometric shapes from the inside to the boundary line with a cylindrical bur and water-cooling. The boundary line had to be touched but not erased. Chair-side assistance was provided to simulate the clinical situation. Tooth 16 was prepared under indirect vision via a dental mirror. Tooth 36 was prepared under direct vision A) without magnification aids, B) with Galilean loupes, 2.5× and light-emitting diode light, and C) with a microscope, 6.4× and coaxial light. The preparation procedure was performed three times in different sequences of the magnification devices and with a break of at least 1 week between each procedure. The correctly prepared contour and the incorrectly prepared areas were evaluated in relation to the whole circumference of the geometric shapes.

Results: For both values the precision was significantly higher when a microscope was used, followed by preparation using loupes; precision was lowest without magnification aids ($p<0.0001$). This was true for both indirect and direct vision ($p<0.05$).

Conclusions: Magnification devices improved the precision of tooth preparation under simulated clinical conditions.

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INTRODUCTION

The use of magnification aids is widespread in professions requiring manual dexterity and preci-

sion. In dentistry, loupes and operating microscopes have become part of the normal equipment of many dentists. They improve near visual acuity and help to compensate for visual deficiencies.[1-3] Recent studies with miniaturized visual tests on the basis of microfilms have shown a high variability in the near visual acuity of dentists. They found that acuity declined with increasing age of dentists older than 40 years.[1,3-6] The influence of magnification aids on visual performance was evaluated in the same studies. Galilean and Keplerian loupes improved near visual acuity and could compensate for presbyopia in persons older than 40 years. The results of Keplerian loupes were superior to those of Galilean loupes due to their higher magnification. The performance of the operating microscope was outstanding and highly superior compared with loupes.[1,3-5] These basic studies did not evaluate the influence of visual acuity on the quality of dental diagnostics and therapy, however. The subjective conviction that magnification devices improve the precision of manual work is not supported by the weak scientific evidence in this field. Most studies of magnification aids and dental treatment are of low scientific rigor, such as expert opinions,[7-10] case reports,[11-13] and case series.[14,15] The few scientific studies that included a control group or followed a standardized study design reported ambiguous results, and some authors found that magnification devices per se did not lead to better diagnostics or better treatment results.[16-22]

The aim of the present study was to evaluate the impact of optical magnification on the precision of tooth preparation under simulated clinical conditions. The null hypothesis was that magnification has no influence on the precision of tooth preparation.

METHODS AND MATERIALS

Test Subjects

Sixteen dentists participated in the study (mean age: 39 years; median age: 31 years; range: 26-67 years). The dentists were employees of the dental school (n=10) and private dental practitioners (n=6). Inclusion criteria were 1) experience with dental loupes and operating microscopes and 2) near visual acuity in the range of a reference group of dentists as determined in an earlier study.[5] The inclusion threshold for experience was the daily use of both loupes and a microscope, ascertained by questioning the participating dentists. Near visual acuity was assessed by a visual test.

Visual Test

Each participating dentist underwent a near vision test as described by Eichenberger and others.[5] The test was performed without magnification aids but with participants wearing their prescription glasses, if needed. The distance was 300 mm, or the focal distance of the correction glasses.

Geometric Shapes

Plastic teeth (OK T 14 and UK T 14, KaVo Dental AG, Biberach, Germany) of a dental phantom head were prepared for the insertion of standardized geometric shapes from a plastic block (A-PTM 99-001, Frasaco, Tettnang, Germany). A geometric circle was fixed as the distal surface of tooth 16 (universal numbering system: tooth 3) and a y-shaped figure as the distal surface of tooth 36 (universal numbering system: tooth 19) in order to simulate a typical indirect and direct preparation (Figure 1A,B). The plastic blocks were reversibly fixed with superglue (Pattex flüssig 3g, Henkel, Düsseldorf, Germany), which allowed reuse of the teeth for standardization purposes. The phantom head with the teeth described earlier was positioned on the dental chair habitually used by patients of the respective dentists to simulate a typical patient setting.

Preparation Procedure

The cavities were prepared using a handpiece (5:1, KaVo Dental), a cylindrical diamond bur (120-μm grit, 1-mm diameter, ISO 806 314 156 524 010 4.0, Intensiv SA, Montagnola, Switzerland), water-cooling, and compressed air. Chair-side assistance was provided by one of the authors (M.E.). The preparation proceeded from inside to the boundary line, with a predetermined limit of preparation depth between 1.5 and 2.5 mm. This depth was indicated by the colored layers in the plastic block. The black line of the geometric shape had to be touched without erasing it. The preparation time was limited to 5 minutes. Tooth 16 was prepared under indirect vision via a dental mirror (TOPvision FS Rhodium, Hahnenkratt GmbH, Königsbach-Stein, Germany). Tooth 36 was prepared under direct vision, using the dental mirror to check the preparation. Each dentist prepared the shape of tooth 16, followed by the shape of tooth 36, under the following conditions:

A. Naked eye, that is, no magnification devices except prescription glasses and customary operating light

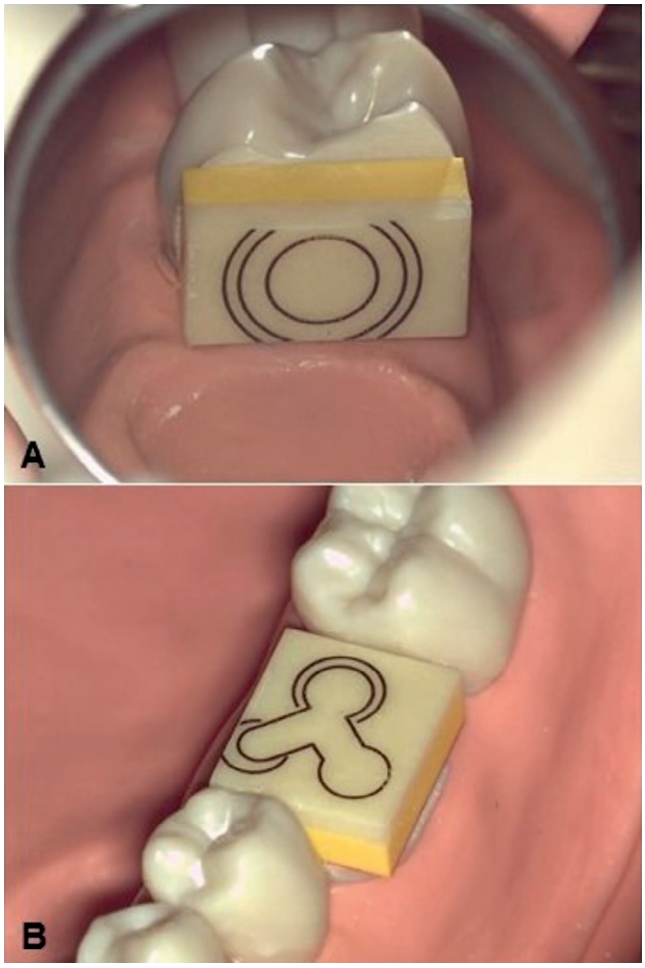

Figure 1. *(A) The circle was fixed as the distal surface of tooth 16 to simulate the clinical situation of indirect preparation (viewed from the 12-o'clock position). (B) The y-shaped figure was fixed as the occlusal surface of tooth 36 to simulate the clinical situation of direct preparation.*

B. Customary Galilean loupes with coaxial light-emitting diode light source; 2.5× magnification factor
C. Operating microscope with integrated light source (Leica, Heerbrugg, Switzerland); 6.4× magnification factor

The test was performed three times in different sequences (A-B-C; B-C-A; C-A-B) with a break of at least 1 week between the tests.

Evaluation of the Prepared Geometrical Shapes

The unprepared surface of the geometrical shapes was colored (Schwan-Stabilo Marker, Heroldsberg, Germany). Photographs of the geometric shapes were taken at 10× magnification using a light microscope (Leica M 420) equipped with a video camera (Leica DFC 495) and linked to a computer. The ideal geometric shapes were superimposed to the photographs of each preparation using the program LAS V4.6.1 (Leica). These superimpositions allowed the user to evaluate the correctly prepared contour (mm) and the sum of overprepared and underprepared areas (mm^2). These values were set in relation to the whole circumference and resulted in two qualitative values for the preparation.

Statistical Analyses

For statistical analysis, the software program R version 3.3.0 (http://www.r-project.org/) was used. The significance level was set at $\alpha=0.05$. The medians of the three preparation sequences were used for the statistical analysis. Descriptive statistics included minimum, maximum, mean, median, and standard deviations. The numeric outcomes were analyzed for differences between the three experimental conditions (eye, loupe, microscope). Because of the small sample size this was done using a nonparametric analysis of variance for longitudinal data according to Brunner and others.[23] The p-values were adjusted to take into account the multiple comparisons using the Bonferroni-Holm correction. Post hoc tests were performed without p-value adjustment if global tests showed significant main effects or interactions with other variables. Additional questions (ie, on indirect vs direct vision) were answered by performing post hoc Wilcoxon signed-rank tests without p-value adjustment.

RESULTS

The near visual test resulted in a mean visual acuity of 1.18, a median of 1.20, and a range of 0.86 to 1.57. These values are within the range of the reference group studied by Eichenberger and others.[5] All test subjects could therefore be included in the study.

The summarized data of both test teeth showed highly significant differences between the three experimental conditions (eye, loupe, microscope) for the percentage of correctly prepared circumference and for the size of the incorrectly prepared area in relation to the circumference ($p<0.0001$, Figures 2 and 3).

A separate analysis of the two teeth allowed a comparison to be made between direct (tooth 36) and indirect vision (tooth 16). The percentage of correctly prepared circumferences is presented in Figure 4 for the three optical conditions and the two teeth separately. For both teeth the percentage of correctly prepared circumferences was significantly higher when a microscope was used, followed by Galilean

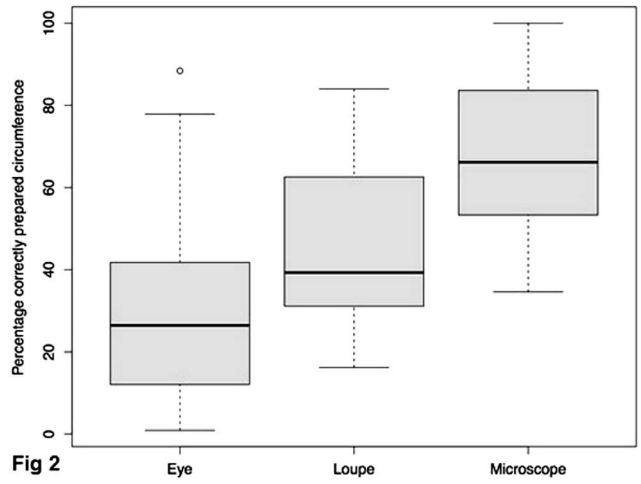

Fig 2

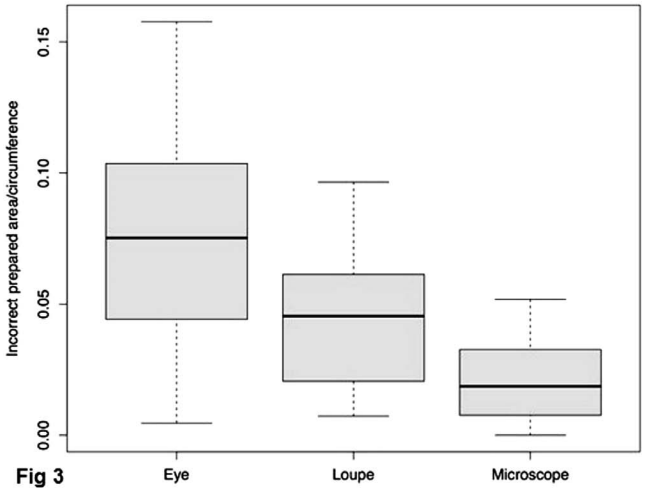

Fig 3

Figure 2. *The summarized data of both teeth showed that the percentage of correctly prepared circumferences was significantly higher when a microscope was used (mean: 67.8%; standard deviation [SD]: 17.6%), followed by loupes (mean: 44.9%; SD: 18.2%) and no magnification aids (mean: 31.2%; SD: 22.7%) (*$p<0.0001$*).*

Figure 3. *Summarized data of both teeth showed that the incorrectly prepared areas in relation to the circumference were significantly lower when a microscope was used (mean: 0.021 mm^2/mm; standard deviation [SD]: 0.015 mm^2/mm), followed by loupes (mean: 0.045 mm^2/mm; SD: 0.025 mm^2/mm) and no magnification aids (mean: 0.076 mm^2/mm; SD: 0.042 mm^2/mm) (*$p<0.0001$*).*

loupes, and was lowest with the naked eye (or wearing prescription glasses) ($p<0.05$). A significantly better performance under direct vision than indirect vision was found for preparations made with the naked eye ($p=0.0076$) and using the Galilean loupe ($p=0.044$). When dentists used the microscope, the difference between direct and indirect vision was not significant ($p>0.05$).

The incorrectly prepared areas in relation to the circumference (mm^2/mm) are presented in Figure 5 for tooth 16 and tooth 36. For both teeth the difference between the naked eye, Galilean loupes, and the microscope was significant ($p<0.05$). A significant difference between direct and indirect vision was noted for the naked eye ($p=0.0052$) but not for the Galilean loupe ($p=0.093$) or the microscope ($p=0.597$).

DISCUSSION

The literature on the effect of using magnification devices on the precision of dental procedures is controversial. To the best of our knowledge no standardized protocol has so far been used to test the impact of loupes or an operating microscope on the precision of tooth preparations. The aim of the present study was to evaluate the effect of magnification on tooth preparation under simulated clinical conditions using a standardized protocol.

To avoid any bias due to limitations of dentists' near vision, a standardized visual test at dental working distance was performed on the study participants.[5] Most of the previous studies about the impact of magnification devices on clinical skills have not tested the dentists' near visual performance, although weak natural near visual acuity might affect the dentists' clinical performance.[16,19,24-28]

To prevent bias resulting from fatigue or training effects, the dentists performed three preparation cycles in rotating order of the visual conditions with a break of at least 1 week between each procedure. The median results of the three cycles were used for statistical analysis to exclude outliers by accidental preparation defaults.

The circle on the distal surface of tooth 16 and the y-shaped figure on the occlusal surface of tooth 36 were chosen to represent common cavities in these locations. The choice of these two locations also allowed comparison of direct vs indirect vision corresponding to the clinical situation. The finding that direct vision allowed a significantly higher precision than indirect vision for preparations made with the naked eye but not for those made using the microscope is of clinical interest and should be further investigated.

The precision of tooth preparation was measured by two values: 1) the percentage of correctly prepared circumference quantified the general precision, and 2) the dimensions of the incorrectly prepared areas were quantified in relation to the circumference, thus giving a weight of the respective imperfections. Both values showed that a highly significantly better performance was obtained using the microscope, followed by Galilean loupes and,

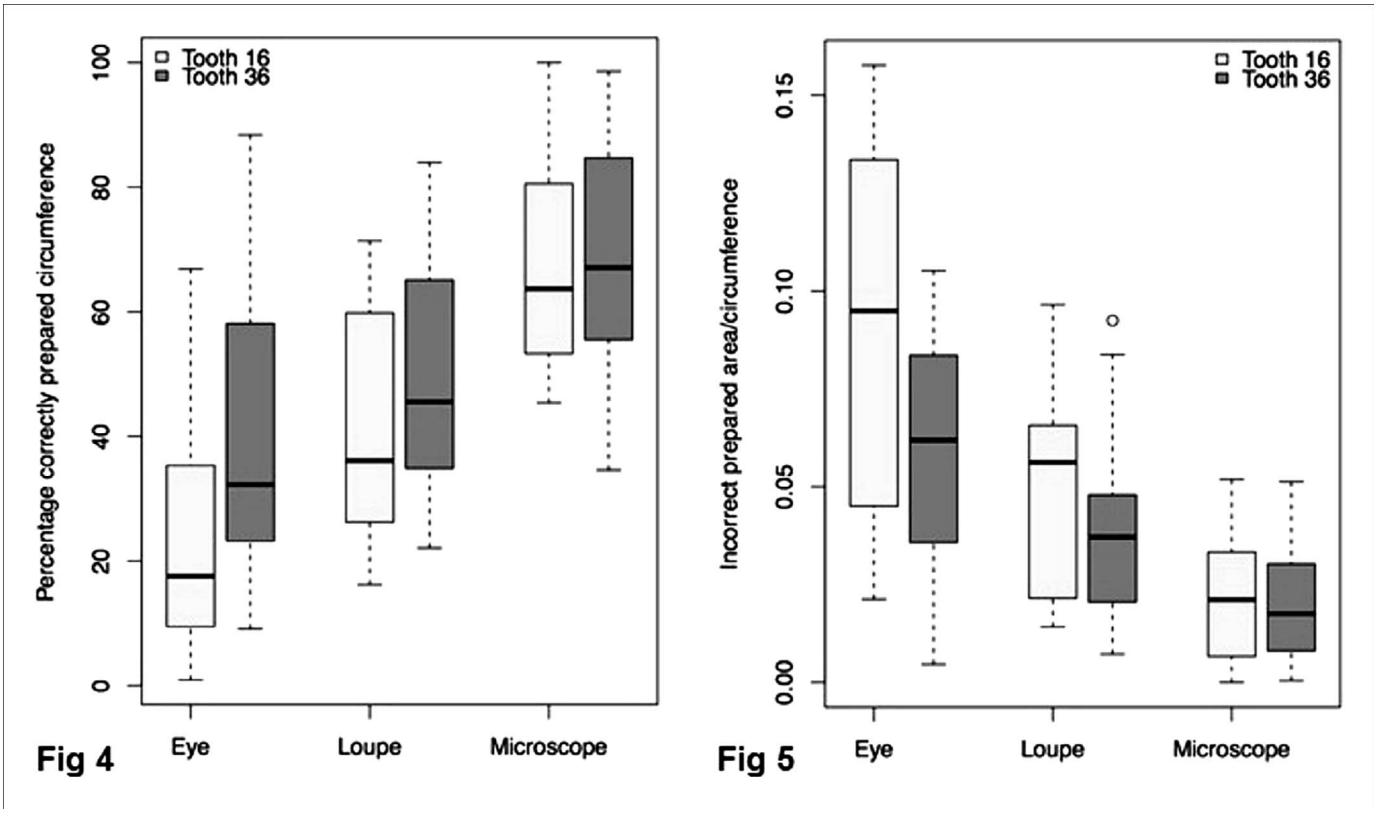

Figure 4. *Percentage of correctly prepared circumferences for direct vision (tooth 36) vs indirect vision (tooth 16). Performance under direct vision was significantly better for preparations made with the naked eye and the Galilean loupe but not the microscope.*

Figure 5. *Incorrectly prepared areas for direct vision (tooth 36) vs indirect vision (tooth 16). Performance under direct vision was significantly better for preparations made with the naked eye but not for those made using loupes or the microscope.*

lastly, the naked eye (with prescription glasses if needed). The results indicate a direct influence of magnification devices on the precision of dental work. This supports commonly expressed expert opinions[29-31] but is in contrast to the results of some experimental studies,[16,17,20] where magnification aids per se did not lead to better clinical outcomes. The inclusion criterion of daily use by the study subjects of all magnification aids tested is essential to avoid bias resulting from lack of expertise. This strict inclusion criterion has not been described in earlier studies and might be a possible explanation for the different outcomes. This criterion, on the other hand, drastically limits the number of potential test subjects and caused the restriction on Galilean loupes in this study. Since earlier studies showed a superior visual performance of Keplerian loupes, it would be interesting to evaluate their impact in a future study. The effects of age and near visual acuity were not further investigated due to the limited number of participants.

CONCLUSION

Magnification devices improved the precision of tooth preparations in a simulated clinical setting. Highly significant differences were noted between preparations made using the optically sophisticated operating microscope, Galilean loupes with coaxial illumination and the naked eye (plus prescription glasses if needed). This was true for direct and indirect vision. The protocol evaluated in this study allowed for an objective assessment of different impacts, for example, magnification aids and direct vs indirect vision, on the precision of tooth preparation.

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Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the Kantonale Ethikkommission Bern. There was no approval number or code and documentation was provided.

Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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