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Visual Acuity and Experience with Magnification Devices in Swiss Dental Practices

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Clinical Relevance

Many dentists are not aware of their visual handicaps. Magnification devices should be used to compensate for individual or age-related visual deficiencies.

SUMMARY

Objectives: The aims of the present study in Swiss dental practices were 1) to provide an update on the prevalence of different magnification devices, 2) to examine the relationship between self-assessed and objectively measured visual acuity, and 3) to evaluate the visual performance of dentists in the individually optimized clinical situation of their respective practices.

Methods and Materials: Sixty-nine dentists from 40 randomly selected private practices (n=20, <40 years; n=49, ≥40 years) participated in the study. A questionnaire was provided to evaluate the self-assessed near visual acuity and the experience with magnification devices. The objective near visual acuity was measured under standardized conditions on a negatoscope. The clinical situation, including the use of habitual optical aids, was evaluated with visual tests on a phantom head.

Results: A total of 64% of the dentists owned a dental loupe: 45% Galilean loupes, 16% Keplerian loupes, and 3% single lens loupes. In total, 19% of the questioned dentists owned a microscope in addition to the loupes. The correlation between the self-assessed and the objective visual performance of the dentists was weak (Spearman rank correlation coefficient=0.25). In the habitual clinical situation, magnification devices (p=0.03) and the dentist's age (p=0.0012) had a significant influence on the visual performance.

Conclusions: Many dentists were not aware of their visual handicaps. Optical aids such as loupes or microscopes should be used early enough to compensate for individual or age-related visual deficiencies.

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INTRODUCTION

Magnification devices are used in many medical professions[1,2] as well as in dentistry.[3-5] Ergonomic benefits,[6-8] better diagnostic capability,[9] and enhanced quality of therapy[10] are potential benefits of the use of magnification devices. Although the body of scientific evidence supporting the impact of magnification on the dentist's performance is weak,[11-16] it seems obvious that good vision is crucial in dentistry, as it is in other medical professions in which vision is important. The influence of presbyopia on the dentist's visual performance is discussed in the literature,[17-19] but scientific studies with objective and discriminatory near vision tests are rare.[20-23] The results of miniaturized visual tests, validated for discriminatory testing of near visual acuity at a dental working distance, showed large variability in the natural vision of dentists (independent of their age) and an important deficiency due to presbyopia for dentists who are ≥40 years old.[21,22] Visual deficiencies could easily be compensated for with magnification devices.[21,22] These studies were performed in the standardized conditions of a dental school. The findings of highly variable natural vision and age-related visual deficiencies were corroborated in a group of dentists in their respective private practices.[23] It is unknown if private practitioners are aware of any existing visual deficiencies and if the individually optimized setting of their own private practices can support good visual performance over the course of the dentist's professional life.

The aims of the present study, which was performed in Swiss dental practices, were 1) to assess the prevalence of different magnification devices, 2) to examine the relationship between self-assessed and objectively measured visual acuity, and 3) to evaluate the visual performance of dentists in the individually optimized conditions of their respective practices.

METHODS AND MATERIALS

Forty private practices were randomly selected from the register of the local dental association in two regions of Switzerland. Multiple dentists from the same practice were included in the study. Dentists were included in the study if they were part of an active private practice and were less than 65 years old. A total of 69 dentists from 40 practices participated in the study (n=20, <40 years; n=49, ≥40 years).

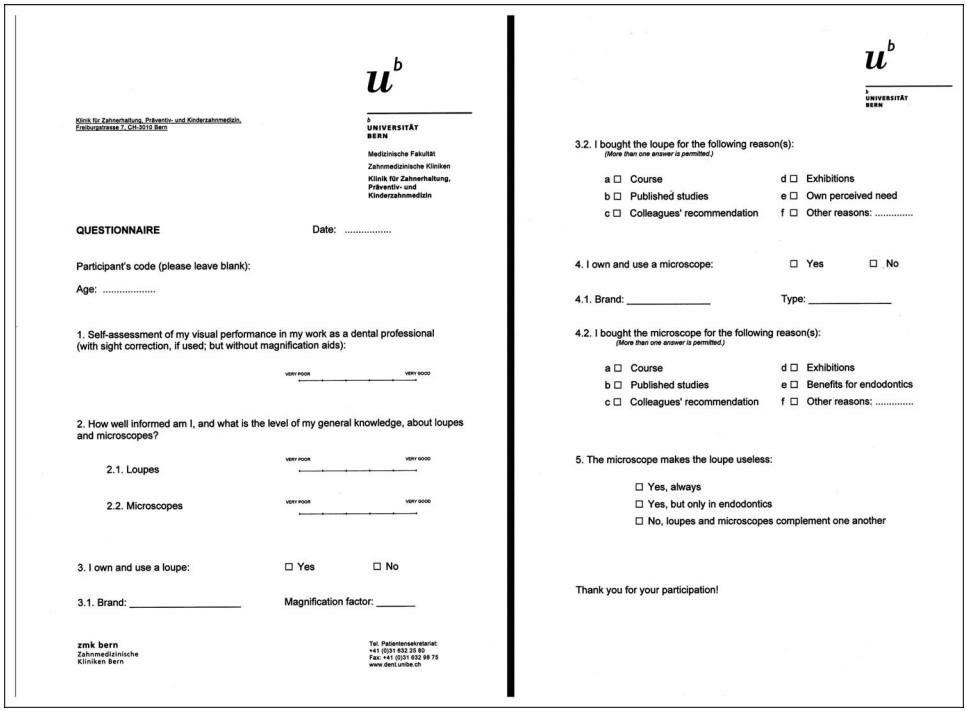
A questionnaire was designed to investigate the dentists' experience with magnification devices and the motivation to use them (Figure 1). A self-assessment of the visual performance as dental professionals was evaluated on a modified visual analog scale (VAS score '0' = very poor; VAS score '5' = very good) (Figure 1).

The visual acuity of the test persons was measured in their respective private practices. Miniaturized visual tests with E-optotypes, as described and validated in previous studies,[21,22] were used. The distance between the three bars of the smallest E-optotype that could be read corresponded to the smallest detectable dimension.[24] Tests with a range from 0.01 to 0.12 mm were used. The smallest recognized dimension was registered (eg, 0.04 mm) and converted into the reciprocal value (eg, 25 mm^{-1}) to obtain a positive association between the value and visual acuity.[22] For the standardized near vision test, the transparent tests were fixed behind a fenestrated piece of black cardboard and mounted on a negatoscope. The natural visual performance was measured at a distance of 300 mm. These measurements were compared with the self-assessment in the questionnaire.

For the clinical visual test in the dentist's respective patient setting, the visual tests were fixed in distal cavities of maxillary molars and premolars of a phantom head, as described by Eichenberger and others[22] (Figure 2). The head was positioned on the patient's dental chair (Figure 3), and the dentists could individually choose the working distance, the light source, and the use of magnification aids, according to the usual setting of their daily work. The influence of age (<40 years or ≥40 years) and magnification device (Galilean or Keplerian loupes) on this visual performance was statistically analyzed. Microscopes were not included in the analysis, as the dentists indicated that they used microscopes only in certain fields of dentistry (eg, for endodontics).

The wearing of individual eyeglasses was allowed during the entire testing procedure. The smallest line of the visual tests that could be read, the eye-object distance, and the respective magnification devices that were used were recorded.

For statistical analysis, the software program R version 2.14.1 (http://www.r-project.org/) was used. The significance level was set at $\alpha = 0.05$. Descriptive statistics were carried out to determine medians, ranges, and standard deviations for the two age groups under standardized visual test conditions and under the optimized individual clinical situation. As data were metric, a nonparametric two-way analysis



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QUESTIONNAIRE Date: .....

Participant's code (please leave blank):

Age: .....

1. Self-assessment of my visual performance in my work as a dental professional (with sight correction, if used; but without magnification aids):

VERY POOR — VERY GOOD

2. How well informed am I, and what is the level of my general knowledge, about loupes and microscopes?

2.1. Loupes (VERY POOR — VERY GOOD)

2.2. Microscopes (VERY POOR — VERY GOOD)

3. I own and use a loupe: ☐ Yes ☐ No

3.1. Brand: _____ Magnification factor: _____

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3.2. I bought the loupe for the following reason(s):
(More than one answer is permitted.)

a ☐ Course
b ☐ Published studies
c ☐ Colleagues' recommendation
d ☐ Exhibitions
e ☐ Own perceived need
f ☐ Other reasons: .....

4. I own and use a microscope: ☐ Yes ☐ No

4.1. Brand: _____ Type: _____

4.2. I bought the microscope for the following reason(s):
(More than one answer is permitted.)

a ☐ Course
b ☐ Published studies
c ☐ Colleagues' recommendation
d ☐ Exhibitions
e ☐ Benefits for endodontics
f ☐ Other reasons: .....

5. The microscope makes the loupe useless:

☐ Yes, always
☐ Yes, but only in endodontics
☐ No, loupes and microscopes complement one another

Thank you for your participation!

Figure 1. *A questionnaire investigated the dentists' experience with magnification devices and the motivation to use them. A self-assessment of the visual performance as dental professionals was additionally evaluated on a modified visual analog scale.*

of variance, followed by exact Wilcoxon rank-sum tests, was used to analyze the influence of age and magnification devices on the best clinical situation. The Jonckheere-Terpstra test followed by exact Wilcoxon rank-sum tests evaluated if the visual performance improved with increasing magnification.[25] The *p*-values were adjusted as a result of multiple comparisons using the Bonferroni-Holm correction.[26] The Spearman rank correlation coefficient was used to detect a relationship between the dentist's self-assessment and the visual performance under standardized visual test conditions.

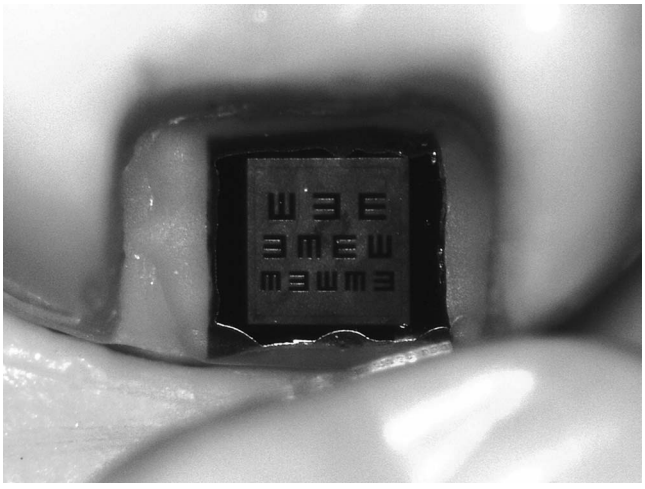

Figure 2. *One of four visual tests in distal cavities of maxillary premolars and molars.*

RESULTS

The questionnaire revealed that 64% of the dentists owned a magnifying loupe system: 45% owned Galilean loupes (G), 16% Keplerian loupes (K), and 3% single-lens loupes (SL). Among the loupe users, 13 dentists (19% of all participating dentists) were using a microscope (M) in certain fields of dentistry (eg, endodontics). These dentists were convinced that loupes and microscopes complement one another, meaning that both magnification devices have advantages in certain clinical situations.[27] The decision to buy and use magnification aids was mainly influenced by colleagues (34%) or by the subjective need for better visual performance (33%). Less important reasons were courses (16%), exhibitions (11%), or scientific studies (6%). A total of 38% of all participating dentists reported a further need for information concerning magnification devices in dentistry.

The results of the self-assessment on a VAS (0-5) showed a median value of 4 and a full range of 0 to 5. Eleven dentists assessed a score of ≤ 2.5, 58 dentists scored >2.5. The Spearman rank correlation coeffi-

Figure 3. *The phantom head was positioned on the patient's dental chair to simulate the clinical situation.*

cient revealed only a weak positive correlation between these self-assessed values and the objective visual test on the negatoscope (correlation coefficient: 0.25). Twenty-two dentists (32% of all participating dentists) with a sufficient or good self-assessed value (>2.5) showed an objective visual acuity below the median of the group (<13.74 mm^{-1}) (Figure 4).

The results of the clinical visual test with the phantom head are presented in Figure 5. In the dentists' respective clinical settings, the visual performance with eventual optical aids showed a significant impact of the dentist's age (p=0.0012) and the magnification device (p=0.03) (Figure 5). When comparing the different clinical conditions without regard for the dentist's age, the best visual performance was achieved with Keplerian loupes, followed by Galilean loupes and by natural vision (all $p \leq 0.0006$). When comparing the different age groups, the post hoc tests detected a significant difference only for natural visual acuity with a free choice of distance (NVf; p=0.02). No significant differences were found between the dentists who were younger or older than 40 years when they were using loupes (Figure 5).

DISCUSSION

Two-thirds of the questioned private practitioners owned a magnification device. This rate is higher than those measured in similar studies, which reported values of 9%,[28] 34%,[26] 44%,[29] and 53.7%.[3] The low percentage reported in the study of Forgie and others[28] might be explained by the date of the survey, as the use of magnification devices has been growing during the last few years.[3-5] One study[4] found 86% of senior dental students routinely using magnifying loupes. This group received basic information concerning magnification systems during the first-year curriculum. This high value could support the effect of basic education as motivation to use magnification devices. Forgie and others[28] reported a strong association between the use of magnification devices and a course about magnification or a practice partner using magnification. The main motivating factors in the present study were the influence of friends and the subjective feeling of needing better vision, but specifically not courses, studies, or the manufacturers marketing at an exhibition. However, the latter three might inform the 38% looking for more information about magnification devices in dentistry.

Remarkable in this context is the uneven distribution of the different loupe systems. We tested dentists in two regions of Switzerland. All Keplerian loupes were found in one region, while the Galilean loupes of the other region were nearly all (16 out of 21) from the same manufacturer. This could confirm the importance of personal relations and recommendations, as indicated in the questionnaire, but this also reflects a lack of knowledge in the dental community.

The self-assessment revealed that most of the dentists were convinced of their good visual performance. However, the Spearman correlation coefficient showed only a weak statistical correlation between the subjective feeling and the objective measurement. This suggests the importance of regular visual tests while one is practicing dentistry. It is clinically relevant that 22 dentists (32%) assessed their vision to be sufficient or good (VAS >2.5), while the objective value was below the median visual performance of all dentists (<13.74 mm^{-1}). These dentists were not aware of their visual deficiency.

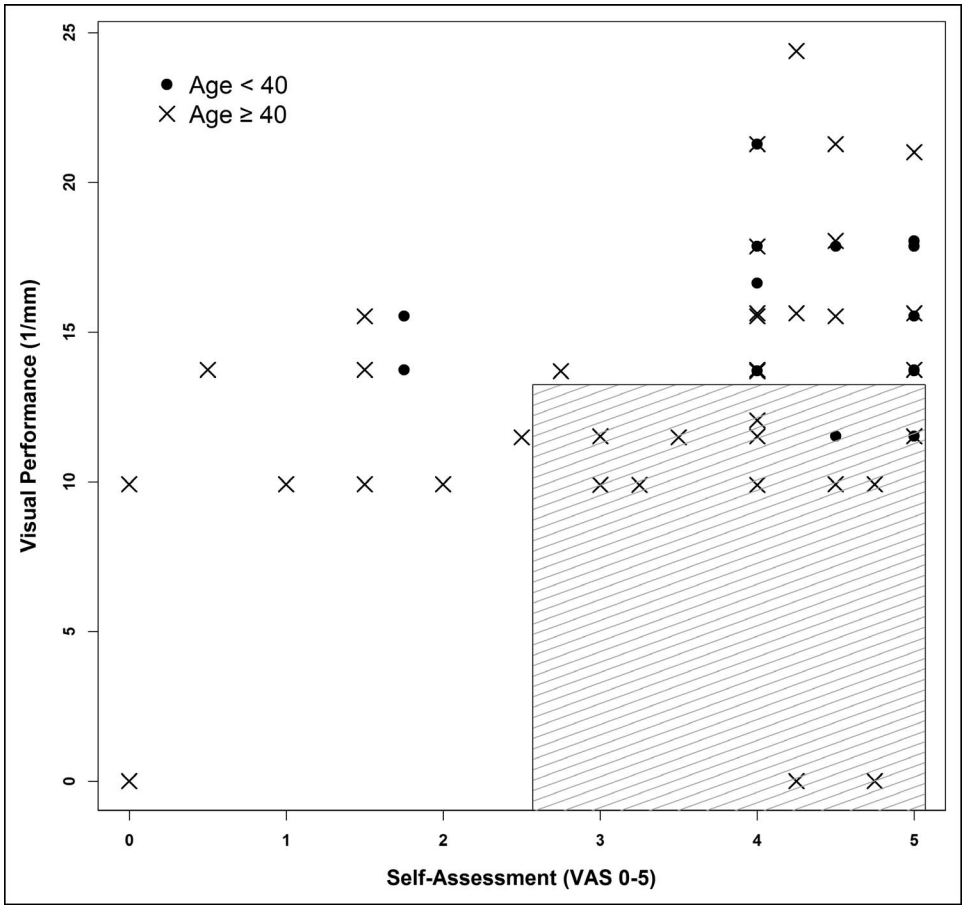

Figure 4. *Objective and self-assessed near visual acuity. The correlation between the self-assessment and objectively measured visual acuity was weak. Notice the 22 dentists (32%) with a sufficient self-assessed score (VAS >2.5) but with poor objective visual acuity (gray rectangle). Twenty of these 22 dentists were ≥40 years old.*

The visual performance in the individually optimized clinical situation of the daily practice is, from a clinical point of view, the relevant parameter to discuss vision of dental professionals. A phantom head with miniaturized visual tests in distal cavities of upper molars offers a validated method for this purpose.[22] It is the nature of an individual clinical setting that neither the working distance nor the light source or the used optical aids are standardized, but rather are individually adapted by the respective dentist. The influence of the light source was not part of this study and should be evaluated in further research under standardized conditions.

Significant differences between the two age groups could only be found for NVf. Younger dentists can profit from natural magnification by reducing the eye-object distance, with a linear relationship between distance and magnification. This is routinely used as a controlling distance and is biologically not possible for older dentists as a result of their presbyopia.[18,19,22] Loupes, with their fixed and ergonomic focal distance, inhibit the natural magnification for young dentists as well. The weak magnification of typical Galilean loupes (2.5×) could compensate for the loss of natural magnification, but it could not significantly improve the visual performance in the group of young dentists. As a consequence, Galilean loupes offer ergonomic rather than optical benefits for young dentists and compensate for presbyopic deficiencies in older dentists. This is illustrated by the equivalence of the visual performance in dentists ≥40 years old with Galilean loupes (G) compared to the performance of dentists <40 years old with natural vision at a free distance (NVf). A former study[22] including Keplerian loupes with a magnification factor of 4.3× showed a significant improvement in the visual acuity independent of the dentist's age. The impact of Keplerian loupes could not be further analyzed in the present study as a result of an insufficient number of young dentists using this type of loupe.

The microscopes were not included in our measurements because none of the dentists used it routinely for the majority of his or her dental work. Nevertheless, it is well known that microscopes enable a highly superior visual performance and

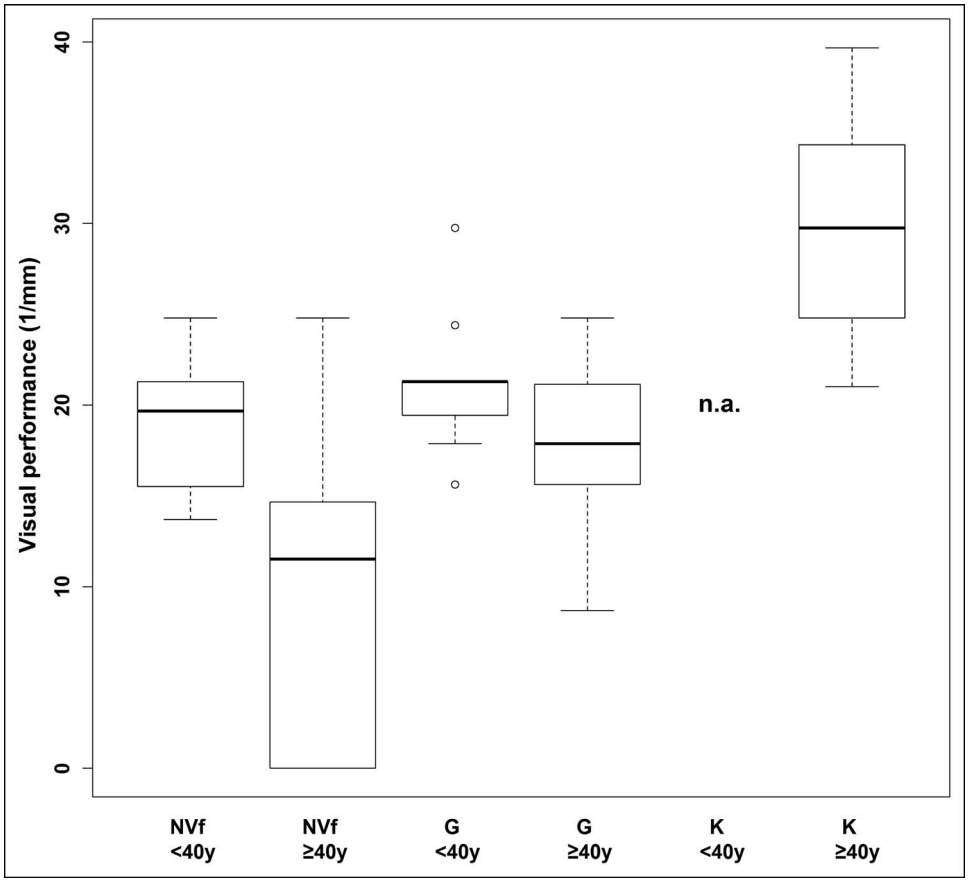

Figure 5. *The visual performance in the dentists' respective clinical settings (mm^{-1}). Dentists younger than 40 years of age showed a significantly better visual performance for NVf compared to dentists who are 40 years or older ($p=0.02$). When using magnification devices, no significant differences could be shown. Notice the similar visual acuity of NVf <40 years and G ≥40 years. NVf = natural visual acuity with a free choice of distance; G = Galilean loupe; K = Keplerian loupe; y = years; n.a. = not available, as only one dentist <40 years old was using a Keplerian loupe.*

could have the potential to solve visual challenges in dentistry.[30-32]

We stated in the introduction that there exists a lack of knowledge about the impact of vision and magnification on the performance of dentists. The results of this study confirm the need for further research in this field.

CONCLUSIONS

Self-assessment cannot replace regular optical near vision tests. A wide range of near visual acuity can be found in the individual clinical conditions of a dental private practice. The visual performance is influenced by magnification devices as well as by the dentist's age. The benefit of Galilean loupes for most of the younger dentists is ergonomic rather than optical. For older dentists, Galilean loupes can compensate for presbyopic deficiencies. The question still remains whether good visual performance affects clinical tasks in different specialties, and this topic should be the subject of further studies.

Acknowledgement

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Human Subjects Statement

This study was conducted at the AMK Universität in Bern, Switzerland under the auspices of the Kantonale Ethikkommission Bern.

Conflict of Interest

The authors 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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