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A Near Visual Acuity Test for Dentists

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Clinical Relevance

Use of a US $5 bill offers a simple and easily available triage test to assess individuals' near vision relative to that of other dentists and to monitor the progression of presbyopia with increasing age. The interindividual variability of near vision was found to be large.

SUMMARY

Unimpaired near vision is crucial in dentistry, but appropriate visual tests at dental working distance are not publicly available. The aim of this study was to validate a novel visual triage test for dentists that is easy to use and freely available. The near visual acuity at 300 mm of 106 dental professionals (aged 21–65 years) was assessed with 1) a validated near visual test for scientific purposes miniaturized on a microfilm; 2) an experimental test using a US $5 bill, in which the first five words of each line in the Lincoln Memorial frieze had to be read under a dental operating light. The Spearman rank correlation coefficient of 0.784 revealed a strong correlation between the two tests ($p<0.0001$). The ability to read six or more words in the memorial frieze meant there was a 94% chance of having a validated near visual acuity greater than or equal to the median score of the dentists tested. If none of the words could be read, the chance of having a near visual acuity below the median of the peer group was 89%. The influence of the dentists' age and experience on their visual performance reported in former studies was corroborated with this new test. The US $5 bill offers a simple and easily available near visual test to rank individuals' near vision relative to that of other dentists and to recognize the progression of presbyopia with increasing age.

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INTRODUCTION

The visual control of small structures is a vital part of dental diagnostics and therapy; therefore, regular visual tests at working distance should be mandatory for dental professionals. Traditional near visual tests, like the reading type test of the British Faculty of Ophthalmologists,[1,2] are printed with conventional typography and underlie the dimensional limitations of this technique. They are not sensitive enough to discriminate between good and bad eyesight for dental purposes. Consequently, studies using these tests show unproblematic and good near vision for almost all test subjects.[3-5] In contrast, recent studies with visual tests based on microfilms have shown that

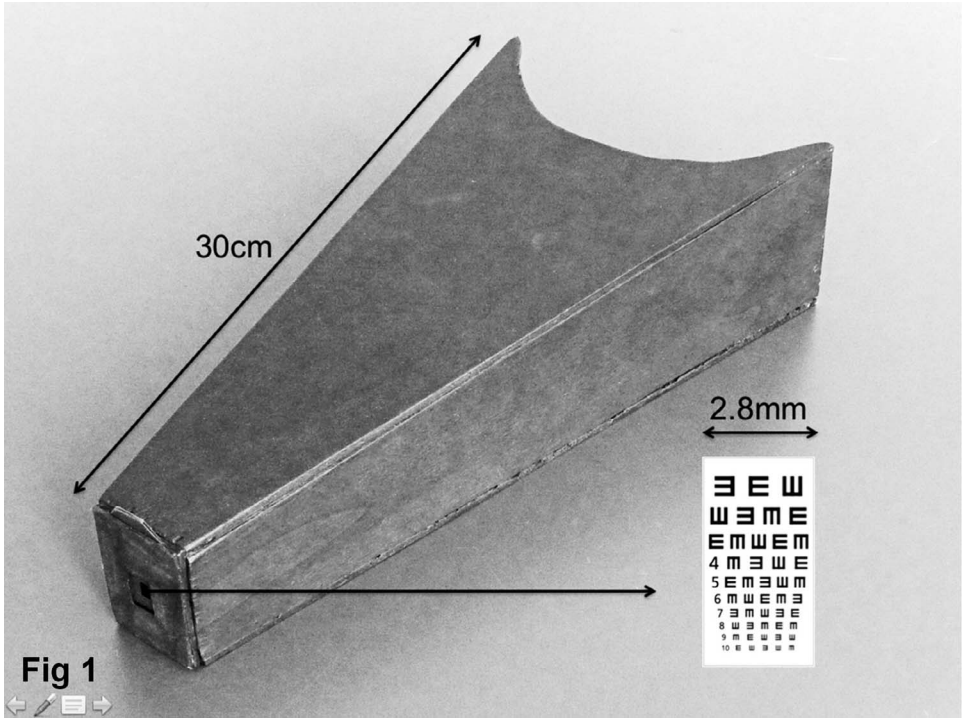

Figure 1. *Near visual test with E-optotypes on a microfilm for the use on a negatoscope. The distance between the bars of the E-optotypes is the relevant dimension and ranged between 0.01 mm and 0.1 mm.*

the near visual acuity of dentists varies widely between individuals if evaluated with tests using suitable dimensions.[6-9] Significant differences in the dimensions of the structures recognized were found in all test groups and age ranges included in these studies. This was also true for hand surgeons when tested using a similar study design.[10] Of particular interest is the presbyopic decrease of visual performance with increasing age. This inevitable and progressive limitation of the near vision starts at an age of around 40 years.[7,11,12] In most cases it remains undetected for years until daily activities like the reading of small letters are affected.[8,9] Magnification devices such as loupes can reliably compensate for presbyopic deficiencies: under simulated clinical conditions, dentists ≥40 years using Galilean loupes (2.5×) had a similar visual performance to younger test subjects with unaided vision. Moreover, it was found that Keplerian loupes and operating microscopes enhance the visual performance of dentists independent of their age.[6-9]

Dentists' self-assessment of their visual performance seems unreliable. Responses to the questionnaires used in the aforementioned studies showed a poor correlation with the objective findings of the visual tests. This was particularly true for dentists ≥40 years.[6-9] Thus, very often, dentists will not be aware of their visual deficiencies, which could easily be compensated for with optical aids.

These findings justify the need for an adequate visual test for dentists. The aforementioned miniaturized visual tests cannot be produced commercially and are limited to use in research. As pointed out earlier, traditional visual tests are not sensitive enough for dental purposes. Therefore, the present study aimed to find and validate an easily accessible and reliable near visual test for dentists.

METHODS AND MATERIALS

One hundred and six dentists and dental students (n=60, <40 years; n=46, ≥40 years; range, 21-65 years) took part in this study. All participants in a continuing education course formed the group of qualified dentists (n=67), and all students in the third year of their course toward graduation (n=39) formed the students' group. No exclusion criteria were applied. The study was approved in accordance with the ethical guidelines of the Review Board of the University of Bern. Visual acuity was tested at a dental working distance of 300 mm with two different visual tests. Correcting eyeglasses or contact lenses had to be worn if necessary. If the focal distance was different from 300 mm, the test was performed at that focal distance.

For the validated near visual test,[7] eye charts with miniaturized E-optotypes (Figure 1) on transparent microfilm were fixed behind fenestrated black cardboard and mounted on a negatoscope (Imatec,

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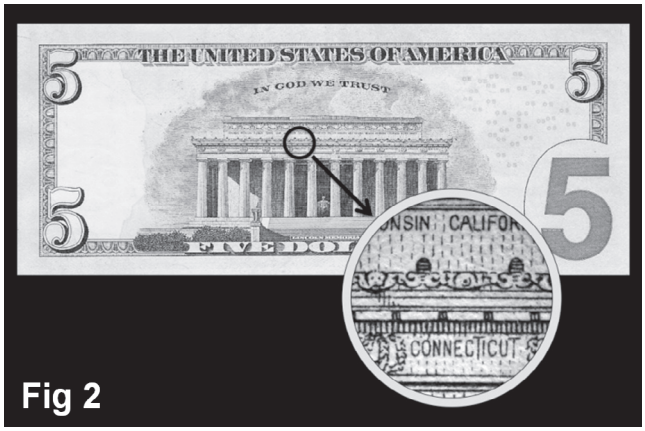

Figure 2. *The US $5 bill shows the Lincoln Memorial in Washington, DC, with the names of all US states aligned in two rows in the frieze. The first five words of both lines had to be read at a distance of 300 mm.*

Basel, Switzerland, 2×8W). The dimensions of the Es ranged between 0.05 mm and 0.5 mm. The distance between the three bars of the E-optotype was the dimension to be detected by the test subject.[13] This distance ranged between 0.01 mm and 0.10 mm. The smallest line that could be read at a distance of 300 mm or at focal distance was recorded. The metric dimension of the bar spacing (eg 0.04 mm) was converted into the reciprocal value (eg 25 mm^{-1}) to obtain a positive association between the value and the detail recognition.[6]

For the experimental near visual test, an unused US $5 bill was fixed on a black A4 sheet and illuminated as rectangularly as possible with a dental operating light (LoLé2, DegréK, Paris, France) from a distance of 700 mm. In the frieze of the Lincoln Memorial, the names of the US states are aligned in two rows (Figure 2). The letters have a width of 0.25 mm. The test subjects had to read the first five words of each row at a distance of 300 mm or at focal distance. The distance of 300 mm was kept constant by means of a 300 mm bar between the test subject's forehead and the bill. The number of words that could be read was recorded.

In the first part of the study, the relationship between the scores of the two tests was evaluated by Spearman rank correlation. In addition, the results were split into four groups for the $5 test (0, 1-4, 6-9, and 10 words read) and into two groups for the E-optotype test (</≥ median mm^{-1}) to describe the suitability as an easy triage test.

For the second part of the analysis, the results were split into three groups: students (n=39), young dentists <40 years (n=21), and older dentists ≥40 years (n=46). By means of a Wilcoxon rank sum test, the influence of age and professional experience on the result was evaluated: students (n=39) vs dentists (n=67), students (n=39) vs young dentists (n=21), and students and young dentists (n=60) vs older dentists (n=46).

In the third part of the study, a self-assessment in the form of a questionnaire answered by 94 test subjects was correlated with the results of the $5 test. Respondents answered the question "How do you estimate your visual performance as a dentist wearing your correction glasses if necessary?" on a visual analog scale with scores ranging from 1 to 10 (1 = very poor, 10 = very good). Of the 67 dentists in the continuing education course, 12 did not answer the questionnaire. The test subjects were split into two groups <40 years (n=49) and ≥40 years (n=45). The relationship between test and self-assessment was evaluated by Spearman rank correlation for both groups.

Statistical analysis was performed with the free statistical software R: version 2.14.1 for the first part of the study and version 3.2.1 for the second and third parts (www.r-project.org). As the analysis was exploratory, no corrections for multiple testing were applied. Correlation coefficients were assessed according to the rules of Hinkle and others.[14] The level of significance was set at α=0.05.

RESULTS

The Spearman rank correlation coefficient between the two tests was 0.784, which indicated a strong correlation.

Data grouped according to the number of words the subjects could read is presented in Figure 3. Of the 106 test subjects, 26 (24.5%) could read all of the requested 10 words of the Lincoln Memorial frieze, whereas 27 of them (25.5%) could read no words at all. Test subjects who could read the majority of the words in the memorial frieze (≥6 words) had a 94% chance of a validated near visual acuity greater than or equal to the median score of the peer group of dentists tested. If none of the words could be read, the chance was 89% of having a near visual acuity below the median of the peer group.

Results of the Wilcoxon rank sum test performed after splitting the test subjects into groups according to age and experience is shown in Table 1. Compared with all the dentists who participated in the study, the students showed significantly better results, while the comparison of students with young dentists <40 years showed significantly better

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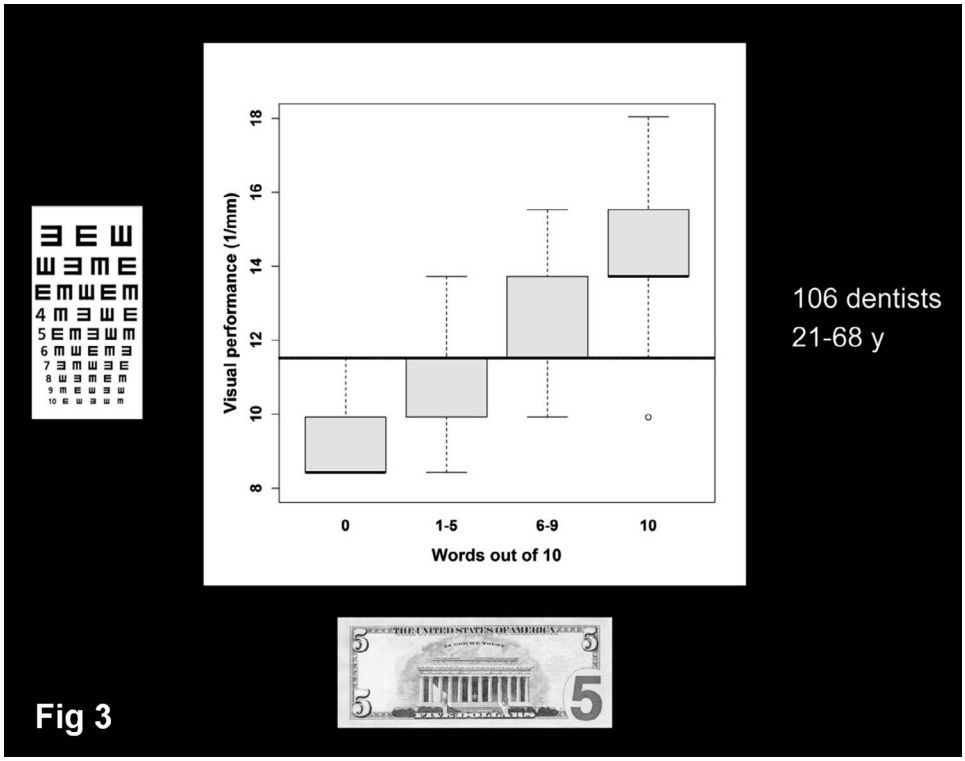

Figure 3. *The results of the $5 test in relation to the median of the E-optotype test (11.7 mm^{-1}). The $5 test allows an easy triage of dentists' visual performance in relation to that of the peer group.*

results for the dentists. The difference between the performance of test subjects <40 years and those aged ≥40 years was highly significant.

Overall, a low correlation was found between the self-assessment and the objective test values (0.41). A negligible correlation was noted for the group of younger participants (0.29) and the group of older participants (0.09). The somewhat higher correlation in the overall data is mainly explained by the discrimination caused by the age groups.

DISCUSSION

Studies with traditional near visual tests suggest that they are not sensitive enough to discriminate between dentists with good and bad eyesight.[3-5] The symbols used in this kind of test are too large due to the dimensional limitations of conventional printing techniques. Thus, the aim of the present study was to find and validate a suitable, simple, and easily available near visual test for dental purposes. The prospective test should reveal visual deficiencies, such as the undetected beginning of presbyopia at an age ≥40 years, which could be easily compensated for by means of medical loupes. Another field of application is in scientific studies, where the visual performance of the examiners is part of the methodology. A suitable visual test could help to exclude test subjects with visual deficiencies before starting the study.

Most banknotes incorporate miniaturized structures or letters printed with a sophisticated technique to prevent forgeries. These letters might serve as potential and easily available near visual tests. Pre-studies with different bills from the United States, the European Union, and Switzerland showed that the US $5 bill, in particular, has the potential to provide a suitable near visual test at a dental working distance. The letters naming all US states in the frieze of the

Table 1: *Comparison of Near Visual Acuity of Different Subgroups*

Comparison	*p*-Value	Assessment
Students vs all dentists	p=0.02	Students performed significantly better
Students vs dentists <40 years	p=0.02	Dentists performed significantly better
Subjects <40 years vs ≥40 years	p< 0.0001	Group of young participants performed significantly better

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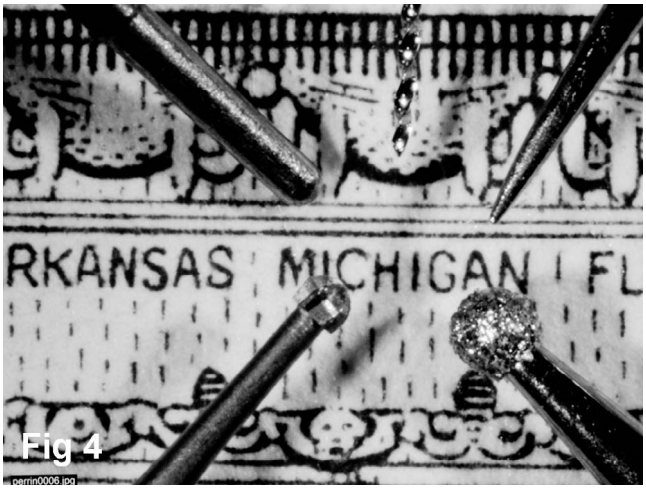

Figure 4. *Common small dental instruments in comparison to the letter size in the frieze (perioprobe, K-file No. 15, explorer No. 12, diamond bur No. 009, and rose bur No. 006).*

Lincoln Memorial have a spacing of 0.15 mm and a width of 0.25 mm. This is in perfect accordance with the size of the E-optotypes used in previous studies[6-9] and with the dimensions of common small dental instruments (Figure 4).

The experimental near visual test includes letters of only one size, unlike traditional visual tests that use progressively smaller lines. This uniform dimension is compensated for by the differing legibility of the letters (eg TEXAS vs DELAWARE). The potential bias that could be introduced by guessing the names of the US states can be counterbalanced by the strong correlation to the standardized E-optotype test.

The hypothesis that the novel test covers the range of a dentist's near visual acuity and offers a valuable opportunity to evaluate dentists' near vision is corroborated by the results of the present study.

Splitting the test subjects into groups—students, dentists $<$40 years, and dentists $\geq$40 years—allowed for the evaluation of differences due to age and due to a lack of professional experience. The results corroborate the hypothesis that the beginning of presbyopia at an age of about 40 years is the main factor limiting near visual acuity. The question why young dentists had a significantly higher near visual acuity than third-year students remains unanswered. A visual training effect is possible, as is the hypothesis that practicing dentists are more conscious of the need for appropriate optical correction.

Both of the tests presented allowed the comparison of one individual's near vision with that of a peer group of dentists. A weak result should prompt further optical examination by an optometrist and the choice of an adequate magnification device to compensate for the visual deficiency.[6-9,12]

It should be noted, however, that there is no established or evidence-based threshold for the visual acuity of dentists. A number of recent studies have shown the advantages of magnification devices for clinical procedures,[15-20] but most of them are case reports or expert opinions with little scientific evidence to support them.[21] Conclusions about the association between near visual acuity and the quality of patient care was beyond the scope of the present study. This question remains open and should be the subject of further research.

CONCLUSION

A US $5 bill can be used as a simple and easily accessible test to qualify the individual near vision of dentists.

Acknowledgement

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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. The approval code for this study is Req-2016-00113.

Conflict of Interest

The authors declare that they have no conflict of interest.

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