Original Article

Analysis of different vision charts used for visual acuity assessment after retinal surgery

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Background: Different visual acuity chart can be targeted to evaluate the visual function of patients with different eye diseases. We conducted a comparative analysis of the digital logarithm of the minimum angle of resolution (LogMAR) vision chart and the standard logarithmic vision chart for the measurement of visual acuity after retinal detachment surgery.

Methods: We used the digital LogMAR vision chart and the standard logarithmic vision chart to measure the visual acuity of 100 patients (100 eyes) who underwent retinal detachment surgery at our hospital using the LogMAR recording method and compared the differences between the mean measurements obtained by both methods for all patients and for different age groups.

Results: When all of the patients were analyzed, the mean visual acuity differed between the digital LogMAR vision chart and the standard logarithmic vision chart by –0.07 LogMAR units. No significant difference was observed in the mean visual acuity between the two vision charts in the 10-20 year and 21-40 year age groups (P>0.05), while a significant difference was observed in post-operative mean visual acuity between the two vision charts for patients aged 41-65 years (P<0.05).

Conclusions: Both the digital LogMAR vision chart and the standard vision chart were effective and reliable for the measurement of visual acuity. The visual acuity measured by the standard vision chart was higher than that measured by the digital LogMAR vision chart. We recommend using the digital LogMAR vision chart as the preferred chart for measuring visual acuity after retinal detachment surgery.

Keywords: Vision chart; retinal detachment; digital LogMAR; standard logarithmic; difference

Submitted Oct 01, 2015. Accepted for publication Nov 26, 2015.
doi: 10.3978/j.issn.1000-4432.2015.11.19
View this article at: http://dx.doi.org/10.3978/j.issn.1000-4432.2015.11.19

Visual acuity measurement mainly refers to measurement of the retinal foveal resolution of the position of two-dimensional objects (1), and vision charts are the most basic, common, and useful tool for ophthalmic examinations. However, because of differences in designs, several vision charts commonly used in China have some limitations. For example, the standard vision chart has few (only one to three) large visual symbols and different numbers of visual symbols on each row, which affects the sensitivity and specificity of visual acuity measurements, especially in patients with eye diseases that significantly affect visual acuity, such as age-related macular degeneration and diabetic retinopathy. Moreover, the distance between the visual symbols varies and shows clustering effects, which affects diagnosis and efficacy monitoring in children with visual impairment (2). To conduct a comparative analysis of the two main vision charts currently used to measure visual acuity after retinal detachment surgery, we used the Weber-Fechner law and the logarithm of the minimum angle of resolution (LogMAR) recording method to determine the visual acuity of 100 patients (100 eyes) who underwent surgery for retinal detachment during January to March 2014 at our hospital. The differences in measurements were compared for the standard vision chart and the digital LogMAR vision chart, and the results are reported below.

Subjects and methods

Digital LogMAR

On the digital LogMAR chart, six numbers [2, 3, 5, 6, 8, and 9] are used as visual symbols, and their size and arrangement follow a uniform, geometric growth rate. The chart consists of a total of 14 rows of visual symbols with five symbols in each row. The growth rate of the visual symbols is referenced in the Draft International Standard (ISO 8596-94) (3); the incremental growth rate is 1.258925, and the distance between the chart and subject is 3 m. The English letter "E" is used as a visual symbol in the standard logarithmic vision chart. The chart consists of a total of 14 rows with one to eight visual symbols on each row, and the distance between the chart and subject is 5 m. The illumination level was 80-320 cd/m^2 for both vision charts (4).

Subjects

A total of 100 patients of various ages who underwent retinal detachment surgery were included in this study. For patients with retinal detachment in one eye, the eye that underwent surgery was measured. For patients with retinal detachment in both eyes, the right eye was measured. The age distribution was as follows: 19 patients (19 eyes) in the 10-20 year age group, 21 patients (21 eyes) in the 21-40 years age group, and 60 patients (60 eyes) in the 41-65 years age group.

Measurement methods

A small shade was used to cover the eye that was not being examined. For the standard vision chart, the technician uses an instructions stick to indicate a visual symbol on the vision chart and asks the patient to gesture or verbally indicate the direction of the opening of the visual symbol. This procedure was repeated for each row and stopped at the last row that the patient could see clearly. The patient was asked to identify all visual symbols in each row. For the digital LogMAR vision chart, the patient was asked to read the numbers (used as visual symbols) out loud starting from the first visual symbol in the first row and continuing from left to right and from top to bottom until the patient could no longer see the numbers clearly. The procedure was repeated twice, and the mean value was used for the subsequent analysis. All results were recorded as LogMAR values.

Table 1 Results of visual acuity measured using the two vision charts

Vision chart	n	Mean visual acuity (LogMAR units)
Digital LogMAR vision chart	100	0.9144±1.1217
Standard logarithmic vision chart	100	0.8362±1.0478
t	–	2.0481
P	–	0.04

Statistical analysis

The statistical analysis was performed with a paired *t*-test.

Results

Visual acuity

The difference in the mean visual acuity measured using the two vision charts was –0.0782±1.0897 LogMAR units, which was significant according to a paired *t*-test (t=2.0481, $P<0.05$). The mean visual acuity value was lower for the digital LogMAR vision chart than for the standard vision chart (*Table 1*).

Difference in visual acuity between age groups

No significant difference was observed in the mean visual acuity measured by the two vision charts in the 10-20 year and 21-40 year age groups ($P>0.05$), while a significant difference was observed in the post-operative mean visual acuity measured by the two vision charts in patients aged 41-65 years ($P<0.05$) (*Table 2*).

Discussion

The benefit of using a logarithmic vision chart

According to the physiological and physical principles of the Weber-Fechner law, when the visual angle changes

Table 2 Difference in visual acuity between age groups

Age group	n	Digital LogMAR vision chart (LogMAR units)	Standard logarithmic vision chart (LogMAR units)	*t*	P
10-20	19	0.8671±1.1031	0.7888±1.0152	0.9381	0.20
21-40	21	0.8465±1.0657	0.7635±0.9711	1.0039	0.20
41-65	60	0.9579±1.1743	0.8822±1.1211	1.6025	0.04

with a geometric growth rate, the visual acuity changes accordingly at an arithmetic growth rate. Thus, to comply with the Weber-Fechner law, the logarithm of the visual angle corresponds to the visual acuity value (or the logarithmic conversion of the visual angle) (5,6), which is also the basis for the design of the logarithmic vision chart. Because the symbols on this chart change at a geometric rate, the geometric mean produces a more accurate measurement of visual acuity. The LogMAR vision chart, however, uses the geometric mean to the represent mean visual acuity; therefore, in this study, we used the LogMAR value to record the visual acuity for statistical analysis. The "decimal method" uses the reciprocal visual angle as a marker of visual acuity, which does not comply with the features of equal-order increments. Therefore, the decimal method uses disproportionate visual symbol increments as markers (6); consequently, the visual acuity measurements may only be used to evaluate the severity of or changes in the patient's condition. In fact, measurements vary between vision charts, and it is important to standardize the results so that they reflect changes in visual acuity. Vision charts are designed according to five strict international standards (visual symbols, visual angles, the visual symbol growth rate, the distance between the chart and subject, and the recording method), and these standards have been used to develop the standard logarithmic vision chart and the standard digital LogMAR vision chart.

Design of visual symbols

For the standard logarithmic vision chart, only one to three visual symbols are present in each row, which contains 0.1-0.3 declmal visual symbols, while eight visual symbols are present in each row containing 0.8-1.0 declmal visual symbols. As the visual symbols become smaller, every line of standard to distinguish the difficulty to increase and the requirement to identify the correct number increase, this has to be done before there is a big difference. Because of the small number of large visual symbols (only one to three), physicians cannot accurately evaluate changes in visual acuity in patients with poor vision, such as those with retinopathy. However, the digital LogMAR vision chart contains five visual symbols per row and requires a subject to correctly identify the same number of visual symbols for each row. For the logarithmic vision chart, "E" is used as the visual symbol, and its opening can face one of four directions: up, down, left, and right. On the LogMAR vision chart, six oval-shaped Arabic numbers [2, 3, 5, 6, 8, and 9] are used as visual symbols. Thus, after an ocular fundus operation (especially after a surgery for macular degeneration), a discernible difference is observed in the difficulty of identifying "E" and numbers as visual symbols for patients whose retina is no longer an ideal flat shape and who may experience visual deformation. Moreover, the LogMAR vision chart has five visual symbols in each row (more than the number of "E" visual symbols on the standard logarithmic vision chart), which reduces random and systematic errors in visual acuity measurements and improves the consistency in vision acuity measurement. Accordingly, in this study, visual acuity measured using the standard logarithmic vision chart was higher than that measured using the digital LogMAR vision chart in patients with poor vision after retinal detachment surgery.

Difference in measurement methods

Using the standard vision chart, the technician indicates the visual symbols using a pointer starting at the first row, following a certain sequence, and asks the subject to verbally indicate or point to the direction of the opening of the "E" symbol. Using the digital LogMAR vision chart, the subject is asked to name the visual symbols starting from the first visual symbol in the first row and proceeding from left to right and from top to bottom until the patient can no longer see the visual symbols clearly. Thus, certain differences exist between these two methods. For example, indicating single symbols using a pointer helps the subject to stay focused, while for the digital LogMAR vision chart, the subject is required to read the visual symbols out loud. Moreover, the subject may look at multiple visual symbols at the same time and is thus more likely to be distracted, leading to a lower visual acuity measurement than that measured with a standard vision chart.

Visual acuity and contrast sensitivity

In this study, among the 100 patients who underwent retinal detachment surgery, an initial screening showed that their visual acuity was 0.86 LogMAR units or higher, indicating that the visual acuity measurements were higher for the first three rows. On the standard logarithmic vision chart, visual symbols are arranged in a Snellen pattern and are increasingly clustered from top to bottom. For instance, only one visual symbol is presented in the first row, while eight visual symbols are presented in row 11, resulting in varying contrast sensitivity in each row. Accordingly, the results of the standard logarithmic vision chart cannot be used for clinical sensitivity analysis of populations with large variations in visual acuity, particularly because contrast sensitivity decreases in middle-aged and elderly populations. If the contrast sensitivity of 20-year-olds is considered as "1" in a baseline comparison, to maintain the same visibility, the background contrast must be set to "2" for 60-year-olds. Because the decrease in contrast sensitivity accelerates with age, a background contrast as high as "6" must be used for 80-year-olds (7). Therefore, to distinguish between the same target and background, middle-aged and elderly populations require more clearly defined boundaries and higher contrast. Accordingly, the significant difference in visual acuity observed in middle-aged and elderly patients in this study may be related to decreased contrast sensitivity in these populations. For patients with retinal detachment, the measured contrast sensitivity decreases with reduced contrast of retinal images because of the compromised structure of the visual pathways (8,9), and thus, any slight decrease in the contrast of visual symbols may result in measurement differences between the two vision charts.

In summary, the two vision charts may be used to measure the visual acuity of different populations. The standard logarithmic vision chart has extensive applications and is practical for routine research and clinical practice, while the novel digital LogAMR vision chart has a cutting-edge design, is a more convenient visual acuity recording method, and is more reliable in specific populations. In this study, the subjects were in vastly different age groups and showed variations in visual acuity. Many variables associated with the cause of retinal detachment may affect visual acuity after surgery; therefore, further research is needed.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Cite this article as: Li H, Chen L, Fang H, Diao H, Liu W. Analysis of different vision charts used for visual acuity assessment after retinal surgery. Eye Sci 2015;30(4):167-170. doi: 10.3978/j.issn.1000-4432.2015.11.19