

A customised portable LogMAR chart with adjustable chart illumination for use as a mass screening device in the rural population

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ABSTRACT

Aim: To develop a customised, portable, cost-effective (logarithmic minimal angle resolution) LogMAR chart with adjustable illumination for use as a mass vision-screening device in the rural population.

Materials and Methods: Visual acuity of 100 individuals was evaluated with a customised chart and compared with the standard Early Treatment Diabetic Retinopathy Study (ETDRS) chart and Snellen's Chart. Bland and Altman analytical techniques were used for analysis.

Results: Test-retest variability of the customised chart was just a one-line difference (95% CI for agreement), and so were the results with the standard ETDRS charts; a variability of 3-line was noted with Snellen's chart. Two-line differences were observed when comparison was made with Standard ETDRS chart and 2 to 3-line differences with Snellen's chart.

Conclusion: The customised portable LogMAR chart with adjustable illumination shows less test-retest variability and better agreement with standard ETDRS chart; therefore, it can be used as a mass vision-screening device in rural settings.

KEY WORDS: Customised logMAR chart, ETDRS chart, vision-screening device

The commonest tool for testing visual acuity in clinical practice is the Snellen chart.^[1] However, it has certain inherent design errors such as non-geometric progression of letter sizes, variable number of letters per line, and the lack of a standardized scoring system.^[1-3] The relatively large gaps between acuity levels at the lower end of the acuity scale on a Snellen chart (6/60-6/24) can result in gross overestimation and underestimation of visual acuity; this makes the assessment of change in visual acuity difficult.^[3] In clinical research, measurement of change in visual acuity is made over time and this might be estimated by different examiners and perhaps in different locations. Therefore, standardization of measurement of visual acuity is particularly important. Gibson and Sanderson reported poor reproducibility of visual acuity with the Snellen chart: *only one-third had the same visual acuity on two occasions, with 13% differing by two lines or more.*^[4]

The new design of an Early Treatment Diabetic Retinopathy Study (ETDRS) chart was an alternative to the Snellen chart and frequently employed in prospective clinical research.^[5,6] The advantages of an ETDRS chart included: geometric progression of letter sizes, equal number of letters per line, and a scoring system.^[2,3] These rather expensive charts are currently used predominantly in clinical research, but not as screening tools. Variable intensities of ambient light and chart illumina-

tion in rooms with open windows, particularly in rural settings additionally limit their use as screening devices.

We developed a portable ETDRS chart with adjustable chart illumination (to provide standard illumination all the time), and this was used as a screening device in the rural population. The visual acuity measurements were compared with those obtained using standard ETDRS and Snellen charts, to observe test-retest variability (TRV) and agreement between the charts.

Materials and Methods

The actual sample size was 97; it was calculated based on Bland and Altman's model of repeatability study for two observations with Type I error at 0.05 and Type II error at 0.2.^[7] The subjects were healthy individuals who accompanied their relatives for a diabetic retinopathy screening camp in rural south India. Participants without ocular disease were selected in order to avoid fluctuations in visual function that might occur in patients with ocular disease. We enrolled 100 such subjects who agreed to participate in the study.

The customised portable chart [Figures 1 and 2] was designed keeping in mind the standard design principles of the ETDRS chart, and included logarithmic letter size progression, inter-letter spacing, interline spacing, the avoidance of words or acronyms, and the use of

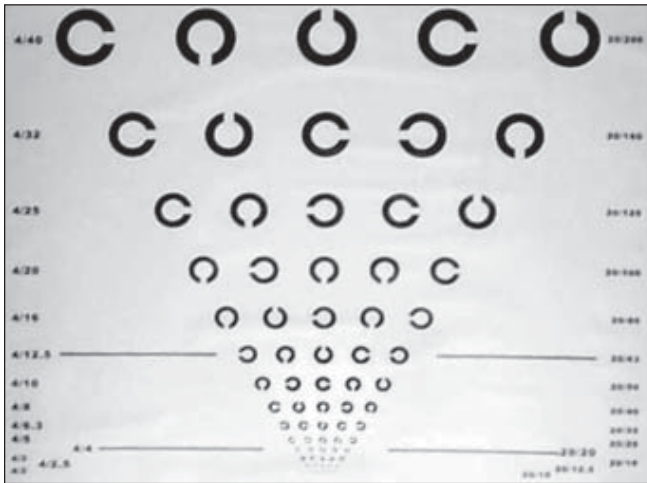


Figure 1: Photograph of a customised chart in use

Landolt's broken ring. The chart was prepared using milky-white mat-shade paper (not on glossy paper which could cause undue reflection). The dimensions of the customised chart (portable one) were $60 \times 29 \times 5$ cm as compared to $62.5 \times 62.5 \times 17.5$ cm of a standard ETDRS chart with the light box (back lit); the weight was just 5 kg instead of 14 kg of standard ETDRS chart.

The customised chart was externally illuminated from below by two halogen bulbs, aligned in such a way that they uniformly illuminated the front part of the chart without glare (front-lit chart). As specified by the British Standards Institute, the illumination at the chart was always kept constant ($1000-1200$ Lux) and modulated by a rheostat and a sensor.^[8]

The customised chart was kept at a distance of four meters from the subject. One eye of each subject based on toss of a coin was assessed. Visual acuity of all subjects was measured in four randomly chosen clinical settings:

1. The Snellen Charts (Clement Clarke UK)
2. ETDRS Charts (Lighthouse Low Vision Products)
3. Customised logMAR chart (with windows closed)
4. Customised logMAR chart (with windows open)

Two versions of each chart with different letter sequencing were used. The subjects were allowed to choose the order of the chart and their visual acuity was measured either unaided or with habitual spectacle correction, if any. The charts were hung at a height such that the top of the third row of letters (0.8 logMAR) was 125 ± 5 centimetres from the floor.^[9] All measurements were made by a single examiner. The end point for Snellen visual acuity as well as logMAR acuity was the lowest line wherein at least half the letters were read correctly. The charts were scored using line assignment method.^[10] The Snellen acuity data were converted to the logMAR format by taking the log to the base 10 of the reciprocal of the Snellen acuity fraction. All acuity scores were adjusted for testing distance, before analysis.

To determine the test-retest variability (TRV) of each of the 4 clinical settings and elucidate agreement among all the charts, the analytical methods of Bland and Altman were used.^[11]

Results

Of the 100 enrolled subjects, 62 were male, and 38 female.

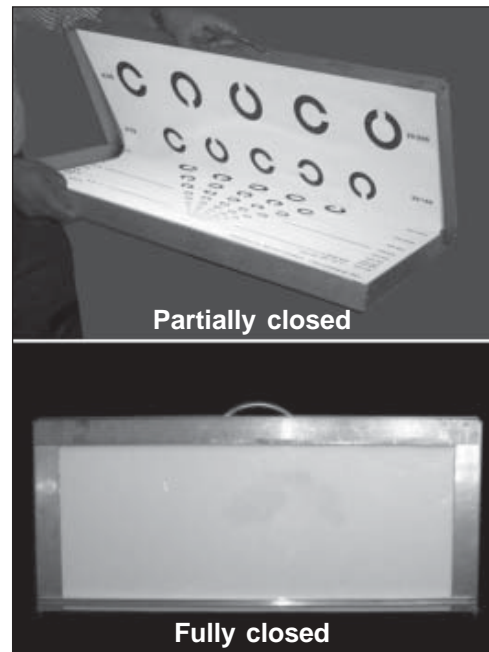


Figure 2: Partially closed customised chart

The mean age was 49.1 years (range, 21-85 years). Table 1 summarizes the results of the test-retest variability (TRV) of each chart (a difference of 0.1 for TRV at 95% CI for the agreement is equal to one-line difference between the two charts, and a difference of 0.2 is equal to a 2-line difference; likewise if the mean difference was negative, the second chart for TRV over-estimated the visual acuity). Table 1 shows that 95% confidence interval for agreement for TRV for Snellen chart was more variable (± 0.30 to 0.37 logMAR; that is, overestimation of 3-lines by the second chart) than ETDRS chart and customised charts (± 0.02 , ± 0.05 to ± 0.07 , and ± 0.01 respectively; that is, less than 1-line difference).

Table 2 demonstrates the agreement between customised charts versus ETDRS and Snellen charts. When ETDRS chart was compared with customised charts (windows closed and windows open), 95% CI for agreement and mean difference showed that customised chart with windows closed overestimated visual acuity by 2 lines, and with windows open, either over or underestimated visual acuity by 2 lines. On the other hand, the difference in overestimated visual acuity was 2-3 lines on Snellen versus customised chart with windows closed, and 1-2 lines with windows open.

Discussion

Despite being the most widely used test for assessing visual function, measurement of visual acuity does not follow a standardized procedure in most clinical settings. Though modifications of the ETDRS chart have been made to reduce the test time,^[10] their applicability in the rural settings with variable ambient illumination has not been reported. Yang *et al* reported lack of adequate illumination when visual acuity was meas-

Table 1: Test-retest variability of the charts

Chart	Mean difference	95% CI for the mean	SD	95% CI for the agreement
1. ETDRS 1 and 2	0.000	0.003 to -0.002	0.010	0.021 to -0.020
2. Snellen 1 and 2	-0.035	0.00 to -0.070	0.175	0.308 to -0.378
3. Customised Chart 1 and 2 (windows closed)	-0.006	0.001 to -0.012	0.033	0.058 to -0.070
4. Customised Chart 1 and 2 (windows opened)	-0.001	0.00 to -0.003	0.008	0.015 to -0.017

The figures show the level of test-retest variability of each chart design as determined using the analytical methods of Bland and Altman

Table 2: Agreement between the charts

Chart	Mean difference	95% CI for the mean	SD	95% CI for agreement
1 ETDRS Vs Customised chart (Windows closed)	-0.01	-0.03 to +0.01	0.10	-0.21 to +0.19
2 ETDRS Vs Customised chart (Windows opened)	0.00	-0.02 to +0.03	0.11	-0.22 to +0.23
3 Snellen Vs Customised chart (Windows closed)	-0.05	-0.03 to -0.07	0.11	-0.26 to +0.16
4 Snellen Vs Customised (Windows opened)	-0.03	-0.01 to -0.05	0.10	-0.22 to +0.15

The figures show the level of agreement between each pair of chart designs shown in the first column as determined using the analytical methods of Bland and Altman.

ured in schools.^[12]

The results of the present study showed that the test-retest variability of our customised chart was comparable to the standard ETDRS chart; viz. less than 1-line variability. The results also highlighted that our chart was in close agreement with the ETDRS chart - a difference of 2 lines - and this difference remained irrespective of surrounding illumination (windows open or closed). In a rural environment with little control over ambient illumination, we did not observe a greater difference in estimation of visual acuity with our chart. This was possible because chart illumination was kept constant by using a rheostat. However, as expected, these differences in the estimation of visual acuity were more (nearly 3-line) when compared with the Snellen chart.

It has been standard clinical practice to consider a change of at least 2-lines on Snellen chart as a cut-off value for clinically meaningful change in visual acuity.^[13] Also, considering the maximal difference of 0.05 logMAR (Mean difference) tolerated by the international standard DIN EN ISO 8597,^[14] visual acuity testing by customized chart is comparable to standard ETDRS chart.

Other advantages included its portability (5 kg vs. 14 kg) and cost, just 5% of the standard ETDRS chart (about 112 US dollars vs. 2700 US dollars). In a country like India where economics does have an important role in the health care decision-making process, use of these customised charts would make a great impact in collecting data in a standardized format for epidemiological studies.

In this study, the optotypes used were Landolt rings for two reasons: population in the rural area was illiterate (no alphabet barrier) and Landolt rings were adopted by the NAS-NRC (National Academy of Science - National Research Council Committee on Vision).^[15] It was more practical for the patients to choose from 4 alternatives of Landolt rings than make 10 choices from Sloan letters; another advantage was equal difficulty in interpreting each ring as four positions of gap were

produced by rotating the target around a fixed point, thus minimizing artefacts and secondary clue.

To conclude, our customised portable ETDRS chart with adjustable illumination provides a simple standard cost-effective procedure in measuring visual acuity, particularly in rural areas with variable ambient illumination, while retaining the accuracy of a standard ETDRS chart. However, the utilization of this customised chart in various ocular pathological states warrants further studies.

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Customised logMAR charts for mass vision-screening

Visual acuity is an important measure of disease severity, progression and the treatment outcome. Standardisation of measurement and reproducibility of visual acuity testing are particularly important. A standardised test chart introduced in 1862 by a Dutch ophthalmologist Hermann Snellen is being used in conventional testing of visual acuity. The chart consists of a series of symbols e.g. block letters, in gradually decreasing sizes corresponding to the distance at which that line of letters is normally visible. As such, printed Snellen charts are less expensive and suited where time and resources are limited.^[1] There are some inherent design flaws in the Snellen chart which include non-geometric progression of letter sizes and variable number of letters per line.^[2] The relatively large gaps between acuity levels at the lower end of the acuity scale can result in gross overestimation and underestimation of changes of visual acuity, compromising the clinical sensitivity. A more scientific method than the Snellen chart for determining visual acuity is imperative for research studies and is desirable now in clinical situations as well as population surveys.

These design problems are addressed in the logMAR (logarithmic minimal angle resolution) acuity chart which has equal number and geometric progression of letter size, equal logarithmic interval between lines, and equal average legibility for each line.^[3,4] logMAR format chart tests reduce test–retest variability. Although these superior charts are useful in research settings, even 20 years after their development, they have still not been widely adopted into routine clinical practice because of unfamiliar scoring system, the chart's size, and the time-consuming perception of logMAR measurements.

Several investigators have produced customised logMAR charts, one such example is an abbreviated logMAR chart that

could combine the advantages of existing charts with a clinically acceptable measurement time.^[5] In addition, if we use Landolt C optotypes, the test turns out to be simpler as Landolt C requires only the orientation of the optotype rather than the name of the optotype. Hence the same chart can be used in numerous populations irrespective of literacy or age enabling a direct comparison of the results. Authors of the article^[6] on a customised portable logMAR Chart published in this issue bring out a chart using Landolt's broken ring letters with adjustable illumination. It is an appreciable effort to bring out a portable, relatively cost-effective logMAR chart that can be used as a mass vision-screening device in rural camp settings.

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