

Full Length Research Paper

Comparison of static visual acuity between Snellen and Early treatment diabetic retinopathy study charts

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The purpose of this prospective study was to compare the Static Visual Acuity (SVA) scores obtained with Snellen versus Early Treatment Diabetic Retinopathy Study (ETDRS) charts in a hospital-based Indian population. Six hundred and thirty eyes within the age group of 10 to 60 years were included in this study. They underwent the routine ocular examination. The distance visual acuity was checked simultaneously using a projected Snellen chart and ETDRS chart in both eyes under the standardized lighting condition. Snellen's visual acuity was then converted to LogMAR and compared with the ETDRS charts. Six hundred and thirty eyes were included in the study. 54% were females and 46% were males. Mean value for Snellen Visual Acuity was 0.043 and that of ETDRS was 0.02365 LogMAR. The mean difference was 1 letter (0.0195 LogMAR) better on ETDRS chart when compared to Snellen chart. The results of this study suggest that for both clinical and research purposes, both Snellen and ETDRS can be used interchangeably.

Key words: Static visual acuity, Snellen chart, ETDRS chart.

INTRODUCTION

The most common measurement of visual function is visual acuity because the test is easily administered with simple equipment. Visual acuity is defined as the "spatial resolving capacity" of the eye or, put another way, the size of an object that can be resolved with an eye (Peter, 2009).

Theoretically, if visual acuity is tested multiple times on a particular chart, the expected difference should be zero. However, in reality, even in the absence of any clinical change, there is a distribution of scores that reflects the underlying variability in the chart measurement. This is called test-retest variability (TRV). The ability to detect true change in vision decreases as the TRV increases. Owing to the deficiencies of the Snellen chart, its TRV between visits is very large, varying from ± 5 to 16.5 letters in normal subjects, and up to 3.3 lines in cataractous, pseudophakic, or early stage glaucoma patients. Thus, a person can have up to a 3.5-line change in vision and this may not represent true change, but chance. Others have shown that up to 13% of patients

can display a 2-line discrepancy in vision on repeated testing with a Snellen chart (Peter, 2009). In clinical practice, this may be acceptable; however, in clinical research it is not. The visual outcomes after an intervention should ideally be independent of the chart used. With a Snellen chart, this may not be the case (Peter, 2009).

In practice, measurement of visual acuity is performed using specialized eye charts. These charts usually consist of uppercase letters arranged in rows with the largest letters at the top of the chart and progressively

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Abbreviations: SVA, Static visual acuity; ETDRS, Early treatment diabetic retinopathy study; TRV, Test retest variability.

smaller letters down the chart. There are numerous charts used for visual acuity testing, but the most common charts in the United States are the Snellen and ETDRS charts.

Snellen chart

Snellen chart, which was first introduced by Dutch ophthalmologist, Dr. Hermann Snellen in 1862, is the current standard for measurement of visual acuity in clinical practice (Peter, 2009). The chart has letters of different sizes arranged from largest at the top to smallest at the bottom, which are read, one eye at a time, at a distance of 6 m (20 feet). Each letter on the chart subtends an angle of 5 min of arc at the appropriate testing distance, and each letter part subtends an angle of 1 min of arc. Thus, it is designed to measure acuity in angular terms. In a healthy adult, the resolution limit is between 30 s and 1 min of arc. The scoring method used is the line assignment method, where a patient gets credit for lines, not letters, read. Accepted convention does not specify Snellen acuity in angular terms; instead, Snellen acuities are usually expressed as a fraction with the numerator equal to the distance from the chart and the denominator being the size of the smallest line that can be read. The reciprocal of the fraction equals the angle, in minute of arc, that the stroke of the letter subtends on the patient's eye and is called the minimum angle of resolution (MAR). The advantages are readily available, easy to perform, quick in assessing and also useful in visual acuity testing in illiterates. The disadvantages are each line has a variable letter size, variable letters per line and lack of standardized progression between lines. Snellen visual acuity is difficult to assess statistically. Parametric analysis cannot be performed with this decimal progression sequence, even if converted to another form. There is an irregular and arbitrary progression of letter sizes between lines. The letters on the Snellen chart do not have equal legibility. Good acuity lines have greater crowding phenomenon. Finally, the term "Snellen chart" has never been standardized, so the criteria to label a chart design as "Snellen" are not defined. Snellen charts from different manufacturers may use different fonts, different letters, and different spacing ratios, and they may be illuminated or projected differently. To overcome the disadvantages of Snellen chart, a new chart was constructed in 1976 by Ian Bailey and Jan Lovie. The Bailey Lovie and ETDRS charts are similar in construction but vary in letters and the distance at which visual acuity is checked.

Early treatment diabetic retinopathy study chart

To overcome the deficiencies of the Snellen chart, the Bailey-Lovie chart was modified in the year 1982 based on the recommendations of the Committee on Vision of the National Academy of Sciences, National Research

Council, and Working Group 39, and by Dr. Rick Ferris for use in the Early Treatment Diabetic Retinopathy Study (ETDRS). This "ETDRS chart" and the protocol to test vision with this chart have become the "gold standard" for most current clinical trials. ETDRS charts were theoretically superior to Snellen charts because interpatient differences were more accurately measured and longitudinal follow-up measurements had more consistent precision, regardless of whether the patients had high or low levels of visual acuity. Bailey Lovie and ETDRS charts have the same chart design but vary in the letters used in their construction. All the letters used in these charts had equal legibility. The letters on the ETDRS chart have a height equal to 5 stroke widths and have non-serif letters. Each row has 5 "Sloan" letters, and there are 14 rows of letters (70 letters). The Sloan letters were proposed by Dr. Sloan in 1952 and are composed of 10 non-serifed, uppercase letters formed within a square outline, with a stroke width of one-fifth the letter height (C, D, H, K, N, O, R, S, V, Z), and with equal legibility. There was consistent spacing between letters and rows, proportional to letter size. The between-letter spacing was 1 letter-width and the between-row spacing was equal to the height of the letters in the smaller row. This controlled the crowding phenomenon seen with the Snellen chart. There were equal (0.1) logarithmic intervals (a ratio of 1.26x) in the progression of letter sizes between lines. There was a geometric progression of the chart difficulty based on the distance from the patient. Despite the fact that ETDRS charts have been proved to be accurate, most of the recently published studies in ophthalmology had used Snellens chart for vision testing of their subjects. The main reason for this is that clinical testing with ETDRS charts is felt to take longer, require specialized lanes, and be more difficult to administer than testing with Snellen charts, so widespread adoption of ETDRS charts has not occurred. This conflict of thoughts between the usage of Snellen and ETDRS motivated the authors of this study to really check the visual outcome with both charts.

Peter (2009) prospectively compared the visual acuity of one hundred and sixty three eyes with Snellen and ETDRS charts. He concluded that visual acuity scores were significantly better on ETDRS charts than Snellen charts. The difference was greatest with poor visual acuity (<20/200) and in patients with exudative AMD. Lim et al. (2010) carried out a study with 40 eyes. A small practice effect was observed for all charts but was greatest for Snellen and least for ETDRS. They concluded that theoretical advantages of the ETDRS design were still measurable in a clinical setting but the magnitude of the advantage in terms of test-retest reliability was fairly small and the time taken to complete the ETDRS is 1.86 times that of the Snellen chart (Falkenstein et al., 2008). Tong et al. (2004) made a comparison of the visual acuity of Snellen with that of ETDRS in macular degeneration patients. He concluded

Table 1. Percentage of males and females enrolled in this study.

| Valid | Frequency | Percentage | Valid percentage | Cumulative percentage |
|-------|-----------|------------|------------------|-----------------------|
| F | 171 | 54.3 | 54.3 | 54.3 |
| M | 144 | 45.7 | 45.7 | 100 |
| Total | 315 | 100 | 100 | |

Table 2. Percentage of refractive error enrolled in this study.

| Valid | Frequency | Percentage | Valid percentage | Cumulative percentage |
|------------|-----------|------------|------------------|-----------------------|
| Astigmatic | 175 | 55.6 | 55.6 | 55.6 |
| Hyperope | 66 | 21 | 21 | 76.5 |
| Myope | 74 | 23.5 | 23.5 | 100 |
| Total | 315 | 100 | 100 | |

that ETDRS measurement yielded better VA, particularly with vision <20/200.

MATERIALS AND METHODS

All patients in the age group of 10-60 years with a best corrected visual acuity of 6/12 or better visual acuity were included in this study. Aphakic and pseudophakic subjects were not included in this study. Also subjects with any underlying ocular pathologies like corneal opacities, lens changes and retinal changes were excluded from this study.

The visual acuity was assessed by a single examiner under standardized room illumination of 160 watts. Lux meter was used to evaluate the lighting condition. Over the patient's best corrected refraction value in place, Snellen's Visual Acuity was assessed at 6 m. After an interval of five minutes, vision was again assessed, with ETDRS charts at 4 m and documented in logMAR value. Finally, Snellen value was converted to logMAR.

Statistical method

The results of this study were assessed using SPSS version 17.0. Kolmogorov-Smirnov test was performed to test for normality. Wilcoxon signed rank test was done to find the correlation between Snellen's and ETDRS charts.

RESULTS

Six hundred and thirty eyes of three hundred and fifteen patients were included in this study. In this population, 54% were females and 46% were males (Table 1). In this study, 56% patients had astigmatism, 21% were hyperopes and 24% were myopes (Table 2). Out of 157 patients, 140 patients had 6/6 p, 16 patients had 6/9 and 1 patient had 6/9 p, while another patient had 6/18 visual acuity in the right eye when tested with Snellens acuity

chart (Figure 1). When the left eyes' visual acuity was tested with Snellen, 171 patients were found to have 6/6 acuity, 130 had 6/6 p, 13 members had 6/9 and 1 patient had 6/9 p (Figure 1).

Of the 171 females included in this study, 97 had astigmatism, 34 were hyperopes and 40 were myopes, and out of the 144 males, 78 had astigmatism, 32 were hyperopes and 34 were myopes (Table 3).

When the subjects were tested with ETDRS chart, 235 patients had 6/6 visual acuity, 67 patients had 6/6 p, 11 patients had 6/9, 1 patient had 6/12 and 1 patient had 6/15 in the right eye; and 232 patients had 6/6 acuity, 71 patients had 6/6 p, 11 patients had 6/9 acuity and 1 patient had 6/12 acuity in the left eye (Figure 2).

On logarithmic scale, the corresponding visual acuities were 0.00 for 157 patients, 0.08 for 141 patients, 0.17 for 17 patients 0.4 for 1 patient in the right eye and 0.00 for 171 patients, 0.08 for 130 patients and 0.17 for 14 patients in the left eye when tested with Snellen's chart, while it was 0.00 for 236 patients, 0.08 for 43 patients, 0.06 for 24 patients, 0.3 for 1 patient and another patient had 0.4 in the right eye and 0.00 for 28 patients, 0.06 for 40 patients and 0.04 for 4 patients in the left eye when tested with ETDRS chart.

The mean of Snellen visual acuity obtained at 6 m was 0.043 and that of ETDRS visual acuity obtained at 4 m was 0.02365 LogMAR. The mean difference between the 2 charts were 0.0195 Log MAR.

Kolmogorov-Smirnov test was done to test for normality. The test showed a value of 0.00 as the significance value. A straight line is seen in the Q-Q plot, a graphical representation for normality. Wilcoxon signed rank test was done to find the correlation between Snellen's and ETDRS chart.

DISCUSSION

Vision is one of the most important tests done in clinical

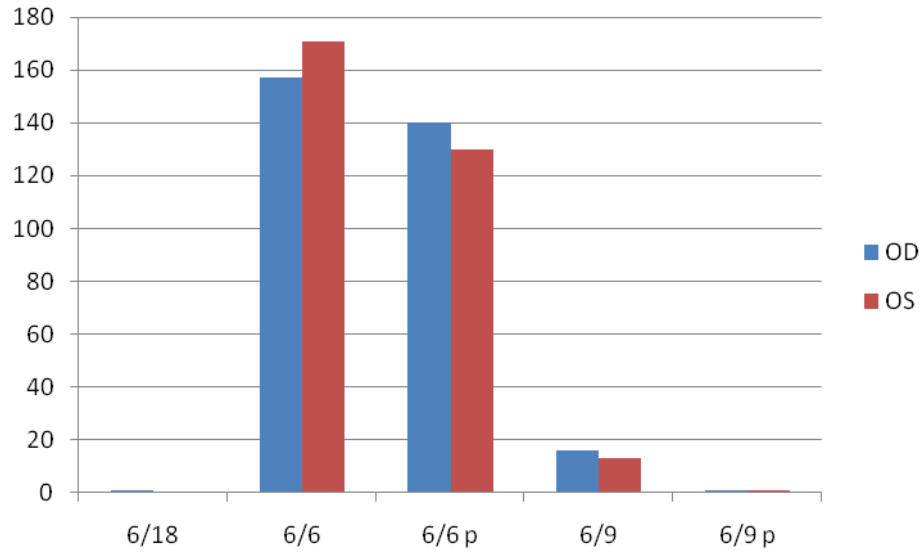


Figure 1. Visual outcomes with Snellen.

Table 3. Distribution of refractive error based on gender.

| Gender | Astigmatism | Hyperope | Myope | Total |
|--------|-------------|----------|-------|-------|
| F | 97 | 34 | 40 | 171 |
| M | 78 | 32 | 34 | 144 |
| Total | 175 | 66 | 74 | 315 |

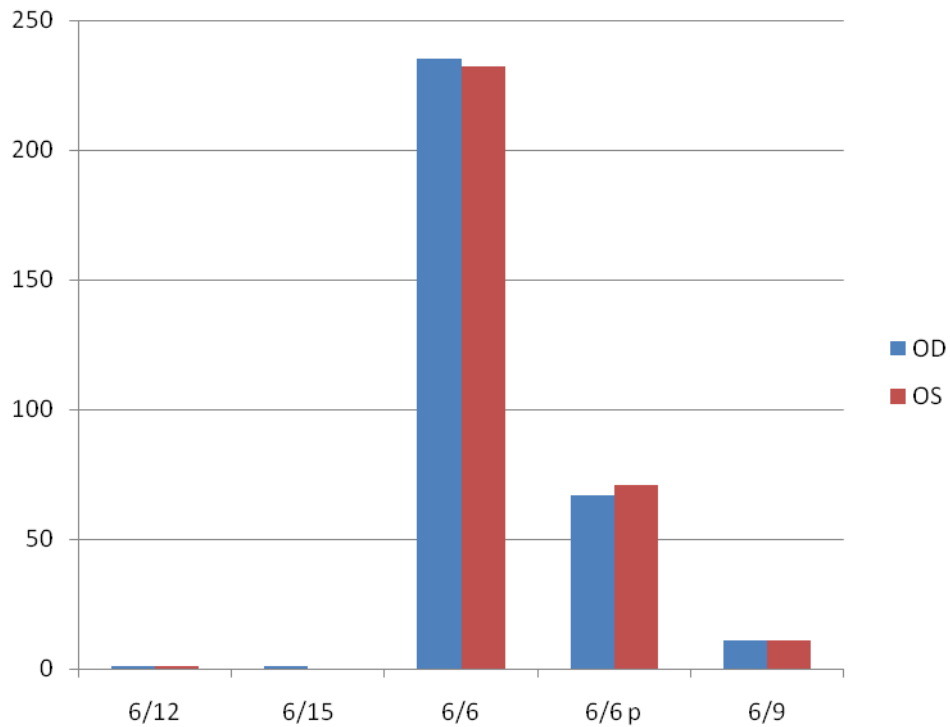


Figure 2. Visual outcome with ETDRS.

practice. In Indian, Senario driving plays a vital role to perform the daily tasks. This is important since visual acuity is used to measure both disease and change. Visual acuity is essential for clinical trials to measure treatment response (Peter, 2009). Accurately ascertaining vision is influenced by several factors, including light intensity; number, size, contrast, and shape of the optotypes; and the design of the test chart. The choice of chart ideally should not influence the outcome of the vision measurement. The Snellen chart has historically been the most popular visual acuity testing measure, but it has considerable flaws. To reduce the variability and enhance the precision of vision testing, newer charts have been proposed. The ETDRS chart based on the Bailey-Lovie chart and tested using the ETDRS protocol, which added a standardized administration and scoring of vision, is the current "gold standard" for vision testing in clinical trials.

Snellen visual acuity has historically been used to evaluate medicolegal decisions, including legal blindness and the ability to drive a car (Leinonen et al., 2005). In United States, 20/50 Snellen vision in at least one eye is the required standard for driving; however, when measured on a Snellen chart, this cutoff encompasses a wide variety of acuities, some of which could prevent a patient from safely driving a car. But in our State of Tamilnadu, a minimum of 6/12 Visual Acuity is required for driving vehicles. The visual acuity variability of Snellen charts is exceedingly high when patients have poor vision (20/200 and 20/400). This is noteworthy because 20/200 is the legal limit for blindness and many statutes rely on demonstrating better or worse vision than this standard. Compounding this problem is that low vision patients exhibit a large variability in acuity differences. Although we did not analyze TRV, patients with poor vision in this study were significantly more likely to have better vision on the ETDRS chart compared to Snellen charts. Thus, to improve the accuracy of determination of legal blindness or whether a patient can drive, we may want to consider a switch to ETDRS charts.

The Snellen chart is the universally accepted method in clinical practice to assess visual acuity despite its known deficiencies, including unreliability and poor reproducibility. It is clearly useful to measure general visual acuity in clinical practice. Unfortunately, Snellen charts are also the "standard" in most retrospective case series and medicolegal decisions. In these areas, the shortcomings of the Snellen chart do not allow appropriate quantification of vision. In contrast, the features of the ETDRS charts allow precise quantification of vision and reliable measures of vision change (Peter, 2009). As such, it has become the "gold standard" in clinical research and for FDA registration trials in the United States. There are numerous reasons why we have not adopted the ETDRS for clinical practice, including the large size of the chart, the unfamiliarity with the testing and scoring protocol, the time it takes to perform, and the

number of letters on the chart. This study was designed to explore the practical differences between visual acuity scores measured on Snellen versus ETDRS charts. It demonstrated that there were slight significant differences in acuity scores obtained between the two charts in a hospital based Indian population. Studies particularly worthy of future investigation on visual acuity with different charts include mild, moderate, severe visual acuity loss and also corneal opacities, lens changes, retinal changes and so on.

Visual acuity scores were significantly better on ETDRS charts as compared to Snellen charts. The difference was greatest with poor visual acuity (<20/200) and in patients with exudative AMD as found in the study of Peter (2009). Lim et al. (2010) concluded that theoretical advantages of the ETDRS design were still measurable in a clinical setting but the magnitude of the advantage in terms of test-retest reliability was fairly small and the time taken to complete the ETDRS is 1.86 times that of the Snellen chart (Falkenstein et al., 2008). Tong et al. (2004) concluded that ETDRS measurement yielded better VA, particularly with vision <20/200. Since Snellen charts are relatively inexpensive, everyone knows how to use them. Of the standard eye charts, Tumbling E charts are considered the best choice because it can be used to check vision for even illiterate people which is not possible with ETDRS charts.

In this study, 56% patients had astigmatism, 21% were hyperopes and 24% were myopes (Table 2). Out of 315 eyes of patients, 97 females and 78 males had astigmatism, 34 females and 32 males were hyperopes, and 40 females and 34 males were myopes (Table 3). Out of these patients, 157 had 6/6 visual acuity, 140 had 6/6 p, 16 patients had 6/9 and 1 patient had 6/9 p, and another patient had 6/18 visual acuity in the right eye when tested with Snellen's acuity chart. When the left eyes' visual acuity was tested with Snellen chart, 171 were found to have 6/6 acuity, 130 had 6/6 p, 13 members had 6/9 and 1 patient had 6/9 p (Figure 1).

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This study showed only a small significant difference between Snellen and ETDRS chart. In the scattered plot

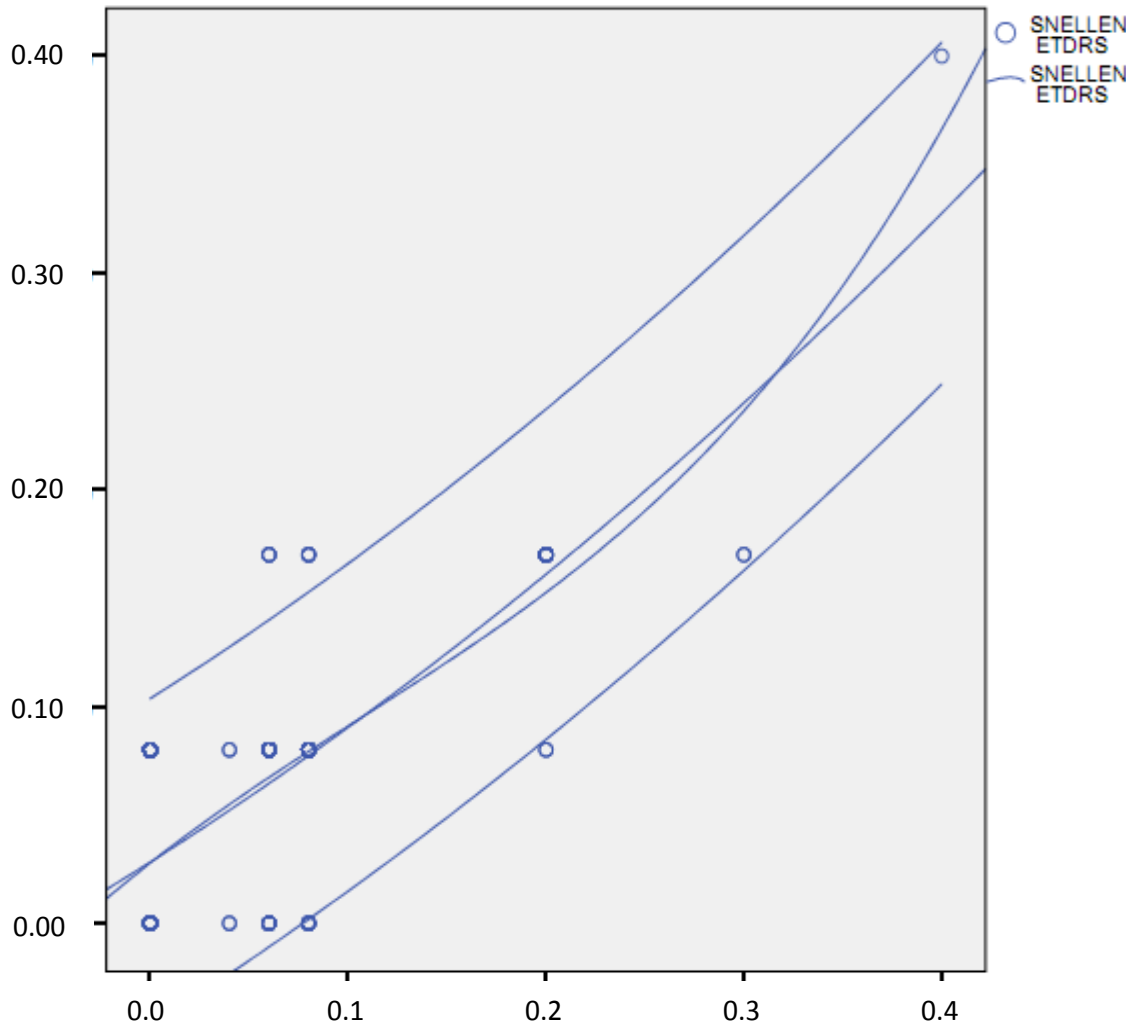


Figure 3. Relationship between Snellen and ETDRS charts.

diagram, regression line and the result obtained is coinciding (Figure 3), this may in turn indicate that Snellen and ETDRS charts can be used interchangeably.

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