

Comparison of Snellen and ETDRS charts in visual acuity assessment: a systematic review



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HIGHLIGHTS

The review paper indicates that the use of EDTRS charts in the assessment of visual acuity provides more reliable and accurate results compared to traditional Snellen charts, which may improve the accuracy of monitoring the effectiveness of treatment.

ABSTRACT

The aim of this review is to compare the two most commonly used tools for assessing visual acuity: the Snellen chart and the ETDRS chart, in terms of their accuracy, reproducibility, and clinical utility in ophthalmic diagnostics. The Snellen chart, introduced in 1862, is widely used but its design can lead to interpretative errors, particularly when assessing patients with various eye conditions. The ETDRS chart, developed for diabetic retinopathy studies, offers greater precision due to its uniform progression in letter size and the use of the logMAR scale. A systematic review of the literature demonstrates that the ETDRS chart is characterised by higher accuracy, lower variability in results, and better reproducibility compared to the Snellen chart, especially in patient populations with cataracts, amblyopia, macular degeneration, and other retinal disorders. Although the ETDRS test takes longer to perform, its superior precision makes it the preferred choice for clinical studies, whereas the Snellen chart remains more practical for routine diagnostics. This review highlights the importance of selecting the appropriate tool for visual acuity assessment depending on the clinical context, suggesting that the ETDRS chart may be a better option in more demanding diagnostic cases.

Key words: visual acuity, Snellen chart, ETDRS chart, ophthalmic diagnostics

INTRODUCTION

The importance of visual acuity in ophthalmic diagnostics

Visual acuity (VA), a key component of ophthalmic examination, holds significant importance in diagnostics. Its impairment can greatly affect a patient's quality of life and may result from ocular, systemic, or neurological conditions. The assessment of VA is essential in every case where vision-related complaints are reported and should include testing for distance and near vision, and occasionally for intermediate distances. This examination can be conducted in various settings, such as outpatient or inpatient care, and constitutes a crucial element of the patient's clinical evaluation [1].

History and popularity of the Snellen chart and the development of the ETDRS chart

The Snellen and ETDRS (Early Treatment Diabetic Retinopathy Study) charts are the most commonly used tools for measuring VA. Introduced by Dr Hermann Snellen in 1862, the Snellen chart has become a standard in ophthalmic diagnostics due to its simplicity and accessibility. However, it has several significant limitations. To address these shortcomings, various improvements were proposed, the most notable being the design developed by Dr Ian Bailey and Dr Jan Lovie in 1976. The Bailey–Lovie chart features letters of uniform legibility, consistent spacing between letters and rows, and a logarithmic progression of letter sizes, enabling more precise measurement of VA. In 1982, this chart was adapted for use in diabetic retinopathy studies (ETDRS) and subsequently became the gold standard for clinical research. Despite evidence that ETDRS charts provide greater accuracy, most reports published in leading ophthalmic journals still utilise the Snellen chart for measuring VA [2].

Objective of the study

The objective of this study is to compare the Snellen and ETDRS charts based on available scientific research, focusing on their accuracy, result reproducibility, and clinical utility in various patient populations. This analysis aims to assess which tool is more appropriate in specific diagnostic scenarios and to contribute to the optimisation of VA testing procedures in ophthalmic practice.

METHODOLOGY

To conduct a reliable analysis, a systematic review of the literature was performed using reputable databases such as PubMed, Scopus, and Web of Science. Studies included in the review were selected based on their methodological quality and adherence to the criteria: assessment of VA using both charts and direct comparison of measurement results. The review analysed studies published over the past

20 years, encompassing both healthy populations and patients with various ocular conditions. Particular attention was paid to the precision of VA measurements, reproducibility of results under different clinical conditions, and the effectiveness of the charts in diagnosing eye diseases such as glaucoma, cataracts, macular degeneration, and diabetic retinopathy. The methodology also considered the time required for testing, patient comfort, and structural differences between the two charts, including the number of letters, their arrangement, and spacing, which could impact the accuracy and reproducibility of results. This study has the potential to make a significant contribution to clinical practice by enhancing the understanding of the advantages and limitations of both methods for assessing VA. The comparison of the Snellen and ETDRS charts will help determine which is more suitable in varying diagnostic conditions and for patients with specific ocular disorders. Additionally, the findings of this study may provide guidance for future clinical research where VA assessment plays a pivotal role.

CHARACTERISTICS OF THE SNELLEN AND ETDRS CHARTS

Snellen chart

The chart most widely used in ophthalmic practice is the Snellen chart. One of its biggest design flaws is the uneven increase in letter size from one line to the next, which negatively affects the repeatability of the results [3]. The number of letters on each line of the Snellen chart varies. At a VA of 6/60, the patient reads one optotype, while at a VA of 6/6 as many as eight, making it more difficult to read successive lines of the board, not only because of the smaller size of the letters, but also the optical crowding effect that occurs – the letters are less legible to the patient when they are close together. VA is determined by the smallest optotype line that the patient can read correctly. While Snellen charts allow for one or two errors per line, their effect on the test result is not uniform across the chart. For example, in a line with two letters, reading one (50%) is sufficient to pass the line, while in a line with eight letters, correctly reading seven (87.5%) is necessary [4].

ETDRS chart

The results obtained with the ETDRS chart are more reproducible and reliable compared to the Snellen chart. The authors of the studies attribute these characteristics to, among other things, the same number of optotypes in each line of the chart, as well as an equal logarithmic decrease in letter size between each successive line [5]. All lines of the ETDRS chart consist of an identical number of optotypes, five to be exact [3]. The spacing between optotypes and consecutive lines was set as follows: each gap between two optotypes has the width of one optotype, while the height of the gap between consecutive lines is equal to the

height of the optotypes in the following line. This arrangement avoids the optical crowding effect known from the Snellen chart [2]. The letters used in the construction of the ETDRS chart (S, D, K, H, N, O, C, V, R, Z) were chosen due to their similar level of reading difficulty. 28 of the 252 possible combinations of the previously mentioned letters were selected based on a similar level of difficulty, and these were used to create the chart [3].

The measurement scale of the Snellen chart

The measurement scale of VA tested with a Snellen chart is usually expressed as a fraction. This notation includes, in the numerator, the distance from which the patient reads the chart (given in metres or feet) and, in the denominator, the distance from which the optotypes in that row subtend an angle of 5 min of arc, which corresponds to the smallest line read by the patient (in metres or feet) [2].

The measurement scale of the ETDRS chart

In some studies, the ETDRS chart is referred to as a 'logMAR' chart, which is a misconception. It is important to note that logMAR does not refer to the type of chart, but instead defines the geometric notation by which VA is described for the ETDRS chart [2]. The advantage of this measurement scale is its linear arrangement. The difference in units between each successive line is 0.1. When tested with the ETDRS chart, 0.02 logMAR units are also assigned for each letter read, which increases the reliability and repeatability of the acquired results [3]. For statistical purposes, the results obtained with both the Snellen and the ETDRS chart can be converted to the logMAR scale for comparison [2].

COMPARISON OF TEST RESULTS

Standardization of measurements

Standardisation of VA measurements plays a key role in ensuring the comparability of clinical findings and in everyday ophthalmic practice. The Snellen and ETDRS charts differ in both design and application, which can affect their accuracy and reproducibility of results. The ETDRS chart allows for more precise measurements. Each line contains a standardised number of letters, and 0.02 logMAR units are assigned for each letter read correctly. This makes it possible to take into account situations where the patient has read part of the letters from several different lines, allowing a more detailed assessment of VA [3]. The Snellen array, on the other hand, is based on a non-proportional scale in which the differences between the lines are irregular and its criteria are not clearly defined, which can lead to errors in interpreting the results, especially when comparing different groups of patients. Tests on the Snellen array are performed from a distance of 6 m, and with

the ETDRS array 4 m from the patient [6]. In studies using charts, where most patients have good VA, a distance of 4 m is adequate as the chart is easily visible to them. However, in studies where patients have poor VA, this distance increases the test time. This is because it is necessary to first carry out the test from a distance of 4 m, and if the patient cannot see any letter, move the chart to a distance of 2 m [2]. Most practices are equipped to test VA using a Snellen array. However, thanks to the geometric progression of optotype sizes on the logMAR scale, the ETDRS array allows results to be easily converted to different test distances, increasing its flexibility in clinical settings. Additionally, the ETDRS array works well in smaller rooms, and adapting offices previously using Snellen arrays to work with ETDRS is feasible [4].

Accuracy and repeatability

Traditional eye charts used at a distance of 6 m are inappropriate for patients with severe visual impairment. Reducing the test distance, e.g. to 3 m (2× magnification) or 1 m (6× magnification), increases the measurement range and assesses vision more accurately [3]. VA testing using computer simulation compared actual VA to measured VA and showed, on average, better accuracy and repeatability of the ETDRS chart, but at the cost of a significantly longer test duration. These differences were particularly evident in the low VA range [7]. A study of 413 participants (773 eyes) in 12 prospective clinical trials conducted at Retina Consultants of Houston between 2005 and 2019 found that 76.6% of eyes had higher ETDRS scores compared to the Snellen chart. Among patients, participants suffered from a variety of retinal conditions, including macular degeneration and diabetic retinopathy. The study confirmed that the ETDRS method is more accurate and produces better VA results than the Snellen method, especially in people with poorer vision [8].

Test duration and practicality

The ETDRS and Snellen arrays differ in terms of test duration, accuracy and practicality. The test using the ETDRS array takes an average of 34.65 s, which is 1.86 times longer than the Snellen test, which takes 18.67 s. The difference is due to the higher number of characters in the ETDRS array (55 vs. 36) and a more uniform character layout, which improves accuracy but increases test time. The ETDRS array has a lower test-retest variability (± 0.14 logMAR) compared to the Snellen array (± 0.18 logMAR), indicating its higher precision. However, the phenomenon of 'crowding' of letters and the more time-consuming procedure can be a source of frustration for patients. The Snellen array, with its shorter testing time and simpler design, remains more convenient in daily practice, although its accuracy is slightly lower. Optimising ETDRS arrays, for example by con-

densing their form, could make them a more practical tool in ophthalmology [9]. Currently, due to the duration of the test, the ETDRS table is recommended especially for use in prospective clinical trials, medico-legal purposes and in setting decision-making standards for the appropriateness of certain medical procedures [4].

TABLE 1

Comparison of key features of the two arrays in the context of visual acuity assessment.

Feature	Snellen chart	EDTRS chart
Measurement scale	fraction (e.g. 6/6)	logMAR scale (e.g. 0.1 for one line)
Number of letters per line	variable	constant, 5 letters per line
Progression of letter sizes	uneven	logarithmic
Test distance	6 m	4 m
Accuracy and repeatability	lower, variable (± 0.18 logMAR)	higher, more precise (± 0.14 logMAR)
Duration of the test	shorter (average 18.67 s)	longer (average 34.65 s)
Clinical use	widely used in daily practice	preferred in clinical trials, especially for precise diagnoses

SPECIFIC APPLICATIONS

Cataract

For patients before and after cataract surgery, studies have shown that the ETDRS array is more accurate than the Snellen array. The results of VA measurements using the ETDRS array are on average 6.05 letters (1.21 lines) better. The ETDRS array is particularly useful in the assessment of subcapsular cataracts, for which the highest correlation of results with cataract type and grade was demonstrated ($p < 0.0001$) [6].

Amblyopia in children

In the population of school-aged children, discrepancies have been observed between the results obtained on Snellen tables (with decimal notation) and ETDRS, particularly for lower VA. The ETDRS array, with its standardised layout and logMAR notation, allows for more accurate and reproducible measurements. This is crucial in the diagnosis and monitoring of amblyopia, where measurement precision is important in the assessment of clinical changes [10].

Age-related macular degeneration

In patients with age-related macular degeneration (AMD), especially in advanced stages of the disease (VA $< 20/200$), the differences between the results from the two boards were most significant. The mean difference was 0.2

logMAR (10 letters), corresponding to three lines on the Snellen array. The ETDRS array was more accurate in assessing VA in this group [11].

Diabetic macular oedema and other retinal conditions

Patients with diabetic macular oedema, epiretinal membrane or neovascularisation in myopia had comparable results on both boards. However, in groups with lower VA, the ETDRS array showed higher precision and was more suitable for clinical studies requiring high repeatability of measurements [12].

Parkinson's disease

Studies have shown that patients with Parkinson's disease have reduced retinal vascular density (VD) and changes in choroidal structure. Although VA measured with the ETDRS array was not significantly different from the results on the Snellen array, the precision of the ETDRS array may be useful for the study of ocular biomarkers in this patient group [13].

Use in determining fitness to drive

Analysis of the results showed that the ETDRS array provides a more accurate estimate of a patient's ability to meet the requirements of the licence plate reading test. The range of overlap results between compliant and non-compliant patients was narrower for the ETDRS board than for the Snellen board, making it a more useful tool [14].

Age and refractive defects

In patients with refractive errors (myopia, hyperopia, astigmatism) and at different ages, the results on the ETDRS and Snellen arrays were similar, but the ETDRS array showed better repeatability and lower standard deviation of results. This can be particularly useful in studies requiring high accuracy. The ETDRS array, with its standardised layout and logMAR notation, offers better precision and repeatability of measurements compared to the Snellen array, especially in populations with low VA and in clinical trials. However, its use requires more time and adequate training, which may limit its widespread use in routine ophthalmic practice. The selection of an appropriate method should take into account the patient's clinical condition, the objectives of the study and the availability of resources [9].

RECOMMENDATIONS

The authors of one study clearly demonstrated that for patients with poorer VA, the ETDRS chart is a more accurate diagnostic tool than the Snellen chart. They suggest that the EDTRS charts should be used in prospective clinical trials. Additionally, based on previously published literature, the use of ETDRS charts for medico-legal purposes and also for

setting standards for selected medical procedures is recommended. In everyday clinical practice, the continued use of Snellen chart is justified, as it is possible to estimate logMAR scores based on the results obtained [6]. The ETDRS chart is the gold standard for monitoring treatment effects. For newer therapies, such as photodynamic therapy, the use of the ETDRS chart is an obligatory method of testing VA [4]. A study by researchers at the Queensland University of Technology in Australia suggested that the Snellen chart should only find use in education, while the logMAR should be adopted as the gold standard in teaching and clinical practice. In the long term, it is the ETDRS charts that will set the stage for accurate measurement of VA, while the Snellen may remain merely a historical relic [15].

CONCLUSIONS

The Snellen chart has less precision due to the irregular number of letters on the lines and their uneven distribution, which makes reading difficult and increases the risk of errors [4]. ETDRS chart, on the other hand, are characterised by a fixed number of letters per line and a uniform, logarithmic decrease in letter size from one line to the next, ensuring greater accuracy and consistency of results [5]. The inconsistency of the Snellen chart is due to the different number of letters on each line and the uneven requirement

for correct reading, which can affect the precision of the results. The logMAR chart eliminates these limitations by assigning a point to each correctly read letter and ensuring consistency between VA levels [4]. According to the computer simulation carried out to assess the accuracy, repeatability and duration of the tests carried out with the Snellen and ETDRS charts, the ETDRS chart was found to be more accurate and repeatable. In contrast, the duration of the test was determined to be more than twice as long, which may be a disadvantage [7]. The Snellen chart is still popular in daily clinical practice because of its simplicity. However, it is not accurate enough for analyses requiring high precision and standardisation [15].

SUMMARY

The literature review confirmed the superiority of the ETDRS charts over the Snellen chart in VA assessment, particularly in studies requiring standardisation and precise results. Despite its simplicity and widespread use, the Snellen chart exhibits significant limitations in accuracy and reproducibility, making it less suitable for patients with advanced ophthalmic conditions. The findings of this review highlight the need for broader adoption of ETDRS charts in clinical practice and scientific research to ensure more reliable and consistent visual acuity assessments.

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Authors' contributions:

Przemysław Ciszewski: lead author, responsible for organising the entire systematic review, including collecting, analysing and interpreting the literature. Preparing the draft version of the article, editing the text and drafting the conclusion section of the review. Communicating with other authors and being responsible for contacting the journal editorial board.

Iga Piórkowska: Literature analysis of specific applications of Snellen and ETDRS charts in the diagnosis of diseases such as cataract, diabetic retinopathy and macular degeneration. Participation in the literature search, selection of relevant studies and assessment of the methodological quality of the papers included in the review. Editing and proofreading of texts, particularly in the analysis of study data.

Aleksandra Grabowska: Assisting in the analysis of the results of the Snellen and ETDRS comparative studies. Collaborating in assessing the accuracy and reproducibility of the results of both tools. Assisting in the development of the methodological chapter and structure of the paper. Analysis of data on test times and patient comfort during visual acuity assessment.

Natalia Godela: Co-authorship of the section on the practical application of both tools in clinical diagnosis. Participation in the literature search, selection of relevant studies and assessment of the methodological quality of the papers. Assisting in the editing of the text, especially in the section on clinical applications.

Sebastian Sirek: Scientific supervision of the entire project, ensuring the methodological correctness of the systematic review. Coordination of the team's work, substantive support and verification of the prepared texts.

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