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Assessment of visual acuity using ETDRS and Snellen charts in patients after posterior vitrectomy with silicone oil endotamponade

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Abstract

Introduction. *Visual acuity (VA) assessment in patients after vitrectomy with silicone oil tamponade (SO) presents an important diagnostic challenge. In everyday ophthalmic practice, Snellen charts and the Early Treatment Diabetic Retinopathy Study (ETDRS) are most often used, which allow systematic monitoring of visual function and observation of the effects of treatment. To compare visual acuity measurements using Snellen and ETDRS charts in pars plana (PPV) vitrectomy patients with silicone oil tamponade.* **Materials and methods.** *This prospective study included 60 eyes of 60 patients (34 women, 26 men). Visual acuity was assessed under standardized conditions using Snellen and ETDRS charts. Snellen's results were calculated on the logarithmic minimum of Angle of Resolution (logMAR) scale.* **Results.** *The average visual acuity for the whole group was 0.91±0.52 logMAR. The ETDRS chart showed significantly better results (0.86 ±0.48 logMAR) compared to Snellen (0.95 ±0.56 logMAR), with an average difference of 0.11 logMAR. 70% of patients (n=42) achieved higher visual acuity scores using the ETDRS chart (mean difference of 0.18 logMAR), while 26.7% (n=16) reported better results with Snellen (difference of 0.11 logMAR). The biggest difference observed was 0.74 logMAR. Differences between methods were more pronounced in patients with significantly reduced visual acuity (>1.0 logMAR).* **Conclusions.** *Snellen and ETDRS charts should not be used interchangeably due to significant differences in results. Differences between methods increase with deterioration of visual acuity, which necessitates cautious interpretation in patients with severe visual impairment. Due to its methodology, ETDRS provides more accurate and repeatable measurements, making it particularly useful for monitoring changes in visual acuity and scientific research. (Gerontol Pol 2026; 34; 98-106) doi: 10.53139/GP.20263417*

Keywords: *vitrectomy, silicone oil, visual acuity, ETDRS chart, Snellen chart*

List of abbreviations: AMD- Age-related Macular Degeneration, **BCVA**- Best Corrected Visual Acuity, **CST**-Central Subfield Thickness, **ETDRS**- Early Treatment Diabetic Retinopathy Study, **logMAR**- logarithm of the Minimum Angle of Resolution, **PPV**- Pars Plana Vitrectomy, **SO**- Silicone Oil, **SORVL**- Silicone Oil-Related Vision Loss, **VA**- Visual Acuity

Introduction

Pars plana vitrectomy - technique, indications and clinical significance

PPV is a microsurgical procedure involving the removal of the vitreous humour in order to gain access to the posterior segment of the eyeball. Surgical access is obtained through the flat part – the area devoid of vessels and distant from critical structures, which minimizes the risk of intraocular complications [1]. Indications include various retinal and vitreous diseases, including retinal detachment, hemorrhages, macular openings, retinal traction, proliferative diabetic retinopathy, and selected inflammation and post-traumatic complications. The tre-

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atment often ends with the use of intraocular tamponade (gas or silicone oil), which facilitates the readhesion of the retina to the retinal pigment epithelium. Due to the possibility of complications in the early and late postoperative period, close clinical control is necessary [2].

Silicone oil as intraocular tamponade

In cases requiring long-term intraocular tamponade, silicone oil is a frequently chosen material due to its chemical stability and the ability to stay in the eye for many months. Due to its physical properties, it is an effective alternative to tamping gases, especially in situations requiring prolonged action or in increased risk of retinal detachment recurrence [3]. The use of silicone oil, however, is associated with the possibility of complications, especially if it is left in the eyeball for a long time. The most commonly observed include cataracts, secondary glaucoma associated with emulsification, endothelial keratopathy, migration of oil to the anterior chamber or outside the eyeball, as well as the phenomenon of the so-called “sticky oil”, which makes it difficult to remove it. Special attention is also paid to SORVL (silicone oil-related vision loss) syndrome, defined as unexplained deterioration in visual acuity during tamponade or immediately after removal of silicone oil [3.4]. The removal of silicone oil can be associated with significant complications in both the anterior and posterior segment of the eyeball. In retrospective studies, recurrent retinal detachment (25%), ocular hypotony (16%) and progression of lens opacification were most frequently observed. In patients with previously diagnosed glaucoma or corneal decompensation, additional procedures such as filtering surgery or keratoplasty were often required at the same time, whereas in patients without anterior segment pathology these complications were much less frequent [5.6].

The effect of silicone oil on the refraction of the eye

Silicone oil has a higher refractive index than the vitreous body, but lower than the natural lens of the eye [4]. Its presence in the vitreous cavity significantly affects the refraction of the eye, differently in patients with a natural lens and after removal of the lens. In aphakic patients, the oil causes a shift toward myopia, and in phakic patients toward hyperopia. The effect on refraction depends on the shape of the silicone oil bubble and the position of the body, and in patients with preserved lens, reduced accommodation is also observed [7]. The refractive changes at complete oil fill range from 5 to 14 diopters. Aphakic eyes become less hyperoptic, while fakal eyes become more hyperoptic by about 5- 7 diopters. Factors such as high myopia or incomplete filling affect the final effect [8]. Silicone oil with a higher viscosity (5000 cSt) has been shown to cause greater changes in refraction and intraocular pressure than oil with a viscosity of 1000 cSt, with similar changes in axial length. In the studies, the average oil retention time was about 5 months [9].

Visual acuity assessment methods – ETDRS and Snellen charts

In clinical practice, visual acuity is most often assessed using Snellen and ETDRS charts. The classic Snellen chart, developed in 1862, despite its universality and simplicity, is characterized by limited precision of measurement. In response to these imperfections, a Bailey--Lovi table was developed in 1976, which used the same degree of difficulty of letters, a constant spacing and a logarithmic increase in their size. The modification of this table resulted in a version of ETDRS, which since the 80s has been the standard in clinical trials, especially concerning diabetic retinopathy. Although higher accuracy of ETDRS tests has been demonstrated, the use of the classic Snellen chart still dominates in publications [10]. The Snellen chart, most commonly used in everyday clinical practice, is characterized by uneven progression of optotypes size and variable number of letters in subsequent lines, which limits repeatability and accuracy of measurement [11]. With visual acuity 6/60 the patient reads only one optotype, while at 6/6 as many as eight, which further intensifies the effect of overcrowding and increases the difficulty of the test. In addition, the lack of a consistent criterion for passing – e.g. in a two-letter row, it is enough to recognize one optotype, while in an eight-letter row seven is already required [12]. The visual acuity measurement scale in this method is recorded in the form of a fraction, in which the meter indicates the distance of the examination, and the denominator - the distance from which a given row of optotypes should be correctly recognizable [10]. On the other hand, the results obtained using ETDRS are more repeatable and reliable compared to the Snellen’s chart. The authors attribute these characteristics, among other things, to the same number of optotypes in each line of the array, as well as an equal, logarithmic decrease in the letter size between each line [13]. All ETDRS lines consist of an identical number of optotypes, more precisely five. The distances between optotypes and consecutive lines have been determined as follows: Each distance between two optotypes has the width of one optotype, while the height of the distance between consecutive lines is equal to the height of the optotypes in the following line. Letters used for

ETDRS chart construction (S, D, K, H, N, O, C, V, R, Z) were selected because of similar difficulty reading. The ETDRS chart is based on the LogMAR scale, characterized by a linear system in which the difference between the next row is 0.1 units. In addition, each correctly identified optotype is assigned a value of 0.02 LogMAR [11].

Aim

The aim of this study is to assess visual acuity in patients after posterior vitrectomy using endotamponade silicone oil, using the two most commonly used measurement methods – Snellen and ETDRS. The purpose of the comparison of both tools is to determine their clinical usefulness in the assessment of visual functions in this specific group of patients. The choice of these two tests is due to their widespread use and differences in design, which can affect the reliability and precision of the results obtained. The work also aims to indicate the possible advantage of one of the methods in post-operative conditions.

Material and methods

A prospective, observational comparative study of visual acuity was conducted in patients after posterior vitrectomy with silicone oil endotamponade. The study included 60 eyes in 60 patients (34 women and 26 men) aged 41 to 83 years (median 66.5 years). All patients underwent the procedure at the Prof. K. Gibiński University Clinical Centre of the Medical University of Silesia in Katowice in the period from November 2024 to April 2025. Among the diagnoses qualifying for the procedure, retinal detachment dominated. In addition, some patients have been diagnosed with retinal membrane, macular openings and various retinal disorders such as vitroretinal traction, proliferative diabetic retinopathy, and vitreous and anterior chamber hemorrhages. Only adult patients (≥18 years) whose visual acuity measurement was performed no later than 14 days after surgery were included in the study group. The condition for participation was the ability to cooperate and the correct execution of tests using ETDRS and Snellen chartss. Patients who did not attend a follow-up examination were excluded. In addition, the exclusion criteria included the presence of advanced optical opacification that prevented a reliable assessment and the lack of written consent to participate in the study or incomplete medical documentation.

Visual acuity testing was performed under controlled clinical conditions, in a room with minimal external light influence, ensuring stable and uniform lighting. Lighting standardization was achieved by using a light source with a luminance intensity in the range of 80-160 cd/m², in accordance with the guidelines of ISO 8596 for visual acuity assessment. Portable printed Snellen and ETDRS optotype charts were used to assess visual acuity, eliminating potential differences resulting from the use of electronic or illuminated charts, which could introduce systematic measurement errors and favor one method over another. All measurements were performed by the same person to ensure consistency of the procedure. The examination was performed with the patient's own refractive correction, if available, and only the results for the eye undergoing posterior vitrectomy with silicone oil endotamponade were included in the further analysis. Visual acuity was measured using a Snellen chart at a distance of 5 meters, with a row of optotypes considered correct if one error was allowed, in accordance with commonly used clinical criteria. Next, an ETDRS chart was used at a distance of 4 meters. The lines contained five optotypes with logarithmically decreasing size by 0.1 LogMAR units, and each correctly recognized character corresponded to a value of 0.02 LogMAR. Visual acuity equal to 1.0 on the Snellen scale corresponds to a LogMAR value of 0.0, which was the reference point in the analyses. In order to enable comparison of the results, the visual acuity obtained from the Snellen charts was converted to the LogMAR scale according to the formula: LogMAR = $\log_{10}$ (Snellen denominator/Snellen numerator) (figure 1). The adoption of a uniform LogMAR scale enabled a direct comparison of the results of both methods of measuring visual acuity, facilitating the assessment of their mutual correlation and differences.

$$\boxed{logMAR = log_{10}\left(\frac{Snellendenominator}{Snellennumerator}\right)}$$

Figure 1. Graphical representation of the conversion of the Snellen fraction to the LogMAR value

Results

The analysis covered 60 eyes of 60 patients after posterior vitrectomy with silicone oil endotamponade. Each patient's visual acuity was assessed using Snellen charts and ETDRS, with only the operated eye being subjected to comparative analysis. The mean visual acuity for the entire study group, regardless of the measurement method used, was 0.91 ± 0.52 logMAR. The mean visual acuity assessed using the ETDRS chart was 0.86 ± 0.48 logMAR, while that assessed using the Snellen chart was 0.95 ± 0.56 logMAR. The average difference between the results obtained from both charts was 0.11 logMAR, indicating a slight advantage of measurement using the ETDRS chart. In further analysis, patients were divided into three subgroups, depending on which chart yielded a higher score. In a group of 42 patients (70%), higher visual acuity values were recorded during the examination using the ETDRS chart, with an average result of 0.88 logMAR on the ETDRS chart and 1.06 logMAR on the Snellen chart, which translates into an average difference of 0.18 logMAR. In a group of 16 patients (26.7%), better results were obtained on the Snellen chart, where the average visual acuity was 0.69 logMAR, and on the ETDRS chart, where it was 0.80 logMAR. The average difference in this group was 0.11 logMAR. In two patients (3.3%), no differences were found between the methods, with a mean visual acuity of 0.85 logMAR. The extreme values also differed between the groups. Among patients who achieved better results on the ETDRS chart, the highest score was 0.10 logMAR and the lowest was 1.86 logMAR. In the group preferring the Snellen chart, these values ranged from 0.15 to 1.70 logMAR. In two patients who had identi-

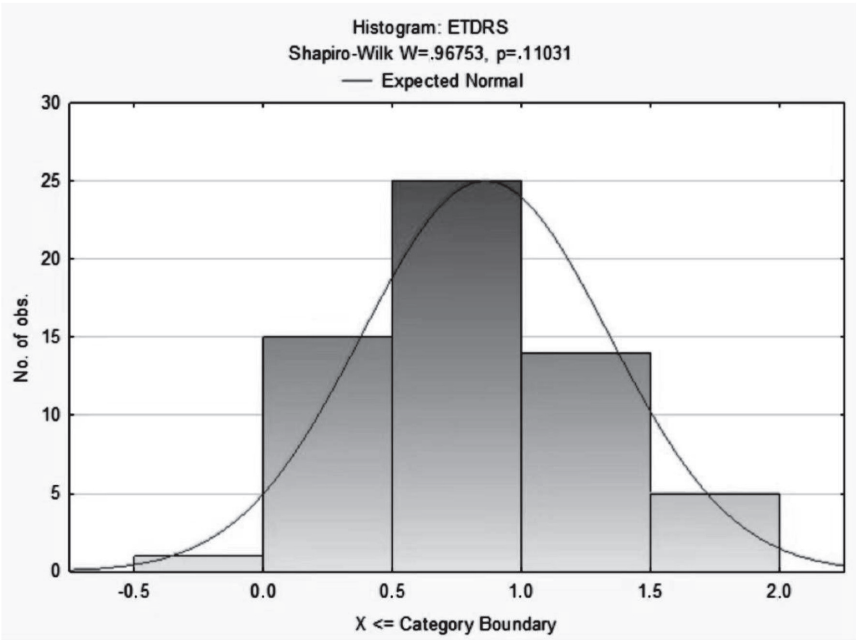

Figure 2. Distribution of visual acuity (logMAR) measured with the ETDRS chart

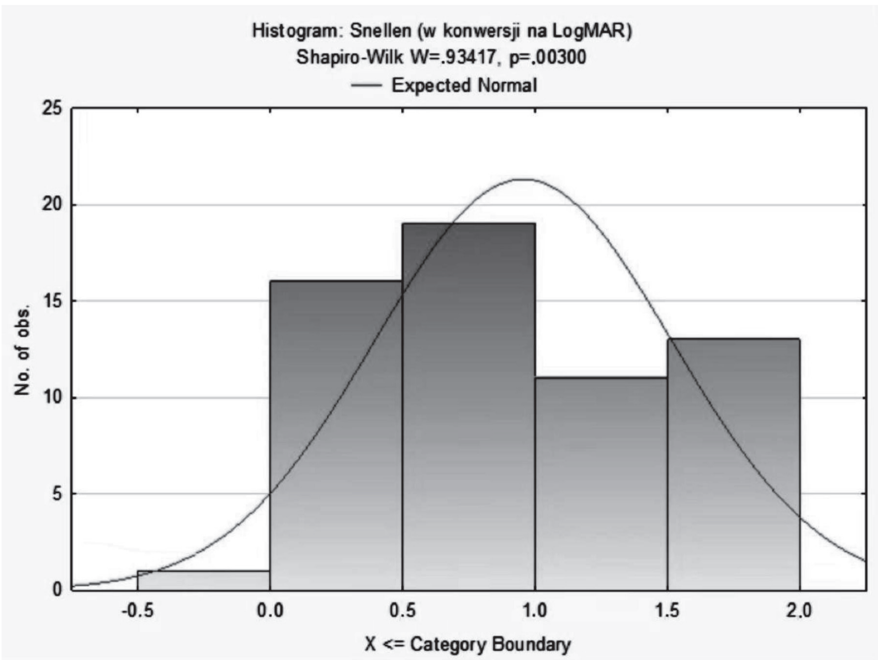

Figure 3. Distribution of visual acuity (logMAR) measured with the Snellen chart

cal results on both charts, the values were 0.00 and 1.70 logMAR, respectively. The largest difference between the results obtained with both methods was observed in a patient whose visual acuity was assessed at 0.96 logMAR on the ETDRS chart and 1.70 logMAR on the Snellen chart, giving a difference of 0.74 logMAR. A correlation was also observed indicating that in patients with poorer overall visual acuity (>1.0 logMAR), the differences between the results obtained using the Snellen and ETDRS charts were more pronounced than in patients with better vision. This may suggest greater sensitivity of the ETDRS charts in assessing weaker levels of vision.

In order to statistically verify the above observations, an analysis of the normality of the distribution of the obtained data was performed. The Shapiro-Wilk test showed that the results for the ETDRS charts (figure 2) had a normal distribution ($p > 0.05$), while in the case of the Snellen charts (figure 3), a deviation from the normal distribution was noted ($p = 0.003$). For this reason, a non-parametric test was used to assess the strength of the relationship between the methods.

The analysis showed a very strong positive Spearman's rank correlation between the visual acuity results obtained on both charts ($R = 0.96$; $p < 0.001$) (figure 4). A correlation coefficient close to unity confirms that, de-

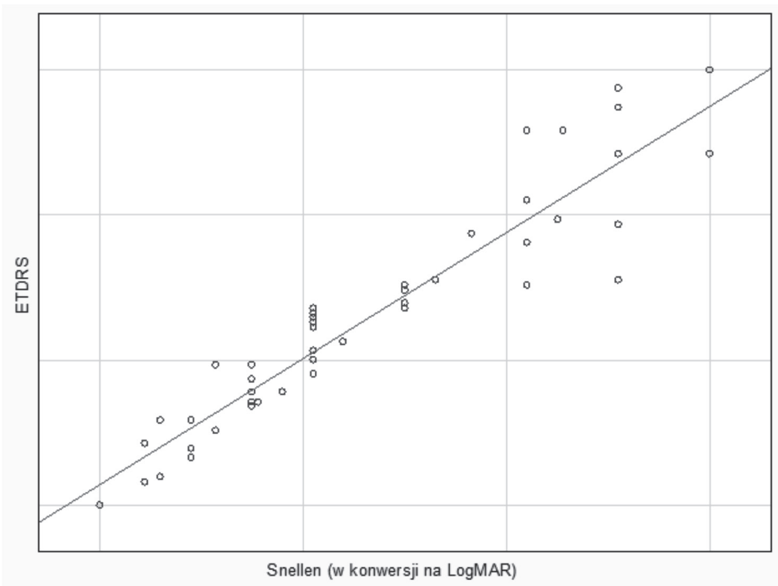

Figure 4. Scatter plot illustrating the correlation between ETDRS and Snellen visual acuity measurements

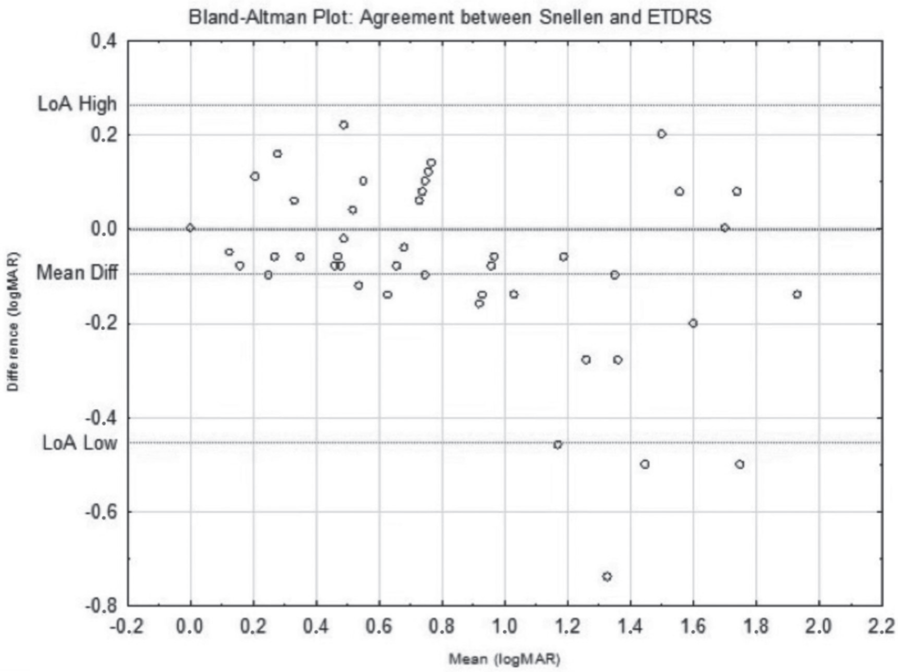

Figure 5. Bland-Altman plot showing the agreement between Snellen and ETDRS charts

spite differences in absolute values, both methods classify patients in a convergent manner- a change in the VA value obtained on one chart is associated with a proportional change in the result on the other.

Despite the high correlation, these methods did not show complete clinical interchangeability, which was confirmed by Bland-Altman analysis (figure 5). This graph showed a systematic bias averaging -0.09 logMAR, confirming the tendency of Snellen charts to underestimate VA (higher logMAR values) compared to ETDRS.

Analysis of the Bland-Altman plot also confirmed that the agreement between measurements is closely related to the level of visual acuity. In the case of people with better vision (low logMAR values), the measurement points are clustered close to the mean difference line. In contrast, in patients with poorer visual acuity (logMAR > 1.0), a significant increase in the spread of results was observed, indicating a limited ability to compare the results of both methods in visually impaired patients.

Discussion

The results of the study indicate significant differences in the assessment of visual acuity depending on the measurement method used. In most of the subjects, the ETDRS chart yielded higher values compared to the classic Snellen chart, and the discrepancies between the methods increased as visual acuity deteriorated. The greatest differences were observed in patients with visual acuity below 1.0 logMAR, suggesting greater sensitivity and precision of the ETDRS test in assessing deeper levels of visual impairment. This phenomenon is reflected in the literature—in patients with cataracts, it was shown that with poorer visual acuity, ETDRS was more discriminating and precise [14]. Similarly, in a group of patients with age-related macular degeneration (AMD), the differences between the methods were particularly pronounced in the case of low VA, where the result obtained on the Snellen chart significantly underestimated the actual result compared to the ETDRS [15]. This phenomenon is clearly visible in patients with AMD, where ETDRS gave better results than Snellen in most of the subjects, especially in those with low VA. The difference was as high as 4 lines in favor of ETDRS [16].

Our observations are consistent with many previous studies. Studies comparing the two methods have shown that the ETDRS chart provides better VA results and is more repeatable than the Snellen chart [13,17]. Similarly, a simulation study reported that the differences between the two methods result from different chart design principles, with the ETDRS providing more reliable and stable measurements [18]. The poorer the patient's vision, the more Snellen underestimates the result compared to ETDRS. For very low VA, this deviation can be up to four times greater than for better VA [19].

The results obtained in this study also correspond with reports concerning patients with macular diseases. In a group of patients with AMD, it was shown that the ETDRS chart allows for more precise monitoring of changes in visual acuity than Snellen, especially in advanced stages of the disease [15]. Similar observations were also made in studies of patients with cataracts and macular pathologies, where the differences between the two tests were clinically significant [14]. Modern, computerized visual acuity measurement systems based on logMAR-COMPlog show excellent agreement with the traditional ETDRS chart, offering similar measurement reliability, which confirms the superiority of these charts [20]. On the other hand, some authors point to the possibility of using both methods interchangeably, especially in groups with preserved good visual acuity. In a study of patients without macular diseases, it was found that the differences between Snellen and ETDRS are minimal and clinically insignificant [21]. However, large-scale studies show that ETDRS gives statistically better results than Snellen for most retinal diseases. Although the condition of the lens did not affect the degree of discrepancy between ETDRS and Snellen results, the degree of retinal edema measured by central macular thickness (CST) did. Increased CST correlated with increased variability [17]. These results suggest that the degree of discrepancy depends on the population studied and the level of visual acuity—the poorer the vision, the greater the ETDRS advantage.

The fundamental reasons for these differences can be found in the design of the charts themselves. The classic Snellen chart is characterized by uneven progression in the size of optotypes, a variable number of letters in each line, and a lack of standardization in terms of passing criteria, which leads to high variability in results [11]. The ETDRS, based on the logMAR scale, eliminates these imperfections by using logarithmic reduction in the size of optotypes, a fixed number of letters in each line, and unambiguous assessment rules [12, 22]. This standardization ensures greater repeatability and reliability of measurement, which is confirmed both in the literature [23] and in our observations. However, it should be remembered that even converting the Snellen fraction to the logMAR scale will not remedy the fundamental flaws of the Snellen chart and may introduce error into the analysis [24]. As an alternative to conversion to logMAR, some authors propose converting Snellen fractions to approximate ETDRS letter values (approxETDRS), which may translate into easier interpretation of results in clinical practice [25]. The problem of imprecise description of visual acuity measurement methodology is common. This is demonstrated by a review of studies on corneal cone, where more than half of the articles did not specify the method used, and many others incorrectly converted Snellen to logMAR [26].

Previous reports demonstrate the superiority of the ETDRS chart, yet the Snellen chart remains the primary tool in routine clinical practice. The main reasons for this are its widespread use, simplicity, familiarity among staff, and shorter test time [12, 27]. However, as the authors rightly point out, each of the arguments against the introduction of ETDRS can be overcome, and the real barrier remains clinical inertia [12]. This difference between the methods has important consequences: the results obtained in the office using the Snellen chart are often worse than in clinical trials where ETDRS was used. On average, this difference is 1-2 lines, which may partly explain why the treatment effects observed in scientific studies are not always reflected in everyday clinical practice [28]. The differences between the Snellen chart and the ETDRS are also important in the context of assessing driving ability. Studies have shown that the ETDRS chart allows for a more accurate determination of the threshold for this ability compared to the Snellen chart, for which the range of measurement uncertainty is wider. In practice, this means that the ETDRS can more precisely identify which patients meet the visual acuity requirements, reducing the risk of misjudging driving ability based on the less sensitive Snellen tests [29].

A key aspect is the specificity of VA measurement in an eye filled with silicone oil. The presence of SO significantly alters the optics of the eye, causing irregular image distortions and resulting in an average refractive error ranging from -2.50 D to -6.00 D [7, 8, 30]. Such a variable refractive error is an additional source of measurement error that overlaps with the differences between the methods used to measure visual acuity. Under such conditions, precise refractive correction before VA testing is particularly important, but at the same time difficult to achieve. As studies have shown, in clinical practice, measurements are often performed without full correction [28]. In the eye with SO, where accurate correction is crucial, standard measurement with the Snellen chart may further underestimate the result. This may explain the large discrepancies between the two charts observed in some patients. In addition, silicone oil can directly affect photoreceptor function and the transparency of optical media, reducing best-corrected visual acuity (BCVA) regardless of retinal status [3]. Therefore, in this specific population, the use of a standardized ETDRS protocol with carefully selected correction is necessary to obtain reliable and repeatable results.

The limitation of this study is the small size and nature of the group, which included only patients who had undergone vitrectomy with silicone oil. In addition, the study was based on single measurements, which may affect the repeatability of the results. In the future, it would be worthwhile to study this in a larger group of patients with various retinal diseases. This is also important because the magnitude of changes in visual acuity between visits may be assessed differently depending on the method used. Clinical studies have shown that in patients with poorer baseline VA, the Snellen chart may indicate a greater apparent improvement than the ETDRS, while in individuals with better visual acuity, the opposite is true—the change is greater when using the ETDRS [13]. This phenomenon shows that the baseline level of vision should be taken into account when assessing changes in visual acuity. This makes it easier to assess the advantage of the ETDRS chart in monitoring VA and making clinical decisions.

A particular value of this study is the fact that it is one of the few to analyze patients after vitrectomy with silicone oil, a group that has rarely been studied in this context. The results obtained indicate that in this population, the use of the Snellen chart may lead to significant diagnostic errors, which further strengthens the argument for the routine use of the ETDRS chart.

Conclusions

The conducted study showed significant differences in VA assessment results depending on the measurement method used. ETDRS and Snellen charts should not be used interchangeably in clinical practice or research due to their different structure, scale, and interpretation of results, which may lead to inconsistent or incomparable results. It was observed that the differences between the results obtained on both charts become more pronounced as visual acuity decreases. This effect was particularly noticeable in the group of patients with visual acuity exceeding 1.0 logMAR, suggesting that in cases of significant visual impairment, the ETDRS chart may provide more accurate and reliable results. Measurement differences occurred regardless of the type of underlying ocular condition, which indicates the universal nature of this discrepancy and highlights the need for conscious selection of a diagnostic tool depending on the purpose of the examination and the patient's clinical condition. Additionally, due to the measurement methodology, the ETDRS chart provides more precise results than the

Snellen chart. This fact makes it particularly useful in monitoring changes in visual acuity and in scientific research requiring high measurement accuracy.

Statements and Declarations

Ethical considerations Ethical approval was not required for this study according to local and national guidelines. The study adhered to the tenets of the Declaration of Helsinki.

Conflict of interest
None

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