

Literature review

CSV-1000E contrast sensitivity test in the assessment of functional vision: a review

Viktoriia Havryliv ^{1,2}, Yurii Lazar ^{1,3}, Taras Havryliv ²¹ Kopf Eye Clinic, Uzhhorod (Ukraine)² Regional Clinical Center of Neurosurgery and Neurology, Uzhhorod (Ukraine)³ Eye Center GlazCo (Prime Medical LLC), Odesa (Ukraine)

Тест контрастної чутливості CSV-1000E в оцінці функціонального зору: огляд літератури

Вікторія Гаврилів ^{1,2}, Юрій Лазарь ^{1,3}, Тарас Гаврилів ²¹ Спеціалізований офтальмологічний центр Kopf Eye Clinic, м. Ужгород, Україна² КНП «Обласний клінічний центр нейрохірургії та неврології» ЗОР, м. Ужгород, Україна³ Офтальмологічний центр GlazCo (ТОВ «Прайм Медікал»), м. Одеса, Україна

Abstract

Purpose. To summarize current evidence on the use of the standardized CSV-1000E test for the assessment of contrast sensitivity (CS) and functional vision in ophthalmic and neuro-ophthalmic disorders, and to review its clinical utility, test-retest reliability, limitations, and factors affecting test results.

Methods. A targeted review of contemporary literature was conducted, with emphasis on publications from 2015 onwards and selected foundational studies from earlier years. Data on the use of the test in glaucoma, amblyopia, cataract, high myopia, after refractive procedures and intraocular lens implantation were reviewed, together with evidence on the clinical relevance of CS assessment in other ophthalmic and neuro-ophthalmic conditions.

Results. The CSV-1000E provides quantitative assessment of CS at 3, 6, 12, and 18 cycles per degree. The test can detect reduced CS despite relatively preserved visual acuity and can be used to assess functional changes after cataract surgery and refractive procedures. The test provides standardized illumination and controlled testing conditions and can be used both in clinical research and ophthalmic practice.

Conclusion. CSV-1000E is a standardized psychophysical tool for the quantitative assessment of contrast sensitivity. It complements conventional visual acuity testing and may be useful for detecting and monitoring visual dysfunction.

Keywords: contrast sensitivity, functional vision, CSV-1000E, quality of vision, photopic conditions, mesopic conditions.

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Corresponding author: Viktoriia M. Havryliv, Ophthalmologist, Kopf Eye Clinic, Uzhhorod, Ukraine, 88000; Regional Clinical Center of Neurosurgery and Neurology, Uzhhorod, Ukraine.

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Резюме

Мета. Узагальнити сучасні дані щодо застосування стандартизованого тесту CSV-1000E для оцінки контрастної чутливості та функціонального зору при офтальмологічних і нейроофтальмологічних станах, а також проаналізувати його клінічні можливості, відтворюваність, обмеження та фактори, що впливають на результати тестування.

Методи. Проведено цільовий огляд сучасної літератури з акцентом на публікації 2015–2026 рр. та окремі фундаментальні роботи попередніх років. Проаналізовано застосування CSV-1000E при глаукомі, амбліопії, катаракті, високій міопії, після рефракційних втручань та імплантації інтраокулярних лінз, а також дані щодо клі-

нічного значення оцінки контрастної чутливості при інших офтальмологічних і нейроофтальмологічних станах.

Результати. CSV-1000E забезпечує кількісну оцінку контрастної чутливості на 3, 6, 12 і 18 *срп*. Тест дає змогу виявляти зниження контрастної чутливості навіть за відносно збереженої гостроти зору, а також оцінювати функціональні зміни після хірургічних і рефракційних втручань. Тест забезпечує стандартизоване підсвічування та контрольовані умови тестування і може застосовуватись у клінічних дослідженнях та офтальмологічній практиці.

Introduction

Functional vision is an integral indicator of the efficacy of the visual system which characterizes the visual task-related ability under real-world scenarios. The visual acuity tested by conventional high-contrast Snellen's test types refers to the resolving power of the eye. Functional vision is an established term recommended by the International Council of Ophthalmology's Resolution (Sydney, 2002) to be used to describe a person's ability to use vision in activities of daily living. There is a distinction between the two key entities that underpin an understanding of vision, visual functions (such as visual acuity, visual field, color perception and contrast sensitivity), which describe how the eye functions and functional vision, which describes how the person functions in vision-related activities. Colenbrander [1, 2] drew on the International Classification of Functioning, Disability and Health Framework (ICF), a World Health Organization (WHO) framework, as a foundation for these definitions.

Contrast Sensitivity Function (CSF) is a quantitative characteristic, with the detection threshold depending not only on the contrast level, but also on the spatial frequency of the stimulus and the involved component of the visual system (photopic/mesopic/scotopic; central/peripheral retina; P and M cellular pathways [3–7]).

Contrast sensitivity (CS) refers to the ability of the visual system to detect differences in luminance between objects and their background and depends on the optical properties of the eye and retinal and visual pathway signal processing [8]. Unlike standard high-contrast visual acuity tests, CS tests can detect functional abnormalities that may be not apparent on conventional visual acuity assessment. CS reduction may be observed in early glaucoma, and becomes more apparent with increasing severity of visual field defect [9–10]. Reduced CS may reflect a functional loss in neovascular age-related macular degeneration (AMD) even in the presence of a relatively well-preserved best-corrected visual acuity (BCVA) [11]. CS abnormalities have been reported in diabetes mellitus patients with little or no retinopathy [12]. Moreover, CS changes have been found in eyes with cataract and may be used for assessing visual quality after intraocular lens (IOL) implantation [13–14]. CS measurements in the clinical setting require the use of standardized methods to enable repro-

Висновки. CSV-1000E є стандартизованим психофізичним інструментом кількісної оцінки контрастної чутливості, що доповнює визначення гостроти зору та може використовуватися для виявлення і моніторингу функціональних зорових порушень.

Ключові слова: контрастна чутливість, функціональний зір, CSV-1000E, якість зору, фотопічні умови, мезопічні умови.

ducible results. CSV-1000E provides quantitative CS assessment at spatial frequencies of 3, 6, 12 and 18 cycles per degree (cpd). Standardized testing conditions and illumination control reduce the influence of external factors on measurements results and allow the test to be used in clinical studies and ophthalmological practice [15, 16].

The purpose of this review was to summarize current evidence on the use of the standardized test CSV-1000E for assessing CS and functional vision in ophthalmological and neuro-ophthalmological disorders, and to review its clinical utility, test-retest reliability, limitations and factors affecting the results of the test.

Methods of literature search

A literature search was conducted in the PubMed/MEDLINE, Scopus and Web of Science and was limited to studies published from January 2015 to August 2026. Selected foundational works published before 2015 were included additionally based on the methodological context. Boolean operators AND and OR were used in searching to combine the search terms “contrast sensitivity”, “contrast sensitivity function”, “CSV-1000”, “CSV-1000E”, and “functional vision», and the clinical key words “glaucoma”, “amblyopia”, “cataract”, “age-related macular degeneration”, “myopia”, “intraocular lens”, “refractive surgery”, “traumatic brain injury” and “optic neuritis”.

Original studies included in major clinical analysis had not only to assess CS using standardized methods, with a primary focus on CSV-1000/CSV-1000E, but also to provide sufficient descriptions of the tests protocol, characteristics of the sample and results. Studies using other standardized methods for assessing CS were included if they provided values for either method-to-method comparison or assessing the clinical role of CS. Methodological, fundamental, and review publications were included separately to justify the principles of contrast sensitivity assessment and result interpretation.

Inclusion criteria were original studies using standardized methods of CS assessment; sufficient descriptions of the test protocol, characteristics of the sample and results; and publications in peer-reviewed journals that have available data sufficient for analysis.

Exclusion criteria were studies that (a) used non-standardized or non-validated methods of CS assessment, (b) failed to provide sufficient description of the study protocol, or (c) provided no relevant primary clinical data.

Pathophysiological aspects of contrast sensitivity

CS is an integral characteristic of the performance of the optical and neurosensory systems and quantifies an observer's ability to detect the smallest (threshold) luminance difference between an object and its background at different spatial frequencies of the stimulus [3, 4, 15–17]. Spatial frequency is measured in cpd and determines the size of the repeated pattern of the image and how often this pattern repeats per unit of distance or angle. It is also a measure of how often sinusoidal components of the structure repeat per unit of distance.

Normal CS function is characterized by an inverted U-shaped curve. The peak sensitivity usually occurs around 4–6 cycles/degree with a lower sensitivity for both higher and lower spatial frequencies [6, 7].

This curve is formed due to a cumulative impact of optical factors (diffraction, aberration and dispersion of light) and neuronal processing of the image in the retina and central visual system [8].

Disorders affecting optical quality or neurosensory processing of the signal lead to a CSF change or CS dysfunction:

- Patients with glaucoma exhibited CS reduction at various spatial frequencies, which became more apparent with increasing severity of visual field defect [9–10]
- Patients with AMD can exhibit CS reduction in the middle-range spatial frequencies to high-range spatial frequencies [11]
- Cataract causes a reduction in CS over the entire spatial frequency range due to both light dispersion and a reduction in image modulation [3, 14]. CS assessment allows to characterize visual quality after cataract surgery with IOL implantation, complementing standard visual acuity assessment. The CS values obtained after IOL implantation may depend on the design of IOL optics and testing conditions [18]. CSV-1000E was used for CS assessment after implantation of various types of multifocal IOLs and an extended depth-of-focus (EDOF) IOL under photopic and mesopic conditions with and without a glare source [19–21]. Huang and colleagues [22] used CSV-1000E to determine preoperative and postoperative CS at 3, 6, 12 and 18 cpd in patients receiving microincision cataract surgery (MICS) with implantation of an aspheric monofocal IOL. CS was significantly higher at every postoperative time point than preoperatively ($P < 0.001$), and remained stable for up to 1 year postoperatively
- Patients with amblyopia can exhibit CS reduction even in the presence of a relatively high BCVA, with the pattern of CS abnormality depending on the clinical variant of the disease [23–26]
- Patients with multiple sclerosis exhibited visual function abnormalities associated with retinal structural changes,

particularly, retinal nerve fiber layer (RNFL) thinning and other neurodegenerative symptoms [27–30]

- Patients with idiopathic intracranial hypertension exhibited deficits in central and peripheral CS, which improved after treatment [31]
- The CSV-1000E demonstrated a certain consistency with other methods of CS assessment, but the results obtained with different CS tests cannot be considered directly interchangeable [16, 32]
- Patients with optic neuritis exhibited a substantial reduction in spatial CS [33]
- Patients with compressive lesions of the anterior visual pathway showed loss of CS over the whole range of spatial frequencies. After surgery, CS improved, but significant contrast deficits remained [34].

Illumination exerts a substantial impact on CS; a transition from photopic to mesopic illumination can result in a decrease in CS, especially at high spatial frequencies [35].

Therefore, CS is a sensitive parameter that reflects both the optic status and neurosensory status of the visual system, and CS assessment allows detecting subclinical changes that cannot be detected by standard visual acuity tests.

Contrast sensitivity measurement methodology

CS measurement allows quantitative assessment of the capacity of the visual system to discriminate low-contrast stimuli at various spatial frequencies [1, 3].

Several standardized methods (e.g., CSV-1000E, VCTS-6500, and FACT) and modern digital platforms are available for CS measurements in clinical practice [16, 32, 36–39].

Comparative studies of the sensitivity of CS methods under simulated conditions of impaired vision (60 healthy volunteers; CSV-1000E vs. quick CSF) showed lower reproducibility and more outliers for the CSV-1000E compared to quick CSF [36]. Spatial CS tests are based on the use of sine-wave gratings with a controlled contrast reduction at various spatial frequencies. The CSV-1000E (Vector Vision, Dayton, OH, USA) device is commonly used to evaluate CSF, and is automatically calibrated to assure 85 cd/m² luminance for photopic conditions. Neutral density filters are placed in front of the eye to reduce the luminance level at the chart from 85 cd/m² to about 3 cd/m² for patients testing under mesopic conditions.

A few studies measured CS under scotopic conditions using dark-adaptation testing [35, 40]. Such testing enables assessing visual functions under conditions that differ from those of standard photopic testing.

A few studies measured CS under conditions of low illumination and glare. They compared scotopic and mesopic CS with glare between pseudophakic and phakic eyes [40], mesopic CS in the presence versus the absence of glare [41], and effects of varying levels of glare on CS measurements under photopic and mesopic vision [42]. Mesopic disability glare was assessed in patients with initial bilateral lens opacification [43]. Such protocols allow

assessing specific visual quality aspects that may be insufficiently reflected during CS testing performed under photopic conditions.

Technical and clinical characteristics of CSV-1000E are presented in Table 1.

Because the results of CS measurements with CSV-1000E may vary from test to retest [15, 44], it is important to maintain the standardized conditions (testing light levels and distance) and adhere to the test procedure over the course of longitudinal observation.

Using CSV-1000E in the clinical setting

CSV-1000E has been used for assessing CS in several eye disorders. Studies have demonstrated that glaucoma (particularly, primary open-angle glaucoma (POAG)) may cause a reduction in CS at various spatial frequencies despite near-normal visual acuity [9, 10]. In a study by Kim and colleagues [9], POAG patients did not show significant differences in visual acuity scores and contrast test scores (for a CSV-1000E contrast test), expressed as black and white symbols, according to three different light systems with different color-rendering index.

Patients with amblyopia can exhibit CS reduction even in the presence of a relatively high BCVA, with the pattern of CS abnormality depending on the clinical variant of the disease [23–26]. Jia and colleagues [23] found that CS remained worse in the amblyopic eye, with the largest and statistically significant differences occurring at higher spatial frequencies, even after treatment for refractive amblyopia. This likely reflected incomplete neurosensory

adaptation. Similar differences in CS in anisometropic amblyopia were found with the use of other psychophysical CS tests by Mohammadi and colleagues [26]. Other psychophysical characteristics may have additional value for the comprehensive assessment of functional vision. For example, a study by Kolomiets and colleagues [46] demonstrated peculiarities of vernier monocular and binocular visual acuity in patients with hypermetropic astigmatism, which underscores the multicomponent nature of visual function assessment.

CS assessment is used to characterize postoperative visual quality after cataract surgery, providing a useful adjunct to standard visual acuity assessment. Eppig and colleagues [47] used the index of contrast sensitivity (ICS) for comparing functional outcomes between pseudophakic eyes implanted with different IOL designs. CSV-1000E was used for assessing CS after implanting various IOL types and after cataract surgery [19–22].

Decreased CS in AMD may reflect functional abnormalities that are not completely characterized by conventional visual acuity testing. Rossouw and colleagues [11] found that, in patients with bilateral neovascular AMD, the Pelli-Robson CS in the better eye was closely correlated with vision-related quality of life [11]. At the same time, these results characterize the clinical utility of assessing CS in AMD and cannot be directly extrapolated to the CSV-1000E test.

Decreased CS is also associated with high myopia, especially in the presence of vitreal and retinal changes. Zhao and colleagues [48] found decreased mesopic CS in

Table 1. Technical and clinical characteristics of the CSV-1000E test based on the data from published studies [15, 16, 32, 44, 45]

Parameter	Characteristic
Stimulus type	Sine gratings
Spatial frequencies (cpd)	3, 6, 12, 18
Number of contrast levels per spatial frequency	8
Luminance source	Automatically calibrated to 85 cd/m ²
Testing conditions	Photopic testing (85 cd/m ²); mesopic testing (≈ 3 cd/m ²) is possible with the use of special mesopic (neutral density) filters
Test distance	2.5 m (recommended); adaptation for near vision if required
Test duration	2–4 minutes
Standardization	Backlit light level is automatically calibrated; standardization of testing conditions
Test-retest reliability	Variable; depends on the spatial frequency and standardization of testing conditions
Major clinical applications	Glaucoma, amblyopia, cataract and IOL, high myopia; research in other ophthalmological and neuro-ophthalmological disorders
Advantages	Standardized testing conditions, contrast sensitivity assessment at the four spatial frequencies, and a short test duration
Disadvantages	Variability in test-retest data, dependence of test results on testing conditions and patient responses, a limited number of spatial frequencies and the need for special equipment

patients with partial posterior vitreous detachment, most likely due to impaired light transmission and increased dispersion in the changed vitreous.

Tasaki and colleagues demonstrated CS deterioration in eyes with epiphora due to lacrimal passage obstruction, likely associated with optical aberrations caused by changes in the tear film on the corneal surface [49]. The CSF improved after lacrimal passage intubation in eyes with epiphora [50].

Fig. 1 shows representative spatial frequency-dependent CS curves formed based on the data from individual studies using the CSV-1000E. They illustrate the differences in the pattern of CS reduction depending on the studied condition and are not intended for direct statistical comparison between conditions. The peak CS is at 6–12 cpd for healthy individuals. The most substantial reduction in CS was seen at the high-frequency range (12–18 cpd) for patients with glaucoma, and in the middle-frequency and high-frequency ranges, for patients with AMD. CS as a function of spatial frequency in amblyopia showed

a moderate reduction in CS in the intermediate and high spatial frequencies, whereas cataract caused a global reduction in CS, which appeared more pronounced at high spatial frequencies.

CS abnormalities have been reported after traumatic brain injuries (TBI), but studies differed in CS assessment methods. Rasdall and colleagues [51] found statistically significantly decreased Pelli-Robson CS in participants with chronic mild TBI. In a study by Lemke and colleagues [52], spatial CS was recorded at 3, 6, 12 and 18 cpd. Among 53 participants able to complete CS testing, 11 (21%) had values more than 2 SDs below the mean. Verejan and colleagues [53] used the on-line test VCSTest.com to assess CS in school-aged children with persisting visual symptoms after head injury. Evaluation of CS revealed changes in the acute phase of mild TBI in with an improvement in 4 months after the trauma. Therefore, the data available confirm that CS may be impaired after TBI, but the results of studies using other CS assessment methods cannot be directly extrapolated to the CSV-1000E test.

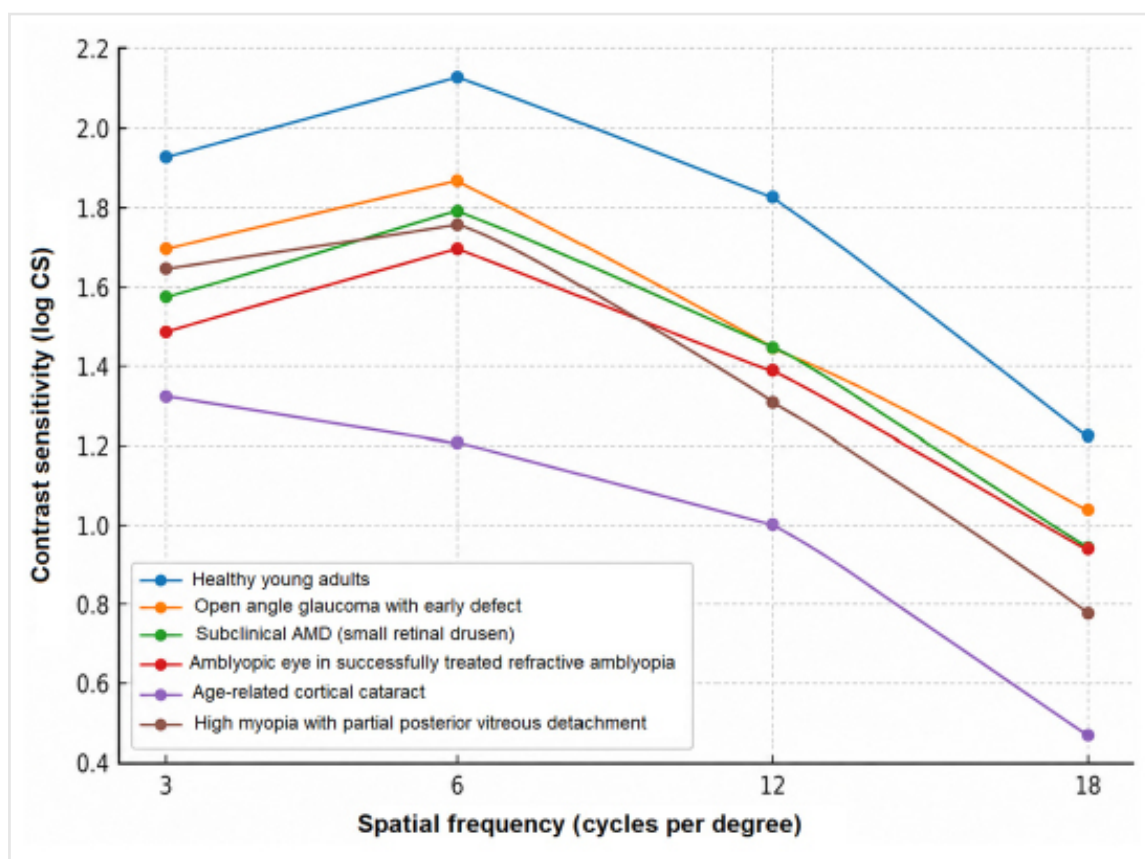


Fig. 1. Representative spatial frequency-dependent log CS curves formed based on the data from studies on various eye disorders using the CSV-1000E (healthy young adults (Koefoed et al. [45]), primary open angle glaucoma with early visual field defect (Bambo et al. [10]); subclinical age-related macular degeneration with small retinal drusen (Davey et al. [54]); amblyopic eye in successfully treated refractive amblyopia (Jia et al. [23]); age-related cortical cataract (Peng et al. [55]); and high myopia with partial posterior vitreous detachment (Zhao et al. [48])). The curves presented have been obtained in separate independent studies are illustrative and not intended for direct statistical comparison between clinical groups. In the profile shown for healthy young adults, the maximum CS occurs at 6 cpd, as shown in the graph.

Hence, CS assessment provides a useful adjunct to standard visual acuity assessment in various ophthalmological and neuro-ophthalmological conditions. The CSV-1000E provides standardized spatial CS assessment and may be used as an adjunctive tool for functional vision assessment. However, the results obtained with different CS tests cannot be considered directly interchangeable, which should be taken into account during their clinical interpretation.

Test-retest reliability, validity and the factors influencing the results of testing

The test-retest reliability of the CSV-1000 is controversial. Kelly and colleagues (2012) [15] concluded that the reliability of the CSV-1000 in adults and children is low, even if the same examiner obtains test-retest data, but they suggested modifications of the procedure that may significantly increase test reliability. Pomerance and Evans [44] demonstrated that the test-retest variance for normals, as measured by the coefficients of repeatability (CoR), was smaller than the mean differences in CS measured with the CSV-1000 before and after beta-blocker therapy in glaucoma patients at almost all spatial frequencies. This indicates the potential suitability of the test for monitoring CS under standardized conditions.

Comparative studies demonstrated that there may be substantial discrepancies in the test results between CS testing methods due to differences in stimuli, spatial frequencies and testing conditions; results from different CS tests are therefore not interchangeable [6, 16, 32, 37]. Franco and colleagues [32] compared the VCTS-6500 and the CSV-1000 tests for visual CS testing in 105 healthy individuals aged 19 to 26 years.

The clinical utility of the CSV-1000E is supported by its ability to detect changes in CS in various pathological conditions. Studies using the CSV-1000E demonstrated reductions in CS at various spatial frequencies in patients with glaucoma [9, 10]. In patients with bilateral neovascular AMD, the Pelli-Robson CS in the better eye was closely correlated with vision-related quality of life [11]. These results confirm the clinical utility of assessing CS in AMD but are not a direct validation of the CSV-1000E test.

Numerous factors can affect the results of CS tests. One of them is the luminance level, with changes in the brightness and adaptation conditions resulting in changes in CS [35]. The standardized back lit testing provided by the CSV-1000E helps control this source of variability. Therefore, it is important to maintain identical testing conditions and follow manufacturer's instructions. Age is another factor affecting CS. Studies indicated that the decrease in CS with age was more substantial in the higher spatial frequency condition [7, 56]. This is associated with age-related changes in the transparency of the optic media and neurosensory retinal structures. CS can be also affected by the transparency of the optic media (particularly, the presence of lens opacities and increased intraocular light scattering) [3, 14].

Comorbidities can affect CS even if they do not reduce visual acuity. Impaired tear film stability and irregular surface of the tear film can result in optical aberrations and impaired capacity to distinguish low-contrast objects [49, 50]. Other factors that may affect the results of psychophysical testing include attention, understanding the task and patient's capacity to perform the procedure in the correct manner and order, which is especially important to take into account when examining children and seniors.

Therefore, the CSV-1000E is a standardized instrument to assess CS quantitatively. Adherence to the testing protocol is essential for valid scores, and the results can be influenced by a number of clinical and external factors. To minimize test-retest variability, it is important to standardize illumination and take into account the status of the optic media, patient's age and the factors that may affect the performance of the psychophysical test.

Discussion

CS may be considered as an adjunct to standard visual acuity testing for a more complete assessment of visual function as it characterizes the ability of the visual system to discriminate low-contrast stimuli. The distinction between concepts of visual functions and functional vision is based on the conceptual approaches by Colenbrander [1] and Bennett and colleagues [2]. Clinical studies have demonstrated that a CS loss may be found in glaucoma [9, 10], and that, in patients with neovascular AMD, reduced CS may be associated with vision-related quality of life [11]. At the same time, the results obtained by other CS tests cannot be directly extrapolated to the CSV-1000E test.

The CSV-1000E is a standardized CS test with a recommended test distance of 8 feet; it is automatically calibrated to assure 85 cd/m² luminance for photopic conditions. The test-retest reliability of the CSV-1000 is, however, controversial. Because the results of CS measurements with CSV-1000E may vary from test to retest [15, 44], it is important to adhere to the test procedure, especially over the course of longitudinal observation.

The results obtained with different CS tests cannot be considered directly interchangeable due to differences in stimulus characteristics, spatial frequencies and testing procedures [6, 16, 25, 32, 37, 57, 58].

This should be taken into account when interpreting and comparing the results between different studies.

Other selected functional deficits (e.g., changes in meridional nonius acuity and vernier acuity) along with CS loss have been reported in patients with amblyopia and astigmatism, which underscores the multicomponent nature of visual function assessment and the utility of complex interpretation of the results [46].

The CSV-1000E test, however, has several limitations. Because the CSV-1000E is a psychophysical test, the results depend on patient's response to the stimuli and proper adherence to the procedure is essential to obtaining accurate results [15, 16]. This should be taken into account especially when examining children and seniors. It is also

important to maintain the standardized conditions (testing light levels and distance) because changes in testing conditions may affect test results [9, 15, 16].

Another important factor is the status of the optic media of the eye. Lens opacity, corneal changes or impaired tear film stability may decrease CS [3, 14, 49]. This should be taken into account when assessing CS dynamics, because changes in CS may be related not only to the primary condition, but also to concomitant anterior segment pathology.

The use of digital platforms for assessing CS is believed to be promising. De Fez and colleagues [38] developed a new iPad-based CS test for measuring the CSF at near vision (Optopad-CSF), and evaluated eyes of healthy subjects in a comparative study between the Optopad-CSF test (near vision) and the CSV-1000E test (distance vision) to validate the former test. However, differences in calibration and technical characteristics of devices remain a significant limitation to the widespread adoption of such methods.

Therefore, the CSV-1000E is a standardized psychophysical tool for assessing CS. At the same time, Kelly and colleagues [15] indicated that the test-retest reliability for CSF chart tests such as the CSV-1000 is low, with its CoR ranging from 0.37 to 0.50 log CS even with outliers removed; they suggested modifications of the procedure to increase test reliability. Other limitations include the subject-dependent nature of the response to stimuli and non-interchangeability of test results between the CSV-1000E and other CS tests. Clinical studies have demonstrated that CSV-1000E may detect a reduction in CS in glaucoma, high myopia or cataract, even in the presence of near-normal visual acuity. The clinical utility of CS testing in macular disease has been demonstrated too, but the results of studies using other CS tests cannot be directly extrapolated to the CSV-1000E test.

It is reasonable to consider the CSV-1000E test not as a stand-alone tool but as part of the comprehensive assessment of visual function. The results of the test should be interpreted taking into account the patient's age, status of optic media, and illumination conditions, and whether the standardized test protocol was adhered to. Future prospects include the optimization of test protocols, digitalization of CS assessment and validation of new CS assessment methods in various clinical cohorts.

Author contributions

Gavryliv VM – concept and design of the review, literature search and analysis, preparation and editing of the manuscript. Lazar YM – analysis and interpretation of scientific sources, critical review and editing of the manuscript. Gavryliv TS – analysis and interpretation of literary data, critical review of the scientific content of the manuscript, making intellectually significant edits. All authors have reviewed the final version of the manuscript, approved it and agree to be responsible for its content.

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Conflict of interest

The authors state that they have no conflict of interest that could influence their view on the subject matter or materials described and discussed in this manuscript.

Data Availability Statement

All data generated or analyzed during this study are included in this published article (within figures and text).

Abbreviations

AMD, age-related macular degeneration; cpd, cycles per degree; BCVA, best-corrected visual acuity; CS, contrast sensitivity; CSF, contrast sensitivity function; CSV-1000E, standardized contrast sensitivity test (VectorVision); FACT, functional acuity contrast test; ICS, index of contrast sensitivity; IOL, intraocular lens; OCT, optical coherence tomography; POAG, primary open-angle glaucoma; RNFL, retinal nerve fiber layer; TBI, traumatic brain injury; VCTS-6500, Vistech contrast test system 6500.

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