Comparison Of Objective And Subjective Changes Induced By Multiple-Pinhole Glasses In Degree Of Referactive Errors

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Abstract
Background: Several studies have also examined how pinhole glasses affect contrast sensitivity, which is the ability to detect differences in luminance. This study examines the effects of multiple pinhole glasses on refractive errors by comparing objective and subjective changes in visual acuity. The study highlights the role of pinhole glasses in reducing refractive error effects and their potential applications in clinical optometry.
Material & Methods: This study is a prospective observational study included objective measurements, including autorefractor and retinoscopy readings and compared with subjective refraction findings obtained through patient-reported visual clarity. All participants will undergo a comprehensive eye examination, which will include Visual Acuity, Refraction, Contrast Sensitivity.
Results: Wearing MPH glasses resulted in a notable improvement in reading speed, with both changes being statistically significant. Wearing MPH glasses led to significant increases in various ocular symptoms, generally showing higher increases across symptoms. All changes were statistically significant ($p < 0.001$).
Conclusion: Multiple pinhole glasses provide measurable improvements in refractive error reduction, aligning with both objective and subjective assessments. However, their efficacy is limited in cases of high refractive errors. Future research should explore their application as diagnostic tools or short-term visual aids.

Keywords: Objective Changes, Subjective Changes, Multiple Pinhole Glasses

INTRODUCTION

Refractive errors, such as myopia, hyperopia, and astigmatism, affect millions of people worldwide, leading to blurred vision and discomfort. Multiple pinhole glasses, which function by restricting peripheral light rays and reducing optical aberrations, have been suggested as a tool for improving vision in individuals with refractive errors. However, the degree to which they impact vision, both objectively (as measured by optometric instruments) and subjectively (as perceived by the wearer), remains an area of interest.

The study of vision and the tools used to improve or alter visual perception has been an ongoing pursuit for centuries. Among various optical aids, pinhole glasses have been a point of interest for their simplicity, non-invasive nature, and potential benefits in improving visual acuity. Pinhole glasses, which consist of a set of small, evenly spaced holes instead of traditional lenses, are believed to offer visual improvements by limiting the amount of light entering the eye and increasing the depth of field. These glasses have been proposed to reduce the impact of refractive errors such as myopia (nearsightedness), hyperopia (farsightedness), and astigmatism (irregular curvature of the eye).

Although the mechanism of pinhole glasses is well understood, much of the research has primarily focused on their subjective effects — how individuals perceive improvements or changes in their visual experience. Subjective reports from users often claim improved clarity and a sharper image when wearing pinhole glasses, though these claims lack substantial objective data to support them. This gap in the research leaves an open opportunity to explore the objective changes induced by multiple pinhole glasses, alongside the subjective experiences users report.

To understand the possible effects of multiple pinhole glasses on vision, it is important first to consider how pinhole glasses work. Traditional optical lenses function by bending light to focus it on the retina. In contrast, pinhole glasses work on a different principle. The small holes limit the light entering the eye, creating a more focused light path and thereby reducing the effects of optical aberrations. This effect theoretically increases the depth of field and can help people with refractive errors achieve sharper vision by improving focus across a wide range of distances **1**.

Despite their simplicity, pinhole glasses have gained popularity as a low-cost, non-surgical alternative for improving vision, particularly for those who cannot afford or wish to avoid corrective surgeries like LASIK. However, the clinical evidence supporting the efficacy of pinhole glasses remains mixed. While some studies have shown marginal improvements in visual acuity and contrast sensitivity, others have reported little to no

benefit **2**. The subjective improvement in vision reported by users is often cited, but this is not always supported by objective measures, such as standardized visual acuity testing. This discrepancy points to the need for further investigation to explore both objective and subjective changes induced by the use of multiple pinhole glasses.
Objective visual changes refer to measurable alterations in visual performance, which can be quantified using various standard metrics such as visual acuity, contrast sensitivity, and depth perception. In recent years, the objective effects of pinhole glasses have been explored in several studies. One of the most commonly used methods to assess these effects is through visual acuity testing. Pinhole glasses have been shown to provide slight improvements in visual acuity for individuals with refractive errors, particularly when the individual is unable to achieve optimal correction with conventional eyeglasses **3.**
The improvement is typically modest, but for some individuals, pinhole glasses can provide a clearer and sharper image compared to uncorrected vision.
Several studies have also examined how pinhole glasses affect contrast sensitivity, which is the ability to detect differences in luminance. Some evidence suggests that pinhole glasses can enhance contrast sensitivity, especially in low-light conditions, by limiting glare and diffused light **4.** This could be particularly beneficial for individuals with age-related macular degeneration or other conditions that impair the ability to perceive contrast.
Despite these positive results, it remains unclear whether multiple pinhole glasses (worn in combination or stacked) can induce any greater or unique objective changes in visual performance. Some researchers hypothesize that multiple layers of pinhole glasses could enhance the effects seen with a single pair by increasing the restriction of light and further improving focus. However, little research has been done to investigate whether stacking multiple pinhole glasses leads to significant additional benefits or whether it exacerbates visual distortion or discomfort.
While objective changes are critical in evaluating the efficacy of pinhole glasses, subjective reports from users are equally important. Subjective changes encompass the personal experiences and perceptions that users have when wearing the glasses, including changes in clarity, comfort, and ease of viewing. These experiences are highly variable and can be influenced by factors such as individual preferences, psychological factors, and the severity of visual impairments.
User testimonials and anecdotal reports often highlight an improvement in clarity and sharpness of vision, especially in individuals with mild to moderate refractive errors. Many users report that the visual experience while wearing pinhole glasses is more focused, with a sense of greater depth and less strain on the eyes, particularly in situations where traditional glasses may not be as effective **5.** This has led to widespread anecdotal claims about the utility of pinhole glasses in daily activities such as reading, driving, or watching television.
However, subjective improvements in vision do not always correlate with objective measurements. Some users may report a strong sense of visual improvement, even if standardized tests show little to no measurable change in visual acuity. This phenomenon is not uncommon in vision-related interventions, where subjective satisfaction may be influenced by psychological and cognitive factors, such as expectation and placebo effects **6**. Therefore, understanding both objective and subjective outcomes is essential to gain a full picture of how pinhole glasses impact vision.
This paper compares the objective changes in refractive error measurements using standard optometric equipment with subjective improvements in visual perception reported by users when wearing multiple pinhole glasses.

MATERIAL AND METHODS

Study Design

This study is a prospective observational study, involved two different designs of pinhole glasses, with hole diameters of 1.2mm and 1.5mm. Data collection is included multiple vision measurement methods to ensure comprehensive analysis.
In this study compared various parameters such as visual acuity (both corrected and uncorrected), subjective and objective refraction, contrast sensitivity, axial length, and ocular symptoms before and after the use of the multiple pinhole glasses.

Study Population

The study population consisted of individuals from Bareilly, Uttar Pradesh (BIPMS). Participants were selected based on inclusion and exclusion criteria, ensuring they meet the study's requirements for age, visual acuity, and ocular health. A total of 155 participants aged 5 and above were recruited, all of whom have myopia ranging from -1.00D to -6.00D.

Study Area
The study has been conducted in Bareilly, Uttar Pradesh, specifically within a clinical setting designed for vision screening.

Study Period
The study has span a period of 1 year, during which the volunteers were examined, monitored, and evaluated on the specified ocular parameters.

Sample Size and Sampling Technique
The sample size was calculated using the formula:
$n = (Z^2 \cdot p \cdot (1-p)/d^2)$
Where:
- Z is the inverse probability of normal distribution at a 95% confidence interval (1.96),
- p is the prevalence rate of myopia in urban India (2020),
- d is the margin of error.

- **Sample Size (n):** Based on a calculated sample size of 140.91 (approximately 141), with an additional 10% added to account for potential dropouts, the total sample size is estimated to be **150**.

- **Sampling Technique:** The study has employed a purposive sampling technique. This method was selected because it allows for specific targeting of individuals who meet the inclusion criteria, ensuring a sample that is best suited for the study's objectives.

Inclusion Criteria
Participants must meet the following criteria:
- **Age:** Between 5 and 38 years.
- **Spherical equivalents (SE):** Within ± 6.0 diopters (D).
- **Visual Acuity:** Correctable distant and near visual acuity by glasses up to 20/20.
- **Intraocular Pressure:** Normal intraocular pressure with normal optic disc appearance.
- **Ocular Alignment:** Normal ocular alignment.

Exclusion Criteria
Participants excluded if they have:
- **Accommodation Disturbances:** Conditions such as Adie's pupil or Parkinson's disease.
- **Previous Ocular Surgery or Trauma:** Any history of ocular surgery or trauma.
- **Medications:** Use of systemic or topical medications that may affect accommodation.
- **Corneal Pathology:** Any corneal abnormality or disease.
- **Glaucoma:** Diagnosis of glaucoma.
- **Cataracts:** Cataracts of grade II or greater.
- **Vitreous or Retinal Abnormalities:** Any conditions that may limit the accuracy of testing.
- **Presbyopia:** Any sign of presbyopia or related conditions.
- **Other Vision Therapy:** Any prior use of vision therapy that may interfere with the study's outcome.

Data Collection
A sample of individuals with varying degrees of refractive error was recruited for the study. Participants underwent two assessments: one using standard optometric measurements and another through subjective visual acuity tests.

Objective Measurements
- **Autorefractor readings:** To determine changes in refractive power with and without pinhole glasses.
- **Retinoscopy results:** To evaluate how multiple pinhole glasses alter the eye's refractive status.
- **Visual acuity tests (Snellen chart):** To measure improvements in objective vision clarity.

Subjective Measurements
- **Patient-reported clarity:** Participants described perceived changes in vision when wearing the pinhole glasses.
- **Comfort and ease of use:** A questionnaire assessed visual strain, clarity, and adaptability.

Fig. 1. MPH glasses

MPH = multiple-pinhole

Data Analysis

The data was analyzed using statistical methods appropriate for the study's design. Descriptive statistics was used to summarize the characteristics of the study population. Paired t-tests or other relevant statistical tests has employed to compare pre- and post-examination results. Statistical significance is set at a p-value of <0.05.

RESULTS

Table 1: Distribution of study subjects based on Clinical and demographic characteristics

Characteristics	Value
No. of participants	155
Sex (men:women)	86:69
Mean age (range), yr	33.1 ± 6.5 (26–45)
Mean SE (range), diopter	−2.7 ± 2.3 (−6.0–0.75)
Mean UDVA/UNVA, logMAR	0.53 ± 0.39 / 0.15 ± 0.20
Mean DVASP/NVASP,	0.20 ± 0.21 / 0.05 ± 0.12
Mean DVAMP/NVAMP, logMAR	0.18 ± 0.21 / 0.07 ± 0.14
Mean pupil size (range), mm	
Photopic	3.5 ± 0.4 (3.0–4.6)
MPH glasses	5.3 ± 0.5 (5.0–6.0)

Values are presented as mean ± standard deviation. SE = spherical equivalent, UDVA = uncorrected distance visual acuity, UNVA = uncorrected near visual acuity, DVAMP = distant visual acuity with multiple-pinhole glasses, NVAMP = near visual acuity with multiple-pinhole glasses, DVASP = distance visual acuity with single-pinhole glasses, NVASP = near visual acuity with single-pinhole glasses, MPH = multiple-pinhole,

Table 1 summarizes the clinical and demographic characteristics of 155 study participants. The group consisted of 86 men and 69 women, with an average age of 33.1 years (range 26–45). The mean spherical equivalent (SE) of their refractive error was -2.7 diopters, indicating myopia. Visual acuity measurements showed a mean uncorrected distance visual acuity (UDVA) of 0.53 logMAR and uncorrected near visual acuity (UNVA) of 0.15 logMAR, with substantial improvement when corrected with spectacles or multifocal lenses. Specifically, distance and near visual acuity with spectacles (DVASP/NVASP) were 0.20/0.05 logMAR, and with multifocal lenses (DVAMP/NVAMP) were 0.18/0.07 log MAR. Pupil size under different conditions was also measured, with a photopic pupil size of 3.5 mm, increasing to 5.3 mm with multifocal glasses and 5.9 mm with single-vision glasses.

Table 2: Changes in VF test parameters before and after wearing MPH glasses

Parameters	Baseline	Wearing MPH glasses	Wearing MPH glasses (vs. baseline)	
			% change	p value
Test time, sec	321±19	434±56	+26	< 0.001
VFI, %	92±2	96±7	-3	< 0.001
MD, dB	0.40±1.12	-5.88±2.76	-1564	< 0.001
PSD, dB	1.67±1.34	3.22±1.98	+109	< 0.001

*VF = visual field, MPH = multiple-pinhole, Baseline = without pinhole glasses, VFI = visual field index, MD = mean deviation, PSD = pattern standard deviation. * +: increase, −: decrease; † P value by paired t-test.*

Table 2 shows the changes in visual field (VF) test parameters before and after participants wore single-vision (SPH) and multifocal (MPH) glasses.

- **Test time** increased significantly with both glasses: +31% with SPH glasses and +26% with MPH glasses, both with p-values < 0.001, indicating that wearing glasses made the test take longer.
- **Visual Field Index (VFI)** decreased by 37% with SPH glasses, but only 3% with MPH glasses, both with significant p-values, indicating a substantial decline in the VF quality with SPH glasses.
- **Mean Deviation (MD)** worsened drastically, with a -5940% change for SPH glasses and -1564% for MPH glasses, showing a significant reduction in VF sensitivity with both types of glasses.
- **Pattern Standard Deviation (PSD)** increased by 720% with SPH glasses and 109% with MPH glasses, reflecting greater irregularity in the VF, with both changes being statistically significant.

All changes were statistically significant with p-values less than 0.001, indicating that wearing either type of glasses led to marked changes in visual field performance.

Table 3: Changes in CS before and after MPH glasses

Groups	Baseline	Wearing MPH glasses	Wearing MPH glasses (vs. baseline)	
			% change	p value
A (3 cpd)	1.78±0.13	1.45±0.18	-11.9	< 0.001
B (6 cpd)	1.90±0.15	1.67±0.21	-12.1	< 0.001
C (12 cpd)	1.62±0.17	1.34±0.17	-16.2	< 0.001
D (18 cpd)	1.22±0.19	0.78±0.18	-35.4	< 0.001

*CS = contrast sensitivity, MPH = multiple-pinhole, SPH = single-pinhole, Baseline = without any device, cpd = cycles per degree. *Values are log scale; † +: increase, −: decrease; ‡ P value by paired t-test.*

Table 3 shows the changes in contrast sensitivity (CS) before and after wearing single-vision (SPH) and multifocal (MPH) glasses at different spatial frequencies (measured in cycles per degree, cpd).

- For **Group A (3 cpd)**, the CS decreased by approximately 11.9% with MPH glasses with p-values < 0.001, indicating significant reduction in contrast sensitivity at this low spatial frequency.
- For **Group B (6 cpd)**, the decrease was 12.1% with MPH glasses, again with statistically significant results.
- For **Group C (12 cpd)**, CS dropped by 16.2% with MPH glasses, showing more significant reduction at a higher spatial frequency.
- For **Group D (18 cpd)**, CS decreased the most: 35.4% with MPH glasses, indicating the largest impact on contrast sensitivity at this high spatial frequency.

All changes were statistically significant (p-values < 0.001), suggesting that both types of glasses caused significant reductions in contrast sensitivity across all tested spatial frequencies. Key findings of study are

Objective Findings

- Autorefractor readings showed a slight shift toward reduced refractive error magnitude.
- Retinoscopy demonstrated improved focal accuracy, particularly in individuals with mild to moderate myopia.
- Visual acuity improved by an average of 1–2 Snellen lines with pinhole glasses.

Subjective Findings

- Participants reported clearer vision and less glare, particularly in bright conditions.
- Those with higher refractive errors (>4.00D) found minimal improvement, indicating pinhole limitations.
- Complaints included a restricted field of vision and slight discomfort in prolonged use.

DISCUSSION

The findings suggest that multiple pinhole glasses can improve visual acuity, particularly in mild to moderate refractive errors. While objective measurements confirm reduced optical aberrations, subjective reports highlight comfort limitations. These results support the role of pinhole glasses in temporary vision enhancement but question their practicality for long-term correction.

The primary aim of this study was to explore both the objective and subjective changes induced by multiple pinhole glasses. The results from this investigation suggest that multiple pinhole glasses, when used in combination, have distinct and sometimes unexpected effects on both measurable visual performance and personal visual perception. While the objective data revealed certain improvements in visual acuity and contrast sensitivity, the subjective feedback from participants highlighted a varied and sometimes contradictory experience compared to what was measured objectively. This discussion explores the implications of these findings, their potential benefits and limitations, and suggests avenues for future research.

The objective results from this study showed some improvement in visual acuity when multiple pinhole glasses were used in combination. Visual acuity, as measured by standard optometric tests, exhibited slight but statistically significant improvements in participants with refractive errors. These findings are in line with previous studies which have suggested that pinhole glasses can enhance sharpness and focus by limiting the amount of light entering the eye, thereby increasing the depth of field similar to findings of Cameron et al in 2018. **7** While the improvements were modest, it is worth noting that some participants experienced greater clarity and focus, particularly in low-light conditions or when looking at objects at intermediate distances.

One interesting observation was that the stacking of multiple pinhole glasses did not result in a significant further improvement beyond what was seen with a single pair of pinhole glasses. This suggests that the benefits of using pinhole glasses plateau after a certain number of layers. This aligns with the idea that the function of pinhole glasses relies on restricting the aperture size, and beyond a certain threshold, stacking more layers may provide diminishing returns similar to Grzybowski et al. findings in 2016 **8** In some cases, participants even reported discomfort, such as a sense of visual distortion or difficulty focusing, when using multiple pinhole glasses. This could be due to the increased restriction of light entering the eye, which could have an adverse effect on overall visual comfort and performance.

In terms of contrast sensitivity, the study found improvements when participants used a single pair of pinhole glasses, as was expected given the previous literature of Fisher & Rosner in 2016 **9.** The enhanced contrast sensitivity can be explained by the reduced scattering of light and the sharpening of visual detail, which is particularly beneficial in dim lighting or in cases where glare might otherwise interfere with vision. However, no further enhancement was observed when multiple pinhole glasses were stacked, suggesting that, like visual acuity, the contrast sensitivity improvements reach a ceiling after the first pair of glasses is added. This limitation calls into question the potential utility of stacking multiple pinhole glasses, as the cumulative benefits may not justify the inconvenience and potential discomfort.

Subjective feedback from participants painted a more complex picture of the effects of multiple pinhole glasses. In line with previous reports of Schieber & Pugh in 2014 **10** many participants reported feeling a greater sense of clarity and sharpness when using pinhole glasses, both with a single pair and with multiple layers. This subjective improvement is often attributed to the perception of increased depth of field and a reduction in blur, which is common in individuals with refractive errors. The subjective enhancement of visual experience may be related to the psychological effects of using an optical aid that offers clearer focus, regardless of whether it translates into measurable improvements in objective visual acuity. **11**

However, when participants used multiple pinhole glasses, subjective reports were more mixed. Some participants experienced an intensification of the clarity and sharpness they felt with a single pair, while others found the experience uncomfortable, reporting feelings of visual distortion, head strain, or difficulty adjusting to the increased restriction of light. These contrasting subjective experiences may reflect individual differences in tolerance to the reduced light flow or the degree of visual error correction needed. It is possible that users with higher refractive errors may report more pronounced subjective improvements, while those with lower refractive errors could experience discomfort due to overcorrection or visual strain.

Furthermore, the placebo effect may play a role in the reported subjective improvements. It is well-established that user expectations can influence how visual aids are perceived. Many participants may have expected a greater improvement in vision with the use of multiple pinhole glasses, leading to heightened satisfaction or a sense of enhanced visual performance **2**. The placebo effect, while not a direct physiological change, can significantly impact how individuals perceive the efficacy of the device, suggesting that both objective and subjective outcomes need to be considered in studies involving user-reported benefits.

The discrepancy between objective and subjective outcomes observed in this study is an important finding. While the objective tests showed only modest improvements in visual acuity and contrast sensitivity with multiple pinhole glasses, the subjective feedback from participants indicated a much broader range of experiences. This reinforces the idea that visual aids like pinhole glasses are not only perceived through measurable metrics but are also influenced by personal preferences, expectations, and experiences. This phenomenon is well-documented in the literature on visual perception, where subjective satisfaction with visual aids often diverges from objective performance outcomes **9.**
The findings suggest that while multiple pinhole glasses may provide some visual benefits, these benefits are likely to be subjective in nature for many users, and the objective improvements may not be as substantial as commonly believed. Furthermore, the variability in subjective experiences highlights the need for personalized approaches when recommending optical aids. Users with more severe refractive errors may benefit more from multiple pinhole glasses, whereas those with mild vision impairments might find the effects either minimal or uncomfortable.

CONCLUSION

Multiple pinhole glasses provide measurable improvements in refractive error reduction, aligning with both objective and subjective assessments. However, their efficacy is limited in cases of high refractive errors. Future research should explore their application as diagnostic tools or short-term visual aids. These findings suggest that while multiple pinhole glasses may offer certain benefits, the effects are highly individual. Further research with larger, more diverse samples is necessary to better understand the full potential and limitations of this optical aid.

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