Research Article

Subjective Quality of Vision in Progressive Addition Lens Users: Evidence of Neurovisual Adaptation from a Rasch-Validated Patient-Reported Outcome Study

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ABSTRACT

Background: Progressive addition lenses (PALs) are the most frequently prescribed optical device for presbyopia, providing a seamless range of vision in the distance, intermediate and near viewing zones. PALs have optical advantages over conventional lenses, but they also can induce visual disturbances that are not well captured by conventional visual acuity measurements. The objective of this study was to assess the subjective quality of vision in PAL users with the Rasch-validated Quality of Vision (QoV) questionnaire and to determine the factors associated with visual symptom burden.

Methods: A cross-sectional observational study was carried out on 59 presbyopic adults aged 40 years and above who were current users of progressive addition lenses. Participants filled out the QoV questionnaire, which measures ten visual symptoms in terms of frequency, severity and bothersomeness.

Results: The mean age of participants was 47.7±7.0 years and 74.6% were male. More than half of the participants (54.2%) had used PALs for more than six weeks, and 78.0% reported wearing their lenses for at least 4 hours per day. Visual disturbances were generally infrequent and mild, the most commonly reported symptoms being starbursts, glare, focusing difficulties, and problems with depth perception. The mean total QoV score was 22.0 ± 18.3, suggesting generally good subjective visual quality. Duration of PAL use was significantly negatively correlated with QoV score ($r = -0.389$, $p = 0.002$). Duration of PAL use was the only significant predictor in multivariable regression analysis ($\beta = -6.36$, $p = 0.036$), suggesting better visual quality with longer PAL wear.

Conclusion: Longer use of PAL is associated with better visual quality and suggests a role of neurovisual adaptation in successful PAL wear. Routine optometric practice incorporating patient-reported outcome measures may provide a more comprehensive assessment of presbyopic correction outcomes over and above traditional measures of visual acuity.

Keywords: Progressive addition lenses; Presbyopia; Quality of vision; Patient-reported outcomes; Visual adaptation; Rasch analysis.

Introduction

Presbyopia is an age-related refractive disorder with a progressive decline in the accommodative ability of the crystalline lens which leads to a decrease in the ability to focus on near objects.1 It is a universal physiological process.2 It usually becomes clinically significant after the fourth decade of life.3 It affects nearly all individuals as they age.4 With the increase in life expectancy, urbanisation and dependence on digital devices, presbyopia has become a significant public health issue affecting visual function, productivity and quality of life.5-6 For example, poor near-vision function in reading, using a smartphone or computer, managing medications, and performing work-related activities can significantly disrupt daily activities and independence.7-8 The burden of presbyopia is particularly important in developing countries such as India, where a large proportion of the working population remains visually active beyond middle age and requires effective optical correction to continue their occupational and recreational activities.9-11 Progressive addition lenses (PALs) remain the most frequently prescribed spectacle-based management option for presbyopia.12 Unlike bifocal and trifocal lenses, which have separate optical zones separated by visible segment lines, PALs have a gradual increase in optical power from the distance portion to the near portion of the lens.13 The progressive design gives continuous vision at varying distances of vision, for greater visual flexibility and a better cosmetic result.14 Thus, PALs have become the method of choice for presbyopic correction in modern optometric practice. PALs are popular, but have optical shortcomings. The change in lens power is gradual and results in the inevitable peripheral astigmatism, distortion and magnification change outside the central progression corridor.15 These optical properties can cause a variety of visual problems, including glare, haloes, starbursts, blurred vision, spatial distortion, difficulty focusing and poor depth perception.16 Such symptoms

can affect patient comfort, adaptation and long-term satisfaction with PAL wear.17 Furthermore, the perception and tolerance of these symptoms can vary widely between subjects and the successful adaptation of PALs is therefore a multifactorial process under optical, physiological and behavioural control. Traditionally, refractive correction efficacy has been based on objective clinical measures such as visual acuity.18 Visual acuity is a simple measure of visual performance, but it tells little about the quality of vision in everyday life.19 Visual acuity testing is generally performed under controlled high-contrast conditions and is limited to measuring central visual resolution.20 However, acuity measures alone do not adequately represent many aspects of everyday visual experience such as glare sensitivity, visual comfort, depth perception, contrast perception and dynamic visual performance.21 Thus, patients can have excellent visual acuity yet continue to report visual symptoms that negatively impact satisfaction and quality of life. Patient-reported outcome measures (PROMs) are increasingly recognised as valuable adjuncts to the assessment of visual function and treatment efficacy.22 PROMs are valuable in that they document subjective experiences that are not visible through traditional clinical testing and give information about the patient's perspective.23 In ophthalmology and optometry patient-reported outcomes have gained increasing importance for the evaluation of treatment success, patient satisfaction and vision-related quality of life. Among the most extensively validated tools to quantify subjective visual quality is the Quality of Vision (QoV) questionnaire, developed by McAlinden and colleagues.24 The QoV questionnaire is founded on Rasch psychometric methodology which, unlike traditional satisfaction surveys, allows for conversion of ordinal responses to interval-level measurements, with improved measurement precision. The instrument measures 10 common visual symptoms including glare, haloes, starbursts, hazy vision, blurred vision, distortion, double or multiple images, visual fluctuation, focusing difficulties and difficulty judging distance or depth perception. For each symptom, three dimensions are evaluated: frequency, severity, and bothersomeness. These provide a comprehensive evaluation of visual symptom burden and its impact on daily life. Patient-reported outcome measures are especially important in the assessment of progressive addition lenses, as successful PAL wear is reliant on both optical performance and neurovisual adaptation. In adaptation the visual system learns to compensate for changes in magnification, peripheral blur and prismatic effects associated with progressive lens optics.25 This adaptive process includes recalibration of eye-head coordination, gaze behaviour and spatial perception.26 Although many users adapt successfully and achieve comfortable vision, others still experience symptoms that may compromise satisfaction and result in discontinuation of lens wear. Understanding these subjective experiences is therefore critical to optimise PAL prescribing practices and improve patient outcomes. Many studies have been performed on the optical properties and performance of progressive addition lenses, but fewer studies have examined subjective quality of vision using validated patient-reported outcome measures. Additionally, there are still no Indian population-based evidences. Differences in occupational visual demands, use of digital devices, socioeconomic status, and access to eye care services may influence both adaptations to PAL and subjective visual experiences. Hence, the results of Western populations may not be directly applicable to Indian PAL users.

The purpose of the present study was to address this gap in the literature by evaluating subjective quality of vision in progressive addition lens wearers using the Rasch-validated Quality of Vision questionnaire. Furthermore, the study aimed to investigate the association between PAL-related factors (duration of lens wear, daily wearing time, and source of prescription) and the perceived quality of vision. This study contributes to a more patient-centred understanding of presbyopic correction by providing insights into real-world visual experiences of PAL users and highlights the need for inclusion of subjective outcome measures into routine optometric practice.

Materials and Methods

This cross-sectional observational study was conducted to evaluate the subjective quality of vision among progressive addition lens (PAL) users using the Rasch-validated Quality of Vision (QoV) questionnaire. Presbyopic adults, 40 years and older, who had been using PALs for at least one month were recruited from optometric and ophthalmic practice settings via convenience sampling. Subjects with ocular pathology, previous ocular surgery, neurological disorders affecting vision, or other conditions likely to influence subjective visual perception were excluded from the study. Written informed consent was obtained from all 59 participants enrolled. The subjective quality of vision was measured by the QoV questionnaire that assesses ten visual symptoms (glare, haloes, starbursts, hazy vision, blurred vision, distortion, double or multiple images, visual fluctuation, focusing difficulties, and difficulty in judging distance or depth perception) in three domains: frequency, severity, and bothersomeness. The demographic and PAL related

information such as age, gender, occupation, duration of PAL use, daily wearing time and source of PAL prescription were also recorded. Data were analysed using Jamovi statistical software (Version 2.6). Descriptive statistics summarised participant characteristics and QoV outcomes. Internal consistency reliability was measured using Cronbach's alpha coefficient. Total QoV scores were evaluated for normality using Shapiro-Wilk test. Pearson correlation analysis was performed to evaluate the relationships between the characteristics of PAL use and QoV scores, and multiple linear regression analysis was used to identify the independent predictors of subjective quality of vision. Statistical significance was set at $p < 0.05$. The research was conducted in accordance with the principles of the Declaration of Helsinki and confidentiality of the participants was protected throughout the research process.

Results

A total of 59 progressive addition lens (PAL) wearers were studied. The mean age of participants was 47.7 ± 7.0 years (range 40–65 years) and 74.6% of the sample were males. More than half of the participants (54.2%) had used PALs for more than six weeks and 78.0% wore their lenses for at least four hours per day. Eye hospitals (40.7%), optical retail stores (39.0%) and optometry clinics (20.3%) prescribed PALs as shown in Table 1.

Table 1. Demographic and Lens-Wearing Characteristics of Participants

Variable	Value
Age (years)	47.7 ± 7.0
Male (%)	74.6
Duration >6 weeks (%)	54.2
Wear time >4 h/day (%)	78
Eye hospital (%)	40.7
Optical store (%)	39
Optometry clinic (%)	20.3

Analysis of the Quality of Vision (QoV) questionnaire revealed that visual disturbances were infrequent and generally mild. The symptoms most often reported were starbursts, glare, difficulty focusing, and difficulty judging distance or depth perception. Distortion, double or multiple images, and visual fluctuation were reported less often as shown in Figure 1.

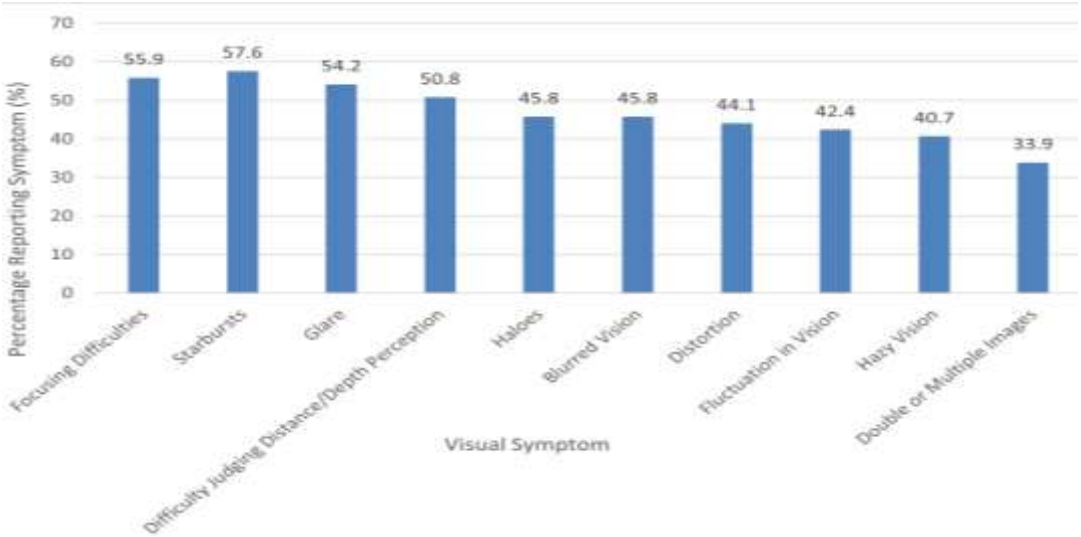


Figure 1: Frequency of visual symptoms reported by progressive addition lens users

The majority of participants reported no or only mild symptoms in all symptom categories, suggesting that progressive lens optics were well tolerated. The reliability of the QoV questionnaire was excellent based on the Cronbach's alpha coefficient of 0.957. The item-deleted alpha values ranged from 0.954 to 0.957, confirming the robustness and internal consistency of the instrument to assess subjective visual quality in the PAL users. The mean overall QoV score was 22.0 ± 18.3, ranging from 0 to 60 and with a median of 17. The QoV score distribution was significantly non–normal (Shapiro–Wilk W = 0.914, $p < 0.001$) and positively skewed towards lower symptom scores as shown in Figure 2.

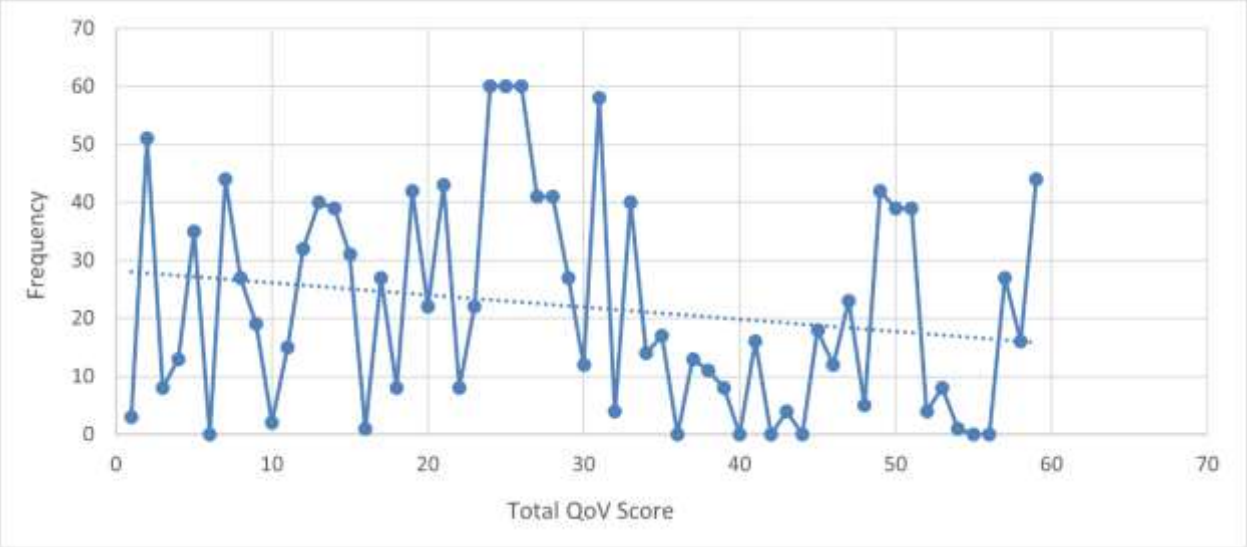


Figure 2: Distribution of Total QoV Scores

This finding indicates that the majority of participants had minor visual complaints but that a smaller number of participants had a greater symptom burden. Correlation analysis revealed a significant positive association between the duration of the PAL use and the daily wearing time ($r = 0.670$, $p < 0.001$). Total QoV score showed significant negative correlations with duration of PAL use ($r= -0.389$, $p= 0.002$) and daily PAL wearing time ($r= -0.301$, $p= 0.021$), indicating that longer and more consistent PAL use was associated with better subjective quality of vision. Multiple linear regression analysis showed that the model explained 18.7% of the variance in Total QoV scores ($R^2=0.187$) as shown in Table 2 and Figure 3. Duration of PAL use was the only significant predictor of subjective quality of vision ($\beta = -6.36$, $p = 0.036$), indicating that longer PAL wear was associated with a lower symptom burden and a better visual quality.

Table 2. Correlation and Regression Analysis of Factors Associated with QoV Scores

Predictor	r	β	p-value
Duration of PAL use	-0.389	-6.36	0.036
Daily PAL wear time	-0.301	-1.72	0.676
Source of prescription	-	NS	>0.05

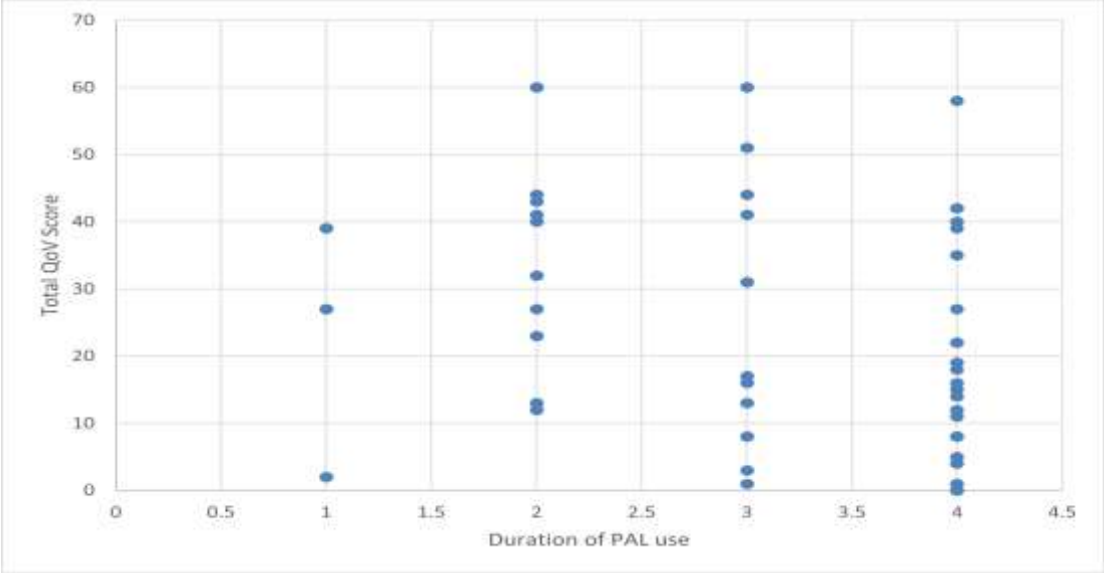


Figure 3: Relationship Between Duration of PAL Use and Quality of Vision

Daily PAL wearing time ($p = 0.676$) and source of PAL prescription ($p > 0.05$) were not significant independent predictors of QoV scores. In conclusion, the results suggest that most PAL wearers had good subjective quality of vision, with visual symptoms being generally infrequent, mild and not bothersome. Better visual outcomes were linked to longer duration of PAL use, supporting the role of neurovisual adaptation in successful PAL wear.

Discussion

The results revealed that the majority of subjects rated the overall visual quality as good. Visual symptoms were predominantly infrequent, mild and minimally bothersome. A few participants reported visual phenomena such as starbursts, glare, difficulty focusing, and problems with depth perception, but these symptoms rarely resulted in significant visual distress or functional impairment. The dominance of starbursts, glare and focusing difficulties seen in the present study agrees with the optical properties of progressive addition lenses.[27] The gradual change in power of the lens inevitably leads to peripheral astigmatism and unwanted aberrations outside the central viewing corridor, which can cause visual disturbances, especially during the initial phase of adaptation.[28] Nonetheless, the relatively low scores on bothersomeness indicate that most users are able to adjust to these optical changes and carry out daily visual tasks without much difficulty.[29] The significant association between duration of PAL use and subjective quality of vision was one of the main findings of this study. Participants with more experience with PALs reported lower QoV scores, indicating fewer visual symptoms and better perceived visual quality. This finding supports the idea of neurovisual adaptation, where the visual system adapts slowly to the optical properties of progressive lenses through changes in eye-head coordination, gaze behaviour and spatial perception. As the adaptation advances, visual disturbances are less perceptible, resulting in an increased visual comfort and user satisfaction. Moreover, the strong negative correlation between daily PAL wearing time and QoV scores suggests that habitual lens wear may assist adaptation. However, in multivariable regression analysis, daily wearing time was not a significant predictor, suggesting that long-term exposure to PALs may be a more important determinant of successful adaptation than the number of hours worn each day. The results highlight the importance of promoting regular lens wear during the adaptation period. Interestingly, source of PAL prescription was not significantly related to subjective quality of vision. Users who obtained lenses from eye hospitals, optometry clinics or optical retail stores reported similar visual outcomes. This finding indicates that once a correct prescription and fitting are achieved, the subjective quality of vision is more dependent on the individual adaptive mechanisms than on the source of dispensing. The QoV questionnaire has a very good internal consistency which supports its reliability as a patient reported outcome measure to assess visual quality in PAL users. Unlike traditional visual acuity testing which only measures central visual resolution, the QoV instrument measures multiple dimensions of the visual experience which directly impact

patient satisfaction and visual performance in the real world. Thus, application of such measures in daily clinical practice may offer a more comprehensive assessment of refractive correction outcomes. Some limitations of the study deserve to be acknowledged. The cross-sectional design restricts the ability to establish causal relationships between PAL use and visual adaptation. Results may also be limited for generalizability due to the relatively small sample size and single-population setting. Moreover, evaluation of lens design characteristics, addition powers, refractive status and fitting parameters was not done which may have affected subjective visual results. Longitudinal studies with larger and more diverse populations are needed to better understand the adaptation process and to identify factors contributing to successful PAL wear. The overall results indicate that progressive addition lenses provide satisfactory subjective visual quality for most presbyopes. The association between extended PAL use and better visual quality observed supports the importance of neurovisual adaptation and the role of patient-reported outcome measures in contemporary optometric practice.

Conclusion

The present study demonstrated that progressive addition lenses provide good subjective quality of vision for the majority of presbyopic wearers. The majority of visual symptoms were reported to be infrequent, mild and minimally bothersome, suggesting successful adaptation to the optical properties of PALs. Starbursts, glare, focusing difficulties and depth-perception problems were the most commonly reported evaluated symptoms, but the overall impact on daily visual function was limited. There was a significant association between longer duration of PAL use and better quality of vision, which emphasises the importance of neurovisual adaptation for successful visual outcomes. Users with higher levels of PAL use reported fewer visual disturbances and better overall visual comfort, suggesting adaptation is a key component to long-term satisfaction with progressive lenses. The findings of this study highlight the value of incorporating patient-reported outcome measures into routine optometric practice to provide a more comprehensive assessment of presbyopic correction outcomes. Progressive addition lenses are an effective and well tolerated solution for presbyopia, with visual quality improving over time with adaptation. Increased patient counselling on the adaptation process and regular follow-up may further increase acceptance, satisfaction and long-term success of PAL wear. Further studies, longitudinal in nature and with larger populations and other lens designs, are needed to explore the factors that influence subjective visual quality and adaptation in PAL wearers.

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Conflict of Interest

The authors declare no conflict of interest.

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