Original Article

Factors associated with good near vision after cataract surgery with monofocal intraocular lens implantation at a tertiary eye hospital in southern India

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Abstract:

PURPOSE: Although multifocal intraocular lenses (IOLs) are effective methods of dealing with surgical presbyopia, there are associated limitations (cost, technique, and patient-reported symptoms). Given their scalability challenge (due to economic factors), it is imperative to explore alternative low-cost and sustainable solutions to achieve good near vision postcataract surgery. This study aimed to determine the proportion of and the factors associated with good near vision in patients following cataract surgery with monofocal IOL implantation.

METHODS: We conducted a hospital-based cross-sectional study at a tertiary eye hospital in southern India from September 2019 to January 2020. Inclusion criteria: Uncomplicated postcataract surgery cases with monofocal IOL at least 30 days ago. Exclusion criteria: patients with any ocular condition (other than refractive errors) that could decrease the vision with best-corrected distance visual acuity < 0.18 Logarithm of the Minimum Angle of Resolution (LogMAR) units. Data collection: we assessed near vision (at 40 cm distance by using near vision card with Early Treatment of Diabetic Retinopathy Study format), distance visual acuity (uncorrected and best-corrected), refractive error (amount and type), type of astigmatism, pupil size, axial length, and contrast sensitivity. We considered a near vision of 0.2 LogMAR units or better as good near vision.

RESULTS: Of the 82 patients (82 eyes), 71 (86.59%) had good near vision. Multiple logistic regression analysis found found that the presence of myopia or myopic astigmatism was significantly associated with good near vision (adjusted odds ratio: 72.63; 95% confidence interval: 1.02–5193.5, $p = 0.049$).

CONCLUSION: About eight of every ten participants had good near vision postcataract surgery with monofocal IOL implantation. Myopia/myopic astigmatism was associated with good near vision.

Keywords:

Monofocal intraocular lens, near vision, spectacle independence

Introduction

Worldwide, uncorrected refractive errors and cataracts are the leading causes of visual impairment and blindness.[1] About 826 million people have near vision impairment due to no or inadequate near vision correction.[2] Impaired near vision reduces the quality of life and its correction increases work productivity.[3,4] Spectacle correction for near vision (the most economical option) is unavailable to more than 90% of the population in rural areas.[5] Cataract surgery has a potential to improve the quality of life by removing the clouded crystalline lens, reducing preexisting refractive error, and minimizing spectacle dependence.[6] Cataract surgery with multifocal intraocular lens (IOL) implantation, which is known to improve near and distance vision, is far from the reach of most patients in low and mid-income countries like India. Given the scalability challenge of multifocal IOL, due to economic factors, it is imperative to explore alternative low-cost and sustainable solutions to achieve good near vision postcataract surgery. Furthermore, alternative solutions could be useful in situations where multifocal IOLs are contraindicated.

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In our clinical practice, we often observe that a few patients enjoy good near vision, and are spectacle free despite monofocal IOL implantation. As high as 68.3% of the patients from the Swedish National cataract registry, reported that they did not use spectacles after routine cataract surgery as they enjoyed good near and distance vision.[6] However, different studies have shown a varied proportion of participants with "good near vision" after monofocal IOL implantation ranging from 2.1% to 71%.[7-10] The knowledge of the factors associated with "good near vision" after monofocal IOL implantation could help in planning a low-cost solution for postcataract surgery presbyopia. Different studies have attributed good near vision in this scenario to the IOL movement, in-the-bag IOL placement, patient's age, residual myopic astigmatism, type of astigmatism, corneal multifocality, axial length, higher-order aberration, and increased depth of focus with pupillary constriction during accommodation.[11-14] This cross-sectional study was planned to determine the proportion of patients in the study setting, who experience "good unaided postoperative near vision" with monofocal IOL implantation and the postoperative factors associated with it.

Methods

After obtaining approval from the institutional ethics committee (YEC-1/2019/186), we conducted this cross-sectional study at a tertiary care hospital in Southern India from September 2019 to January 2020. The study adhered to the tenets of the declaration of Helsinki.

Inclusion criteria

We included postoperative cases of cataract surgery with monofocal IOL implantation who had undergone an uncomplicated cataract surgery at least 1 month ago with best-corrected distance visual acuity better than or equal to 0.18 Logarithm of the Minimum Angle of Resolution (LogMAR) units. As the objective of the study was to assess the postoperative factors, we did not differentiate between the type of cataract surgery (phacoemulsification/small incision cataract surgery) or the type of incision.

Exclusion criteria

We excluded patients with any ocular condition (other than refractive errors) that could decrease vision (such as retinal pathologies, corneal pathologies, uveitis, vitreous opacities, and posterior capsular opacification).

The uncorrected and best-corrected distance visual acuity was expressed in LogMAR units. We assessed the amount of refractive error with objective (streak retinoscopy or automated refractometer-Keratometer, PRK-7000, POTEC Co., Ltd. Germany) and subjective refraction. The refractive status of the eye (emmetropia, myopia, hypermetropia, myopic astigmatism, hypermetropic astigmatism, mixed astigmatism) was noted. Distance vision was corrected using relevant spherical and/or cylindrical lenses to obtain the best-corrected distance visual acuity. Sphero-cylindrical powers were expressed as spherical equivalent (calculated as sphere plus half of the cylinder). In the presence of astigmatism, the type and amount of astigmatism were noted. Astigmatism was interpreted as "with-the-rule (WTR)" when the steepest meridian was 90° ± 15°; as "against-the-rule (ATR)" when the steepest meridian was 180° ± 15°, and as oblique when the steepest meridian was between the ranges of WTR and ATR astigmatism. The uncorrected vision depends on total astigmatism and not the shift of astigmatism (from preoperative reading). Hence, we did not note preoperative astigmatism or surgically induced astigmatism and only measured the total postoperative astigmatism.[15]

We assessed near vision at 40 cm distance by using near vision cards with proportionally spaced lines in Early Treatment of Diabetic Retinopathy Study format. Near vision was expressed in LogMAR Units. Axial length was measured using A-Scan (Ecorule Pro, Biomedix, India). Keratometry and size of the pupil (under mesopic conditions) were measured using automated refractometer-Keratometer (PRK-7000, POTEC Co., Ltd. Germany). An average of three readings were taken for the pupil size, axial length, and keratometry. Contrast sensitivity was assessed using the Pelli-Robson chart. The position of the IOL (in the bag/sulcus) was examined after dilatation of the pupil.

Outcome measure

We considered a near vision of 0.2 LogMAR units or better as "good" near vision.[16]

Sample size

Based on the reported average 70% of patients have good near vision postcataract surgery with monofocal IOL implantation[7,8] the study required a sample size of 81 for estimating the expected proportion with 10% absolute precision and 95% confidence.[17] Expecting 10% nonresponse, we decided to study 90 eligible patients.

Statistical analysis

We analyzed the data using Stata 15 software (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX, USA: StataCorp LLC.). We used descriptive statistics for categorical and continuous variables. We reported the proportion of patients with good near vision (95% confidence interval [CI]). We applied Chi-square and Mann–Whitney *U*-tests to judge the association between the study variables. Multiple logistic regression analysis was undertaken to explore the independent correlates of good near vision. A two-sided $p < 0.05$ was considered statistically significant.

Results

We screened 120 patients and 82 eligible participants consented to take part in the study. We studied a total of 82 eyes of 82 patients. Table 1 shows the key patients' characteristics. Participants' mean age was 60.43 ± 10.13 years (range: 8–78 years). We found that, 48.78% ($n = 40$) participants were females and 52.22% ($n = 42$) were male. Majority (71.95%; $n = 59$) of the eyes had in-the-bag IOL placement. The mean

uncorrected distance vision was 0.22 ± 0.17 LogMAR units. The near vision ranged from 0 to 0.8 LogMAR unit (median = 0.1, interquartile range: 0.1–0.2). Of the 82 patients, 71 had the good near vision (86.59%).

A linear inverse trend was seen between near vision and spherical equivalent. As the amount of myopia increased the near vision improved and distance vision worsened. However, this was not statistically significant ($p > 0.05$). Similarly, a linear trend was observed between age and axial length with near vision. Younger patients tended to have better near vision compared to older patients. Furthermore, patients with shorter axial lengths tended to have better near vision. On bivariate analysis [Table 2] none of the factors were found to be significantly associated with good near vision ($P > 0.05$). On multiple logistic regression analysis, [Table 3] the presence of myopia or myopic astigmatism was found to be significantly associated with good near vision (adjusted odds ratio [Adj OR]: 72.63; 95% CI: 1.02–5193.5, $P = 0.049$).

Discussion

In this study, about eight out of every ten patients had good near vision (85.37%). Existing literature suggests that there is a high degree of variability (2.1%–71%) in good near vision postmonofocal IOL implantation.[7,8,18,19] This heterogeneity could be explained by the differing definitions of "good" near vision. We considered a near vision of 0.2 LogMAR units or better as "good" near vision.[16] When the threshold for "good" near vision was reduced to less than or equal to 0.1 LogMAR units, about only half (56.1%, $n = 46$) of the participants had "good" near vision. Although perfect near vision is the aim of any refractive surgery, in reality, it might not be necessary for patients' routine needs.[20] A more pragmatic approach would be to define "good" near vision as that required for most day-to-day activities, the threshold of which is still debatable.[20]

Participants with myopia/myopic astigmatism were associated with good near vision. By making the eye myopic/myopic astigmatic, the depth of focus increases. Huber.[19] postulated that patients with uncorrected myopic astigmatism tend to have good visual acuity at far to the near range. When one meridian is emmetropic and the other myopic, the retina lies inside the Sturm's conoid of astigmatism for all viewing distances from infinity to the near point of the myopic meridian.[20] Similar results were reported by Verzella and Calossi and Datiles and Gancayco.[21,22] Several studies corrected the distance vision of the participants while assessing near vision while comparing multifocal and monofocal groups.[7,8] By doing this, the effect of myopia or astigmatism (which is known to increase the depth of focus and thus improve near vision) is lost, thereby effectively reducing the proportion of participants with good near vision among the monofocal IOL group.

One might argue against targeting myopia or myopic astigmatism during cataract surgery as it might hinder unaided distance vision and binocularity. In our patients, the presence of low myopia/myopic astigmatism (mean spherical equivalent −0.67D ± 0.44) did not impede uncorrected distance vision significantly (mean uncorrected distance visual

Table 1: Characteristics of patients who had undergone cataract surgery with monofocal intraocular lens implantation ($n = 82$)

Variable	Range	Median	IQR
Age (years)	8-78	63	57-65
Uncorrected distance visual acuity (LogMAR)	0.00-0.78	0.20	0.06-0.31
Spherical equivalent (D)	−2.00-2.25	−0.25	−0.75-0.00
Pupil size (mm)	2.80-5.90	4.00	3.40-4.53
Corneal astigmatism (D)	0.00-3.75	0.75	0.50-1.25
Total astigmatism (D)	−1.50-0.50	−0.50	−0.75-0.00
Axial length (mm)	21.27-25.7	23.03	22.50-23.50
Uncorrected near visual acuity (LogMAR)	0.00-0.80	0.10	0.10-0.20

LogMAR: Logarithm of the minimum angle of resolution, IQR: Interquartile range

Table 2: Association between patient characteristics and near vision among patients who had undergone cataract surgery with monofocal intraocular lens implantation ($n = 82$)

Variable	Near vision		*P*
	Good ($n = 71$)	Poor ($n = 11$)	
Age, median (IQR)	63 (57-65)	66 (59-68)	0.144
Pupil size, median (IQR)	4.00 (3.40-4.50)	4.20 (3.40-4.70)	0.929
Axial length*, median (IQR)	23.05±0.65	23.23±1.16	0.93
Spherical equivalent, median (IQR)	−0.25 (−0.75-0)	0.00 (−0.5-0.125)	0.287
Amount of total astigmatism, median (IQR)	−0.50 (−0.75-0.00)	−0.5 (−0.75-0)	0.538
Gender			
Female (n=40)	33 (82.5)	7 (17.5)	0.289
Male (n=42)	38 (90.5)	4 (9.5)	
Against-the-rule astigmatism			
Present (n=43)	37 (86.0)	6 (14.0)	0.880
Absent (n=39)	34 (87.2)	5 (12.8)	
Myopia/myopic astigmatism			
Present (n=50)	45 (90)	5 (10)	0.325#
Absent (n=32)	26 (81.3)	6 (18.8)	

*Mean±SD, #Fisher's exact test. SD: Standard deviation, IQR: Interquartile range

Table 3: Multiple logistic regression analysis for various factors associated with good near vision

	Adj OR	95% CI		*P*
		Lower	Upper	
Age	0.88	0.77	1.02	0.08
Gender	0.40	0.09	1.74	0.22
Pupil size	0.41	0.14	1.25	0.12
Against-the rule astigmatism	0.23	0.01	5.01	0.35
Amount of total astigmatism	16.56	0.65	418.92	0.09
Axial length	0.64	0.26	1.58	0.33
Spherical equivalent	0.71	0.16	3.21	0.65
Presence of myopia/myopic astigmatism	72.63	1.02	5193.5	0.049

CI: Confidence interval, Adj OR: Adjusted OR

acuity [UCDVA] 0.26 ± 0.18 standard deviation LogMAR units). Thus, participants with myopia/myopic astigmatism in our study had good near vision (mean 0.16 ± 0.12 LogMAR units) without hampering distance vision. This UCDVA was at par with the driving standards as per International Council of Ophthalmology guidelines of 0.3 LogMAR units.[23] Existing evidence suggests that low degrees of astigmatism in one eye neither affects patient's binocular visual function,[24] nor does it encumber the visual quality of life.[25] In fact, it has been established that near stereo-acuity increases considerably after inducing myopic astigmatism in pseudophakic patients with monofocal IOL implantation.[26] The contrast sensitivity was also not impaired (2.13 ± 0.27) in our study.

In our study, we did not find factors such as age, pupil size and axial length to be significantly associated with good near vision. According to Hayashi *et al*., with advancing age the amplitude of pseudo-accommodation decreases.[11,14] Although such a trend was observed in our study, it was not statistically significant. Pupil size is shown to be inversely related to apparent accommodation[27-29] but, we did not find a similar association in this study. Lim *et al*. reported that a pupil size less than 2.6 mm is associated with good near vision.[27] In our study, none of the participants had a pupil size smaller than 2.6 mm (mean 4.04 ± 0.75, range: 2.8–5.9 mm). Shorter eye ball (axial length < 23 mm) was shown to be associated with good near vision by Lim *et al*.[27] Although statistically not significant, we did see a similar trend in our study. Previous studies reported that corneal aberrations and multifocality are associated with good near vision.[28,30] However, we could only measure the amount of corneal astigmatism, which was not significantly associated with good near vision in our study.

Research on the topic of near vision correction with monofocal IOLs is still relevant in the era of multifocal IOLs. Although multifocal IOLs have shown time and again to be an effective method of dealing with surgical presbyopia,[1] they are associated with limitations with respect to cost, technique and patient-reported symptoms (glare, halos, reduced contrast). A survey showed that a majority of the ophthalmologists (61.3%) preferred monofocal over multifocal IOL implantation for themselves owing to the superior quality of vision associated with them.[31] Furthermore, preexisting conditions such as significant corneal astigmatism and retinal pathologies make multifocal IOL implantation unsuitable.[18] Hence, monofocal IOLs are here to stay until at least multifocal IOLs become irreproachable and cost-effective for the masses, and hence, research in this arena is imperative.

Of the various factors associated with good pseudophakic near vision, astigmatism and introduction of myopic refractive error are probably the only modifiable factors that can be targeted during cataract surgery, to suit the patient's near vision needs. A randomized clinical trial could answer this question aptly if the deliberate introduction of myopia/myopic astigmatism compared to targeting distance emmetropia could result in good near vision with monofocal IOL implantation.

Limitations

Due to cross-sectional nature of the study, associations observed might not imply causality.

We only assessed near vision without assessment of the quality of near vision which requires a validated near vision quality questionnaire which assesses the local needs. Such a questionnaire is not available in the local language (Kannada/Malayalam) in the study setting.

Due to the unavailability of corneal topography and aberrometer, we could not measure the corneal multifocality and higher-order aberrations. During near vision assessment, the eye and not the person was the unit of assessment. Hence, the presence of, and effect of monovision were not assessed.

Conclusion

We found that about eight out of every ten participants had good near vision postcataract surgery with monofocal IOL implantation. Myopia/myopic astigmatism was associated with good near vision.

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Conflicts of interest

There are no conflicts of interest.

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