·Clinical Research·

A comparison of visual outcomes in three different types of monofocal intraocular lenses

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Abstract

• AIM: To compare the visual outcomes (distance and near) in patients opting for three different types of monofocal intraocular lens (IOL) (Matrix Aurium, AcrySof single piece, and AcrySof IQ lens).

• METHODS: The present study is a cross-sectional analysis of secondary clinical data collected from 153 eyes (52 eyes in Matrix Aurium, 48 in AcrySof single piece, and 53 in AcrySof IQ group) undergoing cataract surgery (2011-2012). We compared near vision, distance vision, distance corrected near vision in these three types of lenses on day 15 (±3) post-surgery.

• RESULTS: About 69% of the eyes in the Matrix Aurium group had good uncorrected distance vision post-surgery; the proportion was 48% and 57% in the AcrySof single piece and AcrySof IQ group (P=0.09). The proportion of eyes with good distance corrected near vision were 38%, 33%, and 15% in the Matrix Aurium, AcrySof single piece, and AcrySof IQ groups respectively (P=0.02). Similarly, The proportion with good "both near and distance vision" were 38%, 33%, and 15% in the Matrix Aurium, AcrySof single piece, and AcrySof IQ groups respectively (P=0.02). It was only the Matrix Aurium group which had significantly better both "distance and near vision" compared with the AcrySof IQ group (odds ratio: 5.87, 95% confidence intervals: 1.68 to 20.56).

• CONCLUSION: Matrix Aurium monofocal lenses may be a good option for those patients who desire to have a good near as well as distance vision post-surgery.

• KEYWORDS: visual acuity; monofocal lenses; cataract surgery
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INTRODUCTION

Cataract is a major cause of preventable blindness in India. The estimated prevalence of cataract in the elderly population is high, about 53% in south India and 58% in north India [1]. Thus, with such high numbers of cataract patients, it is evident that cataract surgery with implantation of intraocular lens (IOL) is the most common surgery performed on the eye. However, this surgery has changed over time due to the introduction of new types of lenses and techniques. Indeed, surgical techniques have evolved greatly over the past few decades and currently, phacoemulsification is one of the most common procedures used for cataract surgery.

There are many different types of premium lenses such as multifocal, toric, photochromic, and aspheric IOLs. Some of these newer IOLs not only aim to provide emmetropia, but also to reduce pre-existing spherical aberration and give better contrast sensitivity, such as aspheric IOLs [2], whereas others such as toric IOLs reduce the corneal cylinder and help with astigmatism correction [3]. Furthermore, others such as photochromic IOLs reduce retinal toxicity due their property of blocking blue light and multifocal IOLs provide good distant as well as near vision[4,5]. A recent Meta-analysis concluded that multifocal IOLs do improve the near vision compared with monofocal IOLs [4]. However, one common side effect of the use multifocal IOL is the associated glare which may cause difficulty in driving at night. In addition cost of multifocal IOL is prohibitive for its routine use, particularly in our population.

The decision to select a specific IOL may depend on various factors: the type of work involved (such as near/far), surgeon's suggestion based on the clinical features, and more importantly economic factors (cost of the IOL). In our setting, particularly, the decision to choose a particular type of IOL may be primarily based on economic priorities. Thus, monofocal lenses which are often less expensive than multifocal lenses may be preferred by many patients. If, however, we are able to provide a monofocal lens that provides good near vision, it could be considered as a better alternative to multifocals particularly in patients who desire to have good near vision but choose the monofocal lens during surgery. Thus, we conducted the present study to compare the visual outcomes (distance and near) in patients undergoing cataract surgeries and opting for three different

types of monofocal IOLs (Matrix Aurium, AcrySof single piece, and AcrySof IQ lens).

SUBJECTS AND METHODS

Subjects The present study is a cross-sectional analysis of secondary clinical data collected from 153 eyes undergoing cataract surgery (2011-2012). The study was conducted at Laxmi Eye Institute (LEI), a private tertiary eye care centre situated in Panvel (about 50 km from Mumbai), India. About 100-150 patients attend the hospital daily and it has a range of specialties such as cataract, glaucoma, vitreo-retinal ophthalmology, paediatric ophthalmology, and neuro-ophthalmology; cataract surgery forms a large percentage of all the surgeries performed at LEI. The study was approved by the Ethics Committee at LEI for secondary data analysis.

Methods All patients undergoing cataract surgery with phacoemulsification and implantation with Matrix Aurium™ IOL (Medennium Inc.) [6], Alcon AcrySof ® single piece SA60AT (Alcon Laboratories Inc.)[7] and Alcon AcrySof® IQ SN60WF (Alcon Laboratories Inc.)[8] IOLs were included in the present analysis. AcrySof single piece SA60AT IOL is a clear IOL made of ultraviolet-absorbing acrylate/ methacrylate copolymer and its configuration is anterior asymmetric biconvex. AcrySof IQ SN60WF is made of ultraviolet and blue light acrylate/methacrylate copolymer and its configuration is anterior asymmetric biconvex. Matrix Aurium IOL is made of photochromic hydrophobic acrylic material and its configuration is full symmetric biconvex. The phacoemulsification procedure was done using the Alcon INFINITI ® Vision System (Alcon Laboratories Inc.) by a single surgeon. A clear corneal 2.8 mm temporal incision was used and IOL insertion was done using a standard injector. The patients were followed up for postoperative care on day one, at two weeks, and at one month following surgery. For the purposes of analyses we have used uncorrected visual acuity (UCVA), best-corrected visual acuity (BCVA), and distance corrected near visual acuity (DCNVA) on day 15 (±3). Other examinations were: anterior segment examination for corneal clarity, anterior chamber reaction, and IOL position. Patients with retinal and corneal pathologies were excluded from the current analysis.

Variables The main outcome variable was "good distance and near vision" at the final follow up visit. We defined "good near vision" as someone who had a vision of better than N/12 (statistically coded as vision from N/6 to N/12 and N/12 not being included) according to N-notation. We measured distance vision using the Snellen's chart and the visual acuity was converted to logMAR values for analysis. A logMAR value of better than 0.30 (statistically coded as logMAR from 0.0 to 0.30 and 0.30 not being included) was considered as good vision. We also measured the DCNVA and the cut-off of better than N/12 was considered as good DCNVA. Finally, we created two combined variables: 1) the first variable was a combination of both good distance and good near vision; 2) the second variable was a combination of both good distance and good DCNVA.

The main explanatory variable was the type of IOL: Matrix Aurium IOL, AcrySof single piece, or AcrySof IQ. Other variables included in the present analysis were: 1) demographic data (age and sex); 2) preoperative data (distance and near vision); 3) grade of cataract; 4) postoperative parameters (near and distance vision, and post operative spherical error).

Statistical Analysis We calculated the means and standard deviations (SDs) for continuous variables and proportions for categorical variables. We compared the proportions using the Chi-square test, the means were compared using the t-test and ANOVA, and the medians were compared using the Kruskal-Wallis equality of populations rank test. We then used logistic regression models to estimate the association between the type of IOL and the outcome; these models provided the odds ratios (ORs) and the 95% confidence intervals (CIs). The models were built in the following sequence: 1) unifactorial models with just the primary explanatory variable in the models; 2) multivariate models which included age, sex, and grade of cataract in addition to the primary explanatory variable.

RESULTS

A total of 52 eyes (from 36 patients) were included in the Matrix Aurium group, 48 eyes (from 35 patients) in the AcrySof single piece group, and 53 eyes (from 37 patients) in the AcrySof IQ group. The mean ages (SDs) in these groups were 58.9 ±10.4, 60.4 ±11.3, and 57.4 ±14.9y respectively. The proportion of females in the Matrix Aurium group was significantly higher compared with the other two groups (Table 1). Even though the preoperative distance vision was worse in the AcrySof single piece group compared with other two IOLs, the difference was not statistically significant. Additional details on the demographics and preoperative parameters are provided in Table 1.

About 69% of the eyes in the Matrix Aurium group had good uncorrected distance vision post surgery. Though the proportion was higher compared with the other two groups, the difference was not statistically significant (Figure 1). The mean (SD) logMAR values for uncorrected near vision in the Matrix Aurium group was 0.23 (0.16); the values in the AcrySof single piece and AcrySof IQ groups were 0.31 (0.26) and 0.30 (0.24) respectively. These logMAR values were significantly lower compared with the preoperative values across all the three types of lenses (Figure 2). Similarly, the proportion of eyes with good uncorrected near vision was 52% , 47% , and 34% in the Matrix Aurium, AcrySof single piece, and AcrySof IQ groups respectively. We did find that a higher proportion of eyes in the Matrix Aurium group had better DCNVA, and "good distance and

Table 1 Demographics and preoperative parameters of 153 eyes at Laxmi Eye Hospital, Panvel, India (2011-2012)[b] $\bar{x} \pm s$

Parameters	Matrix Aurium group (n=52)	AcrySof single piece group (n=48)	AcrySof IQ group (n=53)	P
Age	58.9±10.4	60.4±11.3	57.4±14.9	0.48
Sex				0.005
Male	17 (33)	31 (65)	28 (53)	
Female	35 (67)	17 (35)	25 (47)	
Eye				0.85
Right	27 (52)	25 (52)	25 (47)	
Left	25 (48)	23 (48)	28 (53)	
Preoperative vision				0.12
Distant vision logMAR	0.48±0.41	0.62±0.41	0.46±0.41	
Near vision				0.24
Good vision (<N/12)	29 (56)	27 (57)	36 (71)	
Poor vision (≥N/12)	23 (44)	20 (43)	15 (29)	
Grade of cataract				0.11
1	13 (27)	5 (11)	11 (24)	
2	19 (39)	24 (51)	23 (50)	
3	9 (18)	16 (34)	7 (15)	
4	4 (8)	2 (4)	2 (4)	
5[a]	4 (8)	0 (0)	3 (7)	

[a]The cataract is nuclear grade 0, but may have posterior capsular cataract or cortical cataract; [b]Some numbers may not add due to missing information.

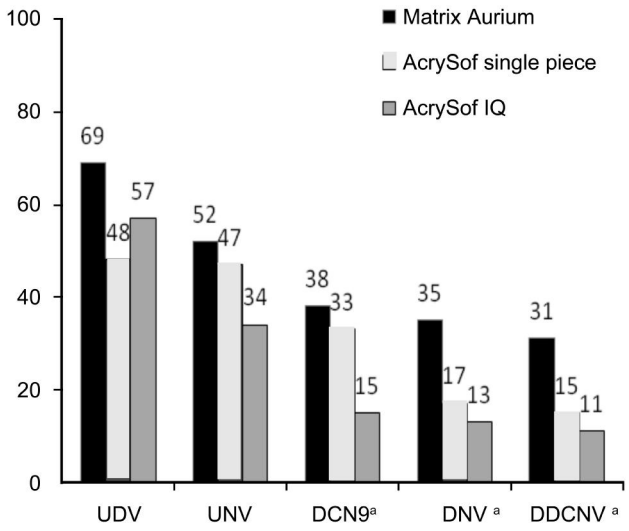

Figure 1 Good visual outcomes [at 15 (±3)d] in three different types of intraocular lens in 153 eyes, Laxmi Eye Hospital, Panvel, India (2011-2012) UDV: Uncorrected distance vision; UNV: Uncorrected near vision; DCNV: Distance corrected near vision; DNV: Distance and near vision; DDCNV: Distance and distance corrected near vision. [a]P<0.05.

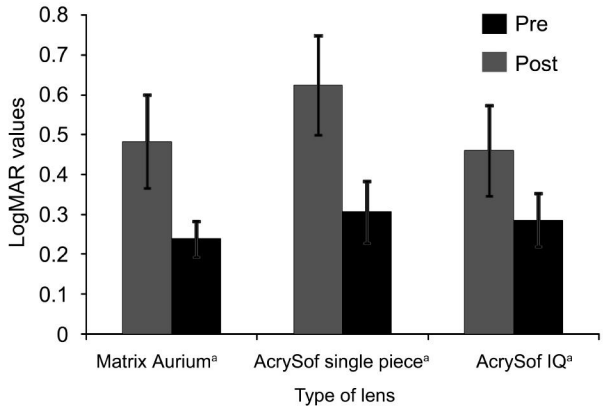

Figure 2 The mean logMAR values [pre- and post-surgery on 15 (±3)d] for uncorrected distance vision in 153 eyes according to the type of lens, Laxmi Eye Hospital, Panvel, India (2011-2012) [a]P<0.01.

near vision" compared with the other two groups (Figure 1). Even after adjusting for age, sex, and grade of cataract (in multivariate logistic models), we found that eyes in the Matrix Aurium group had a significantly better DCNVA compared with the AcrySof IQ lens [adjusted OR (aOR): 5.06, 95% CI: 1.59 to 16.08]. Similarly the AcrySof single piece group was significantly more likely to have good DCNVA compared with AcrySof IQ lens (aOR: 4.46, 95% CI: 1.37 to 14.47). However, it was only the Matrix Aurium group which had significantly better both "distance and near vision" compared with the AcrySof IQ group (aOR: 5.87, 95% CI: 1.68 to 20.56; Table 2). Furthermore, only the Matrix Aurium group had significantly better "distance vision and DCNVA" compared with the AcrySof IQ group (aOR: 6.81, 95% CI: 1.70 to 27.19; Table 2).

We found that about 96% of the spherical errors were less than or equal to zero in the Matrix Aurium group and only 4% of the errors were greater than zero. However, the proportion of individuals who had a spherical equivalent error greater than zero in the AcrySof single piece group and the AcrySof IQ group were higher at 19% and 13% respectively; this difference in proportions was statistically significant in the AcrySof single piece group. The median

Table 2 The association between the type of lens and postoperative vision in 153 eyes at Laxmi Eye Hospital, Panvel, India (2011-2012)

Parameters	Univariate analysis	Multivariate analysis[a]
Good distance vision		
Matrix Aurium	1.73 (0.77-3.84)	2.13 (0.86-5.26)
AcrySof single piece	0.71 (0.32-1.55)	0.84 (0.35-1.98)
AcrySof IQ	Reference	Reference
Good near vision		
Matrix Aurium	2.10 (0.96-4.61)	2.67 (1.10-6.49)
AcrySof single piece	1.71 (0.76-3.84)	2.24 (0.91-5.49)
AcrySof IQ	Reference	Reference
Good distance corrected near vision		
Matrix Aurium	3.52 (1.38-8.97)	5.06 (1.59-16.08)
AcrySof single piece	2.81 (1.07-7.36)	4.46 (1.37-14.47)
AcrySof IQ	Reference	Reference
Good distance and good near vision		
Matrix Aurium	3.48 (1.31-9.26)	5.87 (1.68-20.56)
AcrySof single piece	1.34 (0.45-4.05)	2.71 (0.70-10.46)
AcrySof IQ	Reference	Reference
Good distance and good distance corrected near vision		
Matrix Aurium	3.48 (1.24-9.79)	6.81 (1.70-27.19)
AcrySof single piece	1.34 (0.42-4.30)	2.96 (0.68-12.96)
AcrySof IQ	Reference	Reference

[a]Models are adjusted for age, sex, and grade of cataract.

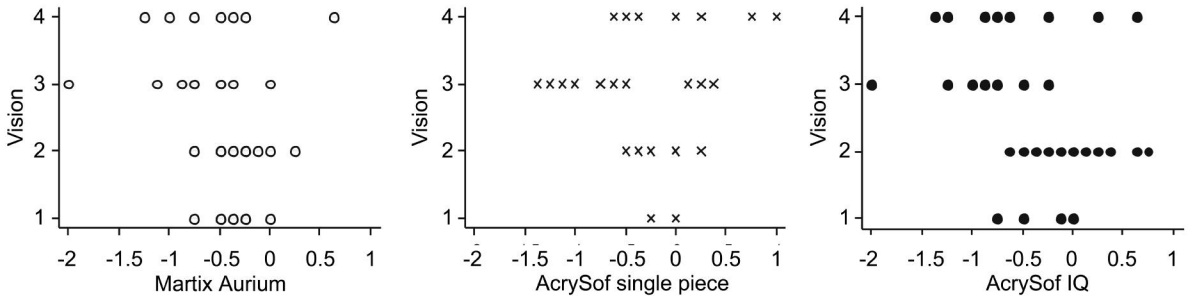

Figure 3 Postoperative visual outcomes and spherical error according to the type of lens, Laxmi Eye Institute, Panvel, India (2011–2012) Type of vision: 1, good distance and good near vision; 2, good distance and poor near vision; 3, poor distance and good near vision; 4, poor distance and poor near vision.

spherical equivalent error [interquartile range (IQR)] was -0.375 (-0.50 to -0.25) in the Matrix Aurium group, -0.25 (IQR: -0.50 to 0) in the AcrySof single lens group, and -0.375 (IQR: -0.75 to 0) in the AcrySof IQ; the difference between these three groups was not statistically significant (P=0.11). The median (range) values of spherical error in the patients who had "good distance and near" vision in the Matrix Aurium group, AcrySof single lens, and AcrySof IQ were -0.31 (-0.75 to 0), -0.25 (-0.25 to 0), and 0 (-0.75 to 0) respectively (Figure 3). We have presented the spherical errors graphically in the three types of lenses in Figure 3.

DISCUSSION

Thus, we found that patients who had used the Matrix Aurium lenses after cataract extraction reported good visual outcomes. They had a significantly better "good distance corrected near vision", "good distance and good near vision", and "good distance and good distance corrected near vision" in these three types of lenses. Furthermore, about highest proportion of the spherical errors were less than or equal to zero in the Matrix Aurium group; this proportion was relatively lower in the AcrySof single piece and AcrySof IQ group.

Previous studies have highlighted that multifocal lenses, in general, provide better near vision compared with monofocal lenses [9-11]. Indeed, Zhao *et al* [11] found that patients in whom multifocal lenses were implanted began with a better uncorrected near visual acuity in the immediate week after surgery and remained so till about six months post surgery compared with those in whom monofocal lenses were implanted; this difference was statistically significant. Though, Kamlesh *et al* [12] reported that 90% of the patients using monofocal lenses (Flex 35, Laboratoires Domilens) had

a distance corrected near vision of worse than N19, we found that about 38% of patients using Matrix Aurium lens had a distance corrected near vision of less than N/12. Thus, potentially compared with other monofocal lenses (not included in our study), the Matrix Aurium group may provide a better near vision. However, in the same study [12] the authors also found that only 10% of the patients with multifocal lens (Progress 3 aspheric, Laboratoires Domilens) had a distance corrected near vision of worser than N/9. Thus, even though, among the monofocal lenses, the Matrix Aurium group may record a higher proportion of patients with good near vision, it may not be as high as multifocal lenses.

The standard monofocal IOLs have a fixed refractive power and focal length; thus most patients require additional support for clear near vision. However, multifocal IOLs are more effective in providing better near vision compared with monofocal IOLs [4]. A particular disadvantage, however, with these lenses is disturbing visual phenomena, such as haloes, glare, and reduced contrast sensitivity. Another major prohibitive factor for the use of these lenses is the cost; they may not be afforded by a majority of the population who have cataract, particularly in low and middle income countries such as India. Several studies have shown that even with monofocal IOL, pseudophakic patients achieved good depth of focus owing to corneal multifocality [13], corneal astigmatism[14], or pupillary diameter[15]. Additionally, due to a greater depth of field, spheric IOLs appear to provide better near vision compared with aspheric IOLs. For instance, Rocha *et al* [16] found that even though mean spherical aberrations was higher in spheric (AcrySof SN60AT) IOL compared with aspheric IOL (AcrySof IQ), the former had better DCNVA. Thus, Matrix Aurium IOL, being a spheric IOL provides a significantly better distance corrected near vision than AcrySof IQ IOL, as seen in our study.

The yellow tinted IOLs or the blue light-filtering IOLs are aimed at achieving electromagnetic transmission similar to that of the natural lens; thus providing photoprotection and possibly better contrast sensitivity [17]. However, blue light is required for resetting the biological clock; a lack of this resetting may lead to psychiatric disturbances (such as diminished tolerance to stress, sleep disturbances, disharmonic psychosis and suicidal tendencies) in some predisposed patients [18-20]. Furthermore, night vision may be altered in blue light-filtering lenses and they provide a lower level of photoprotection compared with that provided by mid-aged crystalline lenses[20]. Though, there is potential for a decrease in scotopic vision, this risk has not been found to be clinically significant in few recent clinical studies [5]. The Matrix Aurium, being a photochromic IOL provides a dual advantage of blocking blue light at bright illumination, as well as allowing blue light in dim illumination which is required for resetting the biological clock and night vision. Significantly, the photochromic property is activated only in the presence of UV light - at bright illumination - when it becomes yellow in colour and blocks blue and violet light[5]. Thus, the problems of vision in dim illumination encountered with other blue light-filtering IOLs do not occur. This advantage distinguishes the photochromic Matrix Aurium IOL from the other monofocal IOLs. In a prospective study, Avalos [21] followed 10 patients for a period of two years and found the efficacy and safety of the photochromic IOLs to be similar to the nonphotochromic variety; thus, they do appear to be a good option for patients who desire a good distance and near vision after cataract surgery.

Our study was not without its limitations. Due to the secondary nature of the data, we had limited control over the variables which could be included for analysis. For instance, we did not have information on contrast sensitivity or subjective assessment of vision and patient satisfaction post surgery. These would have been useful information in the comparison between these three monofocal IOLs. Additionally, the data were collected from one private centre in Navi Mumbai; thus, the results may not be generalisable to entire population.

Nonetheless, in spite of the above limitations, the present study provides useful insight for clinical practice. We have used five different types of visual outcomes (distance, near, DCNVA and two combination visual outcomes); in all these parameters the Matrix Aurium lenses performed better compared with other two-particularly in the combination outcomes (good distance and near vision, and good distance and DCNVA). To the best of our knowledge, this is one of the first manuscripts examining the differences in the visual outcomes in these different types of monofocal lenses. In the current era, where treatment of cataract follows a "cafeteria approach", wherein patients have the choice of the type of surgery as well as the type of lens, offering Matrix Aurium monofocal lenses may be a good option for those patients who desire to have a good near as well as distance vision post-surgery, as well as those who desire good night vision (without glares). In addition to its selective blue blocking property in the presence of UV light it provides macular protection and a better depth of field; thus, has a distinct advantage over other IOLs. It has also been demonstrated that their contrast vision and visual acuity are similar in blue-light-filtering IOLs and clear IOLs [22]. Though, it has been highlighted that multifocal lenses are a cost-effective option (specially in patients who are willing to pay for spectacle independence) [23], use of these Matrix Aurium monofocal lenses may be particularly useful among those patients who are unable to afford the multifocal lenses due to economic factors.

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