Original Article

A comparative study of stereoacuity in patients with various grades of cataract and bilateral pseudophakia

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Purpose: To compare the stereopsis in patients with various grades of cataract and bilateral pseudophakia. **Methods:** A cross-sectional observational study was conducted at a tertiary care center in South India from December 2016 to September 2018, wherein the stereoacuity of patients having bilateral senile cataract or bilateral pseudophakia, was measured using the Titmus Fly chart. Those with any form of squint, glaucoma or retinal pathology were excluded. The patients were divided into three groups based on the severity of cataract, determined by the Lens Opacification Classification System (LOCS)-III. Group 4 included those with bilateral pseudophakia. Statistical analysis was performed using one-way ANOVA test with *post hoc* analysis using the Bonferroni test, to study the difference of stereoacuity between the groups. **Results:** A total of 200 patients were evaluated. The mean stereoacuity was 65.2 ± 18.2, 114.8 ± 83.42, 402.4 ± 223.7 and 107.2 ± 71.68 arc seconds in groups 1, 2, 3 and 4, respectively ($P < 0.001$). The mean best corrected visual acuity (BCVA) in LogMAR units was 0.19 ± 0.15, 0.37 ± 0.24, 0.82 ± 0.26 and 0.14 ± 0.13 in groups 1, 2, 3 and 4, respectively ($P = 0.01$). On comparison between four groups, there was a generalised decrease in BCVA and stereoacuity with increasing grades of cataract except for group 4 which included the bilateral pseudophakics. On *post hoc* analysis to analyse intergroup variation a statistically significant difference in stereo acuity was noticed when group 3 was compared to other groups. **Conclusion:** Stereoacuity decreases with increasing grades of cataract. Better stereoacuity is seen in patients with bilateral pseudophakia when compared with high grades of cataract.

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Stereopsis is the ability to perceive depth, and it occurs as a result of fusion of two slightly dissimilar images by stimulating two disparate retinal elements, within the Panum's fusional area of two eyes. It is graded according to the least horizontal disparity of retinal image that evokes depth perception and is measured in seconds of arc. The Titmus test, the TNO test, the Frisby test and the Lang stereotest are commonly used to assess stereopsis.[1] A stereoacuity of less than 50 seconds is considered normal.[2] Stereopsis is influenced by visual acuity, pupillary distance, cataract and presbyopia. It may be affected by age-related retinal ganglion cell loss[3,4] as well as pediatric refractive errors and amblyopia.[5,6] In this study, we attempted to quantify the effect of various grades of cataract and bilateral pseudophakia on stereopsis.

Methods

A cross-sectional observational study was conducted among patients who visited the ophthalmology department at a tertiary care teaching hospital in Southern India, from December 2016 to September 2018. The study was conducted as per the guidelines of the Declaration of Helsinki and the Institutional ethical committee clearance was obtained prior to initiation. The study was explained and written informed consent of the patients was obtained before their enrolment. Demographic details with relevant data which included age, gender, occupation, presenting symptoms, duration of symptoms were collected. Consecutive patients of either sex, aged above 40 years having age-related cataract and bilateral pseudophakics with BCVA ≥6/12, with normal functioning retina were included in this study. Patients with squint, glaucoma, retinal pathology were excluded from the study.

After assessing best corrected visual acuity (BCVA) using Snellen's visual acuity chart, visual acuity was converted to logarithm of minimal angle resolution (LogMAR). All were subjected to anterior segment examination by slit lamp biomicroscopy, and grading of cataract was performed using Lens Opacities Classification System-III (LOCS-III) developed by Chylack *et al*.[7] The patients were divided into three groups on the degree of severity of cataract and the fourth group comprised patients with bilateral pseudophakia having rigid monofocal Posterior Chamber Intra Ocular Lens (PCIOL)

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[Table 1]. The patients were classified into the groups based on the higher grade of nuclear opalescence. Thereafter, if any had a cortical or posterior subcapsular cataract beyond the limitations for that particular group, then such patients were excluded. A difference in the nuclear opalescence between the two eyes of a patient, which would put them in separate groups, was also taken as a criterion for exclusion. The patients who were pseudophakic were those in whom emmetropia was the postoperative target. A convenience sample of 50 patients in each group was taken. Applanation tonometry and fundus evaluation was performed in all patients. Stereopsis was measured in all patients by a single examiner using Titmus fly chart (Stereo optical company, INC) under best refractive correction by wearing Polaroid glasses at 40 cm distance. Patients were asked identify the circle which was different from the plane of other circles, in the group of four circles. In the determination of stereopsis, if the patient was unable to identify the correct circle two times consecutively then the previous result was considered as the examinee's stereopsis.

For statistical analysis, age, LogMAR visual acuities and steroacuities were used. Variables including age, BCVA are expressed in mean ± standard deviation. Statistical analysis was performed using SPSS 20.0 software (SPSS Inc., Chicago, IL, USA) and *P* values 0.05 or less was considered to indicate a significant difference. Intra group Correlation between LogMAR visual acuity and stereoacutiy was assessed using Pearson correlation coefficient. One-way analysis of variance test (ANOVA) was used for comparison of stereoacuity and LogMAR visual acuity between the groups. Post hoc analysis (multiple group comparison) was done using Bonferroni test.

Results

In our study, 54.5% were males and 45.5% were females. The details of gender, mean age and mean LogMAR BCVA is depicted in Table 1. The frequencies of logMAR BCVA and stereopsis in each group are depicted in Tables 2 and 3, respectively. A comparison of the mean LogMAR visual acuity and mean stereoacuity between the groups revealed a statistically significant difference with $P = 0.01$ and $P = 0.00$, respectively. A generalised decrease in LogMAR BCVA and stereoacuity with increasing grades of cataract was noted. In each group, on determining the correlation between the LogMAR BCVA and stereoacuity, a *r*-value of 0.71, 0.29, 0.46 and 0.37 was obtained for groups I, II, III and IV, respectively [Table 4].

On *post hoc* analysis to analyse intergroup variation a statistically significant difference in stereoacuity was noticed when group III was compared to other groups [Table 5].

Discussion

The present study shows a difference in mean stereo acuity between the participants with different grades of cataract and with bilateral pseudophakia ($P = 0.00$; Table 4). The stereoacuity was significantly worse in subjects with higher grades of cataract (group III) when compared with other groups. It also shows that stereoscopic vision improved significantly in bilateral pseudophakics [Table 5].

Manoranjan *et al*. evaluated 142 patients with age-related cataract using the Frisby test. They found an improved stereoacuity after bilateral cataract surgery with PMMA PCIOL implantation.[8] Hayashi *et al*. measured near stereoacuity 2 weeks after surgery using Titmus test in 100 patients scheduled for bilateral phacoemulsification with monofocal IOL implantation. Apart from an overall improvement in stereoacuity, they identified increasing age, a disparity of spherical equivalent between two eyes, and an increased pupil diameter as factors affecting the outcome.[9]

Sucker *et al*. measured stereoacuity 3 days after phacoemulsification with PCIOL, using Titmus and Lang tests. This study showed an improved mean stereoacuity in bilateral pseudophakics and also recorded the effect of unilateral cataract surgery with pseudophakia on stereopsis.[10]

Luo *et al*. checked near stereoacuity with distance and near correction using Randot stereotests in patients with and without IOL. They observed stereoacuity and near visual acuity with near correction was significantly improved in both groups ($P < 0.01$) and showed improved stereoacuity after bilateral intraocular implantation.[11]

Katsumi *et al*. evaluated aniseikonia and stereoacuity using New Aniseikonia test and Titmus stereotest in 78 patients. The average stereoacuity evaluated with Titmus test in 87.8% of the 41 patients with bilateral PC IOLs and 91.8% of the 37 patients with unilateral PCIOL was less than or equal to 100 seconds of arc.[12]

All the above mentioned studies showed better stereoacuity after cataract extraction, implying a reduced stereoacuity in cataract. However, the stage of cataract which was affecting the stereopsis was not discussed. Our study revealed severely reduced stereoacuity in severe grade of cataract (Mean stereoacuity 402.4 ± 223.7 arc seconds in group III) compared with mild to moderate grades of cataract (Mean stereoacuity 65.2 ± 18.2, 114.8 ± 83.42 in groups I and II). The decrease in visual acuity with increasing grades of cataract may explain reduced stereoacuity. On comparing the correlation of LogMAR visual acuity with stereopsis in each of the groups, although

Table 1: Grouping of patients, gender distribution, mean age and LogMAR visual acuity

	Group I	Group II	Group III	Group IV
Cataract status/grade*	NO1,2. NC1,2. C1,2. P1,2	NO3,4. NC3,4. C3,4. P3,4	NO5,6. NC5,6. C5. P5	Bilateral pseudophakia
Males	26	28	30	25
Females	24	22	20	25
Mean age (years)	49.52±4.15	54.58±5.38	57.46±5.21	57.32±5.71
Mean LogMAR BCVA	0.19±0.15	0.37±0.24	0.82±0.26	0.14±0.13

*As per lens opacities classification system-III: NO=Nuclear opalescence; NC=Nuclear color; C=Cortical cataract; P=Posterior subcapsular opacity; LogMAR=Logarithm of minimum angle of resolution; BCVA=Best corrected visual acuity

a moderate positive correlation was found in the group with milder grades of cataract, other groups with denser cataracts had a weaker positive correlation. Hence, factors other than visual acuity alone, may also limit the stereoacuity in denser grades of cataract.

In this study, the mean stereoacuity in bilateral PC IOLs was 107.2 ± 71.68 arc seconds, with 43 of 50 patients (86%) showing a stereoacuity less than or equal to 100 arc seconds. Although some of the studies evaluated stereoacuity with pseudophakia being either bilateral or unilateral, in our study stereoacuity was assessed only in bilateral pseudophakic patients who had rigid monofocal PMMA IOL implantation following uneventful cataract surgery.

The stereoacuity after implantation of multifocal IOLs have been discussed by various studies. Most revealed a better stereoacuity with multifocal IOL despite the possibility of blurred retinal image compared to unifocal IOLs.[13-15] In our study, stereoacuity in bilateral psuedophakics with single focal IOL was assessed, but further studies on stereoacuity in patients with bilateral/unilateral multifocal IOLs is warranted.

Acosta-Rojas *et al*. studied the patient reported visual disability and found visual acuity to be a significant factor in the presence of cataracts. However, in those with pseudophakia, stereopsis was reported to be more strongly associated with visual disability.[16] Our study shows that stereopsis is limited by the level of visual acuity [Table 4], probably because patients who had comparatively lower visual acuity tend to need relatively larger spatial frequencies to be present in the input images, else they would not be able to achieve stereopsis.[17] Bilateral pseudophakia group showed a significant improvement in near stereoacuity when compared with severe grade of cataract, but no statistically significant difference with mild and moderate grades of cataract ($P > 0.05$).

The role of astigmatism, which may occur in patients following cataract surgery, in the reduction of stereopsis has been studied by Kulkarni *et al.* Their study showed that an increase in the diopter of astigmatism, hypermetropic astigmatism, monocular astigmatism and oblique astigmatism affected the stereoacuity in significant proportions.[18] Dadeya *et al.* and Chen *et al*. have also highlighted the influence of the axis of the cylinder on stereoacuity.[19,20] Our study included bilateral pseudophakics with BCVA greater than 6/12; hence, astigmatism as a factor in affecting stereoacuity was not assessed which could be a major limitation.

Some studies have shown a mild decline in stereo acuity with the age, when people in age group of 17-83 years were tested by different stereo tests such as TNO, Titmus, Frisby near and Frisby –Davis distance stereotests. This has been attributed to the failure of fusional capacity rather than a deficiency of stereopsis at the cortical level.[21] In our study, although there was a significant difference in mean age between the groups [Table 2], no significant drop in stereopsis between groups I and II was noticed, whereas a significant drop in stereopsis was noted in group III who had a higher mean age as compared with others. The difference could also be due to higher grade of cataract.

Although this study assessed stereoacuity in different groups, it has its own limitations. As discussed above that age also has an effect on stereoacuity, considering age-matched groups would have eliminated the effect of age on stereopsis in this study. Stereoacuity assessment with other available tests including Lang's stereo test, Random dot test and Frisby plates could have helped in better documentation and understanding of stereopsis. The assessment of other aspects of visual function including contrast sensitivity, and degree of astigmatism may have been useful. The visual disability due to cataract in addition to the visual acuity, if evaluated, could have added a functional dimension to this study.

Table 2: BCVA (Log MAR) frequencies in different groups

LogMAR BCVA	Group I	Group II	Group III	Group IV
1.4			1	
1.3			5	
1.0			14	
0.7		10	20	
0.6	2	8	5	
0.4	6	6	3	
0.3	13	11	2	15
0.1	20	11		21
0.0	9	4		14

LogMAR=Logarithm of minimum angle of resolution; BCVA=Best corrected visual acuity

Table 3: Stereoacuity frequencies in different groups

Stereoacuity (arc seconds)	Group I	Group II	Group III	Group IV
800			10	
400			22	2
200		5	14	5
140			3	
100	6	13	1	18
80	13	15		13
60	16	7		12
50	6	4		
40	9	6		

Table 4: Mean stereoacuity and LogMAR visual acuity in different groups

	Group I	Group II	Group III	Group IV	*P*
LogMAR VA	0.18±0.15	0.37±0.24	0.81±0.26	0.14±0.13	0.01
Stereoacuity	65.2±18.2	114.8±83.42	402.4±223.7	107.2±71.68	0.00
"*r*" (*P*)	0.71 (0.00)	0.29 (0.030)	0.46 (0.001)	0.37 (0.008)	

VA=Visual acuity; *r*=Correlation coefficient

Table 5: Comparison of Stereoacuity between Group III and lesser grades of cataract and pseudophakia

	Mean difference	Standard error	Significance
Group III			
Group I	337.20000*	25.00211	0.000
Group II	287.60000*	25.00211	0.000
Group IV	295.20000*	25.00211	0.000

Conclusion

Stereopsis should also be considered an important aspect of visual function which decreases with the progression of cataract. The implantation of an intraocular lens may improve not only visual acuity but also stereopsis, thereby lessening the visual disability of an individual.

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Conflicts of interest

There are no conflicts of interest.

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