Changes in stereoacuity following implantable Collamer lens implantation in patients with myopia

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The study evaluated the impact of implantable Collamer lens (ICL) implantation on stereoacuity in myopes in a retrospective case series. Ninety-five eyes of 48 patients were recruited. Distance and near stereoacuity were measured using distance Randot stereotest and TNO test, respectively, before surgery and at 4 weeks postoperatively. Mean age of the patients was 23.67 ± 3.7 years. Mean uncorrected distance visual acuity (UDVA) was 1.28 ± 0.37 logarithm of the minimum angle of resolution (logMAR) (median: 1.3; range: 0.3–1.8), and median best-corrected distance visual acuity (BDVA) was 0.18 logMAR (range: 0–0.6). There was a significant improvement in both UDVA and BDVA postsurgery (P < 0.001; Wilcoxon signed rank test). The overall improvement in stereoacuity was observed in 15/48 (31.25%) and 13/48 (27.10%) subjects for near and distance, respectively, with no significant difference between the two (P = 0.82; Fisher’s exact test). Among stereoblind individuals, the odd’s ratio for near stereoacuity to improve in comparison to distance stereoacuity was 8.85 (95% confidence interval: 1.68–46.70; P = 0.01). ICL implantation for refractive correction aided stereoacuity improvement in myopes more so for near.

Key words: Implantable Collamer lens, myopia, stereoacuity, stereoblind

Stereopsis is the finest element of binocular vision which develops in an infant at around 4 months of birth.[13] It is the ability to perceive depth and objects in a three-dimensional (3D) space. Defocus, misalignment of the two eyes, or altered perception due to media opacity can lead to altered and diminished stereopsis. High refractive errors, thus, are an important cause of diminished stereopsis due to blurred vision despite best correction.[21] Various studies in literature show that stereopsis improves after keratorefractive procedures in children as well as adults.[13] Phakic intraocular lens (pIOL) surgery helps correct treatable ametropia, provides stable refraction, and better visual outcomes.[16] There is no clear evidence as to whether it helps to improve stereoacuity in myopes. Hence, this study was envisaged to assess the change in stereopsis following implantable Collamer lens (ICL) implantation in myopes.

Materials and Methods

The retrospective study adhered to the tenets of Declaration of Helsinki. The data were collected from the records of patients presenting to outpatient department for pIOL surgery for myopia. The inclusion criteria for the ICL implantation were preoperative best-corrected distance visual acuity (BDVA) of 6/24 (Snellen equivalent) or better, stable refraction for at least 1 year and a clear central cornea with myopia or myopic astigmatism. The exclusion criteria included the age younger than 18 years, anterior chamber depth <2.8 mm (as measured on Pentacam), endothelial cell density <2000 cells/mm², white to white measurement <10 mm (as measured on Orbscan II), presence of cataract, glaucoma, unlasered thinning, breaks or retinal detachment, macular degeneration or retinopathy, a past history of any episode of ocular inflammation, patients with severe dry eyes, or those corneal opacity or irregularity. Staar Visian ICL (Walker Avenue, California, USA) was implanted using the prescribed protocol by the same surgeon. Pre- and post-operative visual acuity (Snellen equivalent converted to logarithm of the minimum angle of resolution), stereoacuity, refractive error (spherical, cylindrical, and spherical equivalent), and degree of anisometropia (algebraic difference of the spherical equivalent between the two eyes) were analyzed.

Visual acuity was recorded postoperatively at day 1, day 8, and 4 weeks. Stereoacuity was tested with best-corrected visual acuity (BCVA) and was recorded at 4 weeks of follow-up. Distance Randot stereotest (Stereo Optical Co., Inc., Chicago, IL, USA) was administered while wearing polarizing glasses by trained masked optometrists at 3 m for distance stereopsis (range 400–60 arcsec). Near stereoacuity was measured using the TNO test (Lameris Instrumenten b.v., Utrecht, The Netherlands) and was administered at 40 cm using red, green anaglyphic filters.

Statistical analysis was performed using SPSS version 20 (SPSS Inc., Chicago, IL). For the purpose of analysis in the absence of actual quantitative value of stereocuity tests for gross and null stereopsis, categorization of stereopsis was done into three categories as fine stereopsis (<480 on TNO and < 400 arcsec on distance Randot stereotest), gross stereopsis (>500 arcsec on TNO and >400 arcsec on distance Randot stereotest), and null stereopsis (absence of actual quantitative value of stereoacuity tests for fine and gross stereopsis).

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arsec on TNO and 700–2000 arcsec on distance Randot), and null stereopsis (nonmeasurable stereopsis on test). McNemar’s test was applied for calculating differences in frequency between the paired nominal data of stereoacuity categories pre- and post-operatively. One eye was considered for the analysis of visual acuity. Wilcoxon signed rank test was used to calculate significance levels for the difference before and after surgery. Two sample paired t-test was applied to calculate the relationship among change in stereoacuity with change in visual acuity, spherical equivalent, and anisometropia. Differences were considered statistically significant when P value was <0.05.

**Results**

Of the 48 patients operated, 19 were males and 29 were females. All patients were operated bilaterally, except one who had unilateral myopia (total of 95 eyes). The surgery and postsurgical course were uneventful in all eyes except in one eye, which showed raised intraocular pressure postoperatively, for that augmentation of Yag iridotomy had to be performed. The mean spherical error was −9.9 ± 5.5 D (range: −1 to −19), and the mean cylindrical error was −1.11 ± 1.7 D (range: −6 to 0 D). The average spherical equivalent of the population was −10.49 ± 5.69 D (range: −2.75 to −21 D). Table 1 shows the preoperative and postoperative outcomes of the study population.

There was a significant improvement in visual acuity (both uncorrected distance visual acuity and BDVA) as compared to preoperative levels (P < 0.001; Wilcoxon signed rank test). There was a significant improvement in stereoacuity for both near (P = 0.001) and distance (P = 0.0005) (McNemar’s test).

The difference (two-sample paired t-test) was not found to be statistically significant for change in near stereoacuity with change in UCVA (P = 0.3), BCVA (P = 0.8), spherical equivalent (P = 0.8), and anisometropia (P = 0.5). The change in numbers of distance stereoacuity postoperatively did not allow a similar analysis for distance stereoacuity. Graphs depicting the change in stereoacuity for near and distance are included in Fig. 1a and b.

The overall improvement in stereoacuity was observed in 15/48 (31.25%) and 13/48 (27.10%) subjects for near and distance, respectively, with no significant difference between the two (P = 0.82; Fisher’s exact test) [Table 2]. Improvement of stereoacuity among the stereoblind subjects was observed in 10/12 (83.33%) and 13/36 (36.11%) for near and distance, respectively [Fig. 1a and b]. There was a significantly greater improvement of near stereoacuity in stereoblind subjects when compared with distance stereoacuity (P = 0.007; Fisher’s exact test). The odd’s ratio for near stereoacuity to improve in comparison to distance stereoacuity among the stereoblinds was 8.85 (95% confidence interval: 1.68–46.70; P = 0.01).

**Discussion**

In our series, the patients registered a significant improvement in both near and distance stereopsis postsurgery (P < 0.001). There are only anecdotal reports in literature describing the improvement in stereopsis following posterior chamber pIOLs implantation. However, these studies were limited by reporting outcome for change in stereopsis in a small number of patients that were treated for varied refractive errors, at differing age and with different types of pIOL. This may suggest that stereopsis is susceptible to recovery even later in adulthood if appropriate visual rehabilitation is offered. Enhanced stereocuity postsurgery could be due to the greater retinal magnification of images (11–47%) at intraocular plane versus that at the spectacle plane, corresponding to an improved BDVA of 0.4 and 1.8 lines. Other factors include the elimination of prismatic effect of spectacles, enhanced quality of vision in both eyes, correction of anisometropia, and infrequent use of glasses preoperatively.

The absence of any relationship of stereoacuity with anisometropia could be due to low degree of anisometropia in our patients (median 0.87 D) as anisometropia >3D has the potential to create blur and affect stereocuity. About 84% and 37% patients who were stereoblind for near and distance, respectively, improved following surgery. The greater probability (+8.84) of near stereoacuity to improve than distance may be because myopes have a good near vision despite having a poor distant vision.

![Table 1: Pre- and post-operative demographic data of patients undergoing ICL surgery](https://example.com/table1.png)

| Parameter studied                                      | Outcome                     |
|-------------------------------------------------------|-----------------------------|
| Refractive surgery (number of eyes)                    | 48 patients; 95 eyes        |
| Age (years)                                           |                             |
| Mean                                                  | 23.67±3.7                   |
| Range                                                 | 18-35                       |
| Gender                                                |                             |
| Male                                                  | 19                          |
| Female                                                | 29                          |
| Treatment number                                      |                             |
| Sequential bilateral                                  | 94                          |
| Unilateral                                            | 1                           |
| Preoperative visual acuity (logMAR)                   |                             |
| UDVA                                                  | 1.28±0.37 (range: 0.3-1.8)  |
| BCVA                                                  | 0.17±0.15 (range: 0-0.6)    |
| Preoperative refractive error (spherical equivalent)   |                             |
| Mean±SD                                               | −10.49±5.69 D               |
| Range                                                 | −2.75 to −21 D              |
| Preoperative anisometropia (dipters)                  |                             |
| Mean±SD                                               | 2.87 Dx±2.07 D              |
| Range                                                 | 0.8-4.94 D                  |
| Postoperative visual acuity (logMAR)                  |                             |
| UDVA                                                  | 0.12±0.18 (range: 0-1)      |
| (P<0.001)                                             |                             |
| BDVA                                                  | 0.04±0.1 (range: 0-0.6)     |
| (P<0.001)                                             | (Wilcoxon signed rank test) |
| Postoperative residual refraction (dipters)            |                             |
| Mean±SD                                               | −0.11±0.04 DS               |
| Average vault height at 1 month                       | 413.68±158.4 um             |

SD: Standard deviation, ICL: Implantable collamer lens, UDVA: Uncorrected distance visual acuity, BCVA: Best corrected visual acuity, BDVA: Best corrected distance visual acuity, logMAR: Logarithm of the minimum angle of resolution.
Some of the limitations of our study merit mention. These include a small sample size and short follow-up duration. We used stereotests with fixed disparities that could not establish a stereoscopic threshold. Further, stereoscopic disparity was measured dichoptically using two different principles, that is, polaroid vectograph-based and anaglyph-based principles for distance and near stereoacuity, respectively. It could have resulted in slight differences in accuracy while comparing the distance and near stereoacuities obtained in this study. Both the tests used global stereopsis only. Moreover, patients with low, pre- and post-operative BCVA could also have confounded the results in not producing improvement in stereoacuity. Nevertheless, this is the only study that sought the impact of ICL implantation on the change in stereoacuity in myopia. To conclude, ICL implantation aids in improving stereoacuity postoperatively. It may be utilized as a therapeutic procedure for poor stereopsis preoperatively in certain sportspersons, e.g. in athletes, shooters, car racers. Near stereoacuity may be more amenable to the treatment than distance stereoacuity.

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Conflicts of interest
There are no conflicts of interest.

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