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Title:

Stereopsis simulating small aperture corneal inlay and monovision conditions

Authors:

José J. Castro[1] (PhD), Carolina Ortiz[1] (PhD), José R. Jiménez[1] (PhD), Sonia Ortiz-Peregrina[1] (MSc), Miriam Casares-López[1] (MSc)

Institutional affiliation:

[1]Laboratory of Vision Sciences and Applications. Department of Optics. University of Granada (Spain)

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Corresponding author:

José J. Castro

Department of Optics. University of Granada. Avenida de Fuentenueva, s/n. 18071 Granada (SPAIN)

Phone number: +34 958241902

Fax number: +34958248533

E-mail address: jjcastro@ugr.es

Statement

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PRECIS

Stereopsis and other binocular visual functions studied using a simulated corneal-inlay implantation under a broad range of experimental conditions show a deterioration similar to that found in other surgical techniques.

Introduction

It is well known that presbyopia affects a very high percentage of population, and therefore there is intensive research for developing or improving techniques for its compensation. Intrastromal corneal inlay with a small aperture is a surgical technique of increasing use,[1-6] and is usually combined with a micro-monovision.

An essential aspect to be analysed in all correction techniques is the binocular vision performance[4,7-9] especially in the case of corneal inlays since the state of both eyes is clearly different and inter-ocular differences can arise and limit binocular function.[9-11] Binocular vision with implanted corneal inlays is affected by induced anisocoria since the differences between the pupil sizes can be notable and affect binocular vision, depending on the observation conditions.

Aspects of binocular vision such as binocular summation for the contrast-sensitivity function and the night-vision disturbances have been studied in operations or simulations of corneal inlays.[8,9] However, stereopsis, one of the most advanced functions of our visual system, as it enables us to distinguish spatial (3D) locations of visual objects around us, has hardly been studied for corneal inlay corrections.[3] Furthermore, one of the drawbacks most widely mentioned concerning the monovision technique, which sometimes is used together with corneal inlays, is the reduction or loss of stereoscopic capacity. For example, Artal et al. studied stereoacuity in a simulator of adaptive optics, though limited to three observers under photopic conditions and with parallel visual axes (far distance).[3]

The aim of the present work is to analyse stereoscopic vision under a broad range of experimental conditions simulating anisocoria that could arise in the surgical correction of a corneal inlay. For this, we have studied stereoacuity in a group of subjects with healthy eyes of different pupil sizes using a partially opaque contact lens. Also, we have added the effect of monovision in order to simulate a real situation for many patients operated on for corneal inlays. Under most experimental conditions, stereoacuity was measured in low-illumination surroundings where interocular-differences in pupil sizes are larger and we can expect a higher influence on stereopsis. In addition, we measured stereoacuity for a complete range of distances: far (5.5 m), intermediate (1 m) and near distances (0.4 m) to analyse the deterioration or not of stereopsis as a function of distance, especially for distances shorter than 1.5 m, where stereopsis is decisive. These types of simulation experiments are crucial because we can analyse the potential effect of some surgical techniques under certain conditions, avoiding the surgical effects. Although our main aim is to evaluate stereopsis, we also measured other binocular functions in order to compare the results and to make a more complete analysis of binocular vision. We measured the binocular summation for binocular contrast sensitivity and for a discrimination index as a measure of night-vision disturbances. Halos and/or glare under low-illumination conditions are usually mentioned after surgical techniques.[12,13]

Methods

Subjects

A total of 10 subjects were studied, with ages ranging from 20 to 25 years (22.7±1.8 years). Subjects gave their informed consent in accordance with the Helsinki Declaration. Admission criteria for the experiment were: astigmatism not greater than ±1.0 D, monocular corrected distance visual acuity of 20/20 or better, and no pathological disease or condition that could limit visual performance. Distance visual acuity was measured monocularly and binocularly for all subjects at a working distance of 5.5 m with the Pola VistaVision® Visual Acuity Chart

System (DMD Med Tech srl. Torino, Italy). All participants received a full refractive examination and objective refraction in which the refractive error was determined by non-cyclopegic retinoscopy. Monocular and binocular subjective refraction was also performed. The distance best-corrected visual acuity (DCVA) after trial frame refraction was measured. The mean refractive error (spherical equivalent) was -0.49±0.71 D. All the observers had normal stereopsis according to the Randot stereotest (40 arcsec or lower).

Contact lenses

The effect of anisocoria generated by corneal inlays was simulated by using a partial-opaque soft contact lens (pHema 38% water content), supplied by Servilens Fit & Cover (Granada, Spain) with a clear, circular, central aperture 1.6 mm in diameter. Theses lenses had two base curve radii (8.4 and 8.6 mm) and a 14.5-mm lens diameter. The outer diameter of the opaque region was 11.0 mm. For an acceptable fit, the contact lens had to be well centred both vertically and horizontally and moved from 0.5 to 1 mm on a blink. The lenses were worn for at least 20 min before any measurement. The lenses were fitted on the non-dominant eye (NDE) to create the required anisocoria. Ocular dominance of all subjects was checked with the Miles test.[14] After biomicroscopic examination, no signs of corneal oedema or corneal staining were detected either at the baseline of the study or at the end.

Procedures

After several training sessions, all participants completed the following visual tests: visual acuity, contrast-sensitivity function, and visual-discrimination capacity (monocular and binocularly) and stereoacuity (binocularly) under natural conditions (without small-aperture contact lens).

To study the effect on binocular visual performance after inducing a simple anisocoria or combined with monovision, we also took measurements while observers wore the contact lens in the non-dominant eye (NDE). The measurements were performed binocularly and monocularly in the eye wearing the contact lens under the following conditions: a) no add power; b) with an add power of +0.75 D, a value considered as optimum defocus in a corneal inlay modelling,[3,15] and c) with an add power of +1.25 D, a value used in traditional monovision.[16] The additions were inserted in a trial frame for each subject, as shown in other works[9], and then the interpupillary distance was adjusted. These measurements were completed on different days to avoid observer fatigue. All the tests were performed at three test-distances: 40 cm (near), 1 m (intermediate) and 5.5 m (far). For the CSF and the visual discrimination capacity, the observer position was fixed at the test distance using a chin and a forehead rest to minimize head movements. No mydriatics or cyclopegics were used.

Visual Acuity

Monocular and binocular corrected distance visual acuity (CDVA) were measured using the Pola VistaVision® Visual Acuity Chart at 5.5 m. Monocular and binocular distance-corrected intermediate visual acuity (DCIVA) were measured with the Colenbrander Visual Acuity Chart NO4002 (Colenbrander, M.D., San Francisco, C.A.) at 1 m. Monocular and binocular distance-corrected near visual acuity (DCNVA) were measured with the Near Vision Chart (Promoción Optométrica, Burgos, Spain) at 40 cm.

Contrast-sensitivity function (CSF)

Contrast sensitivity (CS) was evaluated using Gabor patches of gratings displayed on the monitor of the tablet ASUS Transformer Book T100TAF (10.1 inches). Contrast values were reported according to the Michelson contrast. The spatial frequencies tested were: 0.75, 1.5, 3.0, 6.0, 12.0, and 18.0 cycles per degree (cpd), using Gabor patches of gratings with three possible orientations (vertical, left or right). The average luminance level of the monitor was 62.7 cd/m^2 and the test was performed in dim surroundings. The test method used was an alternate forced choice, in which, for each stimulus, the patient had to choose the grating orientation, displayed in a random order. For each spatial frequency, we determined the contrast threshold using an up-down staircase procedure with four reversals. The contrast threshold was calculated by averaging the last three reversals. The grating subtended 1.3 deg for the three test distances (the CSF test was previously set for each distance).

Night-vision disturbances

The visual-discrimination capacity under low-illumination surrounding conditions was also evaluated using the test Halo, based on the freeware software Halo v1.0. This test has been successfully applied in basic and clinical research to quantify night-vision disturbances[17-19] In the test, the subject was shown a central high-luminance stimulus over a dark background on the monitor and, progressively, peripheral luminous stimuli were randomly shown around the central stimulus at different positions and distances from the main stimulus. We used the tablet ASUS Transformer Book T100TAF to run the Halo test. We measured the luminance of the visual stimuli using the spectroradiometer SpectraScanPR-670: 264cd/m^2, 37cd/m^2, and 0.21cd/m^2 were the luminance of the main stimulus, the peripheral ones, and the monitor background, respectively. The spatial configuration was set for each test distance in such a way that the central stimulus and the peripheral ones subtended 0.46 and 0.04 deg, respectively, from the subject position.

The patient's task was to press the left button of the mouse whenever a peripheral stimulus could be discriminated. Once the test was finished, the software calculated the visual-disturbance index (VDI), a parameter widely studied in the literature.[17-20] The VDI ranges from 0 to 1, in such as a way that the higher the VDI, the lower the amount of peripheral stimuli discriminated, and, therefore, the worse the discrimination capacity (a greater influence of halos or night-vision disturbances).

Stereoacuity

For test distances of 1 and 5.5 m, we used the polarized stereotest implemented in the VistaVision® monitor. The stereotest evaluated stereopsis from 300 to 10 arc sec using polarized vertical lines. For each stereoacuity, a total of 5 vertical lines were displayed simultaneously on the monitor, one of them with disparity to be perceived stereoscopically. In this test, the observer wore polarized glasses provided by the monitor manufacturer, and the task was to choose the line that was stereoscopically perceived.

For near vision (40 cm), we used the Random Dot stereo acuity test (Vision Assessment Corporation, IL) which evaluates stereoacuity from 500 to 12.5 arc sec.

Binocular summation

To compare binocular with monocular data in the CS as well as in the visual-discrimination capacity (VDI), we calculated binocular summation, a common metric used to characterize binocular visual performance.[21-22] Under normal binocular-vision conditions, the binocular summation of a visual function is a value higher than 1.0.

We reported binocular summation for the CS dividing the binocular CSF by the best monocular CSF. For each observer, binocular summation was provided as the average of the binocular summation determined for each spatial frequency.[21-22]

The binocular summation for the VDI was calculated dividing the lowest monocular VDI by the binocular VDI since as the discrimination capacity increases, the VDI decreases.[9]

Considering the binocular functions tested, the average pupil size for the eye with natural pupil, measured with a Colvard pupillometer (OASIS, Glendora, CA, USA), ranged from 4.10±0.74 mm for the CSF and a distance of 40 cm to 5.55±1.01 mm for the halometer and a distance of 1 m.

Results

Figure 1 and Table 1 show the results for stereoacuity. We find the results for the four conditions tested (natural pupil, small-aperture contact lens, small-aperture contact lens with monovision +0.75D and small-aperture contact lens with monovision +1.25D) in each of the three distances used: far, intermediate, and near. According to the repeated-measures analysis of variance (ANOVA) we found significant differences ($p<0.05$) in the group of near and intermediate distances. A *post hoc* comparison analysis, for the near and intermediate distance, indicated that the natural pupil condition differed significantly ($p<0.05$) with respect to the other three conditions, with stereoacuity being better for the natural pupil condition. For near and intermediate distance, no significant differences ($p>0.05$) appeared between the three conditions when the small-aperture contact lens was used. For the far distance, we found no statistical difference in all *post hoc* comparisons except in the case natural pupil vs. small-aperture contact-lens monovision +1.25 D.

Figure 2 shows the results for binocular visual acuity. According to the ANOVA analysis, we found no significant differences ($p>0.05$) for any of the conditions tested in the three distances considered. A *post hoc* comparison analysis did not indicate any significant difference, either.

Figures 3 and 4 show the results for the binocular CSF and the binocular summation for the CSF. For the binocular CSF, according to the ANOVA analysis, we found statistical differences ($p<0.05$) for the three distances tested: near, intermediate, and far distance. For the near and intermediate distances, we analysed *post hoc* comparisons and the natural pupil condition was significantly better than the no-add and add +1.25D conditions. *Post hoc* comparisons analysis for the far distance showed that the natural pupil condition was significantly higher than the other three conditions. For the binocular summation (Fig. 4), the ANOVA analysis gave significant differences for the intermediate and far distance ($p<0.05$). For intermediate distance, *post hoc* comparisons analyses showed statistical differences between the natural pupil and the no-add condition. For far distance, we found statistical differences between the natural pupil conditions and the other three conditions, with higher binocular summation being found for the natural pupil condition.

Figures 5 and 6 show the results for the visual disturbance index (VDI): binocular VDI (Fig. 5) and binocular summation (Fig. 6). The ANOVA revealed statistical differences ($p<0.05$) among conditions in the binocular VDI for the far distance and in the binocular summation for the VDI for the three distances. From the *post hoc* comparison analysis, we found that the binocular VDI was significantly lower for the natural pupil condition with respect to the other 3 conditions in the case of far distance, showing that visual-discrimination capacity is better for the natural pupil conditions. In the case of binocular summation for the VDI the *post hoc* comparisons analysis showed that binocular summation was significantly higher ($p<0.05$) for the natural pupil condition than for the adds +0.75D and +1.25D conditions, for near, intermediate, and far distances.

Discussion

The results for stereoacuity show that, although stereoscopic perception occurs for all conditions tested, there was a deterioration in stereopsis for all small-aperture contact-lens conditions with respect to natural pupil being significant mainly for near and intermediate distance. It should be taken into account that the comparison was established under experimental conditions unfavourable to stereoscopic vision. In our experiments the illumination of the setting implies a larger pupil size for the eye with the natural pupil, and induced anisocoria causes large interocular differences[9-11] that limit stereoscopic vision. Under conditions where the anisocoria would be more reduced, the stereoscopic deterioration would be less.

In the study by Fernández et al.,[3] where stereoacuity was tested for only 3 subjects with parallel axes (far-vision scheme) and photopic vision, the authors found that the stereoacuity with the natural pupil did not significantly differ with respect to the conditions of small-aperture and monovision. In the study by Linn et al.,[23] the mean stereoacuity preoperatively and postoperatively measured was not statistically significant, either, although 25% of patients had worsened stereoacuity. In our study, there were significant differences between the condition of the natural pupil and those of small-aperture contact lens with monovision for near, intermediate, and far distance. The experimental differences between the studies may explain the different results.

It is also important to point out that the deterioration in stereopsis found in the optical simulation of the corneal inlays also has been found in other surgical techniques for correcting presbyopia[24,25] and myopia[11] in which, although post-surgical stereopsis is maintained, a significant deterioration can be appreciated.

Although stereopsis is the most advanced function of the binocular visual system and its analysis is key in order to assess the suitability of an emmetropization technique, it is necessary to compare the results with those from studying more binocular functions. Binocular visual acuity is usually one of the most important variables when evaluating visual performance and is widespread in clinical and optometric practice. Our results demonstrate that binocular visual acuity under the conditions that use small-aperture contact lenses is comparable to that of the natural eye. Other clinical studies have indicated that uncorrected near visual acuity with small-aperture inlays is improved without affecting uncorrected distance visual acuity.[26]

Concerning CSF, the deterioration found in our results agree with previous results[8,9] that reported a reduction in the CSF and binocular summation. Lin et al.[8] found a minor reduction in the binocular case and claimed that this reduction was similar to other surgical presbyopia correction procedures. Other surgical procedures to correct ametropia[27] also showed a post-surgical deterioration in the CSF and binocular summation.

As indicated in the Introduction,[12,13] night-vision disturbances often appear after surgical procedures. One way of quantifying these is the VDI used here. We found a significant deterioration for binocular VDI (far) and VDI-binocular summation (near, intermediate, and far). Our results agree with previous ones[9] on inlay simulations for the intermediate distance and for other surgical emmetropization techniques that result in a post-surgical increase in the night-vision disturbances.[27]

The extensive experimental analysis undertaken in this study on binocular functions for different distances and under conditions of large anisocoria allow us to generalize that there is a binocular deterioration, including stereopsis, with respect to the conditions of the natural pupil when we simulate the use of a small-aperture corneal inlay with and without monovision. Although it should be taken into account that no binocular function was found that deteriorated in a generalized way for all the distances tested, depending on the visual function analysed, in some cases the significant deterioration corresponds to one distance and in other cases to another. As indicated above, this deterioration is similar to that reported in other studies using different surgical emmetropization techniques and presbyopia corrections.[8,9,27] It should be pointed out that the experiment conducted here simulated the optical conditions of the technique of emmetropization with and without monovision and that the surgical variables are expected to influence binocular performance. Most experimental conditions in this work were performed under illumination conditions that generate high anisocoria. Under other illumination conditions, the interocular differences in pupil size could be reduced and therefore, better visual performance could be expected. On the other hand, a corneal inlay has an outer diameter of 3.8 mm and in our simulation the opaque region of the contact lens has a diameter of 11.0 mm. Under low-illumination conditions, a presbyopic patient implanted with a corneal inlay would in most cases reach a pupil size of greater than 3.8 mm. In this situation, light passes through the small aperture but also through the peripheral portion of the cornea, resulting in an opaque annulus in front of the pupil, thereby deteriorating visual performance. In addition, mesopic and scotopic pupils of the young participants could be larger compared with presbyopic patients, although, in near vision, myosis due to the accommodation in young eyes could partially compensate for this. In our work, we found pupil sizes under mesopic conditions similar to those reported by Tomita et al.[28] after KAMRA inlay implantation, in which the influence of pupil size on visual acuity was evaluated. These authors found no significant differences in UNVA (uncorrected near visual acuity) or in CNVA (corrected near visual acuity) under mesopic lighting conditions between the small (< 6 mm) and large (> 6 mm) pupil groups. The range of pupil sizes evaluated in the work of Tomita et al. was 6.00 to 8.32 mm. On average, these pupil sizes are larger compared with the range analysed in our study (from 3.00 to 7.00 mm). Other authors have studied the effect of pupil size on visual performance in a large group of patients implanted with a small-aperture corneal inlay.[29,30] The results showed no impact on visual acuity and visual symptoms in photopic pupil sizes and minimal influence in mesopic pupils. Regarding larger pupils under scotopic conditions, subjects implanted with a small-aperture corneal inlay showed slightly worse visual performance, although not statistically or clinically significant. These findings support the contention that the effect on visual performance of a pupil size higher than the corneal-inlay would be negligible compared with the eye wearing the small-aperture contact lens used here and the same pupil size. Apart from differences associated with the dimensions of the opaque annulus, the optical effects of the contact lens would be expected to be similar to those of the corneal inlay, since the stromal depth of the flap/pocket in which the inlay is placed measures only 0.20 mm.[31] Another factor to consider in the use of the small-aperture contact lens is the movement of the lens after a blink, which decentres the contact lens, worsening visual performance. In this sense, the task of discriminating or detecting visual stimulus in the tests of the present study were much longer in time than the re-centring of the contact lens after a blink, allowing the patient to perform the visual tests in an effective way, without the influence of the contact-lens movement. However, apart from the re-centring, the contact lens centration after fitting cannot be completely guaranteed compared with an intrastromal corneal inlay which has been surgically aligned.

An aspect to be highlighted in the present study is that the participants were young patients, whereas patients implanted with a small-aperture corneal inlay are pre-presbyopic or presbyopic. Higher interocular differences would be expected in presbyopic patients for near distance (0.4 m), due to smaller pupil sizes and reduced accommodation, deteriorating visual performance. Tomita and Waring analysed the influence of age on visual outcomes of emmetropized patients implanted with corneal-inlays,[5] for ages ranging from 40 to 65 years, finding on average the same UDVA (uncorrected distance visual acuity) of 20/20 for the different age groups studied, and a mean UNVA of 20/30 or 20/40, with no significant differences, although younger patients generally had better UDVA and UNVA. Regarding the CDVA (corrected distance visual acuity) and the CNVA, no significant differences were found between age groups. Nor were there significant differences in subjective symptoms between the age groups. Patients from the youngest age group of that study were able to accommodate to some degree and older patients had reduced accommodative amplitudes, as opposed to young participants of our study, who had a full accommodative amplitude. In this sense, we expected slight differences in our results in stereopsis, halo perception or CSF (more deteriorated) both in normal anisocoria as well as anisocoria combined with monovision when patients had been pre-presbyopic or presbyopic. However, it should also be considered that most of the visual tests were performed under the most unfavourable lighting conditions, i.e. in a dim ambience, in order to reach the highest interocular differences and check visual functions under these conditions, and therefore under normal conditions, such as those in daily visual tasks, better results would be expected for visual performance.

With respect to monovision, we have checked three different conditions in participants wearing the small-aperture contact lenses: a) no add power; b) an add power of +0.75 D, and an add power of +1.25 D. These add-power values are clinically informative to analyse since the add power of +0.75D causes a defocus that is considered optimum.[3] Furthermore, using optical modelling of a corneal inlay in real eyes, some authors have demonstrated that the best residual defocus is within the range of -0.75 to -1.00D,[15] as opposed to traditional monovision, from -1.00 to -2.00D, with optimum results for -1.25 and -1.50D.[32] In our work the optimum add power was +0.75D, as this gave us the best results of visual function for near and intermediate distances, in agreement with other findings.[3,9] Whether traditional or micro-monovision, the final add power depends not only on achieving the best optical quality or visual function, but also on the need according to the patient’s lifestyle or occupation. Thus it bears analysing the visual function for two different values of add power combined with the small-aperture contact lens, as previously done.[9] It would also have been informative to study the stereopsis of the participants under traditional monovision conditions (without contact lens, and with an add power of +1.25 or +1.50D), but because of the time required for each test, we focused the present work on analysing stereoscopic vision under a broad range of experimental conditions simulating anisocoria. Although patients implanted with a corneal inlay show continuous functional vision over a range of 3.5D,[33] we should mention the limitation of our patients, that is, that they were younger and had a full accommodative amplitude compared with presbyopes.

Our results could have been worse if the participants had been presbyopes, and the effect of the monovision could have been different in the two types of patients for the near distance. However, Tomita and Waring[5] found no significant differences in visual function between different age groups, one of which was formed by pre-presbyopic patients who had some accommodative amplitude, comparable, in some cases to the young participants of our study. An option to minimize the effect of accommodation had been to use cycloplegic, but we performed the visual tests under natural pupil conditions, with no dilation, in order to avoid the shift of the pupil centre, which affects ocular parameters, such as aberrations.[34] Furthermore, repercussions not only in ocular parameters but also in visual function have been reported in decentred small pupils,[35] and thus the use of cycloplegic could deteriorate visual function and optical quality, especially in the eye wearing the small-aperture contact lens.

Therefore, our simulation using small-aperture contact lenses, based on the same optical principle as the small-aperture corneal inlay (to increase the depth-of-focus by a pin-hole) is quite acceptable to analyse stereoscopic vision under a broad range of experimental conditions simulating anisocoria, although, given the potential limitations of this work, such as the decentration of the contact lens with respect to a surgically aligned corneal inlay, additional studies of small-aperture corneal-inlay simulations should been undertaken with presbyopic patients, older than those studied here and simulating more realistic conditions of the corneal inlay (a contact lens like the one used in this work but with an outer diameter of close to 3.8 mm and taking into consideration the effect of contact-lens decentration on visual functions). Additionally, new conditions should also be taken into account as well as new designs of corneal inlay, such as diffractive corneal inlays[36] so as to broaden and complement existing studies on the visual performance in patients with corneal inlays.

We conclude that after a complete binocular analysis, including stereopsis (stereoacuity), contrast-sensitivity, visual acuity, and visual disturbance index at three different distances: near, intermediate, and far, we have shown that optical simulations of small corneal-inlay aperture (with and without monovision) show a deterioration of the binocular visual performance, although this deterioration can be acceptable for patients subjected to this surgical technique since the binocular deterioration found was similar to other surgical procedures of emmetropization.

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Tables

Table 1. Average stereoacuity (arcsec) for the distances and conditions tested. *Significantly different from the other three conditions ($p<0.05$); §significantly different from small-aperture contact-lens monovision +1.25D ($p<0.05$).

Distance (m)	**Natural pupil**	**Natural pupil DE/1.6-mm small-aperture contact lens NDE**		
		No Add	**Add +0.75D**	**Add +1.25D**
0.4	22.55 ± 9.24*	48.90 ± 25.37	38.40 ± 13.00	34.40 ± 13.26
1.0	58.00 ± 23.94*	152.00 ± 124.44	152.00 ± 110.84	168.00 ± 112.43
5.5	46.00 ± 30.62§	65.00 ± 32.40	72.00 ± 35.21	101.00 ± 69.35

Figures

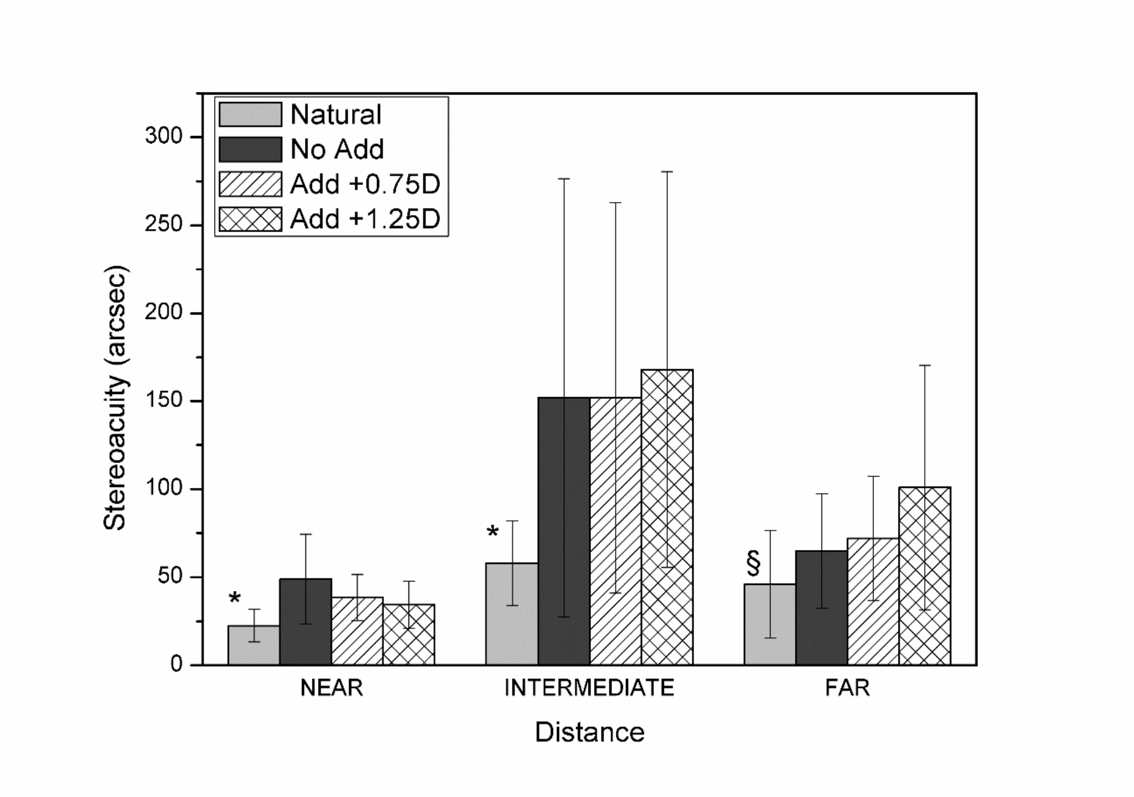

Figure 1. Average stereoacuity (arcsec) for natural conditions and wearing the small-aperture contact lens in the NDE (with no add power and with add powers of +0.75 and +1.25D). The results are shown for the three distance conditions tested: near (0.4 m), intermediate (1.0 m), and far (5.5 m) vision. *Significantly different from other three conditions ($p<0.05$); §significantly different from small-aperture contact-lens monovision +1.25D ($p<0.05$).

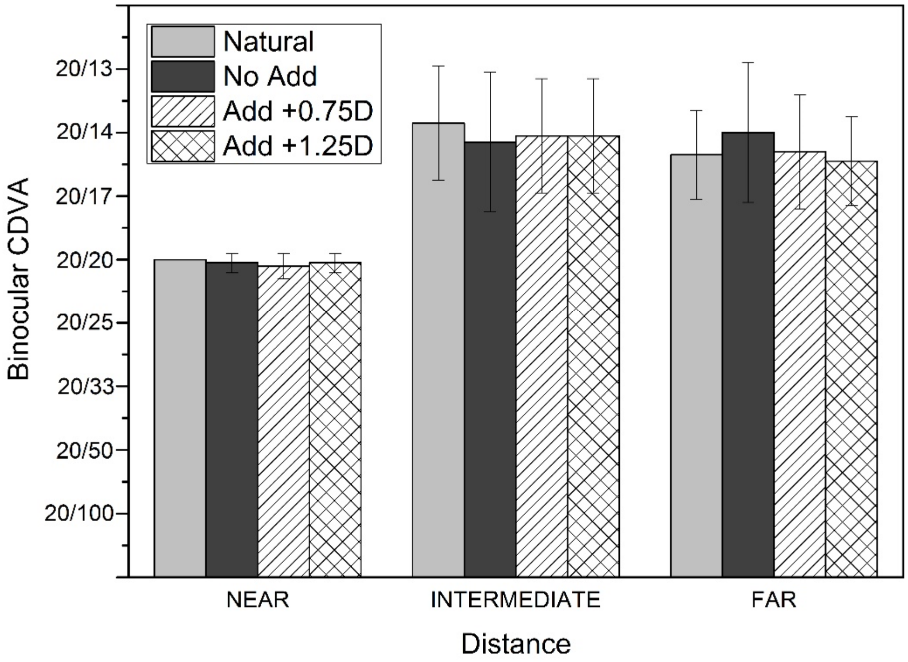

Figure 2. Average binocular CDVA for the distances and conditions tested. No significant differences for any of the conditions at the three distances (near, intermediate, far).

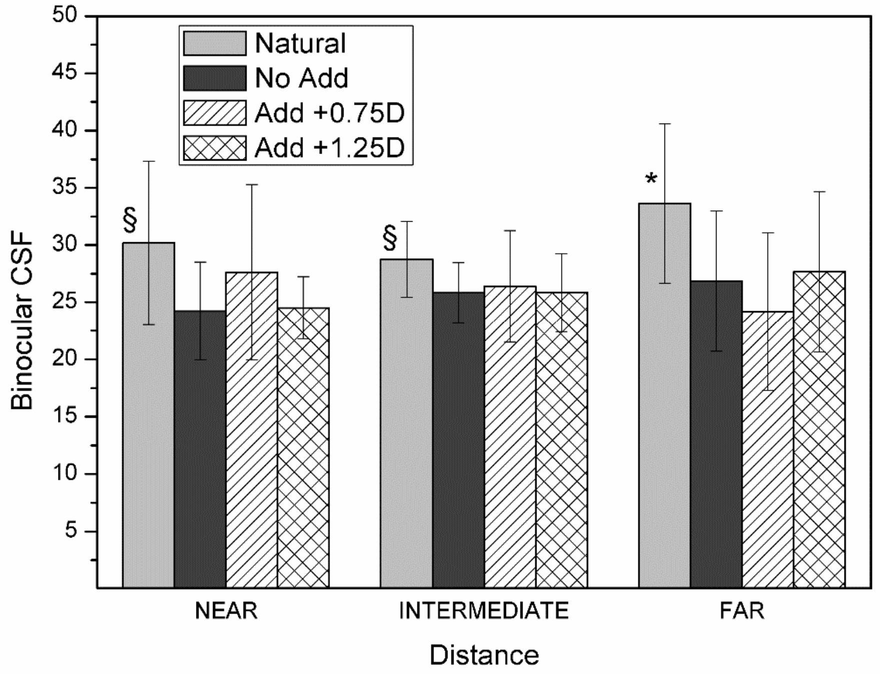

Figure 3. Average binocular CSF for all the conditions and distances tested. *Significantly different from other three conditions ($p<0.05$); §significantly different from no add and monovision +1.25D conditions ($p<0.05$).

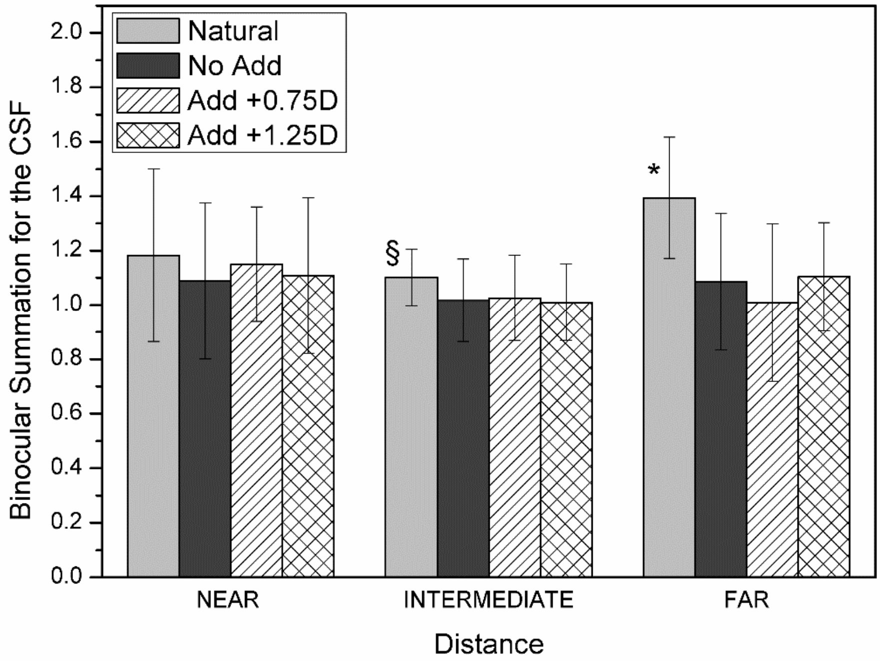

Figure 4. Average binocular summation for the CSF under all the conditions and distances tested. *Significantly different from other three conditions ($p<0.05$); §significantly different from no add condition ($p<0.05$).

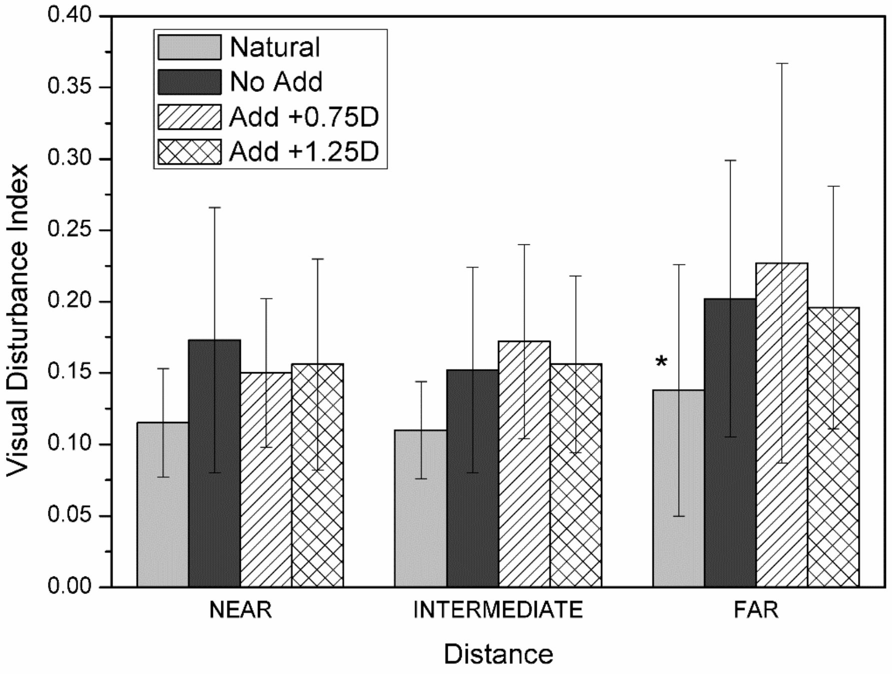

Figure 5. Average binocular visual disturbance index for all the conditions and distances tested.

*Significantly different from other three conditions ($p<0.05$).

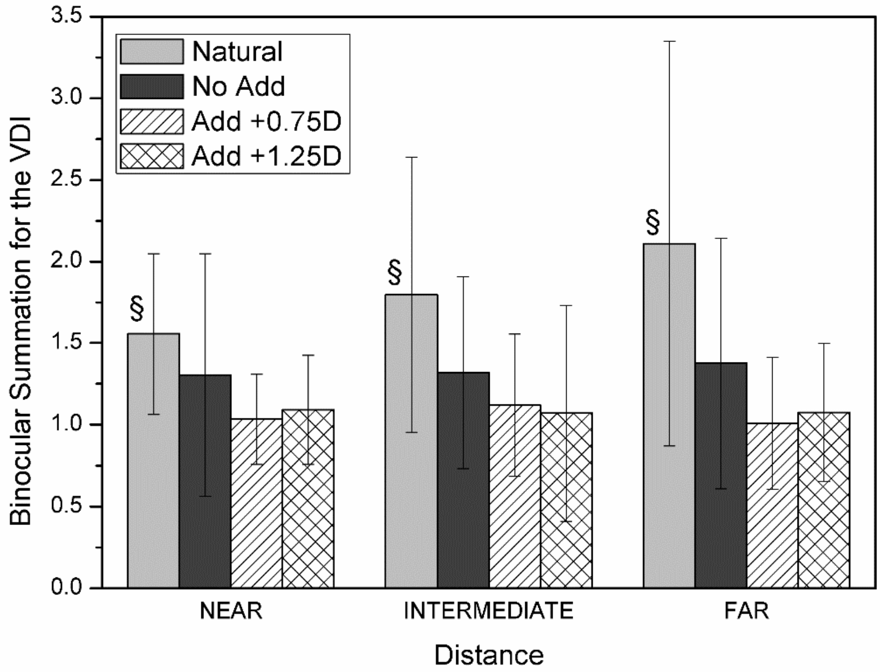

Figure 6. Average binocular summation for the visual disturbance index under all the conditions and distances tested. §Significantly different from small-aperture contact lens monovision +0.75D and +1.25D conditions ($p<0.05$).