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Influence of laser correction of presbyopia using the Presbyond® Laser Blended Vision (LBV) method on the stereopsis

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HIGHLIGHTS

The studies published so far have shown that the use of the Presbyond® LBV method in the correction of all refractive errors and presbyopia allows for maintaining functional postoperative stereoscopy, achieving patient satisfaction and independence from glasses.

ABSTRACT

Presbyond® Laser Blended Vision (LBV) method involves the non-linear aspheric ablation of the cornea with controlled induction of spherical aberrations in both eyes and the induction of micro-monovision of -0.75 to -1.50 D in the non-dominant eye. The article presents the results of published studies analyzing the effect of laser correction of presbyopia using the Presbyond® LBV method on the stereopsis. The studies published so far indicate that the Presbyond® LBV treatment allows for maintaining functional postoperative stereoscopy, achieving patient satisfaction and independence from glasses.

Key words: presbyopia, keratomileusis laser in situ, monovision, stereopsis

PRESBYOND® LASER BLENDED VISION METHOD

The most commonly performed laser refractive procedure to correct presbyopia is the Presbyond® Laser Blended Vision (LBV) method. The method, based on the Femto--LASIK procedure, involves nonlinear aspheric corneal ablation and the induction of a controlled, below-toxic threshold, amount of spherical aberration (SA) in both eyes, and the production of -0.75 to -1.50 D micromotion in the non-dominant (ND) eye. The characteristics of the Presbyond® LBV method and its impact on the sense of contrast were described by the authors in a previous issue [1]. Previously published work has confirmed the high efficacy of the Presbyond® LBV procedure in the correction of presbyopia in both non-dystopian and normal-sighted eyes [2–4]. The Presbyond® LBV procedure has been shown not to reduce contrast sensitivity [1]. The safety profile of this method also distinguishes it from other corneal refractive methods. A study of PresbyMAX multifocal ablation with the creation of a zone for nearsightedness in the center of the cornea confirmed a postoperative reduction in corrected distance visual acuity (CDVA) by 2 lines on the Snellen chart in 13% of patients. It has been shown that inducing corneal multifocality based on the PresbyMAX or Peripheral PresbyLASIK algorithm can lead to increased levels of higher order aberrations (HOAs) and worsened contrast sensitivity [5, 6].

Surgically induced anisometropia can be associated with vision suppression, fusion disorders and loss of stereopsis. Significant deterioration of spatial vision to near and intermediate distances has been shown in some patients after implantation of Kamra® corneal rings due to induced anisocoria following the so-called pinhole effect [7]. Other researchers have confirmed irreversible loss of stereopsis in some presbyopic patients after inducing traditional monovision with LASIK [8, 9]. This disorder may be related to the monocular suppression of the retinal fovea in permanent monofixation syndrome and the formation of an uncorrectable central scotoma [10].

The advantage of the Presbyond® LBV method over traditional monovision is the use of an individualized ablation profile, taking into account the type and size of the refractive defect being corrected, the extent of tolerable monovision, the patient's age and preoperative SA level, with no loss of visual acuity at intermediate distances (blend zone) and no disruption of retinal correspondence [11]. Preoperative exclusion of eye alignment and binocular vision disorders that can decompensate after surgery and cause asthenopic symptoms are critical to the efficacy and safety of any refractive procedure. The purpose of this study is to analyze the effect of Presbyond® LBV treatment on stereopsis.

A STUDY OF SPATIAL VISION

Stereopsis is the third and highest degree of binocular vision, after simultaneous perception and fusion. It is the most perfect function of the visual system that enables depth perception and correct distance assessment based on the difference of retinal images. Spatial vision disorders are associated with poorer visual functioning in daily life and reduced quality of life: frequent headaches, concentration problems, rapid fatigue when reading or working at the computer, difficulty or reluctance to perform various close--up activities, lethargy, and finally, problems with judging distances increasing the risk of tripping and injury [12].

A quantitative study of stereopsis expresses the its value in seconds of arc (arc/sec) – the shorter the distance, the greater the strength of stereopsis. There is a distinction between weakly dissociative tests (usually with polarization filters – Stereo Fly Test, Random Dot E, Randot Stereoacuity Test) and strongly dissociative tests (with red-green filters – TNO test, or without filters – Lang test). The most popular test of spatial vision for nearsightedness is the Stereo Fly Test, which consists of 3 parts: a fly test plate (3000 arc/sec test for screening), symbols or animals (ranging from 400 arc/sec to 100 arc/sec) and circles. The test with circles contains 9 fields (ranging from 800 arc/sec to 40 arc/sec), each with 4 circles, one of which can be seen spatially. The difficulty of the test increases in subsequent fields. The value of the angle of stereoscopic resolving ability should be considered the value of the last set of circles for which the examined person provided the correct answer. Examination of spatial vision for nearsightedness is performed from a distance of 40 cm, in correction of the patient's refractive defect. When there is no response to the 480 arc/sec test, the plate is placed at a double distance (80 cm), but the stereopsis value must then be reduced by the same factor (to a value of 960 arc/sec). Random Dot E Test is based on random dot stereograms and is performed from a distance of 50 cm and 1 m as a screening test. It includes 3 boards: a demonstration board, a test board with a convex letter E (500 arc/sec from 50 cm and 250 arc/sec from 1 m) and a test board blank. The TNO test consists of 7 arrays made by random point stereography and containing simple figures formed from red-green points: arrays I–III (for screening), array IV (attenuation test) and arrays V–VII (for quantitative evaluation of stereopsis from 480 arc/sec to 15 arc/sec). The lack of response to arrays I–III indicates stereoscopic blindness (depth perception above 1980 arc/sec). A depth perception of less than 100 arc/sec as measured by the Stereo Fly Test is considered normal stereopsis (or functional stereopsis). Decreased stereoscopic vision for the TNO test has been defined on the basis of published normative bases as depth perception above 120 arc/sec [13, 14].

LITERATURE REVIEW

Based on a review of Pubmed, Scopus and Web of Science databases, the results of published prospective and retrospective studies evaluating the effect of Presbyond® LBV laser correction of presbyopia on stereopsis were analyzed. The database search strategy included only papers published in English and used the terms presbyopia correction, presbyond, aspheric monovision LASIK, laser blended vision, stereopsis, which were combined with appropriate logical operators. The following were excluded from the analysis: review papers, meta-analyses and systematic reviews, case reports, conference reports and abstracts.

A total of 4 papers were analyzed, published between 2016 and 2022. The follow-up time ranged from 3 [15] to 6 months [16–18]. Stereopsis was measured with the following tests: Stereo Fly Test (2 papers) [16, 18], TNO (1 paper) [17] and Random Dot Test (1 paper) [15]. In all of the reviewed papers, spatial vision testing was performed for nearsightedness; in 1 paper, stereopsis testing was additionally performed with the Random Dot test for distance from 3 m [15].

The study by Zhang et al. [15] included 47 patients with a mean age of 43.4 (±4.9) years (range 38 to 63 years) and with a mean preoperative spherical equivalent (ES) of -5.68 (±1.98) D (range -1.25 to -11.13 D) undergoing Presbyond® LBV. Induced micro-monovision in the ND eye ranged from -0.75 to -2.25 D, with an average of -1.41 (±0.28) D. 3 months after surgery, there was an unknown improvement in stereopsis to near (median: 45 arcsec vs 50 arcsec; $p < 0.05$). At the same time, a statistically significant postoperative reduction in stereopsis to distance (median: 100 arcsec vs 0 arc/sec; $p < 0.05$). The study by Brar et al. [16] included 18 people with hyperopia: mean. ES +1.28 (±1.38) D and 12 myopic patients: mean. ES -2.84 (±1.86) D of Presbyond® LBV-treated patients with induced postoperative average myopia in the ND eye: -1.26 (±0.40) D. 6 months after surgery showed a statistically significant reduction in stereopsis in the absence of correction (89.7 arc/sec vs. 50.7 arc/sec; $p = 0.01$), which returned to preoperative values after the application of near vision correction (53.3 arc/sec; $p = 0.53$). The authors also compared the eye's reading performance up close and at the preferred intermediate distance (60 or 80 cm) before treatment (with progressive glasses) and after Presbyond® LBV treatment (without correction). The text was presented on a screen, and the letter size on a logarithmic scale ranged from 0.16 to 0.8 for nearsightedness and 0.16 to 2.0 for intermediate distances. 6 months after Presbyond® LBV treatment, the preferred reading distance increased significantly from 41.8 cm (with progressive glasses) to 46.2 cm (without correction). At the same time, an increase in reading speed was observed at every distance tested.

The study also assessed patients' postoperative satisfaction rate, postoperative independence from glasses and degree of dysphotopsia. In the satisfaction questionnaire, scores ranged from 0 to 100, where 0 meant total dissatisfaction and 100 meant total satisfaction and no need for glasses. Postoperative spectacle independence (to the far, intermediate and near distance) was assessed as the percentage of patients who did not feel the need to wear glasses at specific viewing distances. The degree of dysphotopsia was determined by patients on a scale of 0 to 3, where 0 meant no symptoms of dysphotopsia; 1 – mild, minimal dysphotopsia not affecting night vision and routine activities; 2 – moderate symptoms of dysphotopsia affecting night vision and routine activities, but acceptable; 3 – severe, bothersome dysphotopsia interfering with daily activities. 6 months after the procedure, the average satisfaction index for distance, intermediate distance and near vision was 98.0 (±2.1), 99.46 (±0.6) and 96.8 (±2.4), respectively. The percentages of patients satisfied with far, intermediate and near distance vision were 93.3%, 100% and 86.6%, respectively. None of the patients studied reported experiencing a glare or halo effect. Mild dysphotopsia (grade 1) was reported by 2 patients (6.6%) at the end of the 6-month follow-up.

The study by Romero et al. [17] included 50 patients with presbyopia, mean age 46.8 (±4.2) years, who were divided into 3 groups according to preoperative refraction. Group 1 included participants with hyperopia: mean. ES +1.71 (±0.62) D, range +0.50 to +3.0 D, group 2. – patients with myopia and ES lower than -3.0 D, mean. ES -2.11 (±0.85) D, a range of -1.0 to -3.0 D, and group 3. – myopic eyes with ES higher than -3.0 D, mean. ES -3.93 (±0.87) D, ranging from -3.0 to -6.0 D. The Presbyond® LBV correction plan was to induce micro-vision in the ND eye from -0.75 to -1.50 D. 6 months after the procedure, a statistically significant improvement in stereopsis was demonstrated in the group of eyes with myopia from -3.0 to -6.0 D; 169.4 (±71.1) arc/sec vs. 215.3 (±99.6) arc/sec; $p = 0.025$, while no changes in stereoscopic vision were noted in the other groups: 183.2 (±70.6) arc/sec vs 181.6 (±73.8) arc/sec in group 1 and 145.7 (±77.0) arc/sec vs 143.6 (±80.0) arc/sec in group 2. The goal of the study by Russo et al. [18] was a retrospective analysis of refractive outcomes and spatial vision in 139 patients (278 eyes) with presbyopia, mean age 53.1 (±5.8) years; range 42 to 70 years, undergoing Presbyond® LBV treatment. Patients were divided into 2 study groups according to preoperative refraction. Group 1 consisted of 39 patients (78 eyes) with myopia, mean ES -3.40 (±1.83) D, ranging from -0.50 to 8.25 D, while group 2 consisted of 100 participants (200 eyes) with hyperopia, mean ES +1.61 (±0.98) D, range from -1.25 to +4.63 D. Induced micro-monovision in the ND eye ranged from -0.13 to -2.25 D, mean -0.90 (±0.44) D. 6 months after surgery, mean postoperative ES in the dom-

inant eye (far distance eye) was +0.20 (±0.35) D (range -0.38 to +1.00) in the myopic group and -0.14 ± 0.42 D (range -1.38 to +0.88) in the hyperopic group. Mean postoperative ES in the ND eye (near distance eye) was -0.90 (±0.44) D (range -0.13 to -2.25 D) and -1.21 (±0.48) D (range -0.13 to -2.25 D), respectively. Postoperative uncorrected distance visual acuity (UDVA) was the same as CDVA or better in 82% of eyes with myopia and 77% of eyes with hyperopia. Postoperative CDVA was within the range of changes up to 1 line on the Snellen chart compared to preoperative CDVA in 92% of eyes with myopia and 77% of eyes with hyperopia. Postoperative stereopsis was stronger than 100 arc/sec (functional stereopsis) in 79% of myopic patients and 85% of hyperopic patients. The average stereopsis value in both study groups decreased significantly (90.7 arc/sec vs. 50.4 arc/sec and 95.6 arc/sec vs. 56.3 arc/sec, respectively), while being within the range of functional stereopsis.

CONCLUSIONS

Few published papers have shown that the Presbyond® LBV procedure may be associated with a reversible reduction in stereopsis, but preserves functional stereopsis in most patients. Presbyond® LBV treatment improves reading speed and allows for patient satisfaction and independence from glasses. Further studies are recommended to complement the results published so far.

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