ORIGINAL ARTICLE

Turk J Med Sci
2009; 39 (6): 837-841

E-mail: medsci@tubitak.gov.tr
doi:10.3906/sag-0903-28

İlknur AKYOL SALMAN
Murat ARSLANKURT
Osman DURSUN
Ahmet YAZICI
Orhan BAYKAL

Department of Ophthalmology,
Faculty of Medicine,
Atatürk University,
Erzurum - TURKEY

Progression of binocular vision following cataract surgery*

Aim: To investigate the progression of binocular vision of patients after cataract surgery in the early postoperative period.

Materials and methods: Eighty four cataract patients were evaluated at postoperative 1 and 3 months after phacoemulsification and posterior chamber monofocal lens implantation. For the evaluation of the grades of binocular vision, synoptophore was used. Stereoscopic acuity was measured with the Titmus Stereotest.

Results: Evaluation at postoperative 3 months was associated with a significantly higher proportion of patients with stereopsis ($P = 0.004$), better levels of stereoacuities ($P < 0.001$) than the evaluation at postoperative 1 month. Significantly higher visual acuities ($P = 0.001$) and lower interocular difference in refraction values ($P = 0.023$) were also noted at postoperative 3 months. The level of stereoscopic acuity was not significantly correlated with the level of visual acuity, interocular visual acuity difference, interocular difference in refraction, and the age of patients ($P > 0.05$). In patients without fusion, suppression was found in the operated eyes with favorable visual acuities, and even in some of those with higher visual acuities compared to the fellow eye.

Conclusion: During the early postoperative period of cataract patients, improvements in binocular vision were observed, which may be attributed to neural factors along with optical factors because of the cerebral basis for binocular vision.

Key words: Binocular vision, binocular functions, stereopsis, stereoacuity, cataract surgery, neuroadaptation

Katarakt cerrahisi sonrasi binoküler görmenin progresyonu

Amaç: Katarakt cerrahisi sonrası erken postoperatif dönemde, hastalarda binoküler görmenin progresyonunu araştırmak.

Yöntem ve gereç: 84 katarakt hastası, fakoemülsifikasyon ve arka kamara monofokal göziçi lens implantasyonu sonrası 1. ve 3. ayda değerlendirildiler. Binoküler görmenin derecelendirilmesinde sinoptofor kullanıldı. Steroskopik görme keskinliği Titmus Stereotest ile ölçüldü.

Bulgular: Postoperatif 3. aydaki değerlendirmede 1. aya göre, hastalarda önemli derecede daha fazla oranda stereopsis ($P = 0.004$), ve daha iyi seviyede stereo keskinlik ($P < 0.001$) saptandı. Ayrıca postoperatif 3. aydaki görme keskinliğindeki artış ($P = 0.001$) ve anizometropi miktarındaki azalma ($P = 0.023$) istatistiki olarak anlamlıydı. İstatistiksel olarak stereo keskinlik düzeyi ile görme keskinliği, iki göz arasındaki görme keskinliği farkı, anizometropi miktarı, yaş arasında korelasyon tespit edilmedi ($P > 0.05$). Füzyonu mevcut olmayan hastalardaki supresyon, görme derecesi iyi olan ve hatta diğer göze göre daha iyi görme derecesine sahip olan, opere gözlerde tespit edildi.

Sonuç: Katarakt cerrahisi sonrası erken postoperatif dönemde, hastalarda binoküler görmede gelişme tespit edildi ve bu gelişmenin optik faktörler dışında, nöral faktörlerle de ilişkili olabileceği düşünüldü.

Anahtar sözcükler: Binoküler görme, binoküler fonksiyonlar, stereopsis, stereo keskinlik, katarakt cerrahisi, nöroadaptasyon

Received: March 30, 2009
Accepted: July 31, 2009

Correspondence
Orhan BAYKAL
Department of Ophthalmology,
Faculty of Medicine,
Atatürk University,
Erzurum - TURKEY

ilkakyol@atauni.edu.tr

* This paper was presented in part at the 29th Meeting of the European Strabismological Association, İzmir, Turkey in June 2004.

Introduction

Human beings attain binocular vision from the 2 retinal images through a series of sensory and motor processes that culminate in the perception of singleness and stereoscopic depth. Keen stereopsis is considered the paramount consequence of binocular vision because optimal performance depends on the normal functioning of all of the underlying vision processes, including central fixation with normal visual acuity in each eye, accurate oculomotor control to obtain bifoveal fixation, normal inter retinal correspondence of visual directions, sensory mechanisms to produce single vision, and neural mechanisms to extract selective depth signals from objects that are nearer or farther than the plane of fixation (1).

Cataract surgery provides improvement in vision, and then substantial improvement in binocular vision (2-5). After cataract surgery, patients' binocular vision is an important measure since binocular concordant information provides better exteroception of form and color and better appreciation of the dynamic relationship of body to the environment, facilitating control of manipulation, reaching, and balance (6). Stereoscopic acuity, one of the qualitative aspects of binocular vision (1), has been commonly evaluated during the clinical vision testing of postoperative cataract patients (3-5, 7-14). To our knowledge, however, data on the progression of the postoperative stereoscopic acuities have not been studied. There is also no study quantifying the binocular vision of the postoperative cataract patients.

Therefore, in this study, we evaluated the binocular vision of patients after the cataract surgery qualitatively and quantitatively, and investigated the progression of it in the early postoperative period.

Material and methods

Eighty four cataract patients who underwent uncomplicated cataract extraction and posterior chamber intraocular lens implantation were included in the study. The operations were performed as one eye surgery in 54 and as second eye surgery in 30 patients. Patients with pathologic changes in the macular area, previous history of anisometropia and amblyopia, high myopia, those with ocular deviations and eye pathology other than cataract were excluded from the study.

In all patients, phacoemulsification and posterior chamber monofocal hydrophilic acrylic intraocular lens implantation in the capsular bag was performed under the topical anesthesia.

Patients were then evaluated 1 and 3 months after the surgery. At each visit, uncorrected and best corrected visual acuities on decimal charts were examined and manifest refractions were recorded as the spherical equivalent value of the noncycloplegic refraction. The grades of binocular vision (simultaneous perception, fusion, and stereopsis) were examined on the synoptophore (15,16). The determination of stereoscopic acuity was done with the Titmus Stereotest (15, 16).

Statistical comparisons of the postoperative 1 and 3 months measurements were made with Wilcoxon signed rank test. The proportion of patients with fusion or stereopsis was compared with χ^2 test. Spearman correlations were used to measure the relationships between stereoscopic acuity and visual acuity, interocular visual acuity difference, interocular differences in refraction, and the age of patients. A P value <0.05 was considered statistically significant.

Results

The mean age of the 52 male and 32 female patients was 58.51 ± 13.60 years.

The mean best corrected visual acuity of the operated eyes was 0.82 ± 0.20 and 0.84 ± 0.19 at postoperative 1 and 3 months, respectively. Significantly higher visual acuities were noted at postoperative 3 months (P = 0.001).

At 1 and 3 months postoperatively, the mean interocular visual acuity difference was 0.15 ± 0.20 and 0.13 ± 0.21, respectively (P = 0.069). The mean respective interocular difference in refraction values as spherical equivalent was 0.81 ± 0.74 and 0.77 ± 0.73 diopters. Significantly lower interocular difference in refraction values were noted at postoperative 3 months (P = 0.023).

The mean stereoscopic acuity levels were 5.18 ± 2.11 circles at postoperative 1 month and significantly increased thereafter to a mean value of 6.58 ± 1.94 circles at postoperative 3 months (P < 0.001).

Simultaneous perception was present in all patients. Fusion was observed in 76 patients (90.47%) at postoperative 1 month; in 80 patients (95.23%) at postoperative 3 months (P = 0.125). Suppression in patients without fusion was noted in the operated eyes in unilateral group, and in secondly operated eyes in bilateral group. In those patients with suppression the mean best corrected visual acuities were 0.64 with the range of 0.32-1.00 in suppressed eyes, and 0.76 with the range of 0.50-1.00 in the fellow eyes.

Stereopsis was observed in 63 patients (75%) at postoperative 1 month; in 72 patients (85.71%) at postoperative 3 months. The number of patients with stereopsis was greater at postoperative 3 months, and it was found statistically significant (P = 0.004). In patients without stereopsis, the mean best corrected visual acuities of the operated eyes were 0.69 ± 0.24 (N = 21) and 0.68 ± 0.27 (N = 12) at postoperative 1 and 3 months, respectively. The mean best corrected visual acuities of the operated eyes of the 9 patients whose stereopsis was observed at postoperative 3 months but not at postoperative 1 month was 0.72 ± 0.19 and 0.74 ± 0.20 at postoperative 1 and 3 months, respectively (P = 0.157). In those 9 patients, the mean interocular visual acuity difference was 0.16 ± 0.15 and 0.10 ± 0.17 (P = 0.131); and the mean interocular difference in refraction values as spherical equivalent was 0.61 ± 0.69 and 0.58 ± 0.48 diopters (P = 0.783) at postoperative 1 and 3 months, respectively.

The level of stereoscopic acuity was not significantly correlated with the level of visual acuity, interocular visual acuity difference, interocular difference in refraction, and the age of the patients (P > 0.05).

Discussion

Binocular vision of cataract patients after the operation has become a major concern since it affects the functional status of the patients (2-6). Stereoscopic acuity, one of the qualitative aspects of binocular vision (1), has been reported and commonly evaluated during the clinical vision testing of postoperative cataract patients (3-5, 7-14). In this study, we also assessed the alterations of binocular vision after the cataract surgery in the early postoperative period both qualitatively and quantitatively.

Simultaneous perception, the first grade of binocular vision, was present in all patients after the operation and it did not change with time.

Fusion, the second grade of binocular vision was observed in more cases at postoperative 3 months compared to postoperative 1 month, but it was not found statistically significant. In the patients without fusion, interestingly, suppression was found in the operated eyes with favorable visual acuities (the mean best corrected visual acuity, 0.64 with the range of 0.32-1.00) and even in some of those with higher visual acuities compared to the fellow eye. This demonstrates that the factors other than the level of visual acuities influence fusion and occurrence of suppression in the patients after the cataract surgery. Interestingly, suppression was noted in the operated eyes in the unilateral group, and in secondly operated eyes in the bilateral group. This may be because they had surgery on their worse-seeing eye, and they have a sighted fellow eye that is dominant. It has been shown experimentally in animal models that, in adult visual cortex, imbalanced binocular input after the closure of a one eye cause a shift in ocular dominance in visual cortex, such that neurons reduce their responsiveness to stimuli delivered to the deprived eye while the open eye increases its influence on cortical cells (17-20).

The number of patients with stereopsis, the third grade of binocular vision, was significantly higher at postoperative 3 months. No significant difference was found in visual acuity of the operated eyes, interocular visual acuity difference, and interocular difference in refraction values of the patients in whom stereopsis was observed at postoperative 3 months but not at postoperative 1 month.

Significant improvement in stereoscopic acuity levels was noted. The mean stereoscopic acuity level was 5.18 circles at postoperative 1 month and significantly rose thereafter to a mean value of 6.58 circles at postoperative 3 months. Meanwhile, significant improvements were observed in both visual acuity of the operated eyes and anisometropia of patients. However, improved visual acuity and reduced interocular difference in refraction did not explain statistically the observed improvement in stereoscopic acuity of the patients. In the reports, visual acuity and interocular difference in refraction have been demonstrated as the important factors for stereoscopic acuity, along with the other factors, such as interocular difference in acuity and age (7-15, 21-24). However, we could not establish any significant association between the stereoscopic acuity and these variables. In our study, the improvement in stereoscopic acuity appears to be dependent on the factors other than the changing visual acuity, interocular differences in acuity, and interocular difference in refraction.

As well known, ordinary binocular vision represents a highly coordinated organization of motor and sensory processes, and if any component in the organization fails, binocular vision compromised to some extent (1,6). In this study, exactly which factors account for time-related changes in binocular functions remained unclear. The observed improvement in binocular vision may be attributed to the neural factors as well as the optical factors, because of the cerebral basis for binocular vision. The adaptation of cortex to the newly formed retinal images might be considered as a possible cause for the improvements, since the brain has a remarkable capacity to adapt to alterations in its sensory environment. It has been shown experimentally in animal models that, in adult visual cortex, when the deprived eye is later allowed to regain vision, binocular responses in the visual cortex have the capacity to recover. Anatomical and chemical correlates for the ocular dominance plasticity and recovery of cortical binocularity in the adult visual cortex are the subject of continuing investigations (17-20, 25, 26).

In conclusion, this study demonstrated both qualitatively and quantitatively the improvements in binocular vision with the course of time after the cataract extraction. The improvements in the binocular vision of the cataract patients during the early postoperative period, without depending on the improvements in some important factors, such as visual acuity, interocular difference in acuity, and anisometropia, may suggest the possibility of the adaptation of cortex to the newly formed retinal images in the patients. Suppression in some of the operated eyes with favorable visual acuities, and even in some of those with higher visual acuities compared to the fellow eye, supports the idea that factors other than the level of visual acuity influence fusion and occurrence of suppression. Further large scale prospective studies will be required to find the factors accounting for time-related changes in binocular functions.

Acknowledgement

The authors would like to thank Ömer Akbulut, PhD for his assistance in the statistical analysis of this study.

References

1. Harwerth RS, Schor CM. Binocular vision. In: Kaufman PL, Alm A, editors. Adler's physiology of the eye. Clinical application. 10th ed. St. Louis: Mosby; 2003. p.484-510.
2. Anand V, Buckley JG, Scally A, Elliott DB. Postural stability changes in elderly with cataract simulation and refractive blur. Invest Ophthalmol Vis Sci 2003; 44: 4670-5.
3. Castells X, Comas M, Alonso J, Espallargues M, Martínez V, García-Arumí J et al. In a randomized controlled trial, cataract surgery in both eyes increased benefits compared to surgery in one eye only. J Clin Epidemiol 2006; 59: 201-7.
4. Elliott DB, Patla AE, Furniss M, Adkin A. Improvements in clinical and functional vision and quality of life after second eye cataract surgery. Optom Vis Sci 2000; 77: 13-24.
5. Kwapiszeski BR, Gallagher CC, Holmes JM. Improved stereoacuity. An indication for unilateral cataract surgery. J Cataract Refract Surg 1996; 22: 441-5.
6. Von Noorden GK, Campos EC. Binocular vision and space perception. In: Von Noorden GK, Campos EC, editors. Binocular vision and ocular motility: Theory and management of strabismus. St. Louis: Mosby; 2002. p.7-37.
7. Comas M, Castells X, Acosta ER, Tuñí J. Impact of differences between eyes on binocular measures of vision in patients with cataracts. Eye 2007; 21: 702-7.
8. Hayashi K, Hayashi H. Stereopsis in bilaterally pseudophakic patients. J Cataract Refract Surg 2004; 30: 1466-70.
9. Sucker J, Zvizdic M, Vogten H. Stereoscopic vision before and after cataract extraction with artificial lens implantation. Ophthalmologe 2000; 97: 676-81.
10. Laidlaw A, Harrad R. Can second eye cataract extraction be justified? Eye 1993; 7: 680-6.

11. Katsumi O, Miyajima H, Ogawa T, Hirose T. Aniseikonia and stereoacuity in pseudophakic patients; unilateral and bilateral cases. Ophthalmology 1992; 99: 1270-7.
12. Katsumi O, Miyanaga Y, Hirose T, Okuno H, Asaoka I. Binocular function in unilateral aphakia. Correlation with aniseikonia and stereoacuity. Ophthalmology 1988; 95: 1088-93.
13. Lightholder PA, Phillips LJ. Evaluation of the binocularity of 147 unilateral and bilateral pseudophakic patients. Am J Optom Physiol Opt 1979; 56: 451-9.
14. Highman VN. Stereopsis and aniseikonia in uniocular aphakia. Br J Ophthalmol 1977; 61: 30-3.
15. Von Noorden GK. Examination of patient-III. Sensory signs, symptoms, and adaptations in strabismus. In: Von Noorden GK, editors. Binocular vision and ocular motility: Theory and management of strabismus. St. Louis: Mosby; 1996. p.206-99.
16. Kanski JJ. Strabismus In: Kanski JJ, editor. Clinical ophthalmology. A systemic approach. Oxford: Butterworth-Heinemann; 2003. p.516-56.
17. Hofer SB, Mrsic-Flogel TD, Bonhoeffer T, Hubener M. Prior experience enhances plasticity in adult visual cortex. Nat Neurosci 2006; 9:127-32.
18. He HY, Hodos W, Quinlan EM. Visual deprivation reactivates rapid ocular dominance plasticity in adult visual cortex. J Neurosci 2006; 26: 2951-5.
19. Sawtell NB, Frenkel MY, Philpot BD, Nakazawa K, Tonegawa S, Bear MF. NMDA receptor-dependent ocular dominance plasticity in adult visual cortex. Neuron 2003; 38: 977-85.
20. Tagawa Y, Kanold PO, Majdan M, Shatz CJ. Multiple periods of functional ocular dominance plasticity in mouse visual cortex. Nat Neurosci 2005; 8: 380-8.
21. Zaroff CM, Knutelska M, Frumkes TE. Variation in stereoacuity: Normative Description, fixation disparity, and the roles of aging and gender. Invest Ophthalmol Vis Sci 2003; 44: 891-900.
22. Wright LA, Wormald RPL. Stereopsis and ageing. Eye 1992; 6: 473-6.
23. Sanfilippo S, Muchnick RS, Schlossman A. Visual acuity and binocularity in unilateral high myopia. Am J Ophthalmol 1980; 90: 553-7.
24. Brooks SE, Johnson D, Fischer N. Anisometropia and Binocularity. Ophthalmology 1996, 103: 1139-43.
25. Liao DS, Krahe TE, Prusky GT, Medina AE, Ramoa AS. Recovery of cortical binocularity and orientation selectivity after the critical period for ocular dominance plasticity. J Neurophysiol 2004; 92: 2113-21.
26. Kind PC, Mitchell DE, Ahmed B, Blakemore C, Bonhoeffer T, Sengpiel F. Correlated binocular activity guides recovery from monocular deprivation. Nature 2002; 416: 430-3.