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CLINICAL STUDY

Gain in visual acuity after cataract surgery improves postural stability and mobility

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Abstract: *Objectives:* Vision plays an important role in postural stability. It has also been shown that visual information from the environment and visual cues significantly contribute to balance skills. The aim of this study was to investigate the effects of visual acuity on postural stability and mobility before and after cataract surgery.
Methods: The study group was composed of 25 male and 11 female patients (age 57–84, mean 66.6±4.7) who had been operated for age-related cataract. Postural stability and mobility were assessed before and four weeks after the surgery by means of Biodex stability system (BSS), Tinetti, Time up and go (TUG) and Functional reach (FR) tests, as well as by gait analysis (gait velocity, step length, step width, cadence, stride length).
Results: Postoperative visual acuity was significantly improved. Gait velocity and cadence increased significantly but step length, stride length, and step width did not change significantly. Postoperative improvement of Tinetti balance, TUG and FR tests were significant. Similarly, antero-posterior stability index (APSI), medio-lateral stability index (MLSI) and overall stability index (OSI) that were examined with BSS improved significantly after the cataract surgery.
Conclusion: These results demonstrated that gain in visual acuity after cataract surgery improves the postural stability and mobility of patients *(Tab. 2, Fig. 1, Ref. 29)*. Full Text in free PDF *www.bmj.sk.*
Key words: cataract, mobility, postural stability, visual acuity.

Postural disturbances frequently result in falls and may consequently lead to negative consequences such as injuries and death, especially in the elderly (1, 2). Five per cent of falls cause fractures, another 10 to 15 % lead to a variety of further injuries (3) and annually affect one in three community-dwelling elderly individuals. Cognitive impairment, muscle weakness, postural hypotension, visual impairment, balance and gait abnormalities, foot problems, while medications are the main causes of falls among the elderly population (4).

Visual functioning has been associated with postural instability (5). Vision plays an important role in acquiring balance by providing the nervous system with timely information regarding the movements of body segments and position in relation to each other and the environment. When people stand with their eyes closed, postural sway increases by 20–70 % (6). Integration of the somatosensory, vestibular, and visual system inputs plays an important role in maintaining the balance. A dysfunction in any of these systems can lead to balance disorder, postural instability, and falls (7).

Many studies have shown that poor vision is an independent risk factor for falls thus increasing the risk ratio almost twice (2, 8, 9). Within visual function, visual acuity, contrast sensitivity, depth perception, and visual field defects have all been implicated as important features (9, 10).

The gait characteristics of patients with visual impairment have been measured in only two studies, while the results have demonstrated that adults with visual impairment walk more slowly and cautiously (shorter stride length and longer time for stride and stance) than do age-matched controls (11, 12).

The aim of this study was to investigate the postural stability and mobility in cataract patients with various clinical tests and to assess the potential improvement of postural stability and mobility after uncomplicated cataract surgery.

Materials and methods

Participants

This study was designed as a prospective clinical study. Thirty-six patients (25 males and 11 females), who had undergone an uneventful phacoemulsification surgery for age-related cataract between May 2007 and May 2008 were enrolled in this prospective study. To be included in the study, written consent was obtained from all participants. The study was approved by the Local Ethical Committee and carried out in accordance with the Declaration of Helsinki.

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Cataract surgery is the most commonly performed surgery in ophthalmology clinics while the elderly are the most common group operated for age-related cataract. However, most of these patients have other ophthalmologic diseases that may blur their vision before and after the surgery. For that reason, we excluded the patients diagnosed preoperatively with any other ophthalmologic pathologies. Patients with corneal pathology, glaucoma, pseudoexfoliation, uveitis, previous eye surgery or eye trauma, or posterior segment pathology were excluded from the study. Since the study group was composed of elder patients, we also tried to exclude patients with systemic diseases possibly interfering with balance and gait scores. For that reason the patients who were known to have any neurologic, rheumatologic, orthopaedic, and vascular diseases including diabetes, were excluded from the study.

During the study, 62 patients who had been operated for age-related cataract were excluded from the study because of the preoperatively diagnosed associated ophthalmologic diseases. Also 77 patients with any of systemic diseases were excluded from the study.

All operations were performed under topical anaesthesia. Uncomplicated phacoemulsification of cataract and hydrophobic acrylic foldable posterior chamber intraocular lens implantation was performed on all of the cataractous patients by the same experienced surgeon (SE). All of the patients were evaluated preoperatively and four weeks after surgery by experienced ophthalmologist and physiatrist. At ophthalmic evaluation, best corrected visual acuity, biomicroscopic findings, and intraocular pressure with Goldman applanation tonometer and fundus findings were recorded. Also 7 patients who did not yield any benefit for best corrected visual acuity were excluded from the study. This group was composed of patients that had preoperatively undiagnosed retinal pathologies as age-related macular degeneration and optic nerve pathologies.

Measurements

Visual acuity

Best corrected visual acuity of patients were obtained as Snellen system with chart projector (Topcon, Japan) and converted to logMAR system (13).

Postural stability

Dynamic postural stability was assessed using BSS (Biodex, Inc., Shirley, NY, USA) (Fig. 1). The BSS support platform can be placed at 8 levels with the resistance of the foot platform changing at each level. A setting of 8 is the most stable while that of 1 is the least stable platform. We arranged BSS from level 8 to 3 for safety of patients. All subjects were evaluated with their eyes open. The foot platform can move a full 20° in any direction at any level. The measures of postural stability that we used were the antero-posterior stability index (APSI), mediolateral stability index (MLSI) and overall stability index (OSI). Postural stability indexes represent the standard deviation of foot platform deflection in degrees from the level position during a test. The higher the stability index the greater the postural instability (14, 15).

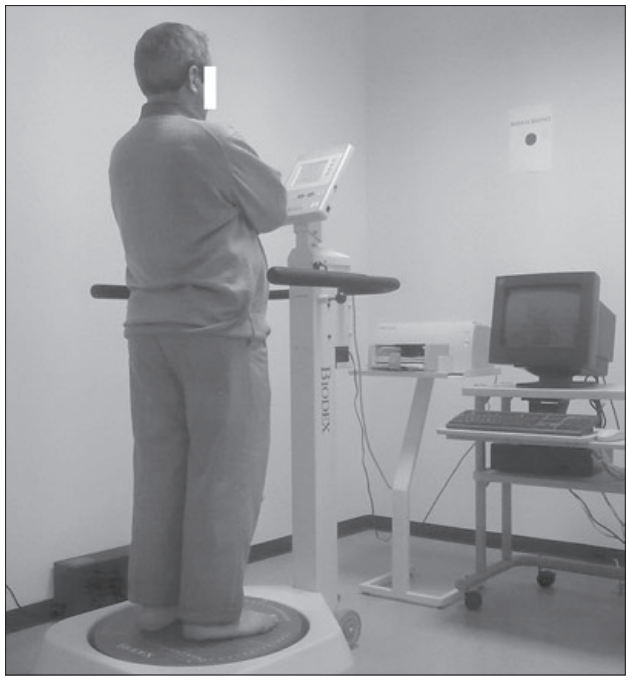

Fig. 1. Assessment of postural stability with Biodex stability system.

Gait analysis

This was performed by having the patients walk on a dark-coloured surface after dipping their feet in talc. They were asked to walk the 10-meter distance at normal walking speed, looking straight ahead. A chronometer was used to measure the time. The gait velocity was measured while the step length, stride length, step width and cadence were evaluated as the mean of three measurements for both sides (16).

Time Up and Go (TUG) test

Subjects were seated with their back against the chair. They were instructed to stand up, walk three metres (to a mark on the floor), turn around, walk back to the chair and sit down. The task was to be done at an ordinary comfortable speed. The stopwatch was started on the word "go" and stopped when the subject sat down. The TUG time was measured in seconds (sec) (17).

Tinetti test

Tinetti test is a standardized assessment of stability and mobility. Balance is evaluated while sitting, rising, standing (immediate and prolonged), and turning. The right and left feet are evaluated separately for swing (step length) and clearance of ground, and then compared. Normally, each foot should completely clear the floor and step completely ahead of the other foot. Step symmetry and continuity are also compared. Other factors assessed are path deviation, trunk stability and stance (normal or wide-based). Maximum score is 12 for gait and 16 for balance (18).

Tab. 1. Visual acuity, postural stability and mobility parameters before and after cataract surgery.

	Preoperative (n=36)	Postoperative (n=36)	P
Visual acuity, logMAR	0.53±0.21 (0.20–1.00)	0.11±0.13 (0–0.50)	<0.001*
OSI	4.5±0.9 (3–7.3)	3.3±0.8 (2.1–5.2)	<0.001
APSI	3.21±1.02 (1.4–5.7)	2.6±0.5 (1.8–3.8)	<0.001
MLSI	3.3±0.83 (2.1–4.8)	2.2±0.7 (1.3–3.6)	<0.001
Tinetti balance	14.8±1.2 (12–16)	15.7±0.7 (13–16)	<0.001*
Tinetti gait	11.5±0.7 (9.00–12.00)	11.7±0.5 (10–12)	0.197*
Gait velocity, cm/sec	121.1±20.2 (94.9–170.6)	151.7±22.3 (116–201.2)	<0.001
Step length, cm	71.3±9.2 (56–94)	73.1±8.5 (57–86)	0.110
Stride length, cm	144±20.3 (114–192)	148.2±16.9 (117–174)	0.076
Walk base, cm	7.1±2.1 (3–12)	7.1±1.8 (4–10)	0.942
Cadence, step/sec	1.8±0.4 (1.1–2.6)	2.1±0.5 (1.5–3.2)	<0.001
TUG, sec	11.5±2.5 (8.1–18.4)	8.9±1.7 (6.5–13.2)	<0.001
FR, cm	28.5±4.6 (21–36.5)	32.5±4.7 (22–41)	<0.001

Data are expressed as mean±S.D. (minimum-maximum), *; Wilcoxon test, OSI – overall stability index; APSI – antero-posterior stability index; MLSI – medio-lateral stability index; TUG – Time Up and Go test; FR – Functional Reach test;

Functional Reach (FR) test

A 100-centimetre ruler was attached to a wall at the level of the subject's acromion. Subjects were asked to extend their arm to 90° and reach forward as far as possible without losing their balance or taking a step (19).

Statistical analysis

Statistical analysis were performed SPSS for windows version 16.0 software. Normality for continued variables in groups was determined by the Saphiro-Wilk test. Paired sample t test and Wilcoxon test were used for normal and non-normal distributed variables, respectively. Pearson correlation analysis was used to assess the relationship between variables. The p values of less than 0.05 were considered significant.

Results

The mean age of the patients was 66.6±4.7 (range 57–74) and mean body mass index (BMI) of patients was 26.2±3.9 (range 18.6–35.9). Preoperative and postoperative best corrected visual acuity, and postural stability and mobility results are shown in Table 1. Best corrected visual acuity of patients was improved significantly (p<0.001). Among postural stability scores with BSS, APSI, MLSI and OSI were improved dramatically (p<0.001). Improvement of Tinetti balance test was significant (p<0.001) but Tinetti gait test was not (p=0.197). In gait analysis, gait velocity and cadence (p<0.001) were statistically significantly better but step length, stride length and walk base did not alter significantly after the operation (p=0.110, 0.076, 0.942 respectively). However, results of FR and TUG test scores were significantly better after cataract surgery (p<0.001). Correlation analysis of preoperative visual acuity with investigated parameters yield significant correlations with OSI, APSI and MLSI (p=0.003, 0.024, 0.007 respectively). Also we found out that Tinetti gait and balance scores were correlated with visual acuity (p=0.029, 0.014 respectively). For gait analysis, the only correlated parameter with visual acuity was gait velocity (p=0.001). Despite the presence of a significant correlation with TUG test (p=0.006), the same correlation could not be detected with FR test (p=0.226) (Tab. 2).

Tab. 2. Correlations (r) between visual acuity and postural stability and mobility parameters.

	Pre-operative visual acuity	
	r	p
OSI	0.487**	0.003
APSI	0.377*	0.024
MLSI	0.440**	0.007
Tinetti balance	-0.365*	0.029
Tinetti gait	-0.406*	0.014
Gait velocity, cm/sec	-0.516**	0.001
Step length, cm	-0.174	0.311
Stride length, cm	-0.075	0.664
Walk base, cm	-0.261	0.124
Cadence, step/sec	0.259	0.127
TUG, sec	0.453**	0.006
FR, cm	-0.207	0.226

r – Pearson's correlation coefficient

Discussion

The purpose of this study was to evaluate the effect of gaining visual acuity on postural stability and mobility. Balance evaluation of BSS revealed that APSI, MLSI and OSI were significantly decreased after cataract surgery compared to preoperative evaluation. Gait velocity and cadence also improved postoperatively. Similarly, Tinetti gait and balance, FR, and TUG tests were significantly better after the cataract surgery (Table 1). In addition to these, we documented a significant correlation with visual acuity and postural stability results, gait velocity, TUG, and Tinetti balance and gait tests (Tab. 2).

It is clear that vision plays an important role in balance. It has also been shown that visual information from the environment and visual cues significantly contribute to balance skills (1). Various studies have documented that visual disturbances affect the postural stability particularly in the elderly patients (5, 20, 21). The diffuse blur of cataract simulation produced significant increases in postural instability, with up to a 30% increase under normal standing conditions and up to 64 % with somatosensory disruption (5). Harwood et al. (10) showed that the rate of falling was reduced by 34 % after cataract surgery in 306 cataract patients with one year follow-up. In a prospective study investigating the rate of falls before and after cataract surgery it has been suggested that cataract surgery is an effective intervention to reduce the risk of falls in elderly patients with cataract-related visual impairment. They also showed that physical activity was increased in the operated group (22).

The Tinetti test has been recommended and widely used in the elderly patients to assess mobility, dynamic balance and gait, as well as to predict falls (18, 23). Similarly to Tinetti test, TUG test is another commonly used test for evaluation of mobility and dynamic balance (17, 24). In study of Huang et al., subjects were divided into three groups according to their initial Tinetti score (low, moderate and high risk of fall). It was concluded that blurred vision significantly altered all three balance scores (Tinetti, TUG and FR) in all risk groups. However, blurred vision had a greater influence on Tinetti and TUG tests than on FR test in subjects with higher risk of falls (4). In our study group, despite the presence of significant correlation with Tinetti and TUG tests, it could not be detected with FR test. This result could be related with a relatively small study group, however we also know that deprivation of visual acuity has a greater impact on dynamic balance compared to static balance while FR test is developed for evaluation of static balance. Hence, the lack of any correlation between visual acuity and FR is in accord with literature (4).

Numerous studies mentioned the alteration of gait characteristics in patients with visual disabilities (11, 12, 25). In a study composed of 183 female patients, Lord et al. (26) showed that gait parameters (walk speed, stride length and cadence) deteriorate as the patients get older. The authors also carried out a significant correlation between visual acuity and gait parameters. Our results were in favour of these results however the correlation analysis revealed a significant relation of gait velocity with visual acuity. There is a significant correlation between impaired contrast sensitivity and postural instability, gait velocity, stride length and cadence in age-related maculopathy patients (11, 25). This finding also implies the impairment of mobility in this subgroup of population but further study is needed to evaluate the relationship between mobility and visual acuity.

By comparison of preoperative and postoperative scores of patients we eliminate several negative factors that may influence the postural stability results and we believe that this is the major eligibility of the present study. In addition to these, despite the presence of case-control studies, we came across only one study (27) investigating the alterations of postural stability with improvement of visual acuity. In that study (27), postural stability of 23 patients was measured with a different method carried out before and 1 to 4 months after cataract surgery. Similarly to our results, the authors concluded that cataract surgery significantly improved the postural stability. Our study differs mainly by using BSS, TUG, FR and Tinetti tests, as well as gait analysis for assessment of postural stability and mobility. We also investigated the relationships between visual acuity and postural stability, and mobility.

Visual acuity as a single measure of visual impairment does not have to identify sufficiently the risk of falls in the elderly but other measures of visual impairment such as contrast sensitivity and depth perception are other important functions of visual system (28). The measurement of just visual acuity of the subjects is the main limitation of this study. Apart from visual acuity, visual field, contrast sensitivity, and depth perception should be included in the examination of patients´vision.

In 70 % of elderly people, or even in more, visual impairment is remediable with relatively simple interventions (correcting the refractive errors and cataract surgery) (8). Intervention strategies e.g. change of glasses or cataract extraction may have the potential of improving visual function and preventing the elderly from falling (28).

In clinical practice, particularly in the elderly patients, visual impairment, postural instability and the risk of falling should be evaluated together by physicians. In patients with untreatable diseases as the dry-type age-related macular degeneration, balance coordination exercises and exercises increasing the mobility should be recommended. Also, the casual life environmental factors potentially leading to falls should be avoided and prophylactic precautions should be encouraged. Studies using exercise interventions in the elderly have shown improvement in balance, reaction time, strength, and flexibility (1, 29).

Conclusions

Our findings suggest that visual impairment among the elderly population with various levels of cataract affects their postural stability and gait characteristics. Correction of vision provides marked improvement in mobility and postural stability in patients with cataract. Patients with falls or postural instability should have their vision assessed. In clinical practice, ophthalmology and physical medicine and rehabilitation clinics should be in close relation for proper management of elderly patients.

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