Impact of Cataract Surgery on Functional Balance Skills of Adults

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Abstract

Objectives: To investigate the impact of phacoemulsification surgery and intraocular lens implantation on the functional balance skills of adults.

Materials and Methods: This prospective study included patients with cataract who were recommended phacoemulsification surgery and intraocular lens implantation between May and October 2016. The Berg Balance Scale and Tinetti Gait and Balance Test were performed by a physical therapy specialist before and 1 month after surgery. Patients were analyzed in terms of age, visual acuity, and balance. Balance scores before and after cataract surgery were compared. We also compared patients with high (≤2 LogMAR) and low (>2 LogMAR) visual acuity. P values below 0.05 were accepted as statistically significant.

Results: Fifty-one patients (27 female and 24 male, mean age 66.96 years) were included in the study. One month after surgery, the patients’ Berg Balance scores and Tinetti Gait and Balance scores were increased by 3.60±5.00% and 4.14±6.55%, respectively. Postoperative increase in visual acuity was significantly greater in the 16 patients with visual acuity less than 0.05 (>2 LogMAR) (p=0.036), but balance scores were not significantly different.

Conclusion: Visual acuity is significantly improved one month after cataract surgery, which also leads to significant increases in low functional balance scores among patients with poorer vision. The rapid increase in vision after cataract surgery enhances balance skills, resulting in safer mobility and increased quality of life.

Keywords: Vision, cataract, balance, phacoemulsification, falls

Introduction

Cataract is a treatable condition that generally emerges in old age and is a leading cause of vision loss. Today, increases in education level and the average human lifespan are increasing the demand for cataract surgery. In addition to reduced vision, cataracts also cause visual problems such as glare, defects in color vision, and loss of contrast sensitivity and depth perception. These symptoms lead to problems such as loss of balance, less independent mobility, falls, injuries, and increased mortality risk in individuals with visual impairment.1 Every year, approximately 646,000 people worldwide lose their lives due to falls, and according to a report from the World Health Organization, falls are the second most common cause of injury-related deaths.2 Furthermore, the daily activities of elderly patients are affected and patient’s quality of life is impaired.3 Cataract surgery is now performed not only to treat blindness, but to improve quality of life. Atasavun and Akş4 reported that studies in different age groups have shown that the incidence of falls is higher among the visually impaired than among individuals with auditory...
There was no significant difference between men and women.

Although there are various studies in the literature evaluating the relationship between vision and balance, some of these studies have not demonstrated functional balance, while vision was not evaluated objectively in others. The relationship between vision and balance cannot be fully elucidated without an objective assessment of vision level, especially for patients with low vision. Some studies involved retrospective evaluations of surveys conducted in patients who had history of falls. However, various factors may be overlooked in these studies due to inaccurate recollection of events. In addition, balance is affected by many parameters such as age, sex, muscle strength, vestibular function, medication use, and comorbidities, it is difficult to form a well-matched control group and establish a direct relationship between vision and balance. Therefore, in the present study, we prospectively enrolled a group of patients whose characteristics did not differ except for vision. By evaluating these patients before and after cataract surgery, the relationship between vision and balance was revealed more clearly, without confounding by other variables.

In this study, we investigated the effect of vision increase in adult cataract patients after phacoemulsification surgery and intraocular lens implantation on functional balance skills.

Materials and Methods

Adult patients with cataract who were recommended phacoemulsification and intraocular lens implantation in our center between May and October 2016 were enrolled in the study. The study was designed in accordance with Declaration of Helsinki criteria and each participant signed an informed consent form before the study. The study was approved by the Antalya Training and Research Hospital ethics committee.

Exclusion criteria for the study were presence of chronic diseases such as rheumatoid arthritis or osteoarthritis, immobility with or without assistive devices or severe lower extremity deformities that might affect mobility, vestibular problems, history of stroke, and presence of dementia or memory problems.

Demographic data such as age, sex, marital status, education level, and occupation were determined for the individuals who met the study criteria and agreed to participate in the study. The patients’ corrected visual acuity was assessed using Snellen E chart before and after cataract surgery. Functional balance was evaluated by the same physical therapist before and one month after surgery using the Berg Balance Scale (BBS) and Tinetti Gait Test (TGT) and Tinetti Balance Test (TBT).

Berg Balance Scale: Designed primarily to assess balance and determine risk of falls in older adults, the BBS consists of 14 items for direct observation of performance. A ruler, stopwatch, chair, step, an area that allows 360 degrees of rotation, and 15-20 minutes are needed to perform the BBS. Each item is scored 0-4 according to the patient’s ability to meet the time and distance requirements of the test. A score of 4 indicates ability to complete the task independently. The maximum score is 56. A score of 0-20 is interpreted as poor balance, 21-40 as acceptable balance, and 41-56 as good balance (Figure 1).

Tinetti Gait and Balance Tests: This test is preferred for determining the risk of falls, especially in the elderly, and consists of 13 items for balance and 9 items for gait. Items are scored binarily (0 or 1) or on a 3-point scale (0-2). Scores are calculated over a maximum of 16 for balance and 12 for gait, for a maximum total score (gait + balance) of 28 (Figure 2).

Statistical Analysis

The research data were entered into a spreadsheet file and evaluated with Microsoft Excel for Mac 2011 version 14.5.9 (151119) and Statistical Package for the Social Sciences version 20 (SPSS 20) (IBM, New York, USA) software. Female and male patients were compared in terms of age, visual acuity, and balance using Mann-Whitney U test. Relationships between the parameters of age, visual acuity, and balance were evaluated with Pearson correlation analysis. Balance scores before and after cataract surgery were compared using dependent-samples t-test. Patients with high (<2 LogMAR) and low (>2 LogMAR) preoperative visual acuity were compared using independent-samples t-test. Values associated with balance were analyzed with one-way ANOVA. P values less than 0.05 were considered statistically significant.

Results

This prospective study included a total of 51 patients, 27 (52%) women and 24 (48%) men, who met the inclusion criteria. Their mean age was 66.96 (33-87 years). There were no significant differences between the male and female patients in terms of age or preoperative and postoperative visual acuity (Table 1). Mean preoperative visual acuity was 1.32±0.75 (0.3-2.5) LogMAR. Visual acuity increased significantly in both groups postoperatively (p<0.001).

Both male and female patients also showed significant postoperative improvements in balance. At postoperative 1 month, BBS scores were increased by 3.60±5.00% (0-20%), while TGT and TBT were increased by 4.14±6.55% (0-38.46%). The increase in TGT and TBT scores was found to be statistically significant (Table 2).

Comparison based on preoperative visual acuity revealed a significantly greater increase in postoperative 1-month visual acuity among the 16 patients in the >2 LogMAR (<0.05) group compared to the 35 patients in the ≤2 LogMAR (≥0.05) group (p=0.036). However, there was no significant difference between these two groups in terms of increase in balance and gait scores (Table 3).
and timely interventions for treatable eye disorders, primarily to prevent falls and accidents. These studies demonstrate that the incidence of fall-related fractures can be reduced through regular eye examination in adults, primarily to the control group (38.1%).

2. STANDING UNSUPPORTED INSTRUCTIONS: Stand barefoot on a flat surface with your feet hip-width apart. If necessary, use a handrail or wall for balance. Score 0 if unable to stand at all, 5 if able to stand independently with confidence. 

3. SITTING TO STANDING INSTRUCTIONS: (DEMONSTRATE TO SUBJECT) Place one foot in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject's normal stride width). 

4. STANDING UNSUPPORTED ONE FOOT IN FRONT INSTRUCTIONS: (DEMONSTRATE TO SUBJECT) Place one foot in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject's normal stride width). 

5. STANDING UNSUPPORTED FEET TOGETHER INSTRUCTIONS: Place your feet together and stand without support. Score 0 if unable to maintain balance for 5 seconds, 1 if able to maintain balance for 5 seconds but needs supervision. 

6. STANDING UNSUPPORTED WITH EYES CLOSED INSTRUCTIONS: Close your eyes and stand still for 10 seconds. Score 0 if unable to maintain balance for 10 seconds, 1 if able to maintain balance for 10 seconds but needs supervision. 

7. STANDING UNSUPPORTED WITH FEET TOGETHER INSTRUCTIONS: Place your feet together and stand without support. Score 0 if unable to maintain balance for 10 seconds, 1 if able to maintain balance for 10 seconds but needs supervision. 

8. REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING INSTRUCTIONS: Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the fingers reach while the subject is in the most forward lean position. When possible, ask subject to use both arms when reaching to maintain rotation of the trunk.) 

9. PICK UP OBJECT FROM THE FLOOR FROM A STANDING POSITION INSTRUCTIONS: Pick up the shoe/sock/letter which is placed in front of your feet. Score 0 if unable to pick up shoe/sock/letter safely and easily, 1 if able to pick up shoe/sock/letter but needs supervision. 

10. TURN TO LOOK BEHIND OVER LEFT AND RIGHT INSTRUCTIONS: Examiner may pick an object to look at directly behind the subject and shoulder. Repeat to the right. 

11. TURN 360 DEGREES INSTRUCTIONS: Turn completely around in a full circle. Please then turn a full circle in the other direction. 

Discussion

Vision is one of the most important factors in maintaining balance and preventing falls. Kulmala et al. demonstrated in their study of elderly women that visual impairment had the greatest impact on falls when compared with other sensory impairments. This finding was attributed to the fact that other senses can somewhat compensate for deficiencies by filling in gaps regarding posture and balance. In a study performed in Turkey, it was shown that individuals with visual impairments demonstrated in 2014 study. However, when we analyzed postoperative changes in balance scores, we found that balance scores increased more among the women in our study. The increase in TBT scores was statistically significant in females (p=0.005) but not in males. 

Figure 1. Berg Balance Scale

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### Manoeuvres

| Maneuver                                      | Normal                                      | Abnormal                                             |
|----------------------------------------------|---------------------------------------------|------------------------------------------------------|
| Setting balance                             | Steady, stable                              | Leans, slides down in chair                         |
| Arising from chair                          | Able to rise in a single movement without   | Multiple attempts required or unable without        |
|                                              | using arms (on chair or walking aid) to pull | human assistance                                     |
| Immediate standing balance (first 5-10 s)   | and push up; and or moves push up, and or    | Any sign of unsteadiness                            |
| Standing balance                            | moves attempting to arise                   | Any sign of unsteadiness regardless of stance or    |
| Balance with eyes closed (with feet as close | Steady, able to stand with feet together    | holds onto object                                    |
| together as possible)                        | without holding object for support          |                                                    |
| Turning balance (360°)                       | Steady without holding any object with feet | Any sign of unsteadiness or needs to hold onto an    |
|                                             | together                                   | object                                              |
| Neathy on stool (patient standing with feet  | Steady, able to withstand pressure          | Any sign of unsteadiness or needs to hold on to     |
| as close together as possible, examiner      | able to turn head a 1/2 half way side to    | another object                                       |
| pushes with light even pressure over 3 times,| side and be able to bend head back to look at   |                                                    |
| examiner pushes with light even pressure     | ceiling; no staggering, grabbing, or        |                                                    |
| over 3 times, examiner pushes with light     | Symptoms of light headedness, unsteadiness, |                                                    |
| even pressure over 3 times, examiner         | or pain                                     |                                                    |
| Nudge on sternum (patient standing with feet | Able to stand on one leg for 5 without      |                                                    |
| as close together as possible)               | holding object for support                  |                                                    |
| One leg standing balance                     |                                            |                                                     |
| Back extension (ask patient to lean back as | Good extension without holding object or    | Cannot turn, will not attempt or no extension sans  |
| as possible, without holding onto object if | staggering                                   | or stagers                                          |
| possible)                                     |                                            |                                                     |
| Reaching up (have patient attempt to remove  | Able to take down object without need to    | Unable                                              |
| an object from behind)                       | holding onto object for support and without |                                                    |
|                                            | becoming unsteady                           |                                                    |
| Bending down (patient is asked to pick up    | Able to bend down and pick up the object    | Unable                                              |
| small objects, such as pen, from the floor)  | and is able to get up easily in single      |                                                    |
| Setting down                                 | attempt without needing to push self up with |                                                    |
|                                             | arms                                       |                                                    |

### Components

| Component                                      | Normal                                      | Abnormal                                             |
|------------------------------------------------|---------------------------------------------|------------------------------------------------------|
| Initiation of gait (patient asked to begin     | Begins walking immediately without          | Hesitates, multiple attempts, initiation of gait is   |
| walking down hallway)                         | observable hesitation; initiation of gait    | not a smooth motion                                  |
| Step height (begin observing after first few   | is in single, smooth motion                 |                                                    |
| steps: observe one foot, then the other,      |                                             |                                                    |
| observe from side                             |                                             |                                                    |
| Step length (observe distance between toe of   | At least the length of individual's foot     |                                                    |
| stance foot and heel of swing foot; observe   | between the stance toe and swing heel; step  |                                                    |
| from side; do not judge first few or last    | length usually longer but foot length        |                                                    |
| few steps; observe one side at a time)        | provides basis for observation)             |                                                    |
| Step symmetry (observe the middle part of the | Step length same or nearly same on both     |                                                    |
| patch of the first or last steps; observe     | sides for most step cycles                  |                                                    |
| from side; observe distance between heel of   | Begins raising heel of one foot (too off)   |                                                    |
| each swing foot and toe of each stance foot)  | as heel of other foot reaches the floor       |                                                    |
| Step continuity                               | (heel strike); no breaks or stops at stride; |                                                    |
|                                              | step lengths equal over most cycles         |                                                    |
| Path deviation (observe from behind; observe  | Foot follows close to straight line as       |                                                    |
| one foot over several strides; observe in     | patient advances                            |                                                    |
| relation to line on floor (e.g., tilts if     |                                              |                                                    |
| possible; difficult to assess if patient uses |                                              |                                                    |
| a walker)                                     |                                              |                                                    |
| Trunk stability (observe from behind; side to | Trunk does not sway; knees or back are not   |                                                    |
| side motion of trunk may be a normal gait      | flexed; arm is not abducted in effort to     |                                                    |
| pattern, need to differentiate this from       | maintain stability                          |                                                    |
| instability)                                  |                                              |                                                    |
| Walk stance (observe from behind)             | Feet should almost touch as one passes     | Any of preceding features present                    |
| Tumbling while walking                        | other                                       |                                                    |
|                                              |                                              | Foot apart with stepping                            |
|                                              |                                              |                                                    |

*The patient begins this assessment seated in a hard, straight-backed, armless chair.

ROM = range of motion.

The patient begins this assessment seated in a hard, straight-backed, armless chair. The examiner pushes with light even pressure over 3 times, refutes ability to withstand displacement.

1. Nudge on sternum (patient standing with feet as close together as possible, examiner pushes with light even pressure over 3 times, refutes ability to withstand displacement)
2. Neck turning (patient asked to turn head side to side and look up while standing with feet as close together as possible)
3. One leg standing balance
4. Back extension (ask patient to lean back as far as possible, without holding onto object if possible)
5. Reaching up (have patient attempt to remove an object from a shelf high enough to require stretching or reaching over toes)
6. Bending down (patient is asked to pick up small objects, such as pen, from the floor)
7. Setting down

**Normal**
- Steady, able to stand with feet together without holding object for support
- Able to rise in a single movement without using arms
- Able to raise head a 1/2 half way side to side and be able to bend head back to look at ceiling; no staggering, grabbing, or Symptoms of light headedness, unsteadiness, or pain
- Able to stand on one leg for 5 without holding object for support
- Good extension without holding object or staggering
- Able to take down object without need to hold onto other object for support and without becoming unsteady
- Able to bend down and pick up the object and is able to get up easily in single attempt without needing to push self up with arms
- Able to sit down in one smooth movement
- Normal

**Abnormal**
- Leans, slides down in chair
- Multiple attempts required or unable without human assistance
- Any sign of unsteadiness or needs to hold onto another object
- Any sign of unsteadiness or needs to hold onto an object
- Any sign of unsteadiness or needs to hold onto another object
- Will not attempt or no extension sans or stagers
- Unable
- Can’t turn
- Fails zero-chiar, misjudges distances (lands off center)

**Figure 2:** Tinetti Balance and Gait Tests
Table 1. Demographic characteristics of the study patients and their visual acuity levels before and after cataract surgery

| Age (years) | Visual acuity (LogMAR) | Preoperative | Preoperative | p     | Fellow eye |
|-------------|------------------------|--------------|--------------|-------|------------|
| Female (n=27) (mean) | 43-79 (66.59±10.02) | 0.3-3.0 (1.31±0.80) | 0.0-0.1 (0.27±0.04) | 0.001 | 0.0-2.5 (0.48±0.67) |
| Male (n=24) (mean) | 33-87 (67.38±13.53) | 0.3-2.5 (1.33±0.71) | 0.0-0.15 (0.01±0.03) | <0.001 | 0.0-1.9 (0.51±0.74) |
| Total (n=51) (mean) | 33-87 (66.96±11.69) | 0.3-3.0 (1.32±0.75) | 0.0-0.15 (0.20±0.04) | <0.001 | 0.0-2.5 (0.48±0.69) |

Table 2. Balance scores of the study patients before and after cataract surgery

| Female | Male | Total |
|--------|------|-------|
| Berg Balance Scale (mean) | 25-56 (48.67±8.69) | 27-56 (50.78±8.43) | 0.369 |
| | 45-56 (52.75±3.44) | 46-56 (53.88±2.95) | 0.230 |
| | 23-56 (50.59±7.00) | 27-56 (52.24±6.59) | 0.224 |
| Tinetti Gait Test (mean) | 5-12 (9.89±1.74) | 7-12 (10.37±0.82) | 0.009 |
| | 8-12 (10.29±1.04) | 10-12 (10.63±0.40) | 0.043 |
| | 5-12 (10.08±1.45) | 7-12 (10.49±1.07) | 0.001 |
| Tinetti Balance Test (mean) | 6-16 (14.11±3.17) | 7-16 (14.78±2.64) | 0.003 |
| | 12-16 (15.21±1.38) | 12-16 (15.58±1.02) | 0.095 |
| | 6-16 (14.63±2.53) | 7-16 (15.16±2.06) | 0.001 |
| Tinetti total (mean) | 11-28 (24.00±4.70) | 14-28 (26.48±0.71) | 0.072 |
| | 20-28 (25.08±1.41) | 22-28 (24.00±1.41) | 0.101 |
| | 11-28 (25.00±1.41) | 17-28 (25.50±0.70) | 0.020 |

This may indicate a stronger association between balance and vision in women.

Preoperative vision level also affects the benefit of cataract surgery on visual outcome.18 When we compared our patients’ results in two groups based on preoperative visual acuity level, the group with preoperative visual acuity worse than 0.05 showed a significantly larger increase in postoperative 1-month visual acuity than the other group (p=0.036). However, we detected no significant differences between these two groups in terms of increases in balance or gait scores. Although studies evaluating the effect of vision on balance and falls have yielded very different results, most authors agree that increased vision has a positive impact on the ability to maintain balance.15,17,19,20 In contrast to these data, the authors of a study published in 2015 argued that visual impairment in elderly cataract patients was not associated with balance disorders or falls.21 Furthermore, Cumming et al.22 found that improving older adults’ vision through treatment actually increased the incidence of falls, but they attributed this discrepant result to the fact that the patients became more mobile and active when their vision was restored. In their study of 413 patients over 50 years old, To et al.17 observed a 78% reduction in risk of falls after surgery on the first eye and 83% after surgery of the second eye. Foss et al.23 reported that the incidence of falls decreased by 32% after surgery on the second eye. Desapriya et al.19 showed that early cataract surgery substantially improved visual acuity but had no significant effect on falls. However, Supuk et al.24 emphasized that after cataract surgery, there was a significant decrease in vertigo rather than in the incidence of falls.

Most of the published studies on this topic have been retrospective, with patients’ visual acuities analyzed after examining the patients’ records or conducting surveys regarding
their falls history.\textsuperscript{4,14,15,16,17,24,25,27} Compared to objective tests, these surveys both provide inadequate information and may give rise to misleading data due to patients’ inaccurate recall of past events. Moreover, as visual acuity is measured at the time of the study, accurate information cannot be obtained about the patients’ visual acuity at the time of falling. The scientific significance of our study lies in the fact that it was planned as a prospective study and the patients were tested and evaluated at the same time by an ophthalmologist and a physical therapist. Most previous studies focused on vision and falls incidence, but there are few studies that have tested and compared patients’ pre- and postoperative balance.

Like many other studies, the current study demonstrates that, by referring individuals to eye examinations at regular intervals, quality of life can be increased and a substantial proportion of falls can be prevented in older adults.\textsuperscript{3,14,15,17,20,28,29}

**Study Limitations**

One limitation of our study is that vision level varied in the patients’ fellow eyes. While the fellow eye also had cataract in some patients, others had near perfect vision (mean LogMAR=0.48). This might have affected their balance scores. The visual benefit of cataract surgery might also vary depending on the status of the fellow eye.\textsuperscript{18} Moreover, sudden increase in vision in one eye while the other eye still has cataract may cause imbalanced vision and consequently impaired balance rather than improved balance. In fact, Meuleners et al.\textsuperscript{25} found that the incidence of falls requiring hospitalization doubled in the interval between first and second cataract surgeries compared with the preoperative period, and argued that ophthalmologists must warn patients to be more careful regarding falls after the first surgery.

Another limitation of the study is that we did not assess any other vision functions such as visual field, contrast sensitivity, depth perception, or color vision, factors that may also play a role in increasing the risk of falls. However, it is known that most of these parameters also improve after cataract surgery.\textsuperscript{3,26} Therefore, we believe that the cataract surgery we performed corrected these parameters to some degree along with visual acuity.

**Conclusion**

This study demonstrates that phacoemulsification and intraocular lens implantation significantly increases visual acuity within the first postoperative month. As a result, the low functional balance scores of individuals with severe visual impairment increased significantly. This significant postoperative improvement in vision functions may contribute to better balance and enhance patients’ quality of life.

**Ethics**

**Ethics Committee Approval:** Antalya Training and Research Hospital Clinical Research Ethics Committee, 2016-129.

**Informed Consent:** Received.

**Peer-review:** Externally peer-reviewed.

**Authorship Contributions**

Surgical and Medical Practices: Fulya Duman, Zeynep Kılıç, Concept: Fulya Duman, Design: Fulya Duman, Data Collection or Processing: Fulya Duman, Zeynep Kılıç, Analysis or Interpretation: Fulya Duman, Emel Ece Özcan Ekşi, Literature Search: Fulya Duman, Writing: Fulya Duman.

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