

Original Research Article

RELATIONSHIP BETWEEN FRAILTY AND POSTOPERATIVE FUNCTIONAL RECOVERY IN ELDERLY PATIENTS UNDERGOING CATARACT SURGERY

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ABSTRACT

Background: Frailty may influence recovery after cataract surgery in older adults despite satisfactory improvement in visual acuity. This study evaluated the relationship between preoperative frailty and postoperative functional recovery following cataract surgery.

Materials and Methods: This prospective observational study included 120 adults aged ≥ 65 years undergoing elective phacoemulsification with intraocular lens implantation. Frailty was assessed using the Clinical Frailty Scale (CFS), with scores of 1–4 classified as non-frail and ≥ 5 as frail. Visual function was evaluated using best-corrected visual acuity (BCVA) and the Catquest-9SF, while functional independence was assessed using the Barthel Index. Outcomes were assessed preoperatively and at 4–6 weeks after surgery. Multivariable logistic regression was used to identify factors associated with functional recovery.

Results: Seventy-six participants (63.3%) were non-frail and 44 (36.7%) were frail. Both groups demonstrated significant postoperative visual improvement. Functional recovery occurred in 85.5% of non-frail participants compared with 56.8% of frail participants ($P < 0.001$). Improvement in Catquest-9SF and Barthel Index scores was greater among non-frail participants. After adjustment for potential confounders, frailty remained independently associated with lower odds of functional recovery (adjusted OR, 0.30; 95% CI, 0.12–0.72; $P = 0.008$).

Conclusion: Preoperative frailty was independently associated with poorer functional recovery after cataract surgery despite substantial visual improvement. Frailty assessment may help identify older patients requiring additional postoperative functional support.

Keywords: Cataract surgery; Frailty; Functional recovery; Clinical Frailty Scale; Catquest-9SF; Older adults.

INTRODUCTION

Cataract remains a major cause of visual impairment among older adults and has consequences extending beyond reduced visual acuity. Difficulties with reading, mobility, household activities, social participation, and maintenance of independence are frequently encountered as visual function deteriorates. Increasing attention has therefore been directed toward the broader geriatric consequences of cataract, including its relationships with falls,

cognitive impairment, depression, functional limitation, and frailty.^[1] Restoration of vision through cataract surgery may consequently influence several aspects of health and everyday functioning that are not adequately reflected by postoperative visual acuity alone.

Frailty has emerged as an important measure of physiological vulnerability in older populations. It reflects reduced physiological reserve and an impaired capacity to withstand acute stressors and differs considerably among individuals of the same

chronological age. In surgical populations, frailty has been associated with postoperative complications, prolonged recovery, loss of independence, institutionalization, and mortality. Recognition of frailty during perioperative assessment may therefore provide clinically meaningful information beyond conventional measures of age and comorbidity. Visual impairment and frailty appear to have a particularly important relationship. A systematic review and meta-analysis involving more than 22,000 older adults found that visual impairment was associated with substantially greater odds of frailty.^[2] Longitudinal evidence has further demonstrated a bidirectional association, whereby visual impairment predicted subsequent frailty and frailty also increased the likelihood of later visual impairment.^[3] These findings suggest that reduced vision and declining physiological reserve may reinforce one another through reduced mobility, physical inactivity, social restriction, and increasing dependence. Age-related ocular disease may also coexist with broader manifestations of vulnerability. Population-based evidence has shown an association between cataract and cognitive frailty among older adults, reinforcing the concept that cataract should not be considered solely as an isolated ocular disorder.^[4] Contemporary reviews similarly emphasize the overlap between frailty and age-related eye disease and the potential importance of incorporating geriatric assessment into ophthalmic care.^[5] Cataract surgery generally produces substantial improvements in patient-reported visual functioning. Studies using the Catquest-9SF have demonstrated meaningful postoperative improvement in vision-dependent daily activities and have supported its usefulness for evaluating functional benefit after cataract extraction.^[6] More recent evidence also indicates that cataract surgery may have wider consequences for healthy ageing. A systematic review and meta-analysis reported an association between cataract surgery and a reduced risk of long-term cognitive decline, although the certainty of evidence varied across included studies.^[7] Despite these benefits, postoperative recovery may not be uniform among older patients. Two individuals achieving similar improvements in visual acuity may experience different levels of recovery in mobility, daily activities, and independence because of differences in baseline physiological reserve. Frailty may therefore represent an important determinant of the extent to which improved vision translates into meaningful functional recovery. The present study aimed to evaluate the relationship between preoperative frailty and postoperative functional recovery in older adults undergoing cataract surgery. We specifically examined whether frail patients experienced reduced functional improvement after surgery despite postoperative improvement in visual acuity.

MATERIAL AND METHODS

Study Design and Setting: This prospective observational study was conducted in the Department of Ophthalmology at Swamy Vivekanandha Medical College Hospital and Research Institute from January 2023 to August 2024. Participant recruitment was undertaken from January 2023 to June 2024, allowing completion of postoperative follow-up by August 2024. Consecutive older adults undergoing elective cataract surgery were evaluated to determine the relationship between preoperative frailty and postoperative functional recovery.

Sample Size: The sample size was calculated for comparison of postoperative functional recovery between frail and non-frail participants. Assuming recovery rates of approximately 80% among non-frail participants and 55% among frail participants, with 80% statistical power and a two-sided alpha level of 0.05, approximately 54 participants were required in each group. Allowing approximately 10% for loss to follow-up or incomplete assessment, the recruitment target was 120 participants.

Eligibility Criteria

Inclusion criteria were:

(1) age ≥ 65 years; (2) visually significant age-related cataract; (3) scheduled for elective phacoemulsification with intraocular lens implantation; (4) ability to complete frailty and functional assessments; (5) availability for postoperative follow-up; and (6) provision of written informed consent.

Exclusion criteria were:

(1) previous major ocular surgery in the study eye; (2) advanced glaucoma, significant corneal opacity, optic neuropathy, retinal disease, or other ocular pathology expected to substantially limit postoperative visual improvement; (3) severe cognitive impairment preventing reliable assessment; (4) major neurological or musculoskeletal disease causing substantial pre-existing functional dependency; (5) unstable systemic illness; (6) inability to complete postoperative follow-up; and (7) major intraoperative complications likely to independently influence postoperative recovery.

Frailty Assessment: Frailty was evaluated during the preoperative assessment using the Clinical Frailty Scale (CFS). The CFS is a clinical measure of overall fitness and frailty and has demonstrated acceptable reliability and clinical utility for perioperative evaluation of older surgical patients [8]. Participants with scores of 1–4 were classified as non-frail, whereas those with scores ≥ 5 were classified as frail. Frailty has been recognized as an important determinant of adverse perioperative and functional outcomes among older surgical patients.^[9]

Ophthalmic and Functional Assessment: Baseline assessment included age, sex, systemic comorbidities, medication history, best-corrected visual acuity (BCVA), intraocular pressure, slit-lamp examination, and dilated fundus examination.

Vision-related functional status was evaluated using the Catquest-9SF questionnaire, which has demonstrated satisfactory psychometric validity and responsiveness to changes in visual function following cataract surgery.^[10] General independence in activities of daily living was assessed using the Barthel Index.

Surgical Procedure and Follow-up: All participants underwent standard phacoemulsification with posterior chamber intraocular lens implantation according to institutional practice. Postoperative assessments were performed at approximately 1 week and 4–6 weeks after surgery.

BCVA, ocular findings, postoperative complications, Catquest-9SF score, and Barthel Index were reassessed during follow-up. Changes in Catquest-9SF were interpreted as indicators of patient-perceived functional improvement; contemporary studies have demonstrated clinically meaningful postoperative changes using this instrument.^[11,12]

Outcome Measures: The primary outcome was postoperative functional recovery, defined as improvement in vision-related functional ability together with maintenance or improvement of independence in activities of daily living.

Secondary outcomes included change in BCVA, change in Catquest-9SF score, change in Barthel Index, postoperative complications, and differences in functional recovery between frail and non-frail participants.

Statistical Analysis: Data were analysed using SPSS version 25.0. Continuous variables were expressed as mean $\pm$ standard deviation or median with interquartile range according to distribution. Categorical variables were reported as frequencies and percentages.

Between-group comparisons were performed using the independent-samples t test or Mann–Whitney U test for continuous variables and the chi-square test

or Fisher exact test for categorical variables. Paired preoperative and postoperative observations were compared using paired t tests or Wilcoxon signed-rank tests.

Multivariable logistic regression was used to assess the independent association between preoperative frailty and postoperative functional recovery after adjustment for age, sex, baseline BCVA, comorbidity burden, and baseline functional status. Adjusted odds ratios with 95% confidence intervals were reported. A two-sided $P < 0.05$ was considered statistically significant.

Ethical Considerations: The study was approved by the Institutional Ethics Committee before commencement of participant recruitment. Written informed consent was obtained from all participants. The study was conducted in accordance with the principles of the Declaration of Helsinki.

RESULTS

Participant Characteristics: A total of 120 participants completed the study and were included in the final analysis. The mean age of the study population was 73.3 ± 5.2 years, and 68 participants (56.7%) were women. Based on the Clinical Frailty Scale (CFS), 76 participants (63.3%) were classified as non-frail (CFS 1–4) and 44 participants (36.7%) as frail (CFS ≥ 5).

Frail participants were significantly older than non-frail participants (75.9 ± 5.3 vs. 71.8 ± 4.6 years; $P < 0.001$) and more frequently had two or more systemic comorbidities (61.4% vs. 35.5%; $P = 0.006$). Baseline Barthel Index scores were significantly lower in the frail group (89.8 ± 8.4 vs. 94.2 ± 6.1 ; $P = 0.003$). Baseline best-corrected visual acuity (BCVA) and Catquest-9SF scores were comparable between the two groups [Table 1].

Table 1: Baseline Characteristics According to Frailty Status

Characteristic	Non-frail (n=76)	Frail (n=44)	P value
Age, years	71.8 ± 4.6	75.9 ± 5.3	<0.001
Female sex, n (%)	42 (55.3)	26 (59.1)	0.683
≥ 2 systemic comorbidities, n (%)	27 (35.5)	27 (61.4)	0.006
Baseline BCVA, logMAR	0.72 ± 0.28	0.77 ± 0.31	0.380
Catquest-9SF score	23.4 ± 4.6	24.2 ± 4.9	0.381
Barthel Index	94.2 ± 6.1	89.8 ± 8.4	0.003

Values are presented as mean $\pm$ standard deviation or number (percentage).

BCVA: best-corrected visual acuity; CFS: Clinical Frailty Scale.

Postoperative Visual and Functional Changes

Both groups demonstrated substantial improvement in visual acuity following cataract surgery. Mean BCVA improved from 0.72 ± 0.28 to 0.18 ± 0.12 logMAR in the non-frail group and from 0.77 ± 0.31 to 0.24 ± 0.16 logMAR in the frail group. The difference in the magnitude of visual acuity improvement between groups was not statistically significant ($P = 0.839$).

Vision-related functional status also improved in both groups; however, the magnitude of

improvement was greater among non-frail participants. Mean Catquest-9SF score decreased from 23.4 ± 4.6 to 13.2 ± 3.5 in the non-frail group and from 24.2 ± 4.9 to 17.8 ± 4.1 in the frail group. The between-group difference in change was statistically significant ($P < 0.001$). The Barthel Index also improved after surgery, with a greater mean increase among non-frail participants than frail participants ($P = 0.045$) [Table 2].

Table 2: Changes in Visual and Functional Outcomes Following Cataract Surgery

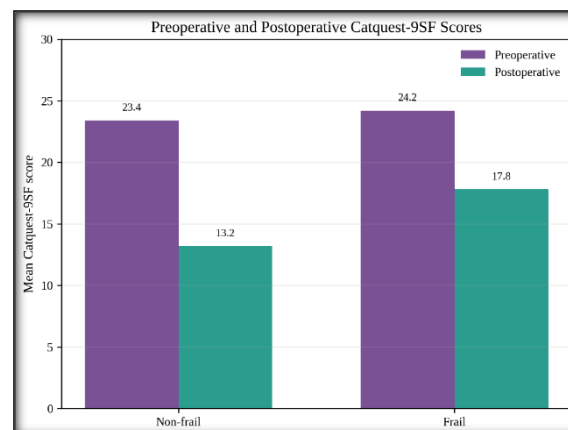
Outcome	Non-frail Preoperative	Non-frail Postoperative	Frail Preoperative	Frail Postoperative	P value for difference in change
BCVA, logMAR	0.72 ± 0.28	0.18 ± 0.12	0.77 ± 0.31	0.24 ± 0.16	0.839
Catquest-9SF score	23.4 ± 4.6	13.2 ± 3.5	24.2 ± 4.9	17.8 ± 4.1	<0.001
Barthel Index	94.2 ± 6.1	97.8 ± 3.6	89.8 ± 8.4	91.5 ± 7.2	0.045

Lower Catquest-9SF scores indicate less difficulty with vision-related activities. Lower logMAR values indicate better visual acuity. The postoperative change in Catquest-9SF score according to frailty status is illustrated in [Figure 1].

Functional Recovery According to Frailty Status

At the final postoperative assessment, 90 of 120 participants (75.0%) achieved the predefined functional recovery outcome. Recovery was observed in 65 of 76 non-frail participants (85.5%), compared with 25 of 44 frail participants (56.8%), representing a statistically significant difference ($P<0.001$). Improvement in Catquest-9SF score was observed in 93.4% of non-frail participants and 79.5% of frail participants ($P=0.036$). Maintenance or improvement in Barthel Index was also more frequent among non-frail participants (92.1% vs. 75.0%; $P=0.014$). Postoperative complications occurred in 5 non-frail participants (6.6%) and 7 frail participants (15.9%); however, this difference was

not statistically significant ($P=0.121$) [Table 3]. The difference in overall functional recovery between frail and non-frail participants is shown in [Figure 2].

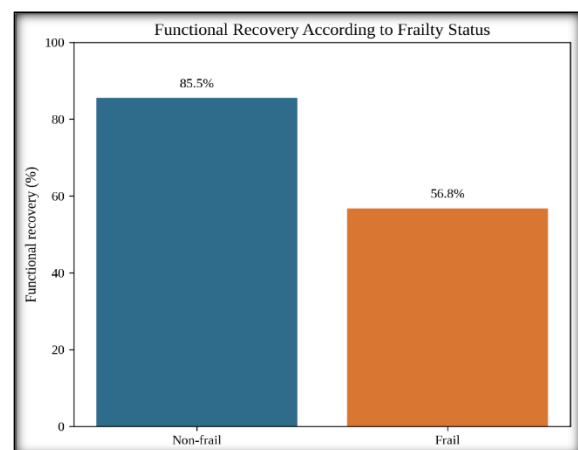
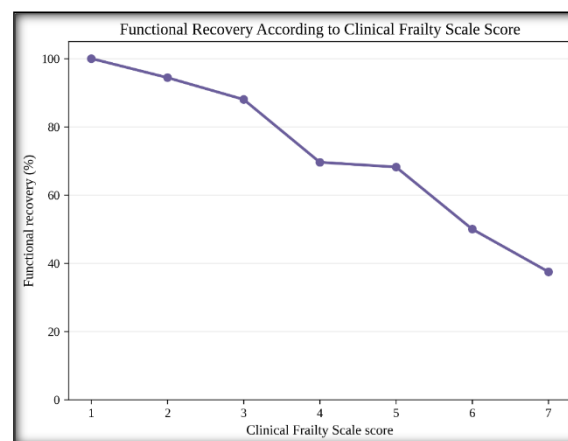
**Figure 1: Preoperative and Postoperative Catquest-9SF Scores According to Frailty Status.****Table 3: Postoperative Outcomes According to Frailty Status**

Outcome	Non-frail (n=76)	Frail (n=44)	P value
Functional recovery, n (%)	65 (85.5)	25 (56.8)	<0.001
Improvement in Catquest-9SF, n (%)	71 (93.4)	35 (79.5)	0.036
Maintained/improved Barthel Index, n (%)	70 (92.1)	33 (75.0)	0.014
Postoperative BCVA ≤ 0.30 logMAR, n (%)	70 (92.1)	36 (81.8)	0.138
Any postoperative complication, n (%)	5 (6.6)	7 (15.9)	0.121

Table 4. Multivariable Logistic Regression for Postoperative Functional Recovery

Variable	Adjusted OR	95% CI	P value
Frailty (CFS ≥ 5)	0.30	0.12–0.72	0.008
Age, per year	0.95	0.89–1.02	0.150
Female sex	1.12	0.48–2.60	0.790
Baseline BCVA, logMAR	0.62	0.19–2.01	0.430
≥ 2 systemic comorbidities	0.59	0.24–1.45	0.250
Baseline Barthel Index, per 5-point increase	1.18	1.01–1.38	0.036

OR: odds ratio; CI: confidence interval; CFS: Clinical Frailty Scale; BCVA: best-corrected visual acuity.

**Figure 2: Functional Recovery According to Frailty Status.****Figure 3: Functional Recovery According to Clinical Frailty Scale Score.**

Relationship Between Frailty Severity and Functional Recovery: A graded decline in functional recovery was observed with increasing CFS score. The proportion of participants achieving recovery was 100.0%, 94.4%, 88.0%, 69.6%, 68.2%, 50.0%, and 37.5% among those with CFS scores of 1 through 7, respectively. This pattern demonstrated an inverse relationship between frailty severity and postoperative functional recovery [Figure 3].

Multivariable Analysis: Multivariable logistic regression was performed to determine whether preoperative frailty was independently associated with postoperative functional recovery. After adjustment for age, sex, baseline BCVA, comorbidity burden, and baseline functional status, frailty remained independently associated with a lower likelihood of functional recovery. Participants with CFS ≥ 5 had approximately 70% lower adjusted odds of achieving functional recovery than non-frail participants (adjusted OR, 0.30; 95% CI, 0.12–0.72; $P=0.008$). Higher baseline Barthel Index was positively associated with postoperative functional recovery (adjusted OR, 1.18 per 5-point increase; 95% CI, 1.01–1.38; $P=0.036$). Age, sex, baseline BCVA, and comorbidity burden were not independently associated with recovery [Table 4].

DISCUSSION

The present study demonstrated that preoperative frailty was strongly associated with postoperative functional recovery in older adults undergoing cataract surgery. Although both frail and non-frail participants achieved substantial improvement in visual acuity, functional recovery was less frequent among frail patients. Only 56.8% of frail participants achieved recovery compared with 85.5% of non-frail participants, and frailty remained independently associated with poorer recovery after adjustment for age, sex, baseline visual acuity, comorbidity burden, and baseline functional status. These findings are consistent with evidence from broader surgical populations showing that frailty is associated with new disability and less favorable recovery after elective procedures.^[13]

The improvement in BCVA observed in both groups confirms that advanced age or frailty does not necessarily prevent a favorable ophthalmic result. Large registry data involving patients aged 90 years and older have shown that useful postoperative visual acuity can be achieved despite frequent ocular and systemic comorbidity.^[14] Similar findings were reported in a case-control study of very old patients, although visual gain was lower with increasing age.^[15] These observations support cataract surgery in appropriately selected older patients but also emphasize that visual success should not be considered equivalent to complete functional recovery.

The greater improvement in Catquest-9SF scores among non-frail participants is particularly relevant

because patient-reported visual function reflects the practical consequences of restored vision in daily life. Grimfors et al. demonstrated that clinically meaningful change in Catquest-9SF scores can be identified following cataract surgery, reinforcing its value beyond visual acuity.^[16] Cataract extraction has also been associated with increased participation in moderate physical activity after first- and second-eye surgery.^[17] In older adults with severe visual impairment, cataract surgery improved activities of daily living and social participation.^[18] The smaller functional gains observed in frail participants may therefore reflect limitations in translating improved vision into increased mobility and independence. Several mechanisms may explain this disparity. Frailty is characterized by diminished physiological reserve, weakness, reduced activity, and vulnerability to stressors. Even after technically successful cataract surgery, limitations related to mobility, balance, cognition, or multimorbidity may restrict resumption of daily activities. Cataract surgery in very elderly individuals has been associated with improvements in quality of life and cognitive performance,^[19] suggesting that visual restoration can contribute to multidimensional recovery. However, the extent of benefit is likely to depend on baseline reserve. Evidence from frail surgical populations suggests that perioperative exercise and nutritional strategies may support functional recovery, although benefits vary across outcomes.^[20]

These findings have practical implications for ophthalmic care. Incorporating a brief frailty assessment before cataract surgery may identify patients who require realistic counselling, closer postoperative assessment, mobility support, rehabilitation, or coordination with geriatric services. Frailty should not be interpreted as a reason to withhold surgery; rather, it may help distinguish expected visual improvement from the likely trajectory of functional recovery.

This study has limitations. It was conducted at a single institution with a modest sample size, and functional recovery was assessed over a relatively short postoperative period. Residual confounding from cognitive, nutritional, socioeconomic, and psychosocial factors is possible. Larger multicentre studies with longer follow-up are needed to determine whether early differences persist. Nevertheless, the findings indicate that preoperative frailty is an important determinant of functional recovery after cataract surgery and may provide clinically useful information beyond age and visual acuity alone.

CONCLUSION

Preoperative frailty was significantly associated with poorer postoperative functional recovery in older adults undergoing cataract surgery. Although both frail and non-frail participants achieved meaningful improvements in visual acuity, frail patients

experienced smaller gains in vision-related functioning and activities of daily living. Frailty remained an independent predictor of reduced functional recovery after adjustment for relevant clinical factors. These findings suggest that incorporating frailty assessment into the preoperative evaluation of older cataract patients may help identify individuals who could benefit from closer postoperative monitoring, individualized counselling, and additional functional support. Cataract surgery can still provide substantial visual benefit in frail older adults; however, recovery should be evaluated using broader functional outcomes rather than visual acuity alone.

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