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Risk of Fractures Following Cataract Surgery in Medicare Beneficiaries

Victoria L. Tseng, MD
Fei Yu, PhD
Flora Lum, MD
Anne L. Coleman, MD, PhD

Context Visual impairment is a known risk factor for fractures. Little is known about the association of cataract surgery with fracture risk.

Objective To determine the association of cataract surgery with subsequent fracture risk in US Medicare beneficiaries with a diagnosis of cataract.

Design, Setting, and Participants Retrospective study of 1-year fracture incidence in a 5% random sample of Medicare Part B beneficiaries with cataract who received and did not receive cataract surgery from 2002 through 2009.

Main Outcome Measures One-year incidence of hip fractures. Analyses were adjusted for age; sex; race/ethnicity; US region of residence; systemic comorbidities, including Charlson Comorbidity Index (CCI) score; ocular comorbidities; cataract severity; and presence of physically limiting conditions. Adjusted odds ratios (ORs) of hip fractures were calculated using logistic regression modeling.

Results There were 1 113 640 US Medicare beneficiaries 65 years and older with a diagnosis of cataract between 2002 and 2009 in the 5% random sample; of these patients, 410 809 (36.9%) received cataract surgery during the study period. There were 13 976 patients (1.3%) who sustained a hip fracture during the study period. The most common fracture-related comorbidity was osteoporosis (n=134 335; 12.1%). The most common ocular comorbidity was glaucoma (n=212 382; 19.1%). Compared with 1-year hip fracture incidence in patients with cataract who did not have cataract surgery, adjusted OR of hip fracture within 1 year after cataract surgery was 0.84 (95% CI, 0.81-0.87) with an absolute risk difference of 0.20%. Compared with matched subgroups of patients who did not receive cataract surgery, patient subgroups that experienced lower odds of hip fracture after cataract surgery included patients with severe cataract, patients most likely to receive cataract surgery based on propensity score, patients 75 years and older, and patients with a CCI score of 3 or greater.

Conclusion In a cohort of US Medicare beneficiaries aged 65 years and older with a diagnosis of cataract, patients who had cataract surgery had lower odds of hip fracture within 1 year after surgery compared with patients who had not undergone cataract surgery.

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FRACTURES SECONDARY TO FALLS are a significant cause of morbidity and mortality in the elderly population,[1] accounting for more than 60% of expenses resulting from fall-related injuries and costing the United States more than $10 billion in the year 2000.[2] Visual impairment has been found to be strongly associated with an increased risk of fractures,[3-5] with reports of increased fracture incidence in patients with poor visual acuity,[4] depth perception,[6] contrast sensitivity,[6] and visual field loss.[7]

Specifically, vision plays an important role in providing a reference frame for postural balance and stability, and cataract-induced changes in vision have been found to be associated with postural instability.[8] A systematic review found that patients who wait more than 6 months for cataract surgery had an increased rate of falls.[9] Furthermore, cataracts have been found to be the most common cause of fracture-related visual impairment,[10] with untreated cataract causing up to 49% of visual impairment in patients with femoral neck fractures related to decreased vision.[10]

Despite the association of poor vision and cataracts with increased fall and fracture risk, only a limited number of studies[11-15] have examined the influence of cataract surgery on fall incidence in visually impaired adults, and only 2 of these studies[11,12] examined the incidence of fractures secondary to falls. These 2 studies examined the relationship of first and second eye cataract surgery with fall and fracture risk in the same population of women in the United Kingdom older than 70 years, with sample sizes of fewer than 350 pa-

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Author Affiliations: Division of Ophthalmology, Warren Alpert Medical School of Brown University, Providence, Rhode Island (Dr Tseng); Center for Eye Epidemiology, Jules Stein Eye Institute, David Geffen School of Medicine (Drs Yu and Coleman), and Departments of Biostatistics (Dr Yu) and Epidemiology (Dr Coleman), Fielding School of Public Health, University of California, Los Angeles; and American Academy of Ophthalmology, H. Dunbar Hoskins Jr, MD, Center for Quality Eye Care, San Francisco, California (Drs Lum and Coleman).
Corresponding Author: Anne L. Coleman, MD, PhD, Jules Stein Eye Institute, David Geffen School of Medicine, UCLA, 100 Stein Plaza, 2-118, Los Angeles, CA 90095 (colemana@ucla.edu).

tients in each study. To our knowledge, no other studies have examined the association of cataract surgery and fracture incidence in visually impaired adults. This study examined the association between cataract surgery and fracture incidence in a cohort of US Medicare beneficiaries.

METHODS

The 2002-2010 Denominator and Physician/Supplier Part B files for a 5% random sample of Medicare beneficiaries were obtained from the Centers for Medicare & Medicaid Services (CMS). Data for all patients with diagnosis codes for cataract were extracted from the Physician/Supplier Part B files using the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*)[16] diagnosis codes (eAppendix 1, available at http://www.jama.com).

Patients with the following characteristics were excluded: age younger than 65 years, residence outside the 50 US states or District of Columbia, lack of Medicare Part B coverage, possession of health maintenance organization coverage not processed by the CMS, and history of cataract surgery before the study period indicated by the presence of aphakia or pseudophakia based on *ICD-9-CM* diagnosis codes. Medicare Part A claims were not included; patients who are admitted as inpatients to the hospital still have physician services billed under Part B.[17] The study was approved by the institutional review board of the University of California, Los Angeles.

The cataract surgery group comprised Medicare patients who had a diagnosis code of cataract and then a procedure code for cataract surgery using *Current Procedural Terminology* (*CPT*)[18] codes from 2002 to 2009. The cataract diagnosis group comprised patients with a diagnosis code of cataract without a cataract surgery procedure code. The cataract surgery group patients were followed up for 1 year after the date of surgery, which was defined by the date of the first service bill for cataract surgery. The cataract diagnosis group patients were followed up for the calendar year in which the diagnosis appeared.

Outcomes

The primary outcome of this study was the occurrence of hip fracture during the follow-up period. The secondary outcome was the occurrence of any fracture during the follow-up period. Fracture occurrence was defined by the first surgical or nonsurgical fracture-related Medicare service; single and multiple fractures were not distinguished. Surgical services were identified by *CPT* codes, and nonsurgical services were identified by *ICD-9-CM* diagnosis codes (eAppendix 2).

To further compare fracture incidence between the cataract surgery and cataract diagnosis groups, a 1-year look back was also performed for the cataract surgery group to determine the incidence of fractures 1 year prior to surgery. Patients who received cataract surgery in 2002 did not have fracture data included in the 1-year look back because Medicare data from 2001 were not available.

Baseline Characteristics

Demographics included age, sex, self-reported race/ethnicity, and US region of residence. Patients were categorized into 5-year age subgroups as was done in previous studies of fracture risk that stratified patients by age.[1,7] Mean age was also assessed, although it may have been underestimated because all patients 98 years and older are coded as being 98 years old in the Medicare database. Patient race in the Medicare database was determined by self-reported data from the Social Security Administration at the time of application for a Social Security number.[19]

Overall systemic health was determined by the Charlson Comorbidity Index (CCI) score, which assigns patients a score between 0 and 6 based on the likelihood of mortality secondary to age and the presence or absence of selected systemic diseases.[20] In the original CCI study cohort, a score of 0 was associated with a 10-year survival rate of 99%, and a score of 5 was associated with a 10-year survival rate of 34%.

Diseases in the CCI include myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic pulmonary disease, rheumatologic disease, peptic ulcer disease, cirrhosis, hepatic failure, immunosuppression, diabetes mellitus with or without complications, hemiplegia or paraplegia, chronic renal disease, malignant neoplasms, multiple myeloma or leukemia, lymphomas, metastatic solid tumor, and AIDS. Charlson Comorbidity Index score stratification was selected based on the original CCI study, which classified 1-year mortality based on CCI score subgroups of 0 (12% mortality), 1 or 2 (26% mortality), 3 or 4 (52% mortality), and 5 or greater (85% mortality).[20]

Systemic conditions that increase the risk of fractures and are not included in the CCI were also examined; these included osteoporosis, hyperthyroidism, hyperparathyroidism, and Cushing syndrome. Ocular comorbidities included glaucoma, age-related macular degeneration, and diabetes mellitus with ophthalmic manifestations. Both systemic and ocular comorbidities were identified using *ICD-9-CM* diagnosis codes (eAppendix 3 and eAppendix 4).

Two additional baseline characteristics that were examined included severe cataracts and physically limiting conditions. As the Medicare database does not have data on visual acuity or cataract surgery wait time, the prevalence of severe cataracts was considered a proxy for these factors. Cataract subtypes that were considered severe included anterior and posterior subcapsular cataracts, total or mature cataract, hypermature cataract, and combined forms of cataract. To determine patient mobility, the presence of 1 or more physically limiting conditions was examined; these conditions included limitations secondary to cerebrovascular disease, hemiplegia, paraplegia, myopathy, neuropathy, and peripheral vascular disease. With the exception of Cushing syndrome, for

which prevalence was too sparse for model inclusion, all baseline characteristics were considered potential confounding factors and included in the statistical model.

Statistical Analysis

Descriptive statistics were used to describe the baseline characteristics for the entire study population, the cataract surgery group, and the cataract diagnosis group. Baseline characteristics of the cataract surgery and cataract diagnosis groups were compared with χ^2 tests. The association of cataract surgery with 1-year incidence of hip fractures and any fractures was estimated using multivariable logistic regression models and expressed as an adjusted odds ratio (OR) with a 95% confidence interval. Potential confounders that were included in the adjusted analysis included age, sex, race/ethnicity, US region of residence, CCI score, osteoporosis, hyperthyroidism, hyperparathyroidism, glaucoma, age-related macular degeneration, diabetes mellitus with ophthalmic manifestations, severe cataract, and having 1 or more physically limiting conditions.

Age was coded as a continuous variable that truncated at 98 years of age because all Medicare patients 98 years and older are coded as 98 years old. Age was analyzed as a categorical variable. Race/ethnicity, sex, and region of residence were coded and analyzed as categorical variables. Charlson Comorbidity Index score was calculated based on the presence or absence of the 20 systemic conditions mentioned earlier in this section; CCI score was thus coded as a continuous variable but analyzed as a categorical variable. All systemic and ocular comorbidities were coded and analyzed as dummy variables based on the presence of the condition. Logistic regression models were also performed on age, sex, CCI score, and severe cataract subgroups to further examine their influences on the 1-year fracture incidence after cataract surgery. Tests of interaction with cataract surgery were performed for age, sex, and CCI subgroups.

The propensity score of having cataract surgery was calculated for each patient by a logistic regression model including all variables in the fully adjusted logistic regression for fractures. Patients were divided into decile subgroups, or 10 subgroups of equal sample size, based on their propensity

Table 1. Baseline Characteristics of Patients With Cataract in the 5% Medicare Sample, 2002-2009

Characteristic	No. of Patients (%)			*P* Value[a]
	All Patients With Cataract (N = 1 113 640)	Cataract Surgery Group (n = 410 809)	Cataract Diagnosis Group (n = 702 831)	
Age, y				
65-69	370 113 (33.2)	80 077 (19.5)	290 036 (41.3)	<.001
70-74	265 993 (23.9)	103 758 (25.3)	162 235 (23.1)	
75-79	226 880 (20.4)	110 278 (26.8)	116 602 (16.6)	
80-84	152 583 (13.7)	76 818 (18.7)	75 765 (10.8)	
85-90	71 817 (6.5)	31 798 (7.7)	40 019 (5.7)	
>90	26 254 (2.4)	8080 (2.0)	18 174 (2.6)	
Mean (SD)[b]	74.0 (7.0)	75.7 (6.4)	73.0 (7.1)	
Sex				
Male	446 186 (40.1)	156 642 (38.1)	289 544 (41.2)	<.001
Female	667 454 (59.9)	254 167 (61.9)	413 287 (58.8)	
Race				
White	980 668 (88.1)	366 062 (89.1)	614 606 (87.5)	<.001
Black	78 110 (7.0)	24 863 (6.1)	53 247 (7.6)	
Asian	19 142 (1.7)	6980 (1.7)	12 162 (1.7)	
Hispanic	17 887 (1.6)	6959 (1.7)	10 928 (1.6)	
Native American	3745 (0.3)	1425 (0.4)	2320 (0.3)	
Other	12 851 (1.2)	4104 (1.0)	8747 (1.2)	
Unknown	1237 (0.1)	416 (0.1)	821 (0.1)	
Region of US residence				
East	461 860 (41.5)	162 066 (39.5)	299 794 (42.7)	<.001
West	181 651 (16.3)	66 351 (16.2)	115 300 (16.4)	
Midwest	282 544 (25.4)	107 246 (26.1)	175 298 (24.9)	
South	187 585 (16.8)	75 146 (18.3)	112 439 (16.0)	
Charlson comorbidity index score				
1-2	732 759 (65.8)	258 024 (62.8)	474 735 (67.6)	<.001
3-4	293 779 (26.4)	118 330 (28.8)	175 449 (25.0)	
≥5	87 102 (7.8)	34 455 (8.4)	52 647 (7.5)	
Systemic comorbidities associated with fracture risk				
Osteoporosis	134 335 (12.1)	54 156 (13.2)	80 179 (11.4)	<.001
Hyperthyroidism	16 667 (1.5)	6259 (1.5)	10 408 (1.5)	.07
Hyperparathyroidism	6085 (0.6)	2400 (0.6)	3685 (0.5)	<.001
Cushing syndrome	460 (0.0)	188 (0.1)	272 (0.0)	.08
Physically limiting conditions[c]	153 604 (13.8)	60 073 (14.6)	93 531 (13.3)	<.001
Ocular comorbidities				
AMD	182 417 (16.4)	87 674 (21.3)	94 743 (13.5)	<.001
DM with ophthalmic manifestations	62 004 (5.6)	26 688 (6.5)	35 316 (5.0)	<.001
Glaucoma	212 382 (19.1)	92 742 (22.6)	119 640 (17.0)	<.001
Severe cataract[d]	233 118 (20.9)	168 180 (40.9)	64 938 (9.2)	<.001

Abbreviations: AMD, age-related macular degeneration; DM, diabetes mellitus.
[a] χ^2 test compares values between cataract surgery and cataract diagnosis groups.
[b] Patient age is truncated at 98 years in the Medicare database, so both mean and SD of age are underestimated here.
[c] Includes conditions secondary to cerebrovascular events, hemiplegia or paraplegia, myopathy, neuropathy, and peripheral vascular disease.
[d] Includes anterior and posterior subcapsular cataracts, total/mature cataract, hypermature cataract, and combined forms of cataract.

scores. The incidences of hip fractures and any fractures were then determined for each propensity score subgroup and compared between the cataract surgery and cataract diagnosis groups. All statistical analyses were conducted using SAS version 9.2 (SAS Institute).

RESULTS

Demographic data are listed in TABLE 1. A total of 1 113 640 unique patients with a diagnosis code of cataract (366.x) were identified and met the inclusion criteria. Of these patients, the majority were female (n=667 454; 59.9%) and white (n=980 668; 88.1%). The plurality of patients were between 65 and 69 years old (n=370 113; 33.2%) and lived in the eastern United States (n=461 860; 41.5%). Of patients with cataract, 410 809 (36.9%) received cataract surgery during the study period. The cataract surgery group was older than the cataract diagnosis group. There was a statistically significant difference in the distribution of all demographic factors between the 2 groups.

Table 2. One-Year Crude Incidence of Fractures Among Patients With Cataract in the 5% Medicare Sample, 2002-2009 (N = 1 113 640)

	1-Year Crude Incidence	
Type of Fracture	No.	% (95% CI)
Any fracture	59 791	5.37 (5.33-5.41)
Head and neck	3214	0.29 (0.28-0.30)
Rib	6448	0.58 (0.56-0.59)
Vertebral	8516	0.76 (0.75-0.78)
Upper limb	18 136	1.63 (1.61-1.65)
Lower limb	27 344	2.46 (2.43-2.48)
Pelvis	3377	0.30 (0.29-0.31)
Hip	13 976	1.25 (1.23-1.28)
Other/unspecified	1947	0.17 (0.17-0.18)

Prevalence of Baseline Comorbidities

Baseline comorbidities are listed in Table 1. The majority of patients in both the cataract surgery and cataract diagnosis groups had a CCI score of 1 or 2; no patients in the study had a score of 0. Osteoporosis was the most common fracture-related comorbidity (n=134 335; 12.1%); there was a low prevalence (<2%) of other systemic conditions related to fractures. When compared with the cataract diagnosis group, there was a significantly higher prevalence of osteoporosis, hyperparathyroidism, and all ocular comorbidities in the cataract surgery group.

The prevalence of severe cataract was significantly higher in the cataract surgery group (n=168 180; 40.9%) than the cataract diagnosis group (n=64 938; 9.2%). The prevalence of 1 or more physically limiting conditions was significantly higher in the cataract surgery group than in the cataract diagnosis group among all the study patients ($P<.001$) but was not different between 2 groups when only examining patients with severe cataract ($P=.35$).

Fracture Incidence

During the study period, the overall 1-year fracture incidence was 1.3% (n=13 976) for hip fractures and 5.4% (n=59 791) for any fractures. Fracture incidences for other body parts are listed in TABLE 2. The crude incidences of hip fractures in cataract surgery and diagnosis groups were 1.3% and 1.2%, respectively, for patients with any cataract and 1.3% and 1.5%, respectively, for patients with severe cataract (TABLE 3).

Fracture Risk

The unadjusted OR of hip fracture within 1 year demonstrated higher odds of fracture in the cataract surgery group compared with the cataract diagnosis group (OR, 1.05; 95% CI, 1.02-1.09). Stepwise adjustment with demographics and comorbidities showed lower odds of hip fracture in the cataract surgery group compared with the cataract diagnosis group for all levels of adjustment (TABLE 4). In patients with severe cataract only, both unadjusted and fully adjusted models demonstrated lower odds of hip fracture in the cataract surgery group compared with the cataract diagnosis group (Table 4).

The absolute risk differences between the cataract diagnosis and cataract surgery groups for hip fractures and any fractures were 0.20% and 0.24%, respectively. The numbers needed to treat for hip fractures and any fractures were 507 and 422, respectively.

Risk of Fractures by Propensity Score Decile

After stratifying by decile of propensity score, which adjusted for all demographic and comorbidity factors noted earlier, the differences in all variables

Table 3. One-Year Crude Incidence of Fractures Among Patients With Cataract in the 5% Medicare Sample, 2002-2009

	Cataract Surgery Group						
	1 Year Prior to Surgery[a]		1 Year After Surgery		Cataract Diagnosis Group[b]		
	No./Total No. of Patients	Incidence, % (95% CI)	No./Total No. of Patients	Incidence, % (95% CI)	No./Total No. of Patients	Incidence, % (95% CI)	*P* Value[c]
Any cataract							
Hip fracture	4261/410 809	1.04 (1.01-1.07)	5321/410 809	1.30 (1.26-1.33)	8655/702 831	1.23 (1.21-1.26)	.003
Any fracture	20 722/410 809	5.04 (4.98-5.11)	23 333/410 809	5.68 (5.61-5.75)	36 448/702 831	5.19 (5.13-5.24)	<.001
Severe cataract							
Hip fracture	1822/168 180	1.08 (1.03-1.13)	2172/168 180	1.29 (1.24-1.35)	982/64 938	1.51 (1.42-1.61)	<.001
Any fracture	8627/168 180	5.13 (5.02-5.24)	9582/168 180	5.70 (5.59-5.81)	3698/64 938	5.69 (5.52-5.88)	.98

[a] Data on fractures prior to 2002 were not available for patients who had cataract surgery in 2002.
[b] One year after diagnosis.
[c] χ^2 test compares crude incidence of fractures 1 year after surgery between cataract surgery and cataract diagnosis groups.

Table 4. Fracture Risk Among Patients With Cataract in the 5% Medicare Sample, 2002-2009

Adjustment Factors	Hip Fractures After Cataract Surgery		Any Fractures After Cataract Surgery	
	OR (95% CI)[a]	*P* Value	OR (95% CI)[a]	*P* Value
Among patients with any cataract (N = 1 113 640)				
Unadjusted	1.05 (1.02-1.09)	.004	1.10 (1.08-1.12)	<.001
+Age	0.84 (0.81-0.87)	<.001	0.98 (0.97-1.00)	.06
+Race, sex, residence[b]	0.83 (0.80-0.86)	<.001	0.97 (0.95-0.98)	<.001
+Comorbidities[b,c]	0.84 (0.81-0.87)	<.001	0.96 (0.94-0.97)	<.001
+Physically limiting conditions and severe cataract[b,d]	0.84 (0.81-0.87)	<.001	0.95 (0.93-0.97)	<.001
Among patients with severe cataract (n = 233 118)[d]				
Unadjusted	0.85 (0.79-0.92)	<.001	1.00 (0.96-1.04)	.98
Fully adjusted	0.77 (0.72-0.84)	<.001	0.92 (0.89-0.96)	<.001

Abbreviation: OR, odds ratio.
[a] Cataract patients without cataract surgery were used as a reference.
[b] Each additional adjustment also includes all the adjustment factors previously listed.
[c] Includes Charlson Comorbidity Index score and systemic and ocular comorbidities listed in Table 1, except for Cushing syndrome, physically limiting conditions, and severe cataract.
[d] Includes anterior and posterior subcapsular cataracts, total/mature cataract, hypermature cataract, and combined forms of cataract.

within each propensity score decile stratum between the cataract diagnosis and cataract surgery groups were within 5%, although some variables remained statistically significant (eTables 1 through 10). There were lower odds of hip fractures within 1 year in patients in the upper 5 deciles of propensity scores (TABLE 5). When compared with the cataract diagnosis group, the odds of hip fractures within 1 year in the cataract surgery group progressively decreased with each increasing decile of propensity score, with the lowest odds of fracture in the highest decile of propensity score (OR, 0.68; 95% CI, 0.61-0.75).

Risk of Fractures by Age and Sex

Tests of interaction were significant for cataract surgery and age ($P<.001$) but not significant for sex ($P=.75$) (TABLE 6). Logistic regression analysis was not performed for cataract surgery and sex because of the test of interaction that was not significant.

When stratified by age and adjusting for all other demographic and comorbidity factors noted earlier, there were lower odds of fracture within 1 year in patients aged 75 years and older in the cataract surgery group when compared with patients with the same age in the cataract diagnosis group (Table 6). When compared with patients of the same age in the cataract diagnosis group, patients 80 to 84 years old in the cataract surgery group had the lowest odds of hip fracture after cataract surgery of all the age groups (OR, 0.72; 95% CI, 0.67-0.78).

Risk of Fractures by CCI Score

When stratified by CCI score, there were lower odds of hip fractures following cataract surgery in patients with a CCI score of 3 or 4 and 5 or greater in the cataract surgery group when compared with patients with the same CCI scores in the cataract diagnosis group (Table 6). The association was stronger for patients with CCI score of 3 or 4 than for patients with CCI score of 5 or greater, with ORs of 0.72 (95% CI, 0.68-0.77) and 0.74 (95% CI, 0.68-0.81), respectively.

COMMENT

Cataract surgery was associated with a 16% decrease in the adjusted odds of hip fracture 1 year after the procedure in Medicare patients 65 years and older when compared with patients with a diagnosis code for cataract who did not have cataract surgery. Patients with cataract surgery had a higher crude risk of hip fracture when compared with patients who did not have cataract surgery, although this was due to unequal age distributions between the 2 groups and likely due to confounding by indication. In patients with severe cataract, the association between cataract surgery and lower odds of hip fracture was even stronger, with 23% reduction in the adjusted odds of hip fracture in the cataract surgery group compared with the cataract diagnosis group.

When compared with patients in the cataract diagnosis group with similar propensity scores, the patients with the highest propensity scores who were most likely to receive cataract surgery experienced the most significant decrease in odds of hip fracture following cataract surgery. Patients who were sicker also experienced lower odds of hip fracture following cataract surgery; patients with a CCI score of 3 or 4 in the cataract surgery group were 28% less likely to experience a fracture than equally sick patients in the cataract diagnosis group, and patients with a CCI score 5 or greater were 26% less likely to experience a fracture following cataract surgery compared with patients with a CCI score 5 or greater who did not receive surgery. When compared with age-matched counterparts who did not receive cataract surgery, this study found that patients aged 80 to 84 years experienced the most significant reduction in odds of hip fracture following cataract surgery of all 5-year age groups older than 65 years. Although sex is associated with the risk of hip fracture,[21] there was no differ-

ence in the risk reduction of hip fractures after cataract surgery by sex.

Comparison With Existing Studies

A literature search was conducted on October 4, 2011, in PubMed with no date restrictions and was limited to articles published in English. The search strategy used the MeSH term *cataract extraction* and the text words *fractures* and *falls*. The searches yielded 44 articles. Studies were included for qualitative analysis if they specifically examined the incidence of fractures or falls after cataract surgery. Studies that only examined the incidence of fractures or falls in patients with cataract but did not examine incidence following cataract surgery were not included. Studies that did not analyze the effect of cataract extraction on fall or fracture incidence separately from other visual interventions were not included. A total of 5 articles met the criteria for inclusion. The comparison of findings from the current study with the small number of existing studies[11-15] of falls and fractures following cataract surgery was limited by differences in sample size, study population, and study design. All existing studies examined the incidence of falls following cataract surgery as a primary outcome, with only 2 studies[11,12] examining fracture incidence as a secondary outcome.

Although all existing studies were prospective, only the studies by Harwood et al[11] and Foss et al[12] were randomized controlled trials. These studies examined fracture incidence in 306 and 239 women with cataracts, respectively. In both of these studies, patients were randomized either to expedited cataract surgery or cataract surgery with normal wait time. Harwood et al[11] reported that expedited cataract surgery reduced the 1-year incidence of falls postoperatively when compared with cataract surgery with normal wait times in the United Kingdom for women older than 70 years. There was a 34% reduction in the rate of falls overall (rate ratio, 0.66; 95% CI, 0.45-0.96). A total of 16 patients sustained fractures following cataract surgery; 4 of these patients were in the expedited cataract surgery group and 12 in the group with normal wait times. The 1-year fracture incidence after expedited cataract surgery was 67% less than the 1-year fracture incidence after cataract surgery with normal wait time (risk ratio, 0.33; 95% CI, 0.1-1.0). Fall and fracture incidence was determined by patient diary recordings, telephone calls, and in-person interviews.

Foss et al[12] examined the same population as that in the study by Harwood et al; they used the same methodology but looked at the effect of second-eye rather than first-eye cataract surgery on

Table 5. One-Year Incidence of Fractures Stratified by Propensity Score of Cataract Surgery Among Patients With Cataract in the 5% Medicare Sample, 2002-2009 (N = 1 113 640)

	Hip Fracture						Any Fracture					
	Cataract Surgery Group		Cataract Diagnosis Group				Cataract Surgery Group		Cataract Diagnosis Group			
Propensity Score Decile Subgroup[a]	No./Total No. of Patients	Incidence, % (95% CI)	No./Total No. of Patients	Incidence, % (95% CI)	OR (95% CI)[b]	*P* Value	No./Total No. of Patients	Incidence, % (95% CI)	No./Total No. of Patients	Incidence, % (95% CI)	OR (95% CI)[b]	*P* Value
1 (n = 114 815)	50/13 023	0.38 (0.29-0.51)	329/101 792	0.32 (0.29-0.36)	1.19 (0.88-1.60)	.26	473/13 023	3.63 (3.32-3.97)	2903/101 792	2.85 (2.75-2.96)	1.28 (1.16-1.42)	<.001
2 (n = 107 921)	90/15 354	0.59 (0.47-0.72)	502/92 567	0.54 (0.50-0.59)	1.08 (0.86-1.35)	.50	699/15 354	4.55 (4.23-4.89)	3753/92 567	4.05 (3.93-4.18)	1.13 (1.04-1.23)	.004
3 (n = 117 691)	201/22 484	0.89 (0.78-1.03)	888/95 207	0.93 (0.87-1.00)	0.96 (0.82-1.12)	.59	1102/22 484	4.90 (4.62-5.19)	4324/95 207	4.54 (4.41-4.68)	1.08 (1.01-1.16)	.02
4 (n = 105 332)	308/27 358	1.13 (1.00-1.26)	926/77 974	1.19 (1.11-1.27)	0.95 (0.83-1.08)	.41	1363/27 358	4.98 (4.73-5.25)	3913/77 974	5.02 (4.87-5.17)	0.99 (0.93-1.06)	.81
5 (n = 111 068)	449/34 330	1.31 (1.19-1.43)	1106/76 738	1.44 (1.36-1.53)	0.91 (0.81-1.01)	.08	1795/34 330	5.23 (5.00-5.47)	4116/76 738	5.36 (5.21-5.53)	0.97 (0.92-1.03)	.36
6 (n = 111 359)	539/39 669	1.36 (1.25-1.48)	1173/71 690	1.64 (1.54-1.73)	0.83 (0.75-0.92)	<.001	2282/39 669	5.75 (5.53-5.99)	4460/71 690	6.22 (6.05-6.40)	0.92 (0.87-0.97)	.002
7 (n = 109 416)	700/43 485	1.61 (1.49-1.73)	1428/65 931	2.17 (2.06-2.28)	0.74 (0.68-0.81)	<.001	2747/43 485	6.32 (6.09-6.55)	4772/65 931	7.24 (7.04-7.44)	0.86 (0.82-0.91)	<.001
8 (n = 113 313)	749/52 738	1.42 (1.32-1.52)	1207/60 575	1.99 (1.88-2.11)	0.71 (0.65-0.78)	<.001	3239/52 738	6.14 (5.94-6.35)	4317/60 575	7.13 (6.92-7.33)	0.85 (0.81-0.89)	<.001
9 (n = 111 397)	819/72 990	1.12 (1.05-1.20)	586/38 407	1.53 (1.41-1.65)	0.73 (0.66-0.82)	<.001	3806/72 990	5.21 (5.05-5.38)	2239/38 407	5.83 (5.60-6.07)	0.89 (0.84-0.94)	<.001
10 (n = 111 328)	1416/89 378	1.58 (1.50-1.67)	510/21 950	2.32 (2.13-2.53)	0.68 (0.61-0.75)	<.001	5827/89 378	6.52 (6.36-6.68)	1651/21 950	7.52 (7.18-7.88)	0.86 (0.81-0.91)	<.001

Abbreviation: OR, odds ratio.

[a] Propensity score of cataract surgery was calculated based on following factors: age, race, sex, region of US residence, Charlson Comorbidity Index score, osteoporosis, hyperthyroidism, hyperparathyroidism, age-related macular degeneration, diabetes mellitus with ophthalmic manifestations, glaucoma, presence of physically limiting conditions, and severe cataract.

[b] For fractures after cataract surgery. Cataract patients without cataract surgery were used as a reference.

the rate of falls. They did not find a significant association between second-eye cataract surgery and decreased odds of falls or fractures but acknowledged that their study was underpowered, with only 8 patients who experienced a fracture during their study period. A systematic review looked at these 2 studies and did not find a significant effect on falls. It did also note other flaws of these studies: confounding variables were not adequately controlled for; both trials had insufficient power; and 10.7% of cases were lost to follow-up secondary to death, patient withdrawal from the study, and patients undergoing surgery outside the study.[15]

Brannan et al[13] reported a statistically significant decrease in the rate of falls after cataract surgery when compared with the rate of falls preoperatively in 31 patients (OR, 0.08; 95% CI, 0.0092 to >0.32). Fall incidence was determined by patient diary recordings and telephone calls. Limitations of the study by Brannan et al include lack of a control group of patients who did not have cataract surgery and a small sample size of 84 total patients. McGwin et al[14] reported that cataract surgery was not associated with decreased odds of falls. They compared patients with cataract who received and did not receive surgery. Fall incidence was determined by patient interviews at baseline and 12 months later; patients did not record falls in a diary or questionnaire. Limitations of the study by McGwin et al include recall bias and lack of stratification of patients by age and comorbidities.

Study Limitations

The limitations of this study are mainly related to its observational and retrospective nature and use of administrative data. Observational studies are inherently limited by their inability to account for unmeasured confounders, leading to the possibility of increased bias and preventing the ability to reach causal conclusions.[22,23] To try to adjust for the inability of this study to account for selection bias and confounding by clinical indication, fracture incidences were compared for the cataract surgery and cataract diagnosis groups after patients in each group were matched by propensity scores; this analysis demonstrated that patients most likely to have cataract surgery experienced significantly lower fracture incidence following surgery when com-

Table 6. Incidence and Risk of Fractures by Age and Charlson Comorbidity Index Score Among Patients With Cataract in the 5% Medicare Sample, 2002-2009[a,b]

	Cataract Surgery Group		Cataract Diagnosis Group			
	No./Total No. of Patients	Incidence, % (95% CI)	No./Total No. of Patients	Incidence, % (95% CI)	Adjusted OR (95% CI)	*P* Value
By Age[c,d]						
Hip fracture						
65-69 y (n = 370 113)	438/80 077	0.55 (0.50-0.60)	1124/290 036	0.39 (0.37-0.41)	1.16 (1.03-1.31)	.02
70-74 y (n = 265 993)	782/103 758	0.75 (0.70-0.81)	1110/162 235	0.68 (0.64-0.73)	0.99 (0.90-1.10)	.87
75-79 y (n = 226 880)	1291/110 278	1.17 (1.11-1.24)	1666/116 602	1.43 (1.36-1.50)	0.78 (0.72-0.85)	<.001
80-84 y (n = 152 583)	1465/76 818	1.91 (1.81-2.01)	2022/75 765	2.67 (2.56-2.79)	0.72 (0.67-0.78)	<.001
85-89 y (n = 71 817)	998/31 798	3.14 (2.95-3.34)	1651/40 019	4.13 (3.93-4.32)	0.80 (0.74-0.88)	<.001
≥90 y (n = 26 254)	347/8080	4.29 (3.86-4.76)	1082/18 174	5.95 (5.61-6.31)	0.77 (0.67-0.88)	<.001
Any fracture						
65-69 y (n = 370 113)	3424/80 077	4.28 (4.14-4.42)	10 385/290 036	3.58 (3.51-3.65)	1.09 (1.04-1.14)	<.001
70-74 y (n = 265 993)	4897/103 758	4.72 (4.59-4.85)	6736/162 235	4.15 (4.06-4.25)	1.04 (0.99-1.08)	.09
75-79 y (n = 226 880)	6038/110 278	5.48 (5.34-5.61)	6782/116 602	5.82 (5.68-5.95)	0.90 (0.86-0.93)	<.001
80-84 y (n = 152 583)	5351/76 818	6.97 (6.79-7.15)	6052/75 765	7.99 (7.80-8.18)	0.87 (0.84-0.91)	<.001
85-89 y (n = 71 817)	2746/31 798	8.64 (8.33-8.95)	4202/40 019	10.50 (10.20-10.80)	0.84 (0.79-0.89)	<.001
≥90 y (n = 26 254)	877/8080	10.85 (10.18-11.55)	2291/18 174	12.61 (12.13-13.10)	0.90 (0.82-0.98)	.02
By CCI Score[c,e]						
Hip fracture						
1-2 (n = 732 759)	2344/258 024	0.91 (0.87-0.95)	3075/474 735	0.65 (0.63-0.67)	0.99 (0.94-1.06)	.86
3-4 (n = 293 779)	1965/118 330	1.66 (1.59-1.74)	3569/175 449	2.03 (1.97-2.10)	0.72 (0.68-0.77)	<.001
≥5 (n = 87 102)	1012/34 455	2.94 (2.76-3.12)	2011/52 647	3.82 (3.66-3.98)	0.74 (0.68-0.81)	<.001
Any fracture						
1-2 (n = 732 759)	11 706/258 024	4.54 (4.46-4.62)	17 895/474 735	3.77 (3.72-3.82)	1.03 (1.00-1.06)	.04
3-4 (n = 293 779)	7979/118 330	6.74 (6.60-6.89)	12 586/175 449	7.17 (7.05-7.30)	0.86 (0.83-0.89)	<.001
≥5 (n = 87 102)	3648/34 455	10.59 (10.26-10.91)	5967/52 647	11.33 (11.06-11.61)	0.90 (0.86-0.94)	<.001

Abbreviations: CCI, Charlson Comorbidity Index; OR, odds ratio.
[a] Tests of interaction for hip fractures: $P < .001$ for cataract surgery × age and cataract surgery × CCI score.
[b] Tests of interaction for any fractures: $P < .001$ for cataract surgery × age and cataract surgery × CCI score.
[c] Adjusted OR for fractures after cataract surgery. Cataract patients without cataract surgery were used as a reference.
[d] Odds ratio and *P* value were adjusted for sex, race, region of US residence, CCI score, osteoporosis, hyperthyroidism, hyperparathyroidism, age-related macular degeneration, diabetes mellitus with ophthalmic manifestations, glaucoma, presence of physically limiting conditions, and severe cataract.
[e] Odds ratio and *P* value were adjusted for age, sex, race, region of US residence, osteoporosis, hyperthyroidism, hyperparathyroidism, age-related macular degeneration, diabetes mellitus with ophthalmic manifestations, glaucoma, presence of physically limiting conditions, and severe cataract.

pared with patients who did not receive surgery.

The Medicare data set is based on billing data from *ICD-9-CM* and *CPT* codes; certain codes for parameters relevant to this study were thus not available, including visual acuity, medication use, and laterality of cataract surgery. Additionally, there were certain relevant parameters for which a code was available but not routinely used by clinicians, including smoking, alcohol use, obesity, visual impairment, and falls. To account for the lack of data on visual acuity and cataract surgery wait time, a subgroup analysis was performed in patients with a diagnosis code for severe cataract, which demonstrated stronger effects than the analysis of the entire study population. To account for the possibility of patient immobility as a confounder, the prevalence of 1 or more physically limiting conditions was determined for the cataract surgery and cataract diagnosis groups. Although there was a significant difference in the prevalence of these conditions for the overall study population, the difference was not significant in patients with severe cataract, suggesting that patient immobility was unlikely confounding the significant association between cataract surgery and lower odds of fracture in patients with severe cataract.

In addition to the lack of certain codes, there are other limitations to the Medicare database. For the 1-year look back of fracture incidence in the cataract surgery, there were no data available before 2002. Therefore, fracture data prior to surgery was not available for patients who had cataract surgery in 2002, and this may have lowered the 1-year look back fracture incidence for the cataract surgery group. There may have also been misclassification of existing codes that were examined in this study. However, in large-scale studies based on claims data, misclassification errors have been shown to occur in the same frequency in both comparison groups as a function of the large size of the population, overcoming the effects of nondifferential misclassification errors.[24]

For patients in the cataract diagnosis group who experienced a fracture, it was not possible to determine whether the diagnosis code for cataract or fracture appeared first in the calendar year. However, given that most types of cataract are chronic, it is likely that the majority of patients in the cataract diagnosis group had a cataract present for most of the calendar year when the diagnosis appeared. Furthermore, by adjusting for CCI score and systemic conditions known to increase fracture risk, the potential confounding effect of systemic comorbidities on fracture risk was reduced for this group of patients. Another limitation of the control group is the inability to identify patients who self-paid for cataract surgery and thus did not appear to have cataract surgery in the Medicare database. However, it is likely that the majority of these patients would still have an *ICD-9-CM* code for pseudophakia, which would have excluded them from the study. Finally, there is a possibility that patients who died or switched to insurance outside of Medicare did not have a full year of follow-up data available. However, given that this study has a short 1-year follow-up period, the dropout rate is most likely small and ignorable, especially for younger and healthier patients who are less likely to die or drop out within 1 year of follow-up.

Study Advantages

This study has several strengths. To date, this is the largest and most comprehensive study of the association between cataract surgery and fracture risk. The Medicare database is highly representative of the US population 65 years and older: in 2009, 38 765 399 of 39 570 500 total US adults aged 65 years and older (98%) were enrolled in Medicare.[25,26] In addition to being representative of the US population, the large sample size in this study increases its statistical power and ability to detect differences accurately between 2 comparison groups. Finally, the Medicare database has a large availability of clinical and procedural ocular and systemic data in addition to regional and demographic data, increasing the ability of this study to assess and control for a wide range of conditions in a diverse patient population.

CONCLUSIONS

Cataract surgery may be associated with lower odds of subsequent fracture in patients aged 65 years and older in the US Medicare population. Future prospective studies using standardized registries of patients with cataracts will help further elucidate the association between cataract surgery and fracture risk. Cataract surgery has already been demonstrated to be a cost-effective intervention for visual improvement, with an estimated cost per quality-adjusted life-year gained for cataract surgery in the first eye of $2023 in the United States[27] and $2727 in the second eye.[28] The results in this study suggest the need for further investigation of the additional potential benefit of cataract surgery as a cost-effective intervention to decrease the incidence of fractures in the elderly.

Author Contributions: Dr Yu had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Tseng, Yu, Coleman.
Acquisition of data: Yu, Lum, Coleman.
Analysis and interpretation of data: Tseng, Yu, Lum, Coleman.
Drafting of the manuscript: Tseng, Yu, Coleman.
Critical revision of the manuscript for important intellectual content: Tseng, Yu, Lum, Coleman.
Statistical analysis: Tseng, Yu, Coleman.
Obtained funding: Coleman.
Administrative, technical, or material support: Lum, Coleman.
Study supervision: Coleman.
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