

Characteristics and outcomes of fall-related open-globe injuries in pseudophakic patients

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Aim: We aimed to identify the characteristics and prognostic indicators of poor visual and anatomic outcome in pseudophakic patients with fall-related open-globe (OG) injuries. We used a case series design, for a total of 26 patients.

Methods: Charts of consecutive pseudophakic patients with fall-related OG injury at a single institution were reviewed. Demographics, ophthalmic history, circumstances of injury, initial best-corrected visual acuity (BCVA), examination findings, surgical interventions, and follow-up BCVA were tabulated for statistical analysis with unpaired *t*-tests and Fisher's exact tests.

Results: Nineteen patients (73%) were women. Mean (\pm standard deviation) age was 80.6 ± 4.6 years (range: 61–97 years). Initial BCVA was $<20/400$ in 24 of 25 patients (96%). Mean ocular trauma score (OTS) was 38.54 ± 10.95 . OTS was lower ($P=0.0017$, $P<0.0001$, and $P=0.0240$) and wound size was larger ($P=0.0440$, 0.0145 , and 0.0026) in patients with final BCVA $<20/40$, $<20/400$, and phthisis at final follow-up, respectively; compared to patients with BCVA $\geq 20/40$, $20/400$, and no phthisis at final follow-up, respectively. Final BCVA $<20/400$ was associated with 360° subconjunctival hemorrhage (SCH), retinal detachment, and proliferative vitreoretinopathy ($P=0.0498$, 0.0181 , and 0.0310 , respectively). Total hyphema, intraocular lens (IOL) damage, and IOL expulsion were associated with needing multiple surgical interventions ($P=0.0345$, $P<0.0001$, and $P=0.0023$, respectively).

Conclusion: Large wound size, low OTS, 360° SCH, total hyphema, posterior injury, and IOL damage are common findings that are also prognostic of poor visual and anatomic outcome in pseudophakic patients with fall-related OG injuries. Ophthalmologists dealing primarily with geriatric populations should contribute to the discussion of fall risk.

Keywords: fall, injury, open globe, pseudophakia, trauma

Introduction

Falls are the most common cause of traumatic morbidity and mortality in the elderly and are responsible for hospitalization in up to one in three people over the age of 65 years.^{1,2} Falls also account for 5% of ocular injuries, of which open-globe (OG) injuries pose the most serious threat to vision. According to the United States Eye Injury Registry, fall mechanism and age >60 years increased the likelihood of blindness, defined as best-corrected visual acuity (BCVA) worse than $20/200$.^{3,4}

In our anecdotal experience, visual outcomes are poor in pseudophakic geriatric patients with fall-related OG injuries, particularly with extracapsular cataract extraction (ECCE) wound dehiscence, but prognostic data are limited. Few reports have addressed geriatric and fall-related OG injuries in general.^{5,6} A report of phakic and pseudophakic geriatric OG injuries (all mechanisms) demonstrated worse initial and follow-up BCVA and lower ocular trauma score (OTS) compared to their younger counterparts.⁵ In a report of OG injuries resulting from falls in phakic and pseudophakic patients of

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all ages, fall-related OG injuries resulted in worse initial and postoperative BCVA, and they occurred more frequently in older patients than in the control database of OG injuries.⁶

The magnitude of the public health and economic consequences of fall-related ocular injuries will increase as the aging population grows. The aim of this study therefore was to investigate the characteristics, visual and surgical outcomes, and prognostic factors of fall-related OG injuries in pseudophakic patients.

Methods

The study protocol was approved by the Human Investigations Committee of the Yale University School of Medicine. A retrospective chart review was performed for all patients who presented to the Yale–New Haven Hospital with OG injury between January 1, 2003, and December 31, 2013. The hospital and outpatient records were reviewed for the selection of cases and tabulation of demographics, ophthalmic history, circumstances and mechanism of injury; BCVA and ocular examination findings at the time of injury; and surgical interventions and the follow-up BCVA and ocular examination findings. Fall-related OG injuries in pseudophakic patients with at least 6 months of follow-up after injury were identified for inclusion in the study.

OTS was calculated as described previously for each patient.⁷ We used unpaired *t*-tests to compare mean \pm standard deviation (SD) of the OTS between patients with 1) history of ECCE versus standard phacoemulsification (PE), 2) history of penetrating keratoplasty (PKP) versus no PKP, 3) final BCVA $\geq 20/40$ versus $<20/40$, 4) final BCVA $\geq 20/400$ versus $<20/400$, and 5) phthisis at final follow-up versus no phthisis. Mean (\pm SD) of wound size (in millimeters) was also compared among the aforementioned groups.

Fisher's exact tests were used to determine if significant associations existed between predictor variables and outcomes. Predictors were presence of layering hyphema (any size), total hyphema, 360° subconjunctival hemorrhage (SCH), intraocular lens (IOL) damage, IOL expulsion, vitreous hemorrhage, retinal detachment (RD), choroidal detachment or rupture, wound size ≥ 10 mm, uveal prolapse, vitreous prolapse, corneal wound (Zone I),⁸ corneoscleral wound within 5 mm of the limbus (Zone II), corneoscleral wound extending ≥ 5 mm from the limbus (Zone III), future RD, and future proliferative vitreoretinopathy (PVR). Outcomes were final BCVA $\geq 20/40$, final BCVA $\geq 20/400$, final BCVA $<20/400$, no light perception at final follow-up, phthisis at final follow-up, ≥ 2 surgeries needed during follow-up, and ≥ 3 surgeries needed during follow-up. An odds ratio >1 (correlative) or <1

(inverse) with $P \leq 0.05$ was considered significant. Statistical analyses were performed using SAS 9.3.

Results

Inclusion criteria were met by 26 pseudophakic patients, 19 of whom (73%) were women. Mean age (\pm SD) was 80.6 ± 4.6 years (range: 61–97 years). Cataract surgery had been performed 4.6 ± 3.4 years (range: 1.5–14.0 years) prior to the date of OG injury, and the procedure was PE in 16 patients (62%) and ECCE in 10 patients (38%). Ocular history also included PKP in four patients (15%) and glaucoma surgery in two patients (8%). Four patients (15%) had dementia, and a majority of patients had at least one or a combination of cardiovascular comorbidities, including hypertension (88%), diabetes (54%), and coronary artery disease (38%).

Falls occurred predominantly indoors and at home. The most common materials of impact were the floor, furniture, and sharp objects (Table 1). The left eye was injured in 14 of 26 cases (54%). BCVA at the time of injury was $\leq 20/200$ in all patients and was $<20/400$ in 24 of 25 patients (96%). One patient could not be tested for visual acuity due to profound dementia.

Hyphema was present in 22 patients (85%), 77% of whom had $\geq 50\%$ anterior chamber (AC) fill. All 26 patients had iris damage, including uveal prolapse in 85% of patients. Approximately half of the patients presented with 360° SCH. Damage to the IOL included expelled or dislocated IOLs in 58% of patients.

Adnexal injuries (periorbital ecchymosis and edema, facial laceration, and orbital fracture) and posterior injuries (vitreous hemorrhage, RD, and choroidal hemorrhage or detachment) were variably present at the time of globe rupture (Table 1). Wound location was predominant in Zones I and II; Zone III wounds occurred in six patients (23%). There were no cases of intraocular foreign body.

Mean OTS was 38.54 ± 10.95 . OTS was significantly lower in patients with 6-month and final BCVA $<20/40$, $<20/400$, and phthisis, compared to patients with BCVA $\geq 20/40$, $20/400$, and no phthisis, respectively ($P=0.0017$, $P<0.0001$, and $P=0.0240$; Table 2 and Figure 1). Wound size was significantly larger in the same categories ($P=0.0440$, 0.0145 , and 0.0026 ; Table 3 and Figure 2). There was no significant difference in OTS or wound size between patients with history of ECCE versus standard PE or between those with PKP versus no PKP. Times to presentation and primary repair were within 24 hours for 24 of 26 patients.

Mean final follow-up was 16.6 ± 14.7 months (range: 6–48 months). BCVA at 6 months and at final

Table I Circumstances and characteristics of injury

	N (%)
Location	
Indoor	18 (69)
Outdoor	8 (31)
Home	16 (62)
Outside the home/not specified	10 (38)
Mechanism of injury	
Rupture	22 (85)
Penetration	4 (15)
Material of impact	
Floor/concrete/front porch	13 (50)
Furniture*	7 (27)
Other object**	6 (23)
Presenting BCVA*** (25)	
NLP	4 (16)
LP/HM	17 (68)
CF	3 (12)
20/200	1 (4)
APD*** (13)	6 (46)
Hyphema	22 (85)
100% AC fill	11 (50)
50%–99% AC fill	6 (27)
<50% AC fill	5 (23)
360° SCH*** (24)	13 (54)
Iris injury	26 (100)
IOL damage	15 (58)
Expulsed IOL	11 (73)
Dislocated IOL	4 (27)
Periorbital ecchymosis/edema	19 (73)
Facial/lid laceration	12 (46)
Orbital fracture	7 (27)
VH	21 (81)
RD	12 (46)
PVR, delayed	6 (23)
Choroidal detachment/rupture	10 (38)
Wound location	
Zone I	18 (69)
Zone II	17 (65)
Zone III	6 (23)
Wound characteristics	
> 10 mm	14 (54)
Uveal prolapse	22 (85)
Vitreous prolapse	13 (50)
6-month BCVA*** (25)	
NLP/prosthesis	6 (24)
LP/HM	5 (20)
CF	7 (28)
<20/40 to ≥20/400	3 (12)
≥20/40	4 (16)
Final BCVA*** (25)	
NLP/prosthesis	6 (24)
LP/HM	7 (28)
CF	5 (20)
<20/40 to ≥20/400	3 (12)
≥20/40	4 (16)

Notes: *Furniture: table (4), night stand (2), and chair (1). **Other objects: walker, car door, cup, fork, thermostat. ***Numbers in parentheses denote total number of patients for whom the data were available if <26.

Abbreviations: AC, anterior chamber; APD, afferent pupillary defect; BCVA, best-corrected visual acuity; CF, count fingers; HM, hand motion; IOL, intraocular lens; LP, light perception; NLP, no light perception; PVR, proliferative vitreoretinopathy; RD, retinal detachment; SCH, subconjunctival hemorrhage; VH, vitreous hemorrhage.

follow-up was <20/400 in 18 of 25 eyes (72%). Twelve eyes (46%) required ≥2 surgeries after injury, including vitrectomy at a later date for cases that involved vitreous loss, nonclearing vitreous hemorrhage, or posterior injury. Seven eyes (26%) developed phthisis, and enucleation was performed on one eye (2%). There were no cases of endophthalmitis, and all patients had received intravenous antibiotics at the time of OG repair.

Fisher's exact tests revealed decreased likelihood of 6-month and final BCVA ≥20/40 in patients with wound size ≥10 mm and RD at the time of injury ($P=0.0491$, Table 4). Patients with 360° SCH, wound size ≥10 mm, RD at initial presentation, delayed RD, or delayed PVR were less likely to achieve BCVA ≥20/400 at 6 months and at final follow-up ($P=0.0498$, $P=0.0181$, $P=0.0022$, $P<0.0001$, or $P=0.0097$, respectively; Table 4). The number of required surgical interventions was more likely to be ≥2 in patients who presented with total hyphema, IOL damage, and IOL expulsion ($P=0.0345$, $P<0.0001$, and $P=0.0023$).

Discussion

While traumatic OG injuries are typically associated with young males,^{9,10} fall-related OG injury represents a demographically and clinically unique entity. Falls are the most common mechanism of OG injury in geriatric patients³ and in pseudophakic wound dehiscence.¹¹ Women with osteoporosis and osteoarthritis face increased fall risk, and as was the case in our study, patients often have significant medical comorbidities, rendering the potential for the fall to be a preterminal event.⁶ Our cases also confirm prior reports of increased prevalence of fall-related OG injuries in elderly women,^{5,6,10,11} tendency for blunt rupture mechanism,^{6,10} and poor visual outcome.^{6,10–12}

Although ocular trauma in the domestic setting is underreported,⁹ our cases further suggest that fall-related OG injuries are most commonly sustained at home.⁵ The surgical wound in pseudophakic patients appears to render the eye susceptible to blunt rupture.^{5,11} In a review of 63 patients with pseudophakic wound dehiscence caused by falls, blunt trauma, and motor vehicle accidents, history of standard PE was associated with better final BCVA compared to history of ECCE.¹¹ In contrast, 14 of our 26 fall cases involved larger ECCE or PKP wounds, but neither of these entities was associated with decreased OTS, increased wound size, or decreased final BCVA compared to standard PE.

While the majority of injuries in the United States Eye Injury Registry demonstrate eventual recovery of functional visual acuity,³ visual acuity in our series was poor both at

Table 2 Ocular trauma score at the time of injury

	N	Mean	SD	P-value
All patients	26	38.54	10.95	
6-month and final BCVA $\geq 20/40$	4	52.00	10.00	0.0017
6-month and final BCVA $< 20/40$	21	35.85	9.14	
6-month and final BCVA $\geq 20/400$	7	51.29	7.87	<0.0001
6-month and final BCVA $< 20/400$	18	33.69	7.01	
No phthisis	18	41.82	10.99	0.0240
Phthisis at final follow-up	7	30.57	5.63	
History of ECCE	10	39.50	12.92	0.7261
History of standard PE	16	37.86	9.76	
History of PKP	4	36.50	7.77	0.4167
No PKP	22	38.95	11.60	

Note: Bold indicates significant values, $P < 0.05$.

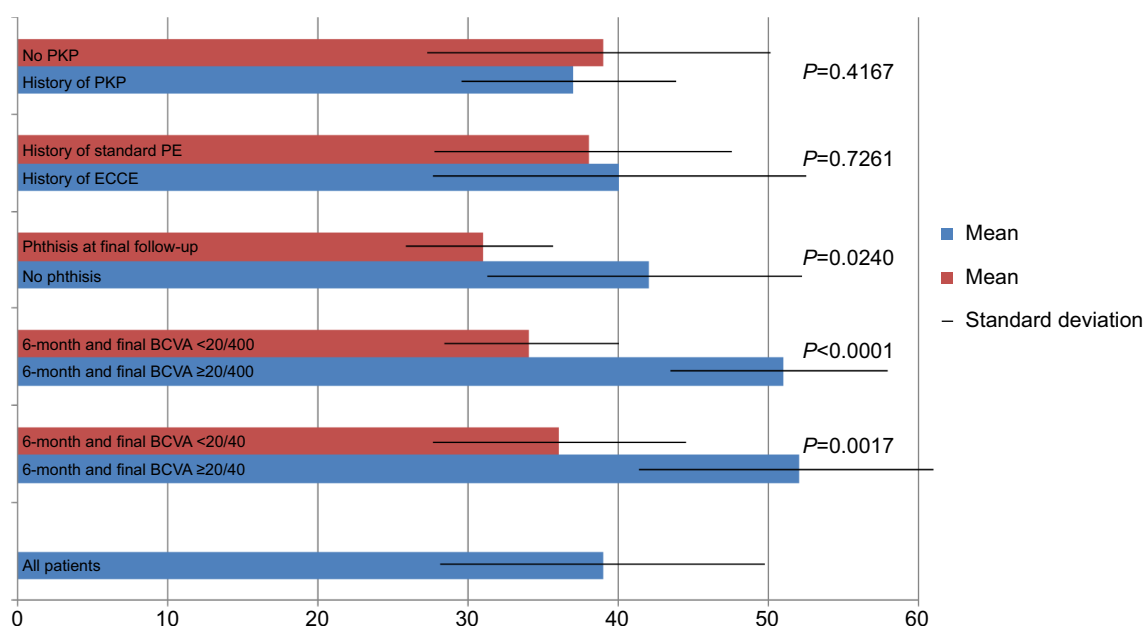
Abbreviations: BCVA, best-corrected visual acuity; ECCE, extracapsular cataract extraction; PE, phacoemulsification; PKP, penetrating keratoplasty; SD, standard deviation.

initial presentation and at final follow-up, including final BCVA $< 20/400$ in 72% of eyes and hand motion vision or worse in more than half. Similarly, final BCVA was $< 20/400$ in 84% of patients with fall-related OG injuries.⁶ In a study of geriatric OG injuries, lower OTS and worse initial and final visual acuity levels were noted in comparison to OG injuries in younger patients.⁵ In our patients, lower OTS, larger wound size, 360° SCH, RD, and PVR were predictive of poor visual outcome, while hyphema, iris injury, IOL damage, adnexal injury, vitreous hemorrhage, and wound location did not yield significant results. The average OTS in this pseudophakic fall population was 38.54 (SD: 10.95); thus, most patients were OTS Class 1 or 2, with $> 50\%$ chance of final BCVA being light perception or worse.⁷ Concordantly, 52% of our

patients had light perception or worse at 6 months and at final follow-up.

Posterior injuries were present in a majority of patients, while adnexal injuries (including periorbital ecchymosis or edema) and facial or eyelid laceration were important presenting signs and were more common in this series than in a population of all mechanisms of OG injury.¹³ There was 100% incidence of iris damage, which in conjunction with a limbal wound, predisposes the pseudophakic patient to hyphema and often bullous SCH.

Enucleation and endophthalmitis have been uncommon outcomes in this population, likely due to blunt (rather than penetrating) OG injury mechanism and the absence of intraocular foreign body.^{5,6,14} However, phthisis tended

**Figure 1** Ocular trauma score at the time of injury.

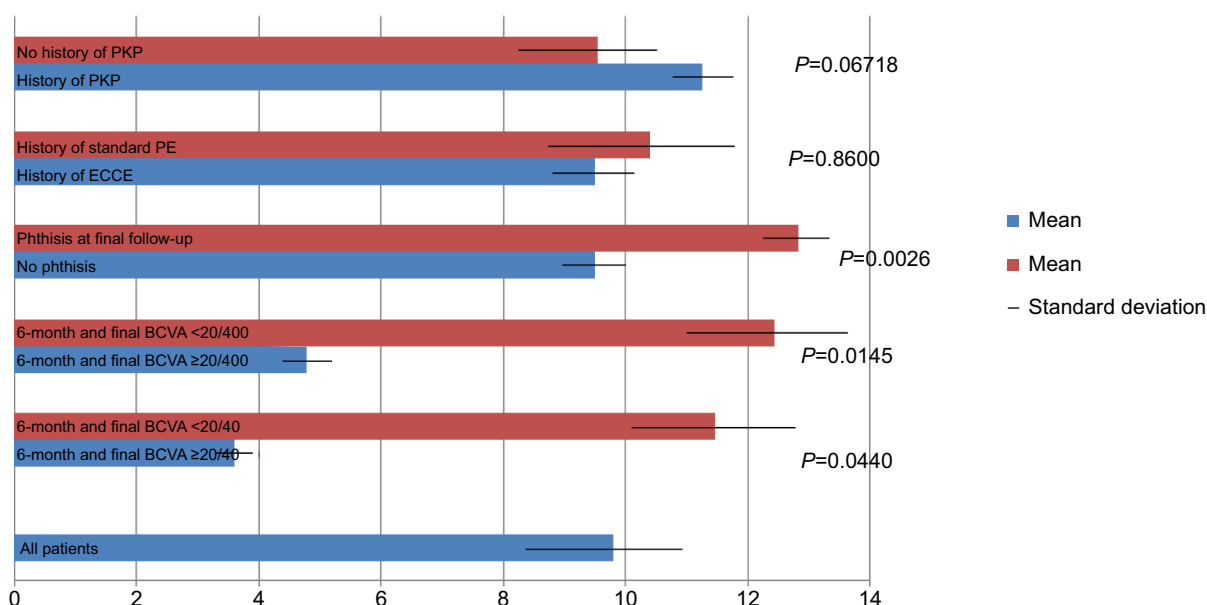
Abbreviations: BCVA, best-corrected visual acuity; ECCE, extracapsular cataract extraction; PE, phacoemulsification; PKP, penetrating keratoplasty.

Table 3 Wound size (mm) at the time of injury

	N	Mean	SD	P-value
All patients	26	9.81	7.20	
6-month and final BCVA $\geq 20/40$	4	3.63	1.70	0.0440
6-month and final BCVA $< 20/40$	21	11.47	7.20	
6-month and final BCVA $\geq 20/400$	7	4.79	2.77	0.0145
6-month and final BCVA $< 20/400$	18	12.44	7.37	
No phthisis	18	9.50	3.84	0.0026
Phthisis at final follow-up	7	12.83	3.43	
History of ECCE	10	9.50	3.84	0.8600
History of standard PE	16	10.04	9.03	
History of PKP	4	11.25	2.50	0.6718
No PKP	22	9.53	7.83	

Note: Bold indicates significant values, $P < 0.05$.

Abbreviations: BCVA, best-corrected visual acuity; ECCE, extracapsular cataract extraction; PE, phacoemulsification; PKP, penetrating keratoplasty; SD, standard deviation.

**Figure 2** Wound size (mm) at the time of injury.

Abbreviations: BCVA, best-corrected visual acuity; ECCE, extracapsular cataract extraction; PE, phacoemulsification; PKP, penetrating keratoplasty.

Table 4 Inverse correlation (odds ratio < 1) of visual outcomes with initial or delayed ocular findings using Fisher's exact test

	P-value	Odds ratio
6-month and final BCVA $\geq 20/40$, by wound ≥ 10 mm	0.0491	0.2941
6-month and final BCVA $\geq 20/40$, by RD, initial presentation	0.0491	0.2941
6-month and final BCVA $\geq 20/400$, by 360° SCH	0.0498	0.0800
6-month and final BCVA $\geq 20/400$, by RD, initial presentation	0.0022	0.2143
6-month and final BCVA $\geq 20/400$, by wound ≥ 10 mm	0.0181	0.0545
6-month and final BCVA $\geq 20/400$, by RD, initial or delayed	< 0.0001	0.1429
6-month and final BCVA $\geq 20/400$, by PVR, delayed	0.0097	0.2500

Abbreviations: BCVA, best-corrected visual acuity; PVR, proliferative vitreoretinopathy; RD, retinal detachment; SCH, subconjunctival hemorrhage.

Table 5 Direct correlation (odds ratio >1) of visual and surgical outcomes with initial or delayed ocular findings using Fisher's exact test

	P-value	Odds ratio
6-month and final BCVA <20/400, by 360° SCH	0.0498	12.5000
6-month and final BCVA <20/400, by RD, initial presentation	0.0498	12.5000
6-month and final BCVA <20/400, by RD, initial or delayed	0.0181	18.3333
6-month and final BCVA <20/400, by PVR, delayed	0.0310	3.0000
≥2 surgeries needed, by hyphema 100%	0.0345	2.7500
≥2 surgeries needed, by IOL damage	<0.0001	2.5000
≥2 surgeries needed, by expelled IOL	0.0023	5.5000

Abbreviations: BCVA, best-corrected visual acuity; IOL, intraocular lens; PVR, proliferative vitreoretinopathy; RD, retinal detachment; SCH, subconjunctival hemorrhage.

to develop in patients with lower OTS and larger wound size. Approximately half of the patients required ≥2 surgeries after injury, with IOL expulsion or dislocation and total hyphema being predictive factors. Limitations to this study include retrospective design and relatively small sample size due to the very specific nature of the injury and population. Furthermore, the presence of dementia in this population also limits the ability to obtain an accurate visual acuity.

In conclusion, fall-related OG injury in pseudophakic patients results in profound visual disability, with damage to multiple ocular structures. Wound size, OTS, hyphema, IOL damage, and posterior injury are important prognostic considerations. Despite vision being maximized in the pseudophakic population, the geriatric patient remains at risk for falls, particularly with previously addressed risk factors. Because visual loss is not a commonly discussed consequence of falls, it is incumbent upon the ophthalmologist, who deals primarily with the geriatric population, to contribute to the discussion of fall risk and direct the pseudophakic patient to appropriate educational resources.

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Disclosure

The authors report no conflicts of interest in this work.

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