

Utility Assessment of Follow-up Evaluation for Commotio Retinae

Henry W. Zhou, MD, MS¹ , Sandra Hoyek, MD¹, Shravan V. Savant, MD^{2,3},
Scott R. Shuldiner, MD¹, Grayson W. Armstrong, MD, MPH¹ ,
John B. Miller, MD¹, and Nimesh A. Patel, MD^{1,2} 

Abstract

Purpose: To perform an outcome and cost analysis of follow-up visits and associated imaging in patients presenting to the Massachusetts Eye and Ear emergency department with commotio retinae. **Methods:** This retrospective consecutive case series comprised consecutive patients presenting to the emergency department from January 1, 2020, to January 1, 2022, who were diagnosed with contusion or other injuries of the eye or orbit (International Classification of Diseases, 10th edition, codes S05.1 and S05.8). Cost analysis was performed using Medicare fee data and previously described methods. Costs considered included follow-up examinations, optical coherence tomography (OCT), and fundus photography. **Results:** Of the 490 patients presenting to the emergency department, 201 had findings of commotio retinae on examination and were included in this study. Of the 201 patients with initial commotio retinae, 142 (70.6%) returned for follow-up. OCT was performed in 34% of patients and fundus photography in 33%. A total of 254 follow-up visits were conducted. Four patients (2.8%) had retinal tears on follow-up, with only 1 (0.7%) developing a retinal detachment. Complications requiring intervention were always heralded by worsening symptoms. The total cost of follow-up was \$60,436 for the cohort and \$425.60 per patient. **Conclusions:** Patients with commotio retinae infrequently develop retinal complications and have a high rate of loss to follow-up. Significant resources are dedicated to following up and imaging patients with commotio retinae. Our results underscore the low utility in multiple follow-up visits among asymptomatic patients.

Keywords

commotio retinae, cost analysis, follow-up, imaging

Introduction

Ocular and orbital trauma are common causes of emergency department visits across the United States. The rate of eye injuries observed in emergency department settings varies widely but has been estimated to be approximately 3.2 to 3.5 per 1000 population.^{1,2} The incidence of eye trauma is highest in younger male patients in their 20s and 30s.^{2,3} The published data reporting the total societal cost of eye trauma in the US, including healthcare costs and lost productivity, are scant; however, the figure is likely high given the incidence and disproportionate burden among working-age cohorts.

Commotio retinae results from blunt trauma to the eye or orbit, which disrupts retinal photoreceptor outer segments.^{4–7} When commotio retinae affects the macula, it is also referred to as Berlin edema.⁸ Isolated commotio retinae found on examination typically resolves without complication in a few days.⁹ Extramacular commotio retinae is associated with particularly excellent visual outcomes.¹⁰ Nevertheless, finding commotio retinae on a fundus examination in an emergency setting often prompts scheduled follow-up with retina specialists.

Here, we present the results of a cost analysis of follow-up visits and associated imaging in a cohort of 201 consecutive patients presenting with commotio retinae to the Massachusetts Eye and Ear (MEE) emergency department.

Methods

This retrospective case series was approved by the Institutional Review Board of Massachusetts General Brigham (protocol ID: 2022P002496). Clinical records were reviewed manually for consecutive patients presenting to the MEE emergency

¹ Department of Ophthalmology, Massachusetts Eye and Ear, Harvard Medical School, Boston, MA, USA

² Department of Ophthalmology, Boston Children's Hospital, Harvard Medical School, Boston, MA, USA

³ Department of Ophthalmology, Beth Israel Lahey Health, Boston, MA, USA

Corresponding Author:

Nimesh A. Patel, MD, Department of Ophthalmology, Massachusetts Eye and Ear, Harvard Medical School, 243 Charles St, Boston, MA 02114, USA.

Email: nimesh_patel2@meei.harvard.edu

Table 1. Medicare Allowable Costs for Follow-up and Imaging of Commotio Retinae.^a

HCPSC Code	Description	Professional Fee	Facility Fee	Total ^b
92012	Intermediate follow-up	\$59	\$102	\$162
92134	OCT	\$51	\$56	\$107
92250	Fundus photography	\$91	\$91	\$182

Abbreviations: HCPSC, Healthcare Common Procedure Coding System; OCT, optical coherence tomography.

^aAllowable costs are based on previous methods described by Lin et al.¹²

^bTotal allowable cost was calculated by adding professional and facility fees.

department from January 1, 2020, to January 1, 2022, who were diagnosed with contusion or other injuries of the eye or orbit (International Classification of Diseases, 10th edition, codes S05.1 and S05.8). Data were extracted from medical records of patients with documented commotio retinae on ophthalmologic examination. A standard examination at initial presentation included a scleral depressed examination of the peripheral retina of the involved eye.

Data extracted from patient records included age, sex, race, ethnicity, mechanism of injury, laterality of eye involvement, visual acuity (VA) on the Snellen chart and in logMAR notation, imaging studies performed, affected quadrants and/or macula, presence or absence of retinal tears and detachments, number of visits before tears and detachments, management of tears and detachments, number of visits before commotio retinae resolution, and time to commotio retinae resolution. Data were gathered from initial visits to the MEE emergency department and follow-up visits to the emergency department, comprehensive ophthalmology clinic, retina clinic, and other subspecialty clinics. Patients with commotio retinae were referred to retina specialty clinics for a follow-up visit 2 weeks after presenting to the emergency department, per institutional protocol. Follow-up visits were included in the cost analysis if they occurred before the documented resolution of commotio retinae.

A cost analysis was performed using previously described methods.^{11,12} Dollar costs were calculated using Medicare fee data from the 2022 US Centers for Medicare & Medicaid Services fee schedules.¹³ The Healthcare Common Procedure Coding System codes used in this analysis were 92012, 92134, and 92250. These codes correspond to the Medicare allowable costs for intermediate follow-up examinations, optical coherence tomography (OCT), and fundus photography, respectively. Costs were calculated using facility-based payment amounts. Costs were rounded up to the nearest whole dollar amount and are reported in Table 1. The US population of 309.3 million people, obtained from the US 2010 Census,¹⁴ was used to estimate the annual incidence of commotio retinae between 2006 and 2013. The total annual cost to the US healthcare system was calculated by multiplying the annual incidence of commotio retinae by the cost per patient, calculated as just described.

Statistical analysis was performed using Excel software (version 16.72, Microsoft Corp) and SPSS Statistics for Windows software (version 28, IBM). Descriptive statistics

Table 2. Demographics and Clinical Characteristics of CR (N = 201).

Characteristic	Value
Mean age (y) $\pm$ SD	30.7 $\pm$ 14.9
Men, n (%)	147 (73.1)
Race, n (%)	
White	123 (61.2)
Black	34 (16.9)
Asian	17 (8.5)
Other	19 (9.5)
Unknown	8 (4.0)
Ethnicity, n (%)	
Non-Hispanic	170 (84.6)
Hispanic	17 (8.5)
Unknown	14 (7.0)
Initial visit	
Mean VA (logMAR) $\pm$ SD	0.28 $\pm$ 0.51
RT/RD on initial visit, n (%)	7 (3.5)
Initial CR regions, n (%)	
Macula	37 (18.4)
Superotemporal	113 (56.2)
Superonasal	67 (33.3)
Inferotemporal	85 (42.3)
Inferonasal	58 (28.9)
Follow-up	
Mean VA (logMAR) $\pm$ SD	0.25 $\pm$ 0.48
Fundus photography, n (%)	66 (33.0)
OCT, n (%)	68 (34.0)
RT/RD on follow-up, n (%)	4 (2.0)
Mean time to RT/RD diagnosis (visits) $\pm$ SD	5.25 $\pm$ 4.03
Mean time to RT/RD diagnosis (days) $\pm$ SD	142.75 $\pm$ 154
Resolution	
Mean final VA (logMAR) $\pm$ SD	0.11 $\pm$ 0.3
Mean time to CR resolution (visits) $\pm$ SD	2.27 $\pm$ 1.41
Mean time to CR resolution (days) $\pm$ SD	36.2 $\pm$ 73.2

Abbreviations: CR, commotio retinae; OCT, optical coherence tomography; RD, retinal detachment; RT, retinal tear; VA, visual acuity.

were calculated as means $\pm$ SDs for continuous variables, and categorical variables were described as frequencies and percentages. Comparisons between 2 groups were performed using a 2-sample *t* test for continuous variables. A Fisher exact test was used for contingency tables and categorical variables. The Pearson correlation coefficient was used to assess any association between continuous variables. Statistical significance was set at $P < .05$.

Results

Of 490 consecutive patients presenting to the emergency department, 201 (41.0%) had commotio retinae on their emergency department examination and were included for analysis. The mean age at presentation was 30.7 $\pm$ 14.9 years. Most patients were men (73.1%), White (61.2%), and non-Hispanic (84.6%). The mean initial VA was 0.28 $\pm$ 0.51 logMAR. Seven patients (3.5%) had retinal tears at presentation (Table 2).



Figure 1. Commotio retinae and sequelae of eye trauma. (A) Representative color fundus photograph of a patient with trauma in the right eye that was taken during initial evaluation in the emergency department. A large region of commotio retinae is seen inferior to the inferior arcade. (B) Color fundus photography was obtained from the same patient 1 month after their initial visit. The area of inferior commotio retinae has resolved. (Color figures available online.)

Table 3. Complications After Commotio Retinae.^a

ID	Age (y) ^b	Pathology	Mechanism	Symptoms	Management	Additional Notes
18	47	Retinal tear; retinal detachment	Fishing line	Yes	Surgery	Symptoms: significant flashes and floaters
43	56	Retinal tear	Bungee cord	Yes	Laser	Symptoms: significant floaters
82	24	Retinal tear	Resistance band	No	Observation	Operculated hole; did not detach
87	26	Retinal tear	Fall	No	Observation	Atrophic hole; did not detach

^aComplications include retinal tears and retinal detachments.

^bAge at time of presentation.

Only 142 (70.6%) patients returned for follow-up. Of all patients, 24 (11.9%) followed up with glaucoma specialists and 46 (22.8%) had gonioscopy. Four patients (2.8%) had new tears at follow-up. Thus, the number needed to treat was 35.5 (142/4). Patients with tears at both presentation and follow-up were older than patients without retinal tears (40.3 ± 18.0 years vs 30.5 ± 13.8 years, respectively; $P = .046$). None of these patients had posterior vitreous detachments (PVDs) at the time of the initial examination or, if available, at the time of the first evaluation by a retina specialist. There was no difference in sex or laterality of eye involvement between patients with tears and those without tears. The mean final VA was 0.11 ± 0.30 logMAR (Table 2).

For imaging, OCT was performed in 68 patients (34%) and fundus photography in 66 patients (33%). Figure 1 shows a representative fundus photograph of uncomplicated commotio retinae and subsequent recovery (Figure 1).

Seven patients (3.5%) had tears/dialysis on initial presentation to the emergency department, 2 of whom (1.0%) had a concurrent retinal detachment (RD). One patient (0.5%) developed a retinal tear after a lensectomy and pars plana vitrectomy (PPV) for native lens dislocation. Four (2.8%) of 142 patients developed tears on follow-up, 1 of whom (0.7%) had a concurrent RD. Overall, 12 patients (5.97%) had retinal tears or dialysis and 3 patients (1.5%) had RDs at some point during their disease. The mean number of days from trauma to diagnosis

was 50.4 ± 106.0 (n = 12) and from trauma to treatment was 18.2 ± 24.8 (n = 8). Of these patients, 3 had a history of myopia; there were no cases of underlying risk factors (eg, high myopia, previous eye surgery, or collagen disorders).

Retinal tears and RDs found on follow-up that required intervention were always newly symptomatic (100%). Of the 2 cases requiring intervention, 1 patient noticed significant flashes and floaters 4 days after the initial trauma and presentation; a horseshoe tear was found in the superotemporal quadrant. The patient subsequently developed a symptomatic macula-on RD requiring repair with PPV and scleral buckling (Table 3). Another patient noticed significant new floaters and called the clinic to schedule a same-day appointment. A hemorrhagic PVD and 1 horseshoe tear in the superotemporal quadrant were identified on subsequent examination and treated with laser retinopexy (Table 3). The remaining 2 cases of retinal tears were deemed chronic and at low risk for complications; thus, intervention was deferred (Table 3). All patients requiring intervention had new symptoms that prompted examination before the scheduled follow-up visit.

The mean number of visits until commotio retinae resolved was 2.27 ± 1.41 . The median days to commotio retinae resolution was 10.5. Overall, 254 follow-up visits, 68 OCT scans, and 66 fundus photographs were performed before commotio retinae resolution. Using Medicare fee data as described in a previous study, the mean per-patient cost of follow-up visits, OCT,

Table 4. Cost Analysis of CR Testing and Follow-up (N = 201).^a

Cost Factor	Value
Visits to CR resolution	
Mean per patient ± SD	2.27 ± 1.41
Total cohort, n	254
Cost per follow-up visit	\$162
Obtained OCT	
Total cohort, n (%)	68 (34)
Cost per OCT	\$107
Obtained fundus photograph	
Total cohort, n (%)	66 (33)
Cost per photo	\$182
Cost of all services	
Total cohort	\$60,436
Cost per patient	\$425.60

Abbreviations: CR, commotio retinae; OCT, optical coherence tomography; RD, retinal detachment; RT, retinal tear.
^aSee Table 1 for details on costs per test.

and fundus photographs was \$162, \$107, and \$182, respectively. The total costs incurred in these categories were \$60,436 for the entire cohort and \$425.60 per patient (Table 4).

Patients with retinal tears had an increased chance of obtaining fundus photography ($P = .006$, Fisher exact test). There was no such association between patients with tears and OCT ($P = .068$, Fisher exact test). There was no difference in the final VA between patients receiving OCT and those who did not (mean logMAR, 0.128 ± 0.379 vs 0.096 ± 0.208 ; $t = -0.611$; $P = .271$, t test). There was no difference in the final VA between patients receiving fundus photography and those who did not (mean logMAR, 0.135 ± 0.391 vs 0.091 ± 0.203 ; $t = -0.804$; $P = .212$, t test). There was no correlation between the number of follow-up visits and the final VA ($R = 0.044$; $P = .649$, linear regression).

Conclusions

In this case series, patients with commotio retinae infrequently developed retinal complications. This is the first study to our knowledge that assessed costs associated with follow-up visits of patients with commotio retinae after eye trauma. Our major findings were as follows: (1) significant resources were dedicated to following up and imaging patients; (2) complications requiring intervention were always heralded by new symptoms, questioning the utility of multiple scheduled follow-up visits; (3) the rate of loss to follow-up was high.

There were material costs associated with follow-up visits, as reported herein. There are also indirect costs levied on clinics and patients. There is an opportunity cost to holding a spot on a clinic schedule. Particularly in large academic centers and subspecialty practices, there is often a backlog of patients awaiting visits who may require intervention. For example, patients in a retina clinic frequently require scheduled intravitreal antivascular endothelial

growth factor injections. The true cost of each follow-up appointment may far exceed the quoted fee schedule.

In addition, given that this population has a high rate of loss to follow-up, unfilled scheduled clinic spots reflect another facet of inefficiencies and lost opportunity costs when scheduling commotio retinae follow-up visits. Moreover, the personal cost incurred to individual patients by these visits is not insubstantial. Chief among these are the burdens of taking time off from work to attend appointments and the cost of traveling to appointments. These costs often fall disproportionately on those most socio-economically disadvantaged, further exacerbating existing inequities in the societal costs of eye trauma.¹⁵ There was a high rate of imaging in this study, and some of the costs could have been offset by reducing ancillary testing.

Data from the Nationwide Emergency Department Sample from 2006 to 2013, as reported by Ramirez et al,¹⁶ showed that there were more than 5 million emergency department encounters for eye trauma in the US. Among these cases, contusion of the eye and adnexa were reported to have an annual incidence of 27 per 100 000 population, which included 672 221 cases across the 8-year study period.

Under an assumption of a 41% incidence of commotio retinae in this population, as seen in the patient cohort for this study, there is an approximate annual incidence of 34 450 cases of commotio retinae in the US, or approximately 11 per 100 000 population. Using this, we estimate a \$14.66 million per year total cost to the US healthcare system to follow patients with commotio retinae if all patients were scheduled for follow-up. This total cost is likely higher given the increase in population and therefore the total incidence of commotio retinae. However, the population in this study was predominantly drawn from the Northeast and New England regions of the US, which may not accurately reflect the demographics of the whole country.

There is a potential risk for developing an acute retinal tear near the time of the initial trauma. It is possible that traumatic forces leading to commotio retinae transmit tractional force at the level of the hyaloid–retinal interface. Older patients who have a more mobile, degenerated vitreous body would be more prone to sudden tractional forces, explaining the significant age difference between patients who developed tears (initially and subsequently) and those who did not. This may be true even in the absence of PVD, which was not initially present in any of the patients with retinal tears.

Complications noted at follow-up visits were rare. The 4 retinal tears found on follow-up examination, in particular the 2 atrophic holes, could have occurred independent of the initial trauma. It is also possible these tears were simply missed on the initial clinical examination. It is particularly encouraging to note that all complications requiring intervention in this cohort were first heralded by symptoms significant enough that the patients reached out to seek urgent care. This suggests that multiple scheduled visits for patients with uncomplicated commotio retinae may be deferred if patients receive strict return precautions and have urgent follow-up available if needed.

Our data demonstrate that complications requiring intervention were diagnosed and treated an average of 18 days after the trauma. Patients should be counseled to return for evaluation if they experience new symptoms, particularly within the high-risk first 3 weeks after trauma. If patients present with commotio retinae and other signs (eg, vitreous hemorrhage), our data suggest that these patients should still be followed up.

Because all patients requiring intervention presented outside the scheduled follow-up visit in the current study, there was no cost savings of the follow-up visit itself in preventing complications such as an RD. The rate of complications would be equal with or without follow-up; therefore, the cost of complications was not a factor in the current study. The cost per quality-adjusted life year could also not be calculated because there were no theoretical VA gains with follow-up visits. It is possible that in a larger study, retinal tears and RDs requiring treatment could be found incidentally at the follow-up visit. For reference, the cost to treat an uncomplicated RD with vitrectomy is \$1323.50 (Current Procedural Terminology [CPT] code 67108) and to treat a retinal tear is \$245.05 (CPT code 67145).

In general, the best-corrected VA after recovery from commotio retinae is good.¹⁷ A case series of 90 patients from the Birmingham Midland Eye Centre found that 74% of patients with macular commotio retinae and 95% of patients with extramacular commotio retinae recovered to VAs of 20/30 or better.¹⁰

A retrospective observational case series from Seoul National University Bundang Hospital suggested that certain features seen on spectral-domain OCT can be used to grade macular commotio retinae and better predict visual outcomes.¹⁸ The lowest of these defined grades, which has the best visual and anatomic outcomes, includes only the characteristic of increased photoreceptor inner segment–outer segment (IS–OS) junction reflectivity that corresponds with loss of the thin hyporeflective optical space. Patients with commotio retinae who also have cone outer-segment termination, IS–OS junction, and outer limiting membrane defects fall into grade 4 and had the worst outcomes.¹⁸ However, this study by Ahn et al¹⁸ assessed visual outcomes but did not assess rates of complications such as tears or RDs.

The anatomic and functional outcomes seen in our cohort affirmed the good outcomes typically seen in patients with commotio retinae. The mean final VA in our cohort was 0.11 ± 0.30 logMAR (approximately equivalent to a mean VA of 20/25 on the Snellen chart). This is consistent with a study by Blegen et al¹⁹ that reviewed 294 cases of commotio retinae after orbital wall fracture and reported a final VA of 20/25 or better on the Snellen chart.

One limitation of our study lies in the heterogeneous sequelae of trauma observed in our cohort. In addition, a significant percentage of this cohort (59 patients [29.4%]) was lost to follow-up. This may suggest that otherwise healthy patients presenting with trauma may not be motivated to return for scheduled appointments if their vision and symptoms improve. Notably, 27 patients lost to follow-up (27/59 [46%]) were pediatric patients at the time of their visit and thus may have opted to seek subsequent care at a dedicated children's hospital.

The lack of a widefield camera in the emergency department setting limited our ability to verify that true commotio retinae existed. Another point is that the initial examinations were not performed by retina specialists and there may have been some inaccuracies. However, many of the follow-up visits were in the retina clinic. Oftentimes, we rely on junior physicians with less experience and evolving examination skills, so the subtle differences between commotio retinae, white without pressure, and shallow RD can lead to medical errors. As such, a follow-up examination in a training facility may still be warranted for the safety of patients after ocular trauma.

Finally, the retrospective noninterventional nature of our case series is a natural limitation of our study. A prospective study of commotio retinae's cost efficacy would not be feasible given the practical considerations. In terms of the cost calculation, in some instances the fundus photography and OCT may not be able to be billed on the same visit. This was not considered in the analysis. Follow-up studies may include a larger cohort of complications after commotio retinae aimed at identifying underlying risk factors that would necessitate scheduled follow-up.

To conclude, patients with commotio retinae rarely develop retinal complications and have a high rate of loss to follow-up. Interventions for complications were prompted by worsening symptoms, indicating that such patients may seek evaluation. Our findings indicate that multiple follow-up visits are not indicated in patients with commotio retinae in the absence of other signs or symptoms and that there are significant costs and opportunity costs associated with these visits.

Ethical Approval

This study was conducted in accordance with the Declaration of Helsinki. The collection and evaluation of all protected patient health information were performed in a US Health Insurance Portability and Accountability Act–compliant manner. This study was approved by the Institutional Review Board, Massachusetts General Brigham (protocol ID: 2022P002496).

Statement of Informed Consent

The requirement for informed consent was waived given the retrospective nature of the study.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of the article: Dr. Armstrong is a consultant to Kriya Therapeutics, Ocular Technologies, Optomed Inc, Chart Biopsy, DynaMed, Xenon-VR, Genentech, and McKinsey & Company. Dr. Miller is a consultant to Carl Zeiss, Alcon, Allergan, Sunovion, Radius, Topcon, and Genentech. Dr. Patel is a consultant to Atheneum, Alcon, Allergan, Alimera, EyePoint, Lifesciences, Guidepoint, Gerson Lehrman Group Inc, Regeneron, Dutch Ophthalmic, Genentech, and EyePoint Pharmaceuticals. None of the other authors declared potential conflicts of interest with respect to the research, authorship, and/or publication of the article.

Funding

Dr. Patel is supported by the Retina Innovation Fund, Massachusetts Eye and Ear, Boston, MA, USA. The funding organization had no role in the design or conduct of this research.

ORCID iDs

Henry W. Zhou  <https://orcid.org/0000-0003-4060-8187>

Grayson W. Armstrong  <https://orcid.org/0000-0001-9102-5868>

Nimesh A. Patel  <https://orcid.org/0000-0002-6681-6104>

References

- McGwin G Jr, Owsley C. Incidence of emergency department-treated eye injury in the United States. *Arch Ophthalmol*. 2005; 123(5):662-666.
- McGwin G Jr, Xie A, Owsley C. Rate of eye injury in the United States. *Arch Ophthalmol*. 2005;123(7):970-976.
- May DR, Kuhn FP, Morris RE, et al. The epidemiology of serious eye injuries from the United States Eye Injury Registry. *Graefes Arch Clin Exp Ophthalmol*. 2000;238(2):153-157.
- Leshno A, Alhalel A, Fogel-Levin M, Zloto O, Moisseiev J, Vidne-Hay O. Pediatric retinal damage due to soccer-ball-related injury: results from the last decade. *Eur J Ophthalmol*. 2021; 31(1):240-244.
- Pahk PJ, Adelman RA. Ocular trauma resulting from paintball injury. *Graefes Arch Clin Exp Ophthalmol*. 2009;247(4):469-475.
- Steinberg Y, Wieder MS, Denisova K, He C, Parsikia A, Mbekeani JN. Evaluation of commotio retinae in orbital fractures. *Arq Bras Oftalmol*. 2022;87(2):0456.
- Sipperley JO, Quigley HA, Gass DM. Traumatic retinopathy in primates. The explanation of commotio retinae. *Arch Ophthalmol*. 1978;96(12):2267-2273.
- Mansour AM, Green WR, Hogge C. Histopathology of commotio retinae. *Retina*. 1992;12(1):24-28.
- Eagling EM. Ocular damage after blunt trauma to the eye. Its relationship to the nature of the injury. *Br J Ophthalmol*. 1974;58(2):126-140.
- Blanch RJ, Good PA, Shah P, Bishop JR, Logan A, Scott RA. Visual outcomes after blunt ocular trauma. *Ophthalmology*. 2013; 120(8):1588-1591.
- Patel NA, Yannuzzi NA, Lin J, Smiddy WE. A cost-effectiveness analysis of intravitreal aflibercept for the prevention of progressive diabetic retinopathy. *Ophthalmol Retina*. 2022;6(3):213-218.
- Lin J, Chang JS, Smiddy WE. Cost evaluation of panretinal photocoagulation versus intravitreal ranibizumab for proliferative diabetic retinopathy. *Ophthalmology*. 2016;123(9):1912-1918.
- Centers for Medicare & Medicaid Services. Overview of Medicare physician fee schedule search. 2023. Accessed October 9, 2023. <https://www.cms.gov/medicare/physician-fee-schedule/search/overview>
- US Census Bureau. Decennial Census by decade. Accessed September 25, 2024. <https://www.census.gov/programs-surveys/decennial-census/decade.2010.html>
- Iftikhar M, Latif A, Usmani B, Canner JK, Shah SMA. Trends and disparities in inpatient costs for eye trauma in the United States (2001-2014). *Am J Ophthalmol*. 2019;207:1-9.
- Ramirez DA, Porco TC, Lietman TM, Keenan JD. Ocular injury in United States emergency departments: seasonality and annual trends estimated from a nationally representative dataset. *Am J Ophthalmol*. 2018;191:149-155.
- Hart JC, Frank HJ. Retinal opacification after blunt non-perforating concussion injuries to the globe. A clinical and retinal fluorescein angiographic study. *Trans Ophthalmol Soc U K (1962)*. 1975;95(1):94-100.
- Ahn SJ, Woo SJ, Kim KE, Jo DH, Ahn J, Park KH. Optical coherence tomography morphologic grading of macular commotio retinae and its association with anatomic and visual outcomes. *Am J Ophthalmol*. 2013;156(5):994-1001.e1.
- Blegen HMJ, Santamaria JA, Mehta A, Reed DS, Drayna PM, Davies B. Patterns and prognosis of commotio retinae in orbital wall fractures. *Ther Adv Ophthalmol*. 2019;11:2515841419862133.