American Journal of Ophthalmology Case Reports 14 (2019) 39–46

Contents lists available at ScienceDirect

American Journal of Ophthalmology Case Reports

journal homepage: www.elsevier.com/locate/ajoc

Case report

Traumatic chorioretinitis sclopetaria: Risk factors, management, and prognosis

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ARTICLE INFO

Keywords:
Traumatic chorioretinitis sclopetaria
Sclopetaria
Traumatic chorioretinal rupture
Chorioretinitis proliferans
Retinitis proliferans
Traumatic proliferative chorioretinitis of Lagrange

ABSTRACT

Purpose: To describe new cases of sclopetaria and evaluate the risk factors, management, and visual prognosis of all reported cases in the literature.
Observations: We performed a retrospective, observational case series. This study included six cases (median age 23, interquartile range 33) of sclopetaria. Additionally, literature searches were conducted in the PubMed and Cochrane Library databases to uncover risk factors associated with all published cases of sclopetaria. Main outcome measure was best corrected visual acuity (BCVA) worse than 20/20. Sixty-seven cases (71 eyes) of sclopetaria have been reported, of which 59 cases (61 eyes) met inclusion criteria in this study. Most were young (median age 19.5 years) men (51/59, 88.1%). Thirty-seven eyes were observed while 24 underwent immediate surgery including six pars plana vitrectomies and three scleral buckles. Compared to initial presentation, BCVA improved in 31/48 (64.6%) eyes, remained stable in 12/48 eyes (25.0%), and worsened in 5/48 eyes (10.4%). Ten patients (16.4%) achieved a final BCVA of 20/20 with median follow up time of seven months. In a multivariate model, location of sclopetaria in the macula, temporal retina, or immediate orbital foreign body removal predicted poor final BCVA with an area under receiver operating characteristic curve of 0.767.
Conclusions and importance: Traumatic chorioretinitis sclopetaria is rare, but reports have increased dramatically over the past two decades. While pars plana vitrectomy may be required for the management of retinal detachments and non-clearing vitreous hemorrhage, close observation is appropriate in most cases. Visual prognosis is poor with most patients attaining 20/200 vision or worse.

1. Introduction

Sclopetaria chorioretinitis is the rupture of the choroid and overlying neurosensory retina secondary to a high velocity-projectile adjacent to but not penetrating the globe. The term is thought to originate either from the term *sclopetum* linked to the name of an old Italian handgun or from the term *sclow* meaning scratch, pull, or tear.[1] Sclopetaria is a rare condition, yet, an increasing number of cases have been reported in the literature over the last several decades – from 11 cases reported between 1980 and 1999[2–5] to 43 reported between 2000 and 2018.[1,6–25]

The sequelae of sclopetaria were first described in 1872 by Herman Cohn, a German ophthalmologist.[26] He described a 23-year-old male gunshot victim who, following enucleation, was found to have fusion of the retina and choroid in the posterior pole, so he termed the condition "chorioretinitis." Subsequently, in 1901, a Hungarian ophthalmologist, Wilhelm Goldzieher, first used the term "chorioretinitis plastica sclopetaria" to describe the fundus findings following a periorbital bullet wound.[27] He noted that the force of the bullet likely caused rupture of the choroid, hemorrhage and ultimately a whitish reactive fibroglial proliferation. The histopathologic findings would later be validated by Dubovy et al. on postmortem examination of the eye of a gentleman shot in 1974.[5] On histopathology, the macula showed defects in Bruch's membrane and the choroid, extensive photoreceptor loss, and hyperplasia of the retinal pigmented epithelium (RPE). The retina and choroid were replaced with dense and loose fibrous tissue respectively. Most recently, photoreceptor degeneration and decreased cellularity in the retinal ganglion cell layer have been demonstrated in mouse models following blast traumatic brain injury.[28]

Given the low incidence of sclopetaria, consensus on management has not been reached as both observation and immediate surgical management have been described.[21] In this study, we report on six new

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https://doi.org/10.1016/j.ajoc.2019.02.004
Received 10 August 2018; Accepted 7 February 2019
Available online 16 February 2019

patients with sclopetaria and describe their treatment outcomes. Moreover, to better understand the risk factors, management, and prognosis, we performed a comprehensive review of all reported cases of sclopetaria.

2. Methods

An observational, retrospective case series was assembled from a single institution (Stanford University). Clinical exams were performed by vitreoretinal specialists (DD, DM, VM). In addition to the case series, the PubMed and Cochrane Library databases, most recently in August 2018 were filtered using the search terms *sclopetaria, traumatic chorioretinal rupture, chorioretinitis proliferans, retinitis proliferans,* and *traumatic proliferative chorioretinitis of LaGrange*. This search was limited to human studies. The search revealed 77 articles and was narrowed to 33 publications on the topic of sclopetaria. Studies were then excluded that noted sclopetaria but did not distinguish management by individual cases.[10] Twenty-three articles (including the present study) were selected for further review based on inclusion of information regarding immediate management and final best corrected visual acuity (BCVA).

Data recorded from the publications included demographic data, injury details, location of sclopetaria, orbital comorbidities, complications, and immediate and delayed management. BCVA was also converted post-hoc to logarithm of the minimum angle of resolution (logMAR) units to allow for comparative analysis.

Data were analyzed using Statistical Analysis Software Enterprise Guide version 7.13 (SAS Institute, Cary, North Carolina). Variables were tested for normality with the Kolmogorov-Smirnov test to determine the appropriate statistical test. Bivariate testing was used to compare subgroups with poor final BCVA (defined a priori as worse than 20/20) to those with final BCVA of 20/20. Exposure variables were excluded if they were missing. Missing variables comprised less than 10% of the sample except for primary location of sclopetaria (18/61, or 29.5% missing), initial BCVA (12/61, or 19.7% missing) and follow up time (10/61, or 16.4% missing). There were no missing outcome data. A multivariable logistic regression model was developed to determine factors most predictive of a poor final BCVA. Predictors were included if they showed an association ($p < 0.10$) with poor final BCVA in crude bivariate analysis. Prediction of poor final BCVA was evaluated using the area under receiver operating characteristic curve (AUROC). Variables were considered to be significant by Bonferroni corrected α-levels of less than 0.003 (0.05/20).

3. Findings

3.1. Case 1

A 13-year-old male presented after he was shot near the left eye with a BB gun while playing with friends. His BCVA was 20/25 OD and 20/70 OS. His intraocular pressure (IOP) was 14 mmHg OD and 10 mmHg OS. Both pupils were round and reactive to light without relative afferent pupillary defect (rAPD). On the left, he had a three by three-millimeter partial thickness conjunctival laceration that was siedel negative and 4 + red blood cells in the anterior chamber. His posterior segment exam was notable for commotio retinae throughout the macula and periphery with vitreous hemorrhage inferiorly and nasally. There was a choroidal hemorrhage with overlying sclopetaria nasally (Fig. 1). Computed tomography scan (CT) revealed a metallic foreign body in the posterior left ethmoid air cells with mild irregularity of the left lamina papyracea. The patient was managed medically with follow up two days after discharge then again at 1, 3, 5, 7, and 11 weeks. Visual acuity remained stable OD but worsened to counting fingers (CF) at one foot OS at 11 weeks secondary to vitreous hemorrhage and large preretinal hemorrhages inferiorly and nasally. Serial B-scan ultrasonography did not show evidence of retinal breaks or detachments.

3.2. Case 2

A 17-year-old male was assaulted on his way home from school by an unknown male with a BB gun. He presented to the emergency room with BCVA of hand motion OD and 20/20 OS. He had a right rAPD and his visual fields were limited inferiorly. There was an entry wound of the upper eyelid. He had a three-millimeter superonasal conjunctival laceration, microhyphema, and round, non-reactive iris. Posterior segment exam was limited by dense vitreous hemorrhage, but B-scan ultrasonography showed no evidence of tears or detachments (Fig. 2). CT showed the BB adjacent to the optic nerve. He underwent urgent orbital exploration with removal of the BB. One week later, the patient was found to have berlin's edema and a fibroglial scar with sharp serrated borders consistent with sclopetaria superiorly. An adjacent localized rhegmatogenous retinal detachment (RRD) was also seen. Optical coherence tomography (OCT) showed rupture through the choroid, RPE and outer retina. Two weeks after presentation, he underwent 25-gauge pars plana vitrectomy (PPV) for RRD repair with endolaser, perfluorocarbon, and gas tamponade. At five months, he was count fingers at two feet in the right eye.

3.3. Case 3

A 63-year-old man suffered a rifle injury to the left eye when the weapon backfired. Presenting BCVA was 20/20 OD and CF at four feet OS. His IOP was 21 mmHg OD and 23 mmHg OS. He had a left rAPD. Examination of the left eye demonstrated a conjunctival laceration without scleral involvement, a corneal epithelial defect, microhyphema and dense vitreous hemorrhage. Plain film showed no metal foreign body and CT showed no orbital or canal fractures. One month later, the patient's visual acuity returned to 20/20 OU. The rAPD resolved and there was clearing of the vitreous hemorrhage. Wide angle photography revealed an area of bare sclera and of subretinal fibrosis consistent with sclopetaria (Fig. 3). Fluorescein angiography showed no leakage on early frames and staining of the fibrogliotic lesions on late frames.

3.4. Case 4

A 33-year-old man presented following a gunshot wound at close range to his right supraorbital region. CT showed fractures of the right frontal bone, medial orbital wall, and ethmoid sinuses with bullet fragments in the extraconal space and bilateral frontal and ethmoid sinuses (Fig. 4). BCVA was 20/400 OD and 20/20 OS. Intraocular pressure was 53 mmHg OD and 19 mmHg OS, necessitating lateral canthotomy and cantholysis reducing the IOP to 15 mmHg OD. A rAPD was present on the right. His extraocular movements were limited in all directions OD with complete ptosis. A subcentimeter entry wound was noted in the right medial brow. The posterior segment exam showed inferior subretinal hemorrhages, a raised perifoveal lesion, an infratemporal crescent of commotio retinae, and superior hemorrhages. OCT four days following the accident showed a full-thickness rupture through the retina, RPE, Bruch's, and choroid consistent with sclopetaria. His BCVA at that time was stable. He underwent conservative management and did not return to clinic for follow-up appointments at one or three months.

3.5. Case 5

A 23-year-old male presented after a self-inflicted shotgun wound to the face. CT scan showed bilateral LeFort III fractures with metallic fragments adjacent the right optic nerve. He had no light perception (NLP) vision in both eyes and IOPs were 10 mmHg on the right and unmeasurable on the left. He had a complex ruptured globe of the left eye with complete extrusion of globe contents ultimately requiring enucleation. In the right eye he had dense vitreous hemorrhage, temporal commotio retinae, and elevation of the retina superiorly. There

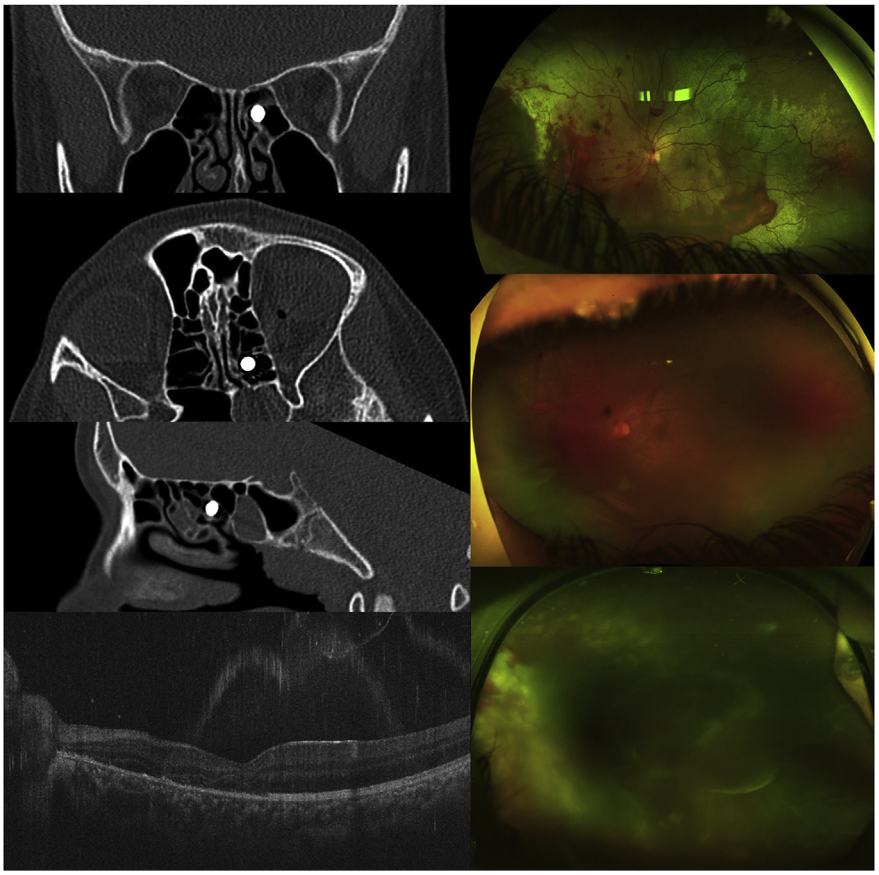

Fig. 1. A 13-year-old male was shot near his left eye with a BB gun. Computed tomography scan on presentation showed a metallic BB in the posterior left ethmoid air cells with mild irregularity of the left lamina papyracea (Top left, Middle left). Optical coherence tomography showed disruption and irregularity of the outer macula (Bottom left). Optos ultra wide-field imaging at presentation (Top right), five weeks (Middle right), and eleven weeks (Bottom right) showed nasal choroidal hemorrhage with underlying sclopetaria, commotio retinae throughout the macula and periphery, and a large vitreous hemorrhage inferiorly and nasally that subsequently evolved into dense vitreous hemorrhage.

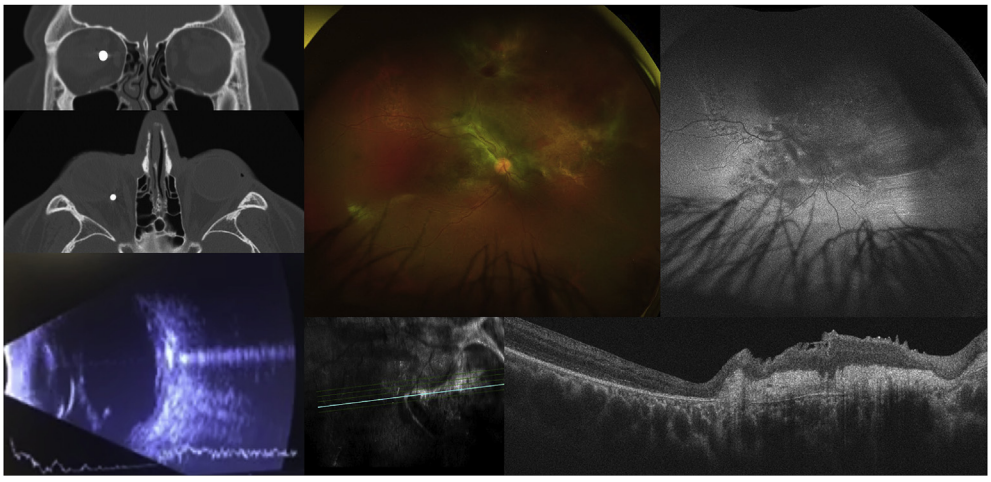

Fig. 2. A 17-year-old male was assaulted on his way home from school with a BB gun. Computed tomography scan demonstrated the BB located within the orbit at the posterior margin of the globe (Top left, Middle left). B-scan ultrasonography shows layered vitreous hemorrhage in posterior pole and hyperechogenicity of the BB (Bottom left). Optos ultra wide-field imaging showed macula-involving commotio retinae, a fibroglial scar with sharp serrated borders superiorly, and an adjacent localized retinal detachment (Top middle). Fundus autofluorescence showed hypoautofluorescence within the area of choroidal rupture (Top right). Optical coherence tomography showed a rupture through the choroid, retinal pigmented epithelium and outer retina consistent with sclopetaria (Bottom right).

was an extensive area of sclopetaria with subhyaloid and intra-retinal hemorrhages in the posterior pole. The retina was attached, but B-scan ultrasonography showed extensive retinal and choroid thickening. He was followed closely while inpatient. Following discharge from the psychiatry unit, four months after the initial incident, he was seen in Retina clinic and found to have a white macula with areas of hemorrhage and macerated tissue with large areas of atrophy and scleral exposure in both the macula and periphery. B-scan ultrasonography showed a tractional elevation of the retina with extensive necrotic appearing tissue. The decision was made to pursue ophthalmic comfort care and globe salvation.

3.6. Case 6

A 69-year-old male presented to the Retina service for new floaters in the setting of a chorioretinal lesion and prior herpes zoster ophthalmicus. He reported a history of BB gun injury to the right eye in childhood without any subsequent surgeries. His BCVA was 20/25 OD and 20/20 OS. His right cornea had a central opacity and with an otherwise normal anterior segment exam. On fundus examination he had pigmentation and chorioretinal atrophy of the nasal quadrant in an area of previous sclopetaria (Fig. 5). OCT showed a normal foveal contour without cystoid macular edema or subretinal fluid in either eye. No intervention was required.

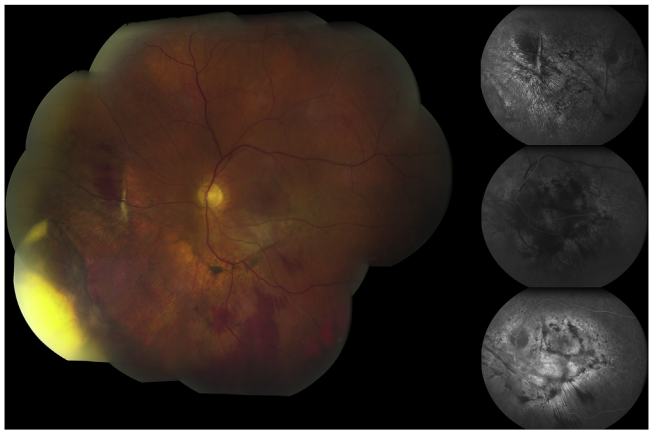

Fig. 3. A 63-year-old male subject following a rifle injury to his left eye. His left eye composite fundus photo at one-month follow-up showed macular and peripheral subretinal fibroglial scars (Left). A nasal fibroglial scar was adjacent to bare sclera consistent with sclopetaria. Additionally, retinal pigmented epithelium hypertrophy was seen throughout the periphery and adjacent to the inferior vascular arcade. Fluorescein angiography (FA) nasally showed a window defect at the area of chorioretinal rupture (Top right), early FA of the macula showed absence of leakage while staining of the fibrogliotic lesion was seen on late frames (Bottom right).

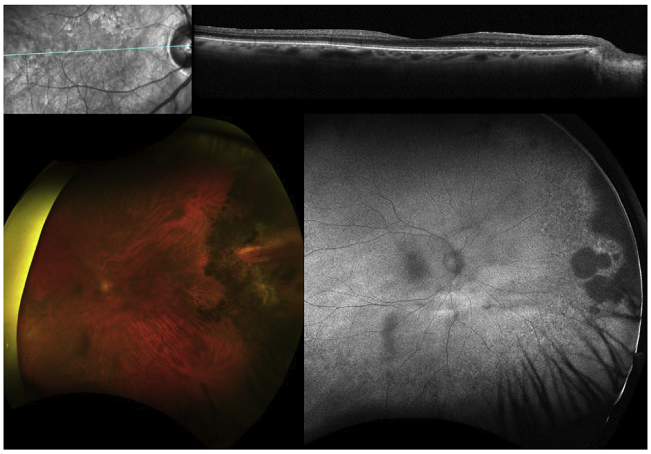

Fig. 5. A 69-year-old male reported a history of BB gun injury to the right eye in childhood without any subsequent surgeries. Optical coherence tomography scan showed normal foveal contour and normal retinal layers (Top left, Top right). Optos ultra wide-field imaging showed severe nasal pigmentation and chorioretinal atrophy of the nasal quadrant consistent with sclopetaria (Bottom left). Fundus autofluorescence showed hypoautofluorescence nasally consistent with loss of retinal pigmented epithelium (Bottom right).

4. Review of the literature

To date, 71 eyes with sclopetaria in 67 patients (including six in the present study) have been described in the literature. Ten eyes were excluded from this review as there was no description of the management and/or final reported BCVA. Of the 59 patients (61 eyes) meeting inclusion criteria in this review, 52 (88.1%) were male (Table 1). The median age at presentation was 19.5-years-old (interquartile range (IQR), 12 years). Where sidedness was reported, 33 were right eyes (60.0%). Patients diagnosed with sclopetaria were most likely to have been injured via indirect trauma to the globe with a BB

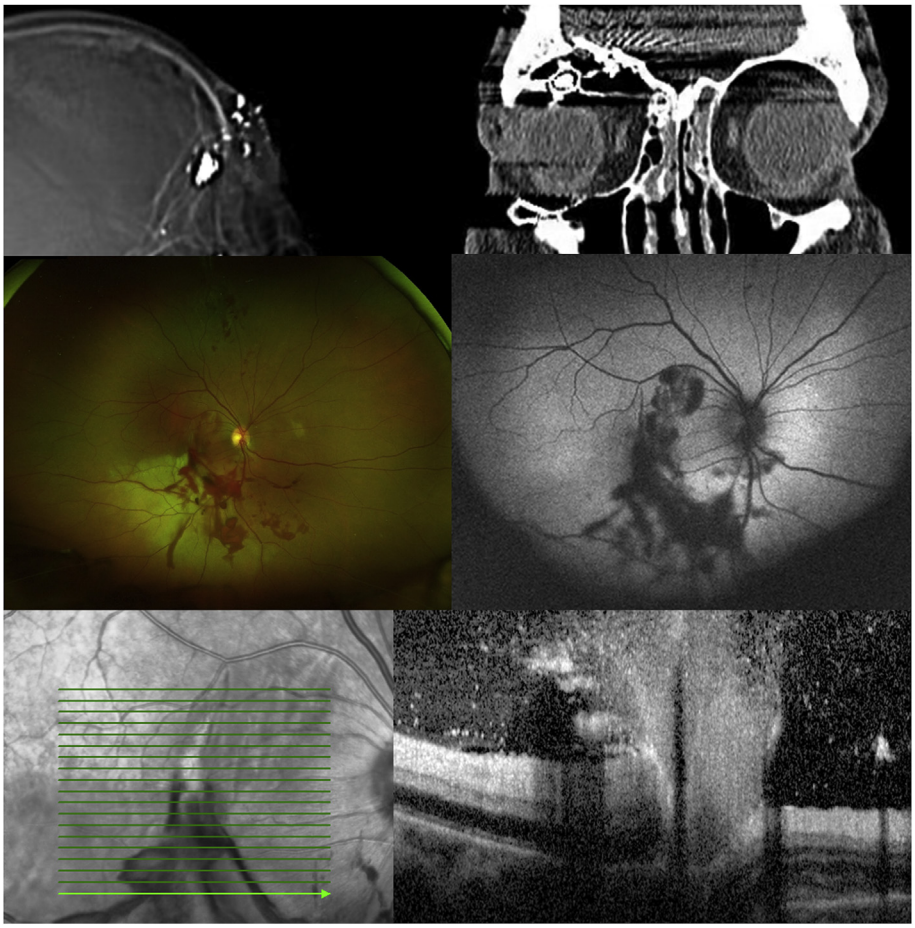

Fig. 4. A 33-year-old male presented following a gunshot wound to his right supraorbital region resulting in complete ptosis. The patient's plain film and computed tomography scans demonstrated multiple fractures and bullet fragments in the right superior and inferior extraconal spaces and bilateral frontal and ethmoid sinuses (Top left and right). His Optos ultra wide-field fundus photo showed superior dot blot hemorrhages, inferior subretinal hemorrhages, infratemporal commotio, and a raised perifoveal area (Middle left), while his fundus autofluorescence showed hypoautofluorescence extending beyond the location of the hemorrhages (Middle right). Optical coherence tomography showed a full-thickness rupture through the retina, Bruch's membrane and choroid consistent with sclopetaria (Bottom).

Table 1
Baseline characteristics of all patients in the literature with sclopetaria.

Characteristic	Overall Frequency (%)	Final BCVA Worse Than 20/20, Frequency (%)	Relative Risk (95% CI)	Unadjusted P Value
Age at Injury Greater Than or Equal to 18	34/59 (57.6)	26/34 (76.5)	0.83 (0.67–1.04)	0.099
Male Sex	52/59 (88.1)	43/52 (82.7)	0.96 (0.70–1.34)	0.830
Right Eye[a]	33/55 (60.0)	29/55 (87.9)	1.21 (0.91–1.61)	0.194
Mechanism of Injury[b]				
BB	23/60 (38.3)	21/23 (91.3)	1.16 (0.94–1.44)	0.140
Bullet	16/60 (26.7)	12/16 (75.0)	0.87 (0.64–1.18)	0.367
Air-gun pellet	5/60 (8.3)	5/5 (100.0)	1.22 (1.08–1.38)	0.002
Miscellaneous metal object (Nozzle, Rod, Foreign body from blast, Nail, Sinker)	5/60 (8.3)	3/5 (60.0)	0.70 (0.34–1.45)	0.338
Paintball	4/60 (6.7)	4/4 (100.0)	1.22 (1.08–1.38)	0.002
Shotgun pellet	4/60 (6.7)	2/4 (50.0)	0.58 (0.22–1.56)	0.284
Cork	1/60 (1.7)	1/1 (100.0)	1.20 (1.07–1.35)	0.002
Foam bullet	1/60 (1.7)	1/1 (100.0)	1.20 (1.07–1.35)	0.002
Tree branch	1/60 (1.7)	1/1 (100.0)	1.20 (1.07–1.35)	0.002

BCVA = best corrected visual acuity.
[a] Four patients with missing data on sidedness in Taban et al. (2008).
[b] Relative risks calculated for each projectile relative to any other projectile.

(23/60, 38.3%) or bullet (16/60, 26.7%). However, direct trauma to the globe with subsequent sclopetaria was also reported with paintballs, a tree branch, foam bullet, and cork.

Initial BCVA was NLP to 20/1000 in 35/49 (71.4%), 20/800 to 20/200 in 7/49 (14.3%), 20/100 to 20/25 in 5/49 (10.2%), and 20/20 in 2/49 (4.1%). Final BCVA was NLP to 20/1000 in 30/61 (49.2%) patients, 20/800 to 20/200 in 12/61 (19.7%), 20/100 to 20/25 in 9/61 (14.8%) and 20/20 in 10/61 (16.4%). Where both initial and final BCVA were recorded, BCVA improved in 31/49 (63.3%) eyes, remained stable in 13/48 eyes (26.5%), and worsened in 5/48 eyes (10.2%). Median initial BCVA was 2.08 logMAR units (IQR, 2.00; 20/2400 in Snellen equivalent; 12 missing). Median final BCVA was 1.70 logMAR units (IQR, 1.57; 20/1000 in Snellen equivalent) with median follow up time of 7 months (IQR, 23.5 months). Follow up time was not significantly different between those with poor final BCVA (> 20/20) compared to those with final BCVA of 20/20 (p = 0.334).

Location of sclopetaria was significantly related to final BCVA with a higher risk of poor outcomes associated with sclopetaria located in the macula (RR, 1.32; 95% CI, 1.10–1.59), temporal retina (RR, 1.32; 95% CI, 1.10–1.59), and superior retina (RR, 1.30; 95% CI, 1.09–1.54) (Table 2).

Table 2
Primary location of sclopetaria in 43 eyes with sclopetaria.

	Superotemporal	Superior	Superonasal
Overall Frequency (%)[a]	3/43 (7.0)	4/43 (9.3)	3/43 (7.0)
Final BCVA Worse Than 20/20, Frequency (%)	2/3 (66.7)	4/4 (100.0)	2/3 (66.7)
Relative Risk (95% CI)[b]	0.83 (0.37–1.88)	1.30 (1.09–1.54)	0.83 (0.37–1.88)
	Temporal	Macula	Nasal
	6/43 (14.0)	6/43 (14.0)	5/43 (11.6)
	6/6 (100.0)	6/6 (100.0)	3/5 (60.0)
	1.32 (1.10–1.59)	1.32 (1.10–1.59)	0.74 (0.35–1.53)
	Inferotemporal	Inferior	Inferonasal
	6/43 (14.0)	2/43 (4.7)	8/43 (18.6)
	5/6 (83.3)	1/2 (50.0)	5/8 (62.5)
	1.06 (0.72–1.58)	0.62 (0.15–2.50)	0.75 (0.43–1.32)

CI = confidence intervals; BCVA = best corrected visual acuity.
[a] Eighteen patients had missing location data.
[b] Relative risks calculated for each location relative to any other location.

The most common comorbidity was intraorbital foreign bodies in 40/61 (65.6%) cases (Table 3). Vitreous hemorrhage occurred in 38/61 (62.3%) cases and typically occurred at the time of injury, though was a delayed complication in three cases - reported at three days, six weeks, and four months. Optic neuropathy (17/61, 27.9%) and hyphemas or microhyphemas (17/61, 27.9%) were also common. Of the seven with subsequent RDs, one was diagnosed at the time of initial injury with the remaining six occurring at one week, one week, two weeks, three weeks, one year, and one and one-half years. Retrobulbar hematomas (RR, 1.20; 95% CI 1.07–1.34), eyelid lacerations (RR, 1.24; 95% CI 1.08–1.41), ptosis (RR, 1.20; 95% CI 1.07–1.34), macular holes (RR, 1.23; 95% CI 1.08–1.39), maculopathy (RR, 1.23; 95% CI 1.08–1.39), and optic nerve avulsion (RR, 1.21; 95% CI 1.08–1.37) were all associated with a higher risk of poor BCVA, while, RD was not (RR, 1.04; 95% CI 0.75–1.44).

Regarding management, 36 eyes were observed, seven underwent globe exploration, six urgent PPV, six urgent foreign body removal, three scleral buckle, two enucleation, one prophylactic scleral buckle, one macular hole repair, one lensectomy, one muscle reattachment surgery, one fracture repair, and one conjunctival closure (Table 4). The six patients who underwent urgent PPV had similar outcomes to those observed, with poor final BCVA in five patients (83.3%). Of those undergoing urgent PPV, five had improvement in final BCVA (83.3%).

5. Prediction model

Backward selection was performed on the following variables as possible risk factors for poor BCVA: age, projectile (air-gun, paintball, cork, foam bullet, tree branch), location of sclopetaria (macula, temporal retina, superior retina), comorbidities (retrobulbar hematoma, eyelid laceration, ptosis, cataract, hyphema or microhyphema, macular hole, maculopathy, optic nerve avulsion) and urgent management (foreign body removal, muscle reattachment surgery, fracture repair, lateral canthotomy, lensectomy). Location of sclopetaria in the macula, location in the temporal retina, and urgent foreign body removal were retained in the model. Area under receiver operating characteristic curve was 0.767, and 10-fold cross validation revealed a true AUROC of 0.737. Therefore, the over-optimism was 0.030, indicating a low degree of overfitting.

6. Discussion

In 1996, Kuhn et al. presented a standardized classification for ocular trauma with the major delineation between closed globe and

Table 3
Comorbidities and their relationship to final visual acuity.

Comorbidity	Frequency n (%)	Final BCVA Worse Than 20/20 n (%)	Relative Risk (95% CI)	Unadjusted P Value[a]
Orbit/Globe				
Orbital Fracture	11/61 (18.0)	10/11 (90.9)	1.11 (0.88–1.39)	0.374
Motility deficit	4/61 (6.6)	3/4 (75.0)	0.56 (0.05–6.03)	0.694
Retrobulbar Hematoma	1/61 (1.6)	1/1 (100.0)	1.20 (1.07–1.34)	0.002
Anterior Segment				
Hyphema/Microhyphema	17/61 (27.9)	16/17 (94.1)	1.18 (0.98–1.43)	0.085
Conjunctival Laceration	12/61 (19.7)	10/12 (83.3)	1.00 (0.75–1.32)	0.977
Eyelid Laceration	9/61 (14.8)	9/9 (100.0)	1.24 (1.08–1.41)	0.002
Corneal Abrasion/Epithelial Defect/Corneal Edema/Corneal Laceration	5/61 (8.5)	4/5 (80.0)	0.96 (0.61–1.51)	0.860
Iridodialysis/Angle Recession	2/61 (3.3)	1/2 (50.0)	0.59 (0.15–2.37)	0.457
Elevated Intraocular Pressure	2/61 (3.3)	1/2 (50.0)	0.59 (0.15–2.37)	0.457
Ptosis	1/61 (1.6)	1/1 (100.0)	1.20 (1.07–1.34)	0.002
Subluxated Lens	1/61 (1.6)	0/1 (0.0)	0.30 (0.03–3.27)	0.321
Cataract	1/61 (1.6)	1/1 (100.0)	1.20 (1.07–1.34)	0.002
Posterior Segment				
Intraorbital Foreign Body	40/61 (65.6)	36/40 (90.0)	1.26 (0.94–1.68)	0.118
Vitreous Hemorrhage	38/61 (62.3)	31/38 (81.6)	0.94 (0.75–1.17)	0.568
Optic Neuropathy	17/61 (27.9)	13/17 (76.5)	0.89 (0.66–1.18)	0.409
Commotio Retinae	16/61 (26.2)	15/16 (93.8)	1.17 (0.97–1.42)	0.108
Retinal Detachment	7/61 (11.5)	6/7 (85.7)	1.04 (0.75–1.44)	0.830
Macular Hole	7/61 (11.5)	7/7 (100.0)	1.23 (1.08–1.39)	0.002
Maculopathy	6/61 (9.8)	6/6 (100.0)	1.23 (1.08–1.39)	0.002
Optic Nerve Avulsion	4/61 (6.6)	3/3 (100.0)	1.21 (1.08–1.37)	0.002

BCVA = best corrected visual acuity.
[a] Variables considered to be significant by Bonferroni corrected a-levels of 0.003 (0.05/20).

open globe injuries.[29] Under the heading of closed globe injuries posterior manifestations include commotio retinae, choroidal rupture, sclopetaria, macular hole, and retinal detachments. High velocity projectiles can lead to coup injuries at the site of impact (e.g. sclopetaria), while pressure waves opposite the site of impact can lead to countercoup injuries (e.g. commotio retinae, choroidal rupture, and traumatic macular holes). Direct ocular compression, on the other hand, leads to equatorial stretching which can result in vitreous base avulsion and retinal dialysis.[30]

Sclopetaria is distinguished from commotio retinae and choroidal rupture in that there is more extensive damage including rupture of the choroid, Bruch's membrane, RPE and neurosensory retina adjacent to the projectile.[31] On examination, bare sclera can often be visualized, though this will typically evolve into a pigmented scar (Figs. 3 and 5). The clinical and pathologic findings following ocular trauma are a result of differences in elasticity of the sclera, Bruch's membrane, RPE, and retina.[32] Bruch's membrane is inelastic and ruptures easily with compressive forces along with its adherent choriocapillaris leading to the acute subretinal hemorrhages often seen in ocular trauma. Similarly, the RPE is relatively inelastic, making rupture more likely and leading to the late pigmentary changes often seen with both choroidal rupture and sclopetaria. Conversely, both the retina and sclera are elastic, requiring high levels of impact energy to disrupt their architecture. Therefore, only a high velocity projectile, such as a bullet, passing adjacent to the globe, could create the shock wave forces that could produce retraction of both the retina and choroid, leaving bare sclera at the site of a break.[28]

Regarding long term complications, commotio retinae can be observed as retinal edema almost universally resolves in a few days.[33] Eyes with choroidal rupture must be observed more closely for the

Table 4
Immediate and delayed management of complications.

	Overall Frequency (%)	Final BCVA Worse Than 20/20, Frequency (%)	Relative Risk (95% CI)	Unadjusted P Value[a]
Immediate Surgery[b]				
Any Immediate Surgery	24/61 (39.3)	22/24 (91.7)	1.17 (0.95–1.44)	0.140
Observation	37/61 (60.7)	29/37 (78.4)	0.86 (0.69–1.05)	0.140
Foreign Body Removal (Non-Intraocular)	8/61 (13.1)	8/8 (100.0)	1.23 (1.08–1.40)	0.002
Globe Exploration	7/61 (11.5)	6/7 (85.7)	1.03 (0.74–1.42)	0.865
Pars Plana Vitrectomy	6/61 (9.8)	5/6 (83.3)	1.00 (0.68–1.45)	0.985
Scleral Buckle	3/61 (4.9)	2/3 (66.7)	0.79 (0.35–1.77)	0.566
Enucleation	2/61 (3.3)	2/2 (100.0)	1.20 (1.07–1.35)	0.002
Muscle Reattachment Surgery	1/61 (1.6)	1/1 (100.0)	1.20 (1.07–1.34)	0.002
Fracture Repair	1/61 (1.6)	1/1 (100.0)	1.20 (1.07–1.34)	0.002
Lateral Canthotomy	1/61 (1.6)	1/1 (100.0)	1.20 (1.07–1.34)	0.002
Lensectomy	1/61 (1.6)	1/1 (100.0)	1.20 (1.07–1.34)	0.002
Delayed Surgery				
Any Delayed Surgery	9/61 (14.8)	7/9 (77.8)	0.92 (0.64–1.33)	0.654
Pars Plana Vitrectomy	6/61 (9.8)	5/6 (83.3)	1.00 (0.68–1.45)	0.985
Scleral Buckle	3/61 (4.9)	2/3 (66.7)	0.79 (0.35–1.77)	0.566
Fracture Repair	2/61 (3.3)	1/2 (50.0)	0.59 (0.15–2.37)	0.457
Lensectomy	2/61 (3.3)	2/2 (100.0)	1.20 (1.07–1.35)	0.002

BCVA = best corrected visual acuity.
[a] Variables considered to be significant by Bonferroni corrected a-levels of 0.003 (0.05/20).
[b] Defined as less surgery performed less than one week after the injury.

development of secondary choroidal neovascularization membranes.[34] Patients with sclopetaria are at higher risk for both delayed vitreous hemorrhage or progression of vitreous hemorrhage (as in Case 1) and retinal detachment, which has given credence to early surgical intervention.[21] Prior to 2014, it was felt that retinal detachment was unlikely to occur in the setting of sclopetaria due to adhesions between the retina and choroid causing them to retract as a single unit. Additionally, as most patients with sclopetaria are young, they have formed vitreous and intact posterior hyaloid which tamponades the retinal break. However, in 2014, Papakostas et al. published three cases of retinal detachment in the setting of sclopetaria.[21] It should be noted that these three patients had preceding surgery (globe rupture repair, nail removal, and BB removal from the orbit) prior to retinal detachment. Based on the results of this review, the incidence of retinal detachment following sclopetaria was 11.5% (7/61) though this finding was not associated with a worse visual outcome ($p = 0.83$).

The visual prognosis following sclopetaria is dependent on multiple features. When considering projectile type, those with the lower muzzle energy (e.g. air-gun pellet and paintball) were more likely to result in poor visual outcome than those with high muzzle energy (e.g. bullet and BB) (Table 1).[35] This was a surprising finding as increased muzzle energy is typically associated with increased damage. Therefore, we propose that the visual prognosis is more likely related to the location of sclopetaria and the associated ocular comorbidities than the projectile type. As anticipated, those with temporal and macular sclopetaria were less likely to achieve 20/20 vision (Table 2). Additionally, the concurrence of a macular hole or maculopathy were risk factors for incomplete visual recovery (Table 3). Those with eyelid lacerations were at higher risk for poor visual prognosis, possibly because these tended to occur in the setting of more extensive orbital damage. The presence of an intraorbital foreign body, vitreous hemorrhage and retinal detachments were not independent risk factors for suboptimal visual recovery. As expected, those with simultaneous optic nerve avulsion had poor visual outcomes.

The most controversial component of sclopetaria is the immediate management. As this review has demonstrated, there is no statistically significant benefit of immediate surgery as compared to observation alone ($p = 0.140$). However, this finding needs to be taken in context as it is unknown what the visual outcome would have been if surgery was delayed. In cases where the clinical suspicion was high for a ruptured globe, globe exploration did not ultimately worsen the chance for visual recovery ($p = 0.865$). Additionally, PPV (6 cases) and/or prophylactic scleral buckle (3 cases) were not statistically beneficial in protecting vision, though the sample size was likely too small to detect a difference. Of the nine patients undergoing delayed surgery, only two ultimately achieved a visual acuity of 20/20. Patients undergoing immediate orbital foreign body removal were statistically less likely to achieve 20/20 vision ($p = 0.002$). The standard of care following inorganic intraorbital foreign body removal includes observation unless they are causing complications or anteriorly located allowing simple removal as loss of vision is almost always associated with the initial trauma.[36] Immediate surgical intervention (especially orbital foreign body removal) is likely not beneficial for ultimate visual recovery, though this decision needs to be tailored to each individual scenario.

7. Conclusions

Ultimately, sclopetaria is a rare sequelae of a high velocity projectile passing tangentially to the eye. The demographic associated with sclopetaria is the same as for trauma elsewhere to the body – young males. Sclopetaria most commonly occurs secondary to BBs, likely due to both the common use of BB guns among this population and the impact velocity enough to rupture the retina, but low not to harm the sclera.[37,38] The visual prognosis is most dependent on the status of the macula and the location of the sclopetaria (with superior and temporal disease having worse outcomes). The immediate and delayed management is equivocal and a case by case approach is likely the safest approach. Fortunately, most patients experience improvements in final BCVA though only 16.4% achieve 20/20 vision.

Patient consent

This report does not contain any information that could lead to the identification of the patients.

Acknowledgements and disclosures

Funding

This work was supported by the National Institutes of Health [grant numbers R01EY026682, R01EY024665, R01EY025225, R01EY024698 and R21AG050437]; and Research to Prevent Blindness.

Conflicts of interest

None reported.

Authorship

All authors attest that they meet the current ICMJE criteria for Authorship

Acknowledgements

None

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajoc.2019.02.004.

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