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RESEARCH COMMUNICATION

Factors affecting visual outcomes of children with open globe injury

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ABSTRACT

Objective: This study described the demographics of pediatric patients who sustained open globe injuries, determined the visual outcome of open globe injuries in pediatric patients and the factors associated with final visual acuity.

Methodology: The medical charts of 195 patients aged 0-18 years seen for open globe injury in a Philippine tertiary hospital for three years were reviewed.

Results: The average age of patients was 7.9 years with 41% belonging to the 5-9 years old group. Seventy-five percent (75%) of the patients were males. Ninety-five percent (95%) of the open globe injuries were accidental, mostly from play (67%). The most common agents of injury were metallic objects (42%) followed by wooden objects (24%). The cornea was injured in 80% of the cases, cornea and sclera in 10%, sclera in 7%, and globe rupture in 3%. Eighty-six percent (86%) of the patients underwent surgery. Initial visual acuity was associated with the presence of complication and the site of injury. Final visual acuity was associated with the initial visual acuity, the interval from injury to consultation, the site of injury, and the presence of complications.

Conclusions: The majority of the injuries were accidental and thus avoidable. The education of parents and caregivers on proper storage of potentially harmful objects at home and proper supervision of children at play are important in addition to early consultation after the injury as well as a timely intervention.

Keywords: *Open globe injuries, visual outcomes, penetrating, children*

Introduction

Ocular traumatic injury is a common cause of unilateral blindness in the pediatric age group, especially in developing countries [1-3]. Around 20-50% of all ocular traumatic injuries were in children [1,4]. It was even as high as 63% in India [5]. In the Philippines, 21% of pediatric ocular traumatic injuries were from open globe injuries particularly penetrating injuries while the rest were from closed globe injuries as defined in the Birmingham Eye Trauma Terminology (BETT) [2,6]. In a study by Martin, 30% of those with open globe injuries were aged 0-16 years [7]. In BETT, open globe injuries are defined as having a full-thickness wound in the cornea or sclera while close globe injuries are those without. Penetrating ocular injuries are any laceration (an outside-in mechanism) involving any material, often sharp, with a single entry site only while perforating ocular injuries are lacerations with entry and exit sites [6]. Globe rupture are injuries with a full-thickness wound from an inside-out mechanism. In a local prospective observational study, a large portion of the subjects suffered from closed globe injury with no visual impairment [2].

In South Africa and Nigeria, 38-66% of children with open globe injuries were sustained during play and 50-55% of these injuries occurred at home. Most injuries occurred in the absence of a caregiver [4,8]. Almost half of the cases were caused by sticks, wire, and glass, with impact with the said objects, often sharp, as the most common mechanism of injury [4,8]. A quarter of the patients consulted the hospital within 24 hours of injury, with consult being earlier in more severe injuries and younger patients [8]. Despite similarities in the surgical management approaches for open globe injuries between children and adults, the management of a child is made difficult by challenges in performing eye examination and assessment and the need for a long-term continuing therapy. Amblyopia also complicates the treatment.

A significant portion of all ocular traumatic injuries are preventable [9,10]. Thus, prevention is vital and strategies to achieve this require information on how the injuries were

sustained and what factors contributed to their visual outcomes to enable redirecting of resources towards the prevention of such injuries. A prospective observational study highlighted that poor visual outcomes were mostly from those with open globe injuries [2]. In another prospective study, although 71% of their patients regained best-corrected visual acuity (Snellen equivalent) of 20/200 or better, only 51% of them regained 20/40 or better [8]. Initiative for the prevention of open globe injuries should be prioritized due to its significant negative effect on visual acuity. At present, there are no local data specific to open globe injuries in children, their visual outcomes, and the factors associated with visual outcomes.

This study aimed to describe the demographics of pediatric patients who sustained open globe injuries, determine their visual outcomes, and determine factors that are associated with their final visual acuity.

Methodology

This study employed a review of medical records of all cases of open globe injuries. This study was approved by the University of the Philippines Manila Review Ethics Board. Patients aged 0 to 18 years who presented to the Department of Ophthalmology and Visual Sciences of a Philippine tertiary hospital in the span of three years for open globe injuries were included. Patients who suffered from closed globe injuries were excluded. Patient records were reviewed, and the following data were collected:

- Age
- Sex
- Laterality (bilateral, unilateral: right or left)
- Time interval from injury to consult (within 24 hours or not)
- Type of open globe injury based on Birmingham Eye Trauma Terminology (BETT)(penetrating, perforating, rupture, or intraocular foreign body)
- Causative agent
- Site of ocular injury (cornea, sclera, cornea-sclera, or globe rupture)
- Nature of the injury (intentional, accidental: sports-related, play, work-related, or others; or unknown)
- Time interval from consult to surgical intervention (within 24 hours or not)
- Complications (none [simple laceration], uveal prolapse, cataract, vitreous loss, intraocular foreign body, retinal detachment, corneal scar, endophthalmitis, more than one complication [*e.g.* uveal prolapse + cataract], others)
- Initial visual acuity
- Operation done
  - None
  - Primary repair (simple repair of the laceration)
  - Primary repair plus another surgery (excision of prolapsed uvea, irrigation and aspiration of lens, anterior chamber wash-out, etc.)
  - Secondary surgery (surgery done on another day not relating to initial surgery but rather to prevent possible complications like secondary cataract formation, etc.)
  - Primary repair plus re-operation (surgery done on another day relating to the initial surgery like a leak, etc.)
  - Primary repair plus another surgery plus re-operation (surgery done on another day relating to the initial surgery i.e. leak, etc.)
  - Enucleation or evisceration
- Length of follow-up consult
- Final visual acuity (outcome)
- Difference between initial and final visual acuity (outcome)

Mean and median values together with tables and graphs were used to summarize data. Statistical analysis was done using Stata Statistical Software Release 14 (StataCorp LP, College Station, Texas). Univariate binomial, multinomial, and ordered logistic regressions were performed. Sex, the time interval from injury to consult, causative agent, site of ocular injury, nature of the injury, and complications were tested for association with initial visual acuity, while the operation done was added to test association with final visual acuity and the difference between initial and final visual acuity. Age was not used since most of those in the 0-4 years group were excluded due to non-quantifiable visual acuity. Time from consult to surgery and nature of injury were also not used since only one patient underwent surgery within 24 hours and only four injuries were intentional. A p-value of <0.05 was considered statistically significant.

Results

A total of 195 patients were included in the analysis. The mean age was 7.9 years with 80 (41%) patients falling in the 5-9 years age group (Figure 1). One hundred forty-seven (75%) patients were males. All injuries were monocular and there was no predilection to laterality noted (right eye: 99 patients vs. left eye: 96 patients). Forty percent (40%) of the patients consulted in the hospital within 24 hours after injury. For the type of open globe injury based on the Birmingham Eye Trauma Terminology, there was difficulty in differentiating the injury if penetrating or perforating due to insufficient data on the mechanism of injury during the initial consult, limited data on ophthalmological examination, and the delay in consult and surgery from time of injury. As such, penetrating and perforating injuries were grouped together. Except for four patients with globe rupture and five with intraocular foreign body, the rest of the cases were from penetrating and perforating injuries (95%) (Figure 2).

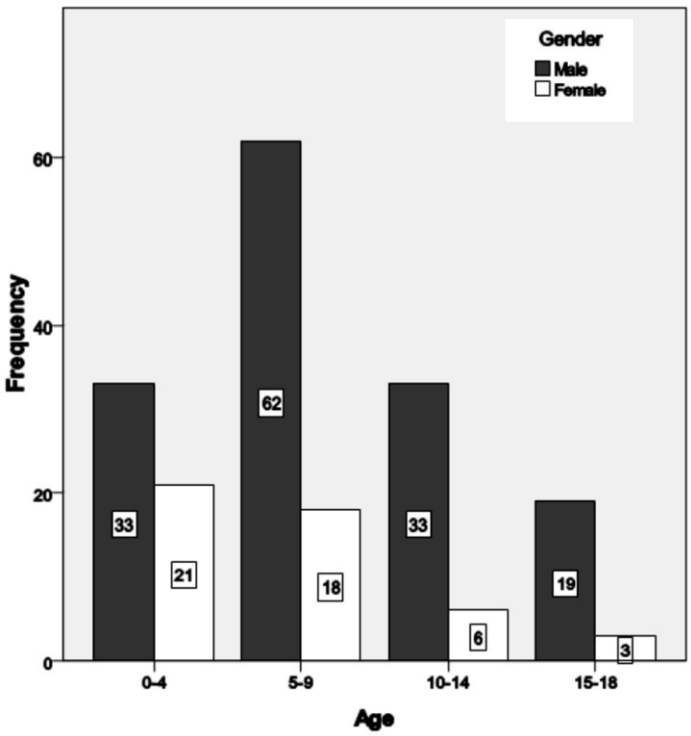

Figure 1. *Age and Gender Distribution.*

Nature and Causative Agents

Six patients were injured intentionally and one was of an unknown cause. The rest (95%) were accidental with 83 (42%) patients caused by metallic objects. A nail was the most common metallic object at 20 (24%) followed by clothesline wire at 16, and scissors and knives at 8 each. There were 22 identified metal objects to have caused the injuries. The second most common causative agent was wooden objects at 47 (24%). A wooden stick other than a broomstick (walis ting-ting) or barbecue stick was the most common wooden object at 17 (36%), followed by a broomstick at 14, barbecue stick at 8, and a plant part (*e.g.* branch, twig) at 5. All causative agents are listed in Table 1. Injuries sustained accidentally were mostly from play (67%) either at home during unsupervised playtime caused by a playmate or a close relative like a sibling. Five (3%) cases were reported to happen at school. Twelve percent were work-related in patients ages 13-18 years in construction work, either by hammering, cutting metal sheets, or working with wires. The remaining 18% were unclassified (*e.g.* injury sustained from a chicken beak or dog scratch).

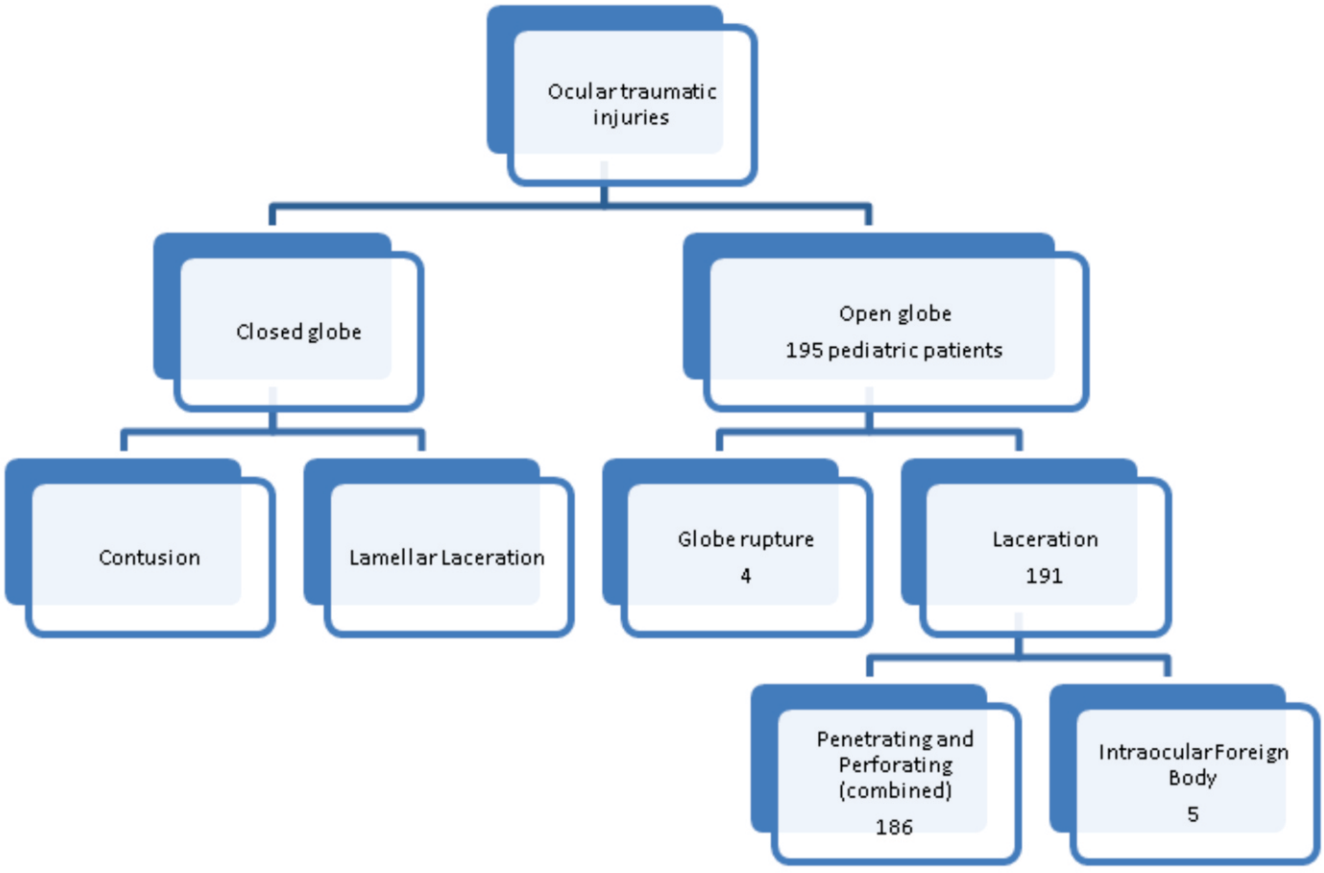

Figure 2. *Type of Open Globe Injury based on the Birmingham Eye Trauma Terminology [6].*

Site of Injury, Complications, and Intervention

The most common site of injury was the cornea in 80% of all the cases, followed by injury to the cornea and sclera (10%), the sclera (7%), and globe rupture (3%). Uveal prolapse (24%) was the most common individual complication while 25% of the patients had more than 1 complication (Table 2). Of the 86% who underwent surgical intervention, only 1% had the surgery done within 24 hours from the consult. The rest had a mean time interval from consult to surgery of 6±9 days. The majority (57%) of the patients underwent primary repair plus another surgery (Table 3). Twenty-seven (14%) patients did not require surgery as most presented with sealed wound despite the presence of full-thickness laceration. They were medically treated with antibiotics and followed up accordingly. Five (2.5%) patients underwent either enucleation or evisceration. Two had globe rupture while three had endophthalmitis. The median patient follow-up was 60 (30-150) days.

Visual Outcome

The initial and final visual acuities were grouped into four: 1.) 20/40 or better, 2.) 20/50 - 20/200, 3.) <20/200 – Light Perception, and 4.) No light perception. Fifty-one (26%) patients, mostly in the 0-4 years age group, had no quantifiable visual acuities (*e.g.* central, steady maintained; fixes and follow) upon initial consult and were excluded in the analysis. Twenty-one (21) patients did not have data on final visual acuity, including five who underwent evisceration or enucleation and were excluded. Of the remaining 123 patients, majority (67%) presented with initial visual acuity of 20/200 to light perception (Table 4). A fourfold increase in the final visual acuity of 20/40

Table 1. *Causative Agent of Ocular Injury.*

Agent	Patient				Total	Percentage
	0-4 years old	5-9 years old	10-14 years old	15-18 years old		
Metal					83	42
Nail	3	10	2	5	20	
Clothesline wire	3	5	3	5	16	
Scissors	2	5	1	0	8	
Knives	1	7	0	0	8	
Steel bar	1	4	0	0	5	
Umbrella	0	2	1	0	3	
Others (e.g. fork, cutter, barb wire, padlock, nail pusher, hanger, galvanized sheet, metal chip, fishhook, hinge, antenna, pliers, ballpen, dart, and headband)					23	
Wood					47	24
Wooden stick	3	7	4	3	17	
Broomstick	5	5	4	0	14	
Barbeque stick	3	4	0	1	8	
Plant part	1	3	1	0	5	
Pencil	1	2	0	0	3	
Plastic					16	8
Toy	1	1	2	1	5	
Others (e.g. headband, hanger, CD cover, stick, PVC pipe, bag, monobloc chair, tile)					11	
Glass	8	4	3	1	16	8
Stone	2	3	3	1	9	5
Others					19	10
Bird's beak	2	1	2	0	5	
Poke by Finger/nail	1	3	0	0	4	
Firecrackers	1	1	0	0	2	
Animal scratch	1	0	1	0	2	
Lollipop stick, construction debris, bike accident, fruit, nail file, clay pot					6	
Unknown					5	3
Total					195	100

Table 2. *Associated Complications of Ocular injury.*

Complication	Patient	Percentage
None (Wound only)	30	15
Uveal Prolapse	47	24
Cataract	38	19
Vitreous Loss	1	1
Intraocular Foreign Body	5	3
Retinal Detachment	0	0
Corneal scar	0	0
Endophthalmitis	14	7
> 1 complication (*e.g.* Uveal prolapse + Cataract)	49	25
Others	5	3
No data	6	3
Total	195	100

Table 3. *Type of Operations Performed.*

Intervention	Patient	Percentage
No Surgical Intervention	27	14
Primary repair (PR)	17	9
Primary repair plus another surgery (PP)	111	57
Secondary Surgery	11	5
PR plus re-operation	1	0.02
PP plus re-operation	4	2.3
Enucleation/Evisceration	5	2.5
No data	19	10
Total	195	100

Table 4. *Distribution of the Initial and Final Visual Acuity.*

	Initial visual acuity		Final visual acuity	
	Number of Patients	%	Number of Patients	%
20/40 or better	14	11	50	41
20/50 - 20/200	15	12	16	13
>20/200 – Light Perception	82	67	40	32
No light perception	12	10	17	14
Total	123	100	123	100

Table 5. *Difference between Initial and Final Visual Acuity.*

Change in Visual Acuity	Frequency	Percent
Shift down of 2 groups	2	1
Shift down of 1 group	8	6
No change	61	50
Shift up of 1 group	24	20
Shift up of 2 groups	28	23
Total	123	100

or better compared to the initial and a decrease of half in the <20/200 – light perception group. An additional five patients had a final visual acuity of no light perception.

The difference between the initial and final visual acuity was also determined using the four groups of visual acuity

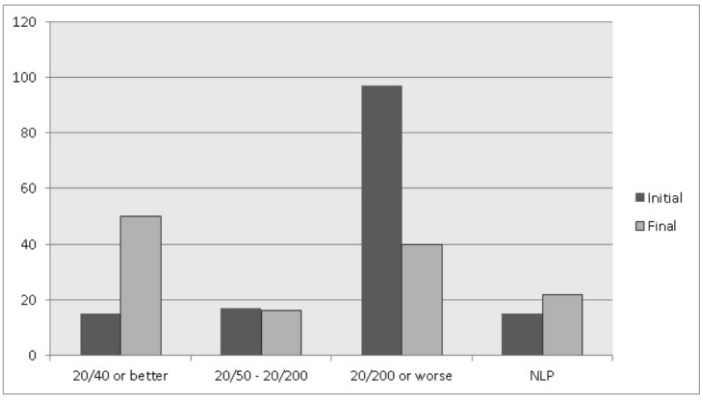

Figure 3. *Initial and Final Visual Acuity.*

(20/40 or better, 20/50 - 20/200, <20/200 – Light Perception, and No light perception). A shift up of two groups means that the initial visual acuity of the patient improved two groups higher (*e.g.* a patient with an initial visual acuity of 20/400, Group 3) improved to a final visual acuity of 20/40, Group 1) (Table 5). There was an improvement of visual acuity in 43% of patients with 36 patients improving to a final visual acuity of 20/40 or better (Figure 3). Twenty-eight (23%) patients had visual improvement of two groups or equivalent to > 7 Snellen lines while the visual acuity of 10 (7%) patients got worse.

Factors Associated with Visual Acuity

Only 118 patients were included in the tests for association as five (5) were excluded due to incomplete data such as the presence of complications. The initial visual acuity has a significant association with presence of complication ($p<0.0001$), and site of injury ($p<0.01$). Patients with any of the individual complications except for endophthalmitis (coefficient = 2.10) had better initial visual acuity than those with >1 complication. Scleral injury (coefficient= -0.14) had a better initial visual acuity than those with corneal injury while those with globe rupture had worse (coefficient= 17.67). The initial visual acuity was not significantly associated with sex ($p=0.68$), the time interval from injury to consult ($p=0.77$), and the cause of injury ($p=0.57$).

The final visual acuity was significantly associated with the initial visual acuity ($p<0.0001$), where the worse visual acuity was on presentation resulted in the worse final visual acuity also. It was also significantly associated with the time interval from injury to consult ($p<0.03$), complication ($p<0.0001$), and site of injury ($p<0.03$). Interval of greater than 24 hours between injury and hospital consult resulted in worse visual acuity than those seen within 24 hours. Similar to the initial visual acuity, patients with any of the

individual complications except for open globe injury-related endophthalmitis (coefficient = 2.10) had a better final visual acuity than those with >1 complication. Those with globe rupture had worse visual acuity compared to those with corneal injury (coefficient= 15.97). The final visual acuity has no significant associations with sex (p=0.40), operation performed (p=0.65), and cause of injury (p=0.14).

The difference between initial and final visual acuity was significantly associated with the time interval from injury to consult (p<0.02), and the operation performed (p<0.02). Consultation with the hospital within 24 hours after the injury led to the stabilization or improvement of visual acuity. Primary repair plus another surgery led to the most stabilization or improvement in the visual acuity. Patients with only one complication had more improvement in their visual acuity than those with >1 complication. The difference between initial and final visual acuity has no significant association with sex (p=0.51), site of injury p=(0.59), cause of injury (p=0.33), and complication (p=0.06).

Discussion

This study is the largest published case series on pediatric open globe injuries in the Philippines to our knowledge and is almost of similar size to the case series done in India [5,11,12]. This study found that pediatric open globe injuries were most common among the 5-9 years old and male patients. Although Merca and Valbuena found that ocular trauma, in general, was most common in the 2-6 years old, the 5-9 years old may be taller and agile leading to more access to the causative agents identified in the study and were older leading to being left alone at home more often than their younger counterparts, while some were just starting to attend school [2]. Similar to other studies, males were more affected than females ascribed to their active behavior. Although a portion of the injuries was claimed to be inflicted by a sibling or a playmate, most of the data on who inflicted the injury was not specified since some patients who were not attended to during the time of the injury were too young to narrate or recall what happened.

Most (95%) of the open globe injuries in this study were from penetrating and perforating injuries. Although this finding is similar to those in India (78%), this study presented significantly higher proportions [12]. This highlights the continuous need to educate caretakers to put the identified causative agents including nails, wires, scissors, and knives out of children's reach and if possible, secured locations. However, some identified agents are household fixtures, like broomsticks, umbrellas, and hangers in Filipino houses. Keeping commonly cited sharp agents out of children's reach may be insufficient since numerous agents, even the seemingly harmless ones can cause open globe injuries if handled incorrectly. Thus, increased attendance by caretakers is also vital together with proper disposal of barbecue sticks and other wooden sticks inside the house. Although some of the patients were informally working to earn a living even if they were still minors, proper occupational protective equipment shall be provided to them.

Similar to India, the most common site of injury in this study was the cornea, which was also found to have poorer visual acuity at initial consult compared to scleral injury [1]. We postulate that the propensity of having the cornea getting injured in this series may have been due to the poorer visual acuity and thus, the patients affected had a higher chance of consulting hospital as opposed to those with scleral injury who opted to just observe their conditions at home. Uveal prolapse remained the most common complication since it is the most proximate structure to the cornea and sclera and the first to prolapse in a laceration. Eighty-six percent needed surgery with 57% requiring additional procedures on top of the full-thickness wound repair indicating that other intraocular parts were involved.

This study also found that half of the children seen in the hospital, especially those who required surgical intervention, had stable vision in up to two months while 43% experienced an improvement in visual acuity. These highlight the importance of consulting an eye care facility, in the presence of an open globe injury. This, in turn, highlights the need for accessible eye care for everyone, especially when being seen within 24 hours after the injury was found to be significantly associated with a better final visual acuity [13,14]. This finding was contrary to findings in South Africa that the time interval from injury to consult was not significantly associated with final visual acuity [8]. This may be from the lesser severity of open globe injuries in their patients as evidenced by their high proportion (70%) of population having a final visual acuity of 20/200 or better as opposed to this study where only half had the same final visual acuity.

This study also identified factors associated with visual outcome. Visual acuity at initial consult was poorer if the cornea was involved or in the presence of globe rupture. Initial visual acuity was also poorer with the presence of more than one complication. Since initial visual acuity was found to be significantly associated with the final visual acuity, it can be used by ophthalmologists in prognosticating the visual acuity of patients with the parents or caretakers

during the initial consult. However, this shall not limit ophthalmologists to employ the most appropriate surgical treatment as improvements were found to be significant after surgical intervention.

The findings of this study may not present new learnings to those who ascribed that the same findings were reported in prior studies involving population from other countries and as such are automatically applicable to Filipinos. However, local studies like this can present different findings such as the importance of immediate hospital consult despite the low-resource setting and the increased need to attend to children since some of the common causative agents identified are commonly found in Filipino houses that cannot be kept away from them such as a broomstick. This study is limited by its retrospective nature, making the collection of data on who inflicted, the injury, the absence of a caretaker, and other details surrounding the injury difficult. However, even if made prospective, collecting these data will still be inherently difficult since the reliability of the informant, who will be either too young to remember, afraid to tell the truth, or not around to witness the injury, is often poor.

Prevention is vital in addressing pediatric open globe injuries considering that half of the patients in this study were already severely visually impaired or blind. Aside from properly storing sharp materials, adequate adult supervision and programs to educate the parents, caretakers and children are also needed. Grieshaber and Stegmann recommended that effective prevention should stress parental awareness, careful supervision, greater home safety, safe toys, and avoidance of hazardous games [8]. Apart from the preventive measures, it is also highly recommended that once the injury has occurred, parents and caretakers should immediately seek eye care consult.

Conclusion

Open globe injuries remain a significant cause of pediatric unilateral blindness. Penetrating or perforating injuries from metallic and wooden objects were often the cause. Since half ended up severely visually impaired or blind, prevention is vital. However, keeping sharp objects out of children's reach may not be sufficient. Attending to children more and seeking immediate eye care if the injury happened already help with improving the visual acuity.

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