OCULAR TRAUMA DUE TO FIREWORKS

AN OBSERVATIONAL STUDY

IN A TERTIARY EYE CARE CENTRE

DISSERTATION SUBMITTED TOWARDS
FULFILLMENT OF THE RULES AND REGULATIONS
FOR THE M.S. BRANCH III OPHTHALMOLOGY
EXAMINATION OF THE TAMILNADU DR. M.G.R.
MEDICAL UNIVERSITY
TO BE HELD IN APRIL, 2016
BONA FIDE CERTIFICATE

This is to certify that this dissertation entitled “Ocular trauma due to fireworks: an observational study in a tertiary eye care centre” done towards fulfilment of the requirements of the Tamil Nadu Dr MGR Medical University, Chennai for MS Branch III Ophthalmology examination to be conducted in April 2016, is the bonafide original work of Dr. Neethu Ann Kurien, Post Graduate student in Ophthalmology, Christian Medical College, Vellore.

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INTRODUCTION

Vision is one of the important senses of perception, which helps one to lead an independent and fulfilling life. Vision impairment even of the mildest form can slow down one's activities, and hence needs rehabilitation to achieve one's full potential.

Decrease in vision can be due to various factors, which can be preventable, curable, or rehabilitated to enable the patient to come back to social life and make him or her as independent as possible with various methods of
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I wish to thank my statistician Mrs. Tunny Sebastian, Department of Biostatistics, for her help and valuable opinions.

I appreciate the kind support of other staff, faculty of medical records department and residents of Department of Ophthalmology.

I would also like to acknowledge the amazing help and support given by my husband Jacob, during this period.
INTRODUCTION

Vision is one of the important senses of perception, which helps one to lead an independent and fulfilling life. Vision impairment even of the mildest form can slow down ones’ activities, and hence needs rehabilitation to achieve ones full potential.

Decrease in vision can be due to various factors, which can be preventable, curable, or rehabilitated to enable the patient to come back to social life and make him or her as independent as possible with various methods of management. According to WHO, 80 % of visual impairment can be either prevented or cured.(1)

One major preventable cause of ocular morbidity is ocular trauma. Trauma to the globe encompasses a wide variety of presentation and clinical manifestation. It may result in significant ocular morbidity leading to unilateral blindness. Though there have been significant advances in both the medical and surgical management of such injuries, prevention is much better.

Trauma to the eye can range from superficial and trivial injury to grave and devastating vision threatening entity. It is important, to assess the extent of injury, whether it is an open or closed globe injury, and also the mechanism or agent which led to the trauma. Injuries to the eye can occur during road
traffic accidents, or with sharp objects such as knife, glass piece, wood or thorn, household items like pen, hooks, broom stick, etc.

Firecrackers form one such agent which are used during various celebrations, and if not used appropriately can lead to serious ocular morbidity.

Firecrackers have been increasingly found to cause ocular trauma in various studies across the globe. They have been found to be associated more among the children and the youth. Injuries are more difficult to prevent in children as they are not always supervised while playing and not always aware of the consequences of their action. Men were noted to be more predisposed to injuries due to fireworks.

Fireworks have been associated with injuries which vary according to the type of cracker, mode of injury, active participation, intervention etc.
This study is an effort to obtain demographic profile of the local population who presented to our hospital with trauma to the eye due to fireworks, along with the mode and nature of injury, and the final visual outcome after appropriate management.
AIMS AND OBJECTIVES

Aim:

To review the epidemiological profile, nature, type of ocular trauma caused by fireworks

Objective:

1. To characterize the visual outcome and prognosis in patients with ocular trauma due to fireworks

2. To enhance educational awareness for protection of eyes and precautionary measures during usage of fireworks.
METHODOLOGY

Study Design:

This is an observational retrospective and prospective study

Study Population:

All patients who report to the emergency services and out patient department of Ophthalmology, with history of trauma to eye with firecrackers.

Inclusion Criteria:

Patient of any age group who had ocular trauma due to firecrackers and who was willing to take part in the study.

Study Period:

Retrospective study was conducted from the month of October 2013 till July 2014.

The prospective study was undertaken from August 2014- August 2015.

Ethics Committee Approval:

Once the study proposal was made, it was put forward to the Institutional Research Board. After obtaining the approval from the ethics committee, the study was initiated.
Statistics

Sample Size Calculation

Sample size calculation was made based on a study done in Delhi, India. According to that study, the prevalence of visual acuity below 5/200 is 31% following fireworks injury*

\[ N = \frac{4 \times p \times q}{d^2} \]

Where,

\( N = \) Calculated Sample Size
\( p = \) 40% (approx. prevalence of visual acuity beyond 20/200)
\( q = \) 1 - p = 60%
\( d = \) 10% (Precision)
\( \alpha = \) 5%

Therefore, \( N = \frac{4 \times 40 \times 60}{10 \times 10} = 96 \) patients required for the study


Methodology:

Retrospective Study:

For the retrospective study, initial data of patients who had come with ocular trauma due to fireworks was collected from the emergency services record.
The files were collected from the medical records department and information was gathered regarding the details of the injury.

Patients were called back after six months for complete ocular examination, including a best corrected visual acuity in both eyes. Data consisting of their socioeconomic status, exact circumstances which led to the injury were collected during this visit. Those patients who had not regained their vision up to the full potential were followed up till they had a surgical intervention, so that their final visual outcome was obtained.

Prospective Study

Recruitment:

All patients who presented to our emergency services and out patient department with trauma to the eye with firecrackers were recruited for the study after taking an informed consent. For children who were injured with crackers, child’s assent and parents’ informed consent were taken.

Data Collection

Data was collected in a questionnaire which was implemented by the primary investigator, which included:

Demographics: Age, Gender, Hospital Number
Day of Presentation
Socioeconomic score
Details of Injury: mode, time, place, occasion, active participant or bystander.
Details about firecracker: type, mode of lighting, mode of acquisition
Details on Protection: proximity to cracker, protective eye wear, supervision by adults in cases where children are involved
Likely reason for mishap: negligence, device malfunction, attempt to reignite, recovering a failed device (misuse), personal failure, manipulation.
Any past ocular history: Glasses, Cataract, Low Vision, Eye Surgeries
Any Systemic Illness: Diabetes Mellitus, Hypertension

**Examination:**

Following history collection, a thorough examination was undertaken, which included systemic examination to look for any injuries or burns on the rest of the body or face for any laceration, contusion or haematoma.

*Ocular examination:* Presenting visual acuity was recorded using Snellens visual acuity chart. A thorough anterior segment examination using slit lamp bio microscope, posterior segment examination with +78 D/+90 D lens, indirect ophthalmoscopy using 20 D lens, tonometry, gonioscopy (when indicated), B Scan Ultrasonography (in case of hazy view to posterior segment), computed tomography to rule out intra ocular foreign body if suspected were done, to quantify the site and severity of ocular damage.
The ocular injuries were classified according to Birmingham Eye Trauma Terminology (BETT) into open globe and closed globe.

After complete ophthalmic and systemic examination, patient was given the appropriate treatment, depending on the standard of care. Those patients who had trivial injuries were advised medical management and were followed up in the out patient department till complete recovery. Patients who required surgical intervention and close monitoring were admitted and appropriate treatment was given as an in patient. On discharge, they were reviewed in the out patient services, till complete recovery.

Follow Up:
Patients were requested to come for follow up evaluation six months after the injury to ascertain their best corrected visual acuity. Patients who had not completed the treatment were followed up within the study period, and their final visual outcome was obtained.

Data Entry and Analysis
Data was entered in EpiData Version 3.1 software, and data analysis was done using SPSS software.
Statistical Analysis

Descriptive statistics, which comprises of continuous variables, will be reported using Mean +/- SD such as age. Time taken to report will be measured using Median (IQR). Other categorical variable such as gender, mode of injury, time of injury, place of injury, time of injury, etc. will be reported using frequency and percentage.

Chi square test will be used to find out the risk factors which can lead on to poor visual outcome following fireworks injury. Visual outcome is defined using WHO classification as best corrected visual acuity in the better eye

0: Normal: 6/6 to 6/18
1: Visual impairment: <6/18 to 6 /60
2: Severe Visual Impairment: <6/60 to 3/60
3: Blind : <3/60
LITERATURE REVIEW

Vision Impairment even in mild forms can affect the potential to perform well in any sphere of life.

BLINDNESS AND VISION IMPAIRMENT

Definition

According to the World Health Organisation (WHO), blindness is defined as visual acuity of less than 3/60, or a corresponding visual field loss to less than 10° in the better eye after best possible correction. Vision impairment has been defined as visual acuity of less than 6/18, but equal to or more than 3/60 or a corresponding visual field loss to less than 20° in the better eye after best possible correction. (1)

Visual impairment can be divided in to moderate and severe. Moderate visual impairment is when the best corrected visual acuity of the better eye is less than 6/18 but more than or equal to 6/60 and severe visual impairment when best corrected visual acuity of the better eye is less than 6/60 but better than or equal to 3/60. (1)
**Epidemiology**

Worldwide, in 2010, there were 39 million people who were blind and 285 million people who had vision impairment. (2) Out of those who were blind, women constituted 60 percent. In South Asia, the prevalence of blind people above the age of 50 was 4.4%.

According to a systematic review done in India in 2010, blindness was estimated to be around 8.0 million and 62 million visually impaired. (2)

A nation wide survey done in India by Murthy et al, from 1999-2001, found that the prevalence of blindness (presenting visual acuity <6/60) was 8.5%. (3) In a cross sectional study conducted in rural central India, in 2011, out of 4711 subjects, 0.5% were blind and 7% had vision impairment. (4)

The Chennai Eye Disease Incidence Study, conducted from 2007 to 2010, on 4419 subjects, noted the incidence of blindness after a 6 year follow up to be 0.48%. (5)

**Epidemiology in children**

In 1997, a global survey done before the initiation of VISION 2020, estimated that 1.4 million children were blind, of which 50% of blindness was avoidable. According to global estimates of 2010, in the age group of less than 14 years, 1.42 million are blind, and 18.93 million are visually impaired. (2)
The prevalence of childhood blindness in Southern India in a study conducted by Dandona et al, on 2861 children of age less than 15 years is 0.17 % (6) In another study done in southern India, out of 14,423 children, the prevalence rate of mono ocular vision impairment was found to be 1.13 in 1000. (7)

Tadic et al, observed that visual impairment affected relationships among peers, participation in social gatherings, independence in day to day activities, emotional and psychological wellbeing and hopes about the future. (8)

**Low vision in children**

Children who have defective vision in the first decade are at great risk of developing severe amblyopia if not intervened early. They can go on to develop squint, loss of binocular vision. Such children become less attentive in class due to difficulty in following lessons in school causing them to being dropped out of school. Therefore the effort to optimise the visual outcome must first be to restore the anatomic integrity of the eye and second to prevent amblyopia.

**Amblyopia in children**

Developing countries have been found to have a higher prevalence rate of amblyopia. Amblyopia in children can be seen up to an upper age limit of
-10 years, in those who are exposed to amblyopia inducing conditions like traumatic cataract. Also, they are at increased risk of blindness in the non amblyopic eye due to orbital or ocular trauma. They are socially and economically at a disadvantage, because most of the jobs need vision in both eyes. Amblyopic children and their families undergo severe psychological stress and in turn affect their social wellbeing. The goal of amblyopia treatment is the achievement of maximum visual acuity for an individual patient. In brief treatment consists of removing media opacities, correction of significant refractive errors with glasses or contact lenses, encouraging the child to use the amblyopic eye by an occluding patch and monitoring for recurrence.

CAUSES OF VISION IMPAIRMENT

In a systematic review of the surveys conducted across 39 countries in 2010, it was found that, uncorrected refractive error (43%) and cataract (33%) form the main causes of visual impairment. Blindness was due to cataract, glaucoma, and age related macular degeneration. Corneal opacities contribute to 1% of visual impairment and 4% of blindness. i.e., 4.9 million(2) The incidence of ocular trauma has not been mentioned in this study.
OCULAR TRAUMA

According to WHO, around 55 million eye injuries causing hindrance to daily activities occur every year. At least 750,000 cases need hospitalization every year, which includes 200,000 open-globe injuries. Around 1.6 million become blind due to these injuries, and 2.3 million develop bilateral low vision and 19 million develop unilateral blindness or low vision. (10) From the international level, an estimated 500,000 blinding eye injuries occur annually world wide, making ocular trauma the principal cause of unilateral blindness in the world today and the second leading cause of blind eyes in at least one recent major study from the developing world. (11–13)

There has been significant research regarding the epidemiology of ocular trauma. This interest in ocular trauma has been accompanied by a growing awareness of the financial and visual impact of eye injuries which have been estimated to have cost $175 to 200 million for 227,000 days of hospital care in US. (14)

In a study of 6704 individuals done in an urban slum in Delhi, India, by Vats et al, prevalence of ocular trauma was found to be 2.4 %, and 11.4% of these injuries led to blindness.(15) In a cross sectional study done in South India in 5150 individuals, the prevalence of blindness in any eye which sustained ocular trauma was found to be 0.8%. (16)
AETIOLOGY OF OCULAR TRAUMA

Eye trauma can range from relatively trivial superficial injury to vision threatening problems. It can involve varied structures causing damage to cornea, lens, retina, optic nerve, or the entire globe.

Trauma to the eye commonly occurs in patients who sustain blunt facial injury. In a study by Holt et al, out of 1436 cases of maxillofacial trauma, 67% had ocular injuries, and 3% of these injuries caused blindness. (17) Blunt trauma to the face can be due to various causes such as during road traffic accidents, sports, assault, firecrackers, explosions, etc. Blunt trauma to the face can not only be associated with visual impairment but also the stigmata of facial deformation, due to facial bone fracture and orbital rim fracture.

Eye trauma can be work related, while working in factories, construction sites, sports related recreational activities, accidental during road traffic accidents, riots, under the influence of alcohol, house repairs, yard work, cutting firewood in rural population and missile injuries in the war front.

Ocular trauma in children is a common and preventable cause of ocular morbidity. Around 90% of all ocular injuries can be avoided by providing proper eye protection and adult supervision.(18)

Trauma among children have increased and may be due to lack of adult supervision and carelessness regarding handling of household tools, accidents.
in school and during festivals involving firecrackers. (19–25) More than 50% of eye injuries occur at home. This reflects the amount of time children spend at home and risks around the home.

CLASSIFICATION OF OCULAR TRAUMA

Trauma research has usually divided ocular trauma either according to the mechanism of injury (e.g.: blunt versus penetrating) or the activity within which the injury occurred (e.g.: occupational, sports, assault). The latter method of analysing ocular injuries offers the advantage of aiding in the formulation of specific prevention strategies.

Ocular trauma can be classified broadly as open globe and closed globe injuries. Studies done across the world, has shown that open globe injuries have a higher rate of blindness compared to closed globe injuries, and is also associated with increased rates of hospitalisation thereby increasing the economic burden and have poor visual outcome at the end of treatment.(26, 27)

The common agents found to be the cause of open globe injury at home in children were knife, pen, sewing needle, and glass, where as closed globe injury were due to finger, fist, and ball. Endophthalmitis was also found to occur in injuries caused with wooden piece, and broomstick.(19)
Classification of globe injury was based on the *Birmingham Eye Trauma Terminology (BETT)*. Its introduction has led to standardization of the terminology used to describe any kind of eye trauma in a comprehensive and consistent manner.(28)

Injury can be classified mainly into two: open globe and closed globe injury. **Open globe injury** is defined as an injury which leads to a full thickness wound involving the coats of the eye ball; whereas **closed globe** is not a full thickness wound. **Contusion** is an injury caused either due to the effect of change in shape of the eye or by energy transferred by the agent causing the injury.

**Lamellar laceration** is a type of closed globe injury, in which the wound is caused by a sharp object, but fails to be full thickness. In contrary, **laceration in open globe injury** is the same as described above, except that it causes a full thickness wound.
The *other types in closed globe* injury include superficial foreign body and mixed, in which mixed consists of two or more other types of closed globe injury in the same patient.

*Laceration* is divided into three subgroups

Penetrating

Intra ocular Foreign Body (IOFB)

Perforating

*Penetrating injury* is one in which there is only one entrance wound in to the wall of the eye ball. *Perforating injury* consists of both an entry and an exit wound. *Rupture* is an injury caused by a blunt object which causes a full thickness wound. This type of wound is different from penetration, because it is due to an inside – out mechanism, where as the former is due to outside- in mechanism. Inside – out mechanism, means that the blunt force causes a rise in intra ocular pressure and the eye ball gives way at the weakest point, like in case of wound dehiscence of an old cataract surgery wound.

*Mixed injury in open globe* injuries is when there are two or more types of open globe injury in the same patient.

*Zones in open globe* injury include:

Zone 1: Isolated to cornea (including Corneoscleral limbus)

Zone 2: Corneoscleral limbus to a point 5mm posterior in to the sclera

Zone 3: Posterior to the anterior 5mm of sclera
**Zones in closed globe** injury include:

Zone 1: External which consists of bulbar conjunctiva, sclera, cornea

Zone 2: Anterior segment involving structures internal to cornea like anterior capsule, lens, posterior capsule, pars plicata

Zone 3: Posterior segment (pars plana and structures posterior to posterior lens capsule)

**Grade/ Visual acuity** in both open and closed globe injury are:

Grade 1: >6/12 (>20/40)

Grade 2: 6/16 to 6/60 (20/50 to 20/100)

Grade 3: 5/60 to CF 2m (19/100 to 5/200)

Grade 4: CF 1.5 m to PL (4/200 to PL)

Grade 5: No PL

**Pupil** (affected eye): Positive: RAPD present

Negative: RAPD absent

**OCULAR TRAUMA DUE TO FIREWORKS**

Ocular trauma due to fire crackers have been found to be one of the main causes of ocular morbidity in studies done across the globe, affecting mainly children and the youth who are the main participants in celebrations involving pyrotechnics. This section of the population forms the next
generation earning members of the family, there by causing a decrease in the productivity and increase in the disability adjusted life years.

Firecrackers are explosive light and sound emitting devices used across the globe for celebrations. It is used in various parts of the world during regional, national, and international festivals, such as Diwali, Ramadan in India, Independence Day celebration in The United States, Chinese New Year, Sports events like Olympics, New Year celebrations etc.

Firecrackers can be classified as

Class A: High explosives such as TNT, Dynamite
Class B: Low Explosives such as display crackers used for public displays
Class C: Common firecrackers available for the general public for use. It consists of sparkler, ground spinner, flare or fountain, rockets etc.

Firecrackers are made of chemicals to impart them colour, combustibility, smoke and sound. They also contain metal and small rock pieces mainly in the home made crackers which can be truly dangerous with respect to injuries to the various body parts including the eye. Trauma due to fire works can cause soft tissue laceration, contusion, haematoma, burns and fractures other than open and closed globe injuries.
The mechanism by which fire crackers causes damage is by high pressure and temperature during explosion causing superficial as well as deep seated damage of head and neck including the eye, ear etc.(29)

Mishaps due to crackers can occur due to various reasons, such as:

**Device failure:** It occurs when a firecracker which is expected to burst in a stimulated time bursts or explodes unexpectedly before or after its presumed time, even when adequate measures have been taken to light them in the correct manner. This usually occurs, when there is a manufacturing defect.

**Misuse:** It leads to ocular trauma when the person tries to light the cracker in a wrong manner for e.g. by holding it in hand, trying to relight a half burnt cracker

**Manipulation:** Is described as the situation where firecracker is altered for e.g. when children try to burn the gun powder of the half burnt or unused cracker by putting them in a heap, and trying to light them., or when they try to come close and blow at a dying cracker to keep it from extinguishing.

**Personal failure/Negligence:** is a condition where those who are lighting the crackers get hurt due to their own mistakes, for e.g. failing to move away from the cracker on time, or when they use the wrong method of lighting such as matchstick.
**Intervention:** is when the ocular trauma occurred due to active manipulation, or misuse of cracker by the patient.

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**FACTORS INVOLVED IN OCULAR TRAUMA**

**Age**

At least two large studies have suggested a bimodal age distribution with the maximum risk occurring among young adults and individuals 70 years of age and above. (30) The excess risk of severe trauma among very young individuals has been reported in many studies (16,31,32). Schein’s study at the Massachusetts Eye and Ear Infirmary found that although subjects under 15 years of age made up only 8% of the study population, they incurred one third of severe injuries, including 36% of hyphemas and 25% of all open globe injuries. (33)

Because of difficulties in managing paediatric cataracts and the potential for amblyopia, the outcome of paediatric ocular injury may be particularly severe. Among children with open globe injuries **good prognostic indicators** include age greater than 8 years, good pre op visual acuity, injury outside the visual axis, and low post-operative astigmatism. (34) Other investigators have also noted that involvement of the lens and need for lensectomy carries a relatively grave prognosis. (35)
The consequences of paediatric ocular trauma pose a serious challenge to the patient, family and treating ophthalmologist. Several features make treatment difficult which include 1) the child’s high level of anxiety which may need general anaesthesia for proper eye examination 2) vigorous and exuberant healing response with a significant fibrotic component 3) battle with amblyopia which begins at the moment of injury and compounded by media opacities, aphakia, undesired astigmatism and retinal pathology (36–38).

The type and mechanism of ocular injury tend to vary with age as well. Various studies report falls as a leading cause of open globe trauma in the elderly (trauma to old surgical wounds). For young adults motor vehicle accidents, occupational trauma and assault are important aetiologies. (22, 24, 31, 32, 39) Among children, domestic accidents play and organised sports account for greater than 70% of open globe injuries. (34)

There are large series describing the epidemiology of paediatric eye injuries. However large population based studies are few. Estimates of the incidence of ocular trauma in children have ranged from 8.5 to 15.2 per 100,000 per year. These injuries occur 4 times more common in boys than girls with 3% occurring under the age of 5, 36% between ages of 5 and 14 years, and 29% between ages 15 and 24 and 31% in individuals over the age of 25 years. (35, 36)
Fireworks were a prominent cause of serious ocular morbidity in 1950s and 1960s, leading to almost 15% of ocular trauma to the eye in children.

In a study conducted in the US, of the 8200 patients that had reported to emergency care for treatment of fireworks related injuries, children constituted half of those who were injured, with eyes being the most commonly affected organ followed by hands and fingers. (40)

Table 1. Studies on children affected by ocular trauma with firecrackers

<table>
<thead>
<tr>
<th>Study (Ref)</th>
<th>Study Period</th>
<th>Number</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singh et al(41)</td>
<td>2005</td>
<td>26 patients</td>
<td>50% ≤15 years</td>
</tr>
<tr>
<td>Malik et al India(42)</td>
<td>2005-2009</td>
<td>101 patients</td>
<td>54% ≤ 14 years of age</td>
</tr>
<tr>
<td>Clarke et al (43)</td>
<td>1979 - 1992</td>
<td>237 patients</td>
<td>68% (10-14 years)</td>
</tr>
<tr>
<td>Witsamann et al (44)</td>
<td>1990-2003</td>
<td>85,800 (children≤19 years of age)</td>
<td>.40% ≤ 15 years of age</td>
</tr>
<tr>
<td>Unterlauft et al(45)</td>
<td>2005-2013</td>
<td>122 patients</td>
<td>mean age group 26.2±13.0 years, 25% ≤ 18 years</td>
</tr>
<tr>
<td>De Faber et al(46)</td>
<td>2008-2009</td>
<td>268 patients</td>
<td>&gt; 50% were &lt; 17 years of age.</td>
</tr>
<tr>
<td>Jing et al(47)</td>
<td>2009</td>
<td>30 patients</td>
<td>70% ≤ 12 years of age</td>
</tr>
</tbody>
</table>
The above table shows that the susceptible population are children and youth as they participate more frequently in such events and are more susceptible to severe eye injuries. (41, 48, 49)

**GENDER**

Hospital based studies of all ocular injuries, injuries requiring hospitalisation and open globe injuries indicate that a major portion of those with superficial to severe ocular injuries were male. This disparity in genders reflects more adventurous or aggressive behaviour among boys.

**Table 2:** Studies describing the gender predominance in ocular trauma with firecrackers

<table>
<thead>
<tr>
<th>Study (Ref)</th>
<th>Study Period</th>
<th>No. of patients</th>
<th>Other details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canner et al USA(48)</td>
<td>2006-2010</td>
<td>25,691</td>
<td>50% ≤ 20 years and 77% were men</td>
</tr>
<tr>
<td>Kong et al China(50)</td>
<td>2008 to 2013</td>
<td>99</td>
<td>86 men</td>
</tr>
<tr>
<td>Thygeson et al, Denmark (51)</td>
<td>1974-1999</td>
<td>4000</td>
<td>482 hospitalised with serious eye injuries, mostly boys &amp; young men</td>
</tr>
<tr>
<td>Mansourri et al Iran (52)</td>
<td>2000-2002</td>
<td>437</td>
<td>84.6% men</td>
</tr>
</tbody>
</table>

**IN VolVEMENT OF BYSTANDERS**

From July 1990 to December 1994, 4575 serious eye trauma due to fire crackers were reported in the US. Bystanders were injured more than the
fireworks operator (35%). In another study from the US 45% of those injured were just bystanders or spectators of firework display. (53) In a recent prospective study done in South India during the festival of Diwali, of 49 patients it was noted that equal number of bystanders were also injured, showing that eye injuries can involve not only those who are lighting the cracker, but also those who are watching as well. This shows the importance of adequate eye protection for those who are watching fireworks as well (54) and importance of avoiding firework display or using fireworks in overcrowded areas.

**SOCIOECONOMIC STATUS**

A risk factor of international importance in ocular trauma is socioeconomic status. Studies among children in Brazil and Australia have found eye injuries to be more common and severe among children of poorer families. (55) Similar results were noted by Mansouri et al where patients from the lower socio economic strata of society were found to be associated with more severe ocular injuries. (52) In a retrospective study, conducted during the spring festival in China, out of the 25 patients, rural residents were found to have higher rates of injury compared to urban residents. (47)

**FEATURES OF OCULAR INJURY DUE TO FIREWORKS**

According to the data from the National Electronic Injury Surveillance System database maintained by the United States Consumer Product Safety
Commission (CPSC) around 12000 persons receive treatment each year in United States emergency departments due to fireworks-related injuries; of these, an estimated 20% are eye injuries. (53).

In a study done in Iran in 2009, during the occasion of Wednesday Eve Festival, out of 1817 patients who were injured by fireworks, eye was one of the most frequently injured areas (24.5 %). The other areas involved were hands, and face, with burns, laceration, contusion and even amputation. (56)

**SEVERITY OF INJURY**

Various studies across the globe has shown the severity of injury caused by fireworks

**Table 3**: Studies demonstrating severity of injury due to ocular trauma with firecrackers

<table>
<thead>
<tr>
<th>Study (Ref)</th>
<th>Study Period</th>
<th>No. Of Patients</th>
<th>Details of Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>De Faber et al, Netherlands(46)</td>
<td>2008-2009</td>
<td>268</td>
<td>1/3rd of eyes - permanent damage, 47 eyes: irreversible loss of vision, 24 eyes: complete loss of vision. Rockets : more serious ocular injury</td>
</tr>
<tr>
<td>Mansouri et al, Iran(52)</td>
<td>2000-2002</td>
<td>437</td>
<td>50% severe eye injury 1% no light perception</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reasons for severe injury : Grenades, bystander, older age, outdoor, lower SES, and males</td>
</tr>
</tbody>
</table>
Rashid et al, Malaysia(57) 2008 30 70% ≤ 12 years of age 9% ≤ 6/60

Malik et al, India(42) 2005-2009 101 17 patients open globe injury 3 eyes - PL Negative

Wisse et al(58) 7742 19% severe ocular trauma – penetration/ perforation/ globe rupture 3.9% enucleation. 16% severe vision loss
Reasons for severe injury: permissive legislation, heavier class fireworks

Smith et al(49) 1972 to 1993 316 children 29% sustained eye injuries, complete / partial loss of vision in 7 cases
Reasons for severe injury: Rockets and Illegal fireworks

REASONS FOR LOSS OF VISION
Ocular trauma can involve varied structures within the eye which can lead to decrease in vision starting from the corneosclera anteriorly to the retino-choroidal layers posteriorly.

Conjunctiva can have sub conjunctival haemorrhage, foreign body, boggy chemosis and tears which may cover up an open globe injury such as an occult scleral tear. Corneal injuries includes corneal epithelial defects, lamellar or full thickness laceration, foreign body within the cornea, concussive endotheliopathy.
**Trauma to the iris and ciliary body** can cause hyphaema, iridodialysis, sphincter tears, traumatic mydriasis, traumatic iritis and angle recession with injury to the ciliary body.

**Lenticular trauma** consists of anterior capsular breach, traumatic cataract, subluxation or dislocation of lens, phacodonesis due to zonular rupture.

There can be early increased *intra ocular pressure* due to trabeculitis or low intra ocular pressure due to occult scleral rupture.

There can be vitreous base detachment, vitreous haemorrhage, and posterior vitreous detachment following concussive injury to the globe.

**Retinal injuries** consists of commotio retinæ, berlins’ oedema, nerve fibre layer ‘flame ‘ shaped haemorrhage, intra retinal haemorrhage, sub retinal bleed, retinal tears, retinal detachment retinal dialysis, purtscher’s retinopathy, macular hole. **Choroidal** rupture is one of the most frequent choroidal findings in trauma.

Damage to the optic nerve consists of direct optic nerve trauma that is a penetrating injury causing impingement of the nerve and indirect optic nerve trauma, which is due to closed head trauma. Indirect injury can be anterior or posterior indirect optic neuropathy

The following table shows the structures affected and the resulting loss in vision in those patients
Table 4: Studies showing the cause for loss of vision due to ocular trauma with firecrackers

<table>
<thead>
<tr>
<th>Study (Ref)</th>
<th>No. of patients</th>
<th>Structures involved</th>
<th>Visual acuity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sacu et al (59)</td>
<td>102</td>
<td>Penetrating corneal &amp; scleral trauma, traumatic cataract, IOFB*, RD*, and optic nerve damage.</td>
<td>18% &lt; 6/60</td>
</tr>
<tr>
<td>Sundelin et al (60)</td>
<td>52</td>
<td>Orbital fracture (3%), cataract and dislocation of lens (6%), retinal damage (11%), globe perforation (3%)</td>
<td>12% &lt; 6/18</td>
</tr>
<tr>
<td>Knox et al(61)</td>
<td>47</td>
<td>Penetrating injury (26%), cataract, RD*, optic nerve damage, supra choroidal haemorrhage, macular scar (38%) irreparable open globe injury (17%)</td>
<td>53% ≤ 6/60 visual acuity</td>
</tr>
<tr>
<td>Singh et al</td>
<td>26</td>
<td>IOFB* (12%), Vitreous haemorrhage (12%) Endophthalmitis (4%)</td>
<td>31% ≤ CF 1m</td>
</tr>
</tbody>
</table>
| Patel et al(54) | 49              | Corneal/Scleral/Corneoscleral laceration (29%) Traumatic cataract (29%) Subluxation of lens (9%) RD* (4%) IOFB* (4%) Traumatic Endophthalmitis (6%) | 37% ≤ 6/12
|               |                 | Eyes number: 3 : 20/200–20/50 5 : < 20/200 to CF 2 : PL/ HM 8 : No PL                  |                                      |

*IOFB- Intra ocular foreign body, * RD- Retinal detachment
**Table 5:** The percentage of vision loss in various studies on ocular trauma due to firecracker is given below:

<table>
<thead>
<tr>
<th>Article</th>
<th>Year</th>
<th>No. of eyes</th>
<th>&gt;6/12</th>
<th>6/12-3/60</th>
<th>CF</th>
<th>HM</th>
<th>LP</th>
<th>NLP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lee (62)</td>
<td>1966</td>
<td>262</td>
<td>–</td>
<td>–</td>
<td>14.8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hatfield</td>
<td>1969</td>
<td>377</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>10.6%</td>
<td></td>
</tr>
<tr>
<td>Copper and Ten (63)</td>
<td>1981</td>
<td>314</td>
<td>36.0%</td>
<td>15.0%</td>
<td>29.0%</td>
<td></td>
<td></td>
<td>4.8%</td>
</tr>
<tr>
<td>Vernon (64)</td>
<td>1988</td>
<td>57</td>
<td>93.0%</td>
<td>–</td>
<td>7.0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Levitz et al (65)</td>
<td>1999</td>
<td>20</td>
<td>75.0%</td>
<td>8.3%</td>
<td>–</td>
<td>–</td>
<td>8.3%</td>
<td>8.3%</td>
</tr>
<tr>
<td>Kuhn et al (66)</td>
<td>2000</td>
<td>185</td>
<td>39.0%</td>
<td>35.0%</td>
<td>10.0%</td>
<td>7.0%</td>
<td>2.0%</td>
<td>6.0%</td>
</tr>
<tr>
<td>Singh et al (41)</td>
<td>2005</td>
<td>26</td>
<td>23.0%</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>31.0%</td>
<td></td>
</tr>
<tr>
<td>Mansouri et al (52)</td>
<td>2007</td>
<td>437</td>
<td>–</td>
<td>–</td>
<td>7.6%</td>
<td></td>
<td></td>
<td>1.1%</td>
</tr>
<tr>
<td>Knox et al (61)</td>
<td>2008</td>
<td>47</td>
<td>–</td>
<td>–</td>
<td>53% &lt;6/60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>De Faber et al (46)</td>
<td>2009</td>
<td>315</td>
<td>83.0%</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>8.6%</td>
</tr>
</tbody>
</table>


In a study by Knox et al, of the 47 patients, 72 eyes were injured, had a significant number of ocular morbidity, due to the usage of rockets in private
In a study by Kuhn et al, bottle rockets were responsible for the serious vision lowering injuries.(66).

In an Indian based prospective study, 26 patients who were injured with fireworks were followed for a period of six months, a better visual acuity at presentation, absence of relative afferent pupillary defect and endophthalmitis had a better visual outcome at the end of six months follow up.(41)

**TYPE OF CRACKER CAUSING INJURY**

**Table 6:** Type of firecracker causing injury to eye leading to decrease in vision

<table>
<thead>
<tr>
<th>Study (Ref)</th>
<th>No. of patients</th>
<th>Type of cracker</th>
<th>Severity of Injury</th>
<th>Vision (Va)</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Academy of Paediatrics(40)</td>
<td>8500</td>
<td>Illegal Sparklers Bottle rockets</td>
<td>Burns 10% corneal abrasion 10% Irreparable damage of globe&gt;50% Death 16 individuals</td>
<td>Enucleation and permanent blindness &gt;50%</td>
</tr>
<tr>
<td>Wilson RS et al (67)</td>
<td>143</td>
<td>Bottle rockets</td>
<td>&gt;75% severe injury</td>
<td>30% permanent loss of Va</td>
</tr>
<tr>
<td>Knox et al (61)</td>
<td>47</td>
<td>Rocket</td>
<td>36% of injuries</td>
<td>8% enucleation alone Phthisis/Mac ulopathy/Retinal &amp; Optic neuropathy</td>
</tr>
<tr>
<td>Study</td>
<td>Participants</td>
<td>Type of Firecracker</td>
<td>Injury Types</td>
<td>Rates</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------</td>
<td>---------------------</td>
<td>----------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>Sundelin et al (60)</td>
<td>52</td>
<td>Bangers</td>
<td>50% of injuries</td>
<td>27% permanent eye damage</td>
</tr>
<tr>
<td>Kumar et al (68)</td>
<td>51</td>
<td>Bombs Sparklers</td>
<td>37% of injuries</td>
<td>19% of injuries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bottle rocket</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Puri et al (69)</td>
<td>157</td>
<td>Fountain String bomb</td>
<td>39% of injuries</td>
<td>23% of injuries</td>
</tr>
<tr>
<td>De Faber et al (46)</td>
<td>268</td>
<td>Bangers Rockets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malik et al (42)</td>
<td>101</td>
<td>Fountain Bullet bomb</td>
<td>Closed globe injury</td>
<td>Open Globe injury</td>
</tr>
<tr>
<td>Sudesh et al (70)</td>
<td>42</td>
<td>Bomb Fountain Rockets</td>
<td>83.3% of injuries</td>
<td>9.5% of injuries</td>
</tr>
<tr>
<td>Mansouri et al</td>
<td>437</td>
<td>Rockets</td>
<td>62% of injuries</td>
<td></td>
</tr>
<tr>
<td>Smith et al (49)</td>
<td>316</td>
<td>Rockets</td>
<td>67% of injuries</td>
<td></td>
</tr>
<tr>
<td>Kuhn et al (66)</td>
<td>185</td>
<td>Bottle rockets</td>
<td>80% of injuries</td>
<td></td>
</tr>
</tbody>
</table>

It was initially argued that ban on usage of firecrackers can lead to the use of dangerous and illegally made fire crackers. But it was noted that when aerial devices, small firecrackers and Class C firecrackers were legalised, the rate of ocular trauma also increased. Sparklers, which are considered to be harmless, was noted to cause mainly corneal abrasions. They are associated with temperature as high as 1000°F, and can ignite clothing and hence cause burns on the body.
# CAUSE OF MISHAP

**Table 7-** Showing causes of mishaps and resulting loss of vision

<table>
<thead>
<tr>
<th>Study (ref)</th>
<th>No. of Patients</th>
<th>Cause of mishap</th>
<th>Type of cracker</th>
<th>Severity of Injury/other details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mansouri et al(52)</td>
<td>437</td>
<td>Deliberate manipulation and device malfunction.</td>
<td>Rocket malfunction due to short fuses, tip over, and erratic flight</td>
<td>44% legally blind, 8 of 10 had optic nerve damage, and 10 % needed enucleation.</td>
</tr>
<tr>
<td>Sundelin et al(60)</td>
<td>52</td>
<td>Device manipulation (37%)</td>
<td>Bangers</td>
<td>27% had permanent eye damage</td>
</tr>
<tr>
<td>Ipsen et al(72)</td>
<td>433</td>
<td>_</td>
<td>Illegal fireworks</td>
<td>19% eye injuries</td>
</tr>
<tr>
<td>Authors</td>
<td>Sample Size</td>
<td>Lighting Type</td>
<td>Causes</td>
<td>Devices</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------</td>
<td>-----------------------</td>
<td>---------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Bagri et al (73)</td>
<td>65</td>
<td>Unsupervised lighting</td>
<td>-</td>
<td>fountain</td>
</tr>
<tr>
<td>Singh et al (41)</td>
<td>26</td>
<td>Unsupervised lighting</td>
<td>-</td>
<td>rocket</td>
</tr>
<tr>
<td>Puri et al (69)</td>
<td>157</td>
<td>Unsupervised (92%)</td>
<td>Misuse (41%) Device failure (35%) Personal Failure (17%)</td>
<td>sparkler</td>
</tr>
</tbody>
</table>
PROTECTIVE MEASURES AGAINST OCULAR TRAUMA

Schein and Vinger recommended a 3 part strategy to prevent loss of vision from ocular trauma.

Determine the patient’s injury potential: Obtain a history of prior ocular trauma and identify functionally one eyed patients (vision less than 6/12) in the worse seeing eye.

Prescribe appropriate protective devices. Although proper protective eye wear is often given for individuals engaged in welding and drilling on the job, the home hobbyist may go unprotected if not identified and counselled by taking a thorough history. The appropriate frame also should be specified.

Recommend a supplier who provides the prescribed eye wear at a reasonable price without undue delay.

Most studies show that non-compliance either by the worker or the employer with available or even mandated protective eye wear is the single greatest risk factor for ocular injury in the work place. Studies show that rates of protective eye wear are higher (up to 20%) for cases of superficial injury, whereas such eye wear was only rarely worn when penetrating injury resulted. (74)

Although organized public displays were popular, accidents continued to happen most often in private or family celebrations, which emphasises the importance of expertise and awareness while handling fire crackers and supervision of children during such occasions. On these occasions, firecrackers are used in overcrowded areas where the distance between the people lighting it and the viewers/bystanders are not much. Even though wearing protective glasses were popular during sports, the need and use
of similar protective eye wear had still not reached the masses during bursting of crackers. But ordinary spectacles do not prevent ocular damage caused by rocket or exploding fire crackers. For this poly carbonate spectacles are better.(64)

LEGISLATION IN FIREWORKS

Even legally approved fireworks have been found to cause injuries. In the US, ocular trauma rate has been found to be fifty percent more in those states where firecrackers were easily available compared to those states where the rules have been strict regarding availability and use.(71)

In 1966, the US federal government had banned all firecrackers containing more than 130 mg of explosives. Ten years later, they brought about set specifications for the manufacture of fireworks to prevent malfunction. Thus Class C firecrackers were allowed for sale only in certain states of US. Even then, it was noted that Class C or the approved common fireworks caused 116 of the 175 injuries, due to misuse, personal failure, unsupervised lighting and device failure. (71)

UK has strict legislation regarding the usage of fireworks in public areas, hence the damage caused by the same is less.(61) WHO had put forward a worldwide ban on the production of firecrackers in 1984. A retrospective study in Hungary has showed that there is a lower incidence in the fire cracker related eye injuries due to the strict legislative ban on private usage of fireworks (66)
In a retrospective study done by Chan et al in Belfast, they noted that the lifting of the legislative ban on fire cracker usage had caused a significant increase in the injuries related to the usage of the same. (75)

After the Jewish Purim festival (1999-2003) where it was noted that most of the injured were children below 15 years of age education and information campaign was conducted which resulted in a decrease in the trauma rate by 50%, compared to the data in 1999. (76)

Various methods have been proposed to reduce injury due to fireworks, such as increasing awareness on pyrotechnics, legislation to restrict dangerous fireworks, to ensure the quality of manufacture of fireworks, to promote public displays by trained technicians, to restrict the usage of Class C fireworks, education campaigns etc.

In India, Supreme Court has given verdict to ban the usage of loud speakers from 10:00 pm to 6:00 am, which also included a special clause inclusive of fireworks in the ban. Although, this has been officially passed, it is hardly enforced, and therefore the usage of firecrackers continues without any restrictions..

JUSTIFICATION FOR THE STUDY

Compared to most other Indian studies, this study has a retrospective and prospective arm with a larger sample size and a longer follow up period,
which has helped us to find the final visual acuity after a definitive management has been done. It helped us identify the various occasions, practices and customs in which fireworks are used in the state of Tamil Nadu, which leads to ocular trauma. Various prospective and retrospective studies have been done in North India during Diwali but the numbers enrolled are few, the follow up is short and the final data is not available for all patients studied. (41, 69, 77, 78)

It will also focus on the local population, to see if there is any relation between their socio economic status and increased incidence in fire cracker injury. During festivals, fireworks are burst at homes, crowded side streets, and also in large play grounds. Lighting fireworks in crowded areas can result in injury, not only to the individual involved but also to the by standers in the vicinity which could involve children. In the study it will be analysed if such circumstances have increased the chances of ocular morbidity and thus help in educating the community about it.

Different varieties of firecrackers are now available in the market. At the same time combination crackers, homemade bombs, pose a threat in the hands of children. Each of these types of illegal firecrackers can cause various injuries with varying visual outcome which can be identified with the study. Manipulation, misuse, and trying to re-ignite unlit fireworks can also lead to ocular trauma. Awareness against such activities can play a big role in reducing ocular morbidity. This study will help us to determine the practices regarding usage of protective eye wear while bursting firecrackers.
RESULTS

A total of 96 patients (122 eyes) were evaluated, and the demographic profile is shown in figure 1 and 2. Of the 28 patients who sustained bilateral injury, 26 patients had bilateral closed globe injury, one had bilateral open globe injury and the other patient had one eye open and other eye closed globe injury.

Table A. Showing the number of patients in the study

<table>
<thead>
<tr>
<th></th>
<th>Retrospective</th>
<th>Prospective</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients</td>
<td>27</td>
<td>69</td>
<td>96</td>
</tr>
<tr>
<td>Eyes</td>
<td>34</td>
<td>88</td>
<td>122</td>
</tr>
<tr>
<td>Lost to follow up</td>
<td>7 patients (10 eyes)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bilateral injury</td>
<td>28 patients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of eyes with loss of vision</td>
<td>21</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. AGE

The age of the patients affected by the firecracker injury ranged from 1 year to 75 years, with the mean age being 19.88 years. Most of the patients i.e. 61 out of 96 were below the age of 20 years (≤ 19 years) (Figure 1)

Figure 1: Age distribution of patients with fire cracker injury
2. GENDER DISTRIBUTION
There was a male preponderance with a male: female ratio of 3.5:1.

Figure 2: Sex Distribution

3. SOCIOECONOMIC STATUS
The socioeconomic status of the patients were ascertained according to modified Kuppuswamy scale and is depicted in Figure 3. Majority of those affected belonged to the upper lower class (48.95%) followed by the lower middle (36.45%) (Figure 3)

Figure 3: Socioeconomic status distribution
4. MODE OF INJURY
It was found that, most of the injuries occurred to the bystanders (53.8%), followed by personal failure of those who lighted the crackers (20.4%). 10.8 % of injuries were caused by misuse (Figure 4)

![Mode Of Injury](image)

Figure 4: Mode of injury

5. PLACE OF INJURY
The most common place of occurrence of ocular trauma due to fireworks happened at homes, closely followed by public places. One unusual place of accident was found in a mango farm, when the patient burst crackers to scare monkeys away from the farm. (Figure 5).
6. OCCASION DURING WHICH INJURY OCCURRED

The most common occasion during which patients were injured while using firecrackers was during Diwali (59.37%), followed by funeral processions (20.83%). Other festivals include those conducted in local temples, Christmas and New Year celebration. Apart from festivals, other instances where fireworks are used are during celebration for winning in cricket, elections, and trying to scare monkeys away by using loud crackers. Injury has also occurred while trying to sweep away debris of half lit and unused crackers. (Figure 6)
7. TYPE OF FIRECRACKER

The main crackers which caused injury were bombs, cone fountain, and string bomb. Few other crackers which caused injuries were an assortment of gun powder put together by children from unused and old crackers. String bombs caused injury mainly during funeral processions on the road. (Figure 7)
8. MODE OF LIGHTING

The main method used to light crackers in our study was with a matchstick. (Figure 8)

![Mode of lighting](image)

Figure 8: Mode of lighting

9. INTERVENTION

Most of the injuries were due to personal failure or negligence, and did not include any intervention (78%). There was active intervention of the crackers in 19%. (Figure 9)

![Intervention](image)

Figure 9: Intervention
10. CAUSE OF MISHAP

Negligence was the cause of ocular injuries in 76.04% and trying to recover a failed device caused it in 4.16% (Figure 10)

![Pie chart showing cause of mishap](image)

**Figure 10: Likely cause of mishap**

11. HANDLING OF CRACKER

Firecracker injury occurred mainly to innocent bystanders (57%), who were in proximity to the cracker. (Figure 11)

![Pie chart showing handling of firecracker](image)

**Figure 11: Handling of firecracker**
12. PROXIMITY TO CRACKER
Large number of injuries occurred to those who were close to the crackers up to 1m, (78.11%) but flying particles from certain crackers travelled at high speed to cause ocular trauma even when more than two metre away (14%)(Figure 12)

Figure 12: Proximity to firecracker

13. ADULT SUPERVISION
Of the 59 individuals below the age of 18 years 66 % did not have any adult supervision. In spite of adult supervision, 34% were found to have got injured (Figure 13)

Figure 13: Adult supervision during lighting crackers (age less than 18)
14. FACIAL INJURY

Injuries to the face were noted in 13 patients and were mostly lacerations (76.92%).

Lid tear was present in one patient which needed suturing (Figure 14)

Figure 14: Facial injury associated with ocular trauma

15. EXTERNAL INJURIES IN OPEN AND CLOSED GLOBE INJURIES

Burns on the eye lid were noted in 58% of eyes and foreign bodies’ mostly small cracker particles were seen under the conjunctiva in 3% of eyes. (Figure 21). Some of the patients sustained a combination of injuries. In the closed globe injury group burns on the eye lid with corneal epithelial defect was the most common combination (Figure 15 and 22)
16. OCULAR TRAUMA

Majority of injuries caused by firecracker were closed globe injuries (93%) (Figure 16)

Figure 21: External Injuries

Figure 16: Classification of ocular trauma
17. TYPE OF EYE INJURY
Of the 122 eyes, which were injured, 88% of eyes had sustained contusion, 7% were penetrating injuries alone. (Figure 17) Mixed open injuries included penetrating injury and intra ocular foreign body, mixed closed globe injury included contusions and superficial foreign body.

![Type of Injury](image)

Figure 17: Type of Injury

18. ZONE OF INJURY
Eighty one percent of the ocular injuries were zone 1 closed globe injuries, zone 1 of open globe injuries consisted of 6% (Figure 18)

![Zones of Injury](image)

Figure 18: Zone of Injury
19. GRADE OF INJURY

The presenting visual acuity of 6/12(20/40) or better was seen in 50% of patients, and 35.25% of the patients had vision ranging from (CF 1.5 m) 4/200 to light perception.

![Figure 19: Grade of Injury](image)

20. RELATIVE AFFERENT PUPILLARY DEFECT

Relative afferent pupillary defect was noted in 3% (4) of eyes i.e. 3 with closed globe injuries and 1 eye with an open globe injury (Figure 20).

![Figure 20: Relative Afferent Pupillary Defect](image)
21. PRESENTING SYMPTOMS

All patients presented with redness, and 77% of patients complained of decrease in vision. (Figure 21)

![Symptoms](image)

**Figure 21: Presenting Symptoms**

22. ANTERIOR SEGMENT INJURIES

Figure 22 shows the anterior segment injuries in both the open and closed eye groups together and Table A shows the distribution in each of the groups separately.

The main injury in both groups together was corneal epithelial defect (51.63%) followed by hyphaema. Traumatic cataract was seen in 15% of the eyes. There were two patients who on examination of the injured eye had subluxated lens. The first patient had a full thickness corneal tear with subluxated lens due to the present firecracker injury, whereas the second patient had sustained childhood trauma causing subluxated lens, with prior vision of hand movements. This patient presently sustained...
only eyelid burns, abrasions and corneal epithelial defect. One another patient had sustained both full thickness corneal tear and partial thickness corneal tear adjacent to it.

Figure 22: Anterior segment injuries

Table B: Showing anterior segment injuries in closed globe and open globe injuries (Some eyes had more than one type of injury)

<table>
<thead>
<tr>
<th>Anterior Segment Injuries</th>
<th>Closed Globe N=114 (Number of eyes)</th>
<th>Open Globe N=8 (Number of eyes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corneal Epithelial Defect</td>
<td>61(53.50%)</td>
<td>2(25%)</td>
</tr>
<tr>
<td>Hyphaema</td>
<td>21(18.42%)</td>
<td>4(50%)</td>
</tr>
<tr>
<td>Subluxated Lens</td>
<td>-</td>
<td>1(12.5%)</td>
</tr>
<tr>
<td>Cataract</td>
<td>12(10.52%)</td>
<td>6(75%)</td>
</tr>
<tr>
<td>Iridodialysis</td>
<td>11(9.64%)</td>
<td>1(12.5%)</td>
</tr>
</tbody>
</table>
Partial thickness corneal tear & 2(1.75%) & 1(12.5%) \\
Full Thickness Corneal Tear & 0 & 8(100%) \\
Intra stromal foreign body & 12(10.52%) & 0 \\
Foreign body in anterior chamber & 0 & 3(37.5%) \\
Anterior Capsule Breach & 0 & 6(4.09%) \\

### 23. POSTERIOR SEGMENT INJURIES

Of 122 eyes, 29 eyes (23.77 %) had sustained posterior segment injuries. The posterior segment injury consisted of commotio retinae (13%) followed by berlins oedema (7.3%) in both groups together. Three eyes developed traumatic macular hole and 1 eye had retinal detachment. (Figure 23)

![Posterior Segment Injuries](image)

Figure 23: Posterior segment injuries
24. MANAGEMENT OF OCULAR TRAUMA

Conservative management was given for 87.77% of the closed globe injuries. 14 patients underwent surgical management (8 open globe and 7 closed globe injuries, 1 patient underwent surgery for bilateral open globe injury) (Figure 24). The 7 eyes with closed globe injury which needed surgical management had sustained unilateral injury (Figure 24)

![Pie chart showing Medical (107, 88%) and Surgical (15, 12%) management with total n=122.](image)

Figure 24: Management of Firecracker Injury

25. SURGICAL MANAGEMENT

Figure 25 shows the surgical management in both the open and closed eye groups together and Table B shows the distribution in each group separately. In the open globe injury group, the most common surgery was corneal tear repair in all 8 eyes followed by lens matter aspiration in 5 eyes. Lens matter aspiration was the most common surgery done in both groups combined together. 4 eyes needed a second surgery, (2 eyes had secondary intra ocular lens implantation (IOL), 1 had
membranectomy, and optical iridectomy, 1 had Pars Plana Vitrectomy (PPV) after IOL implantation for dense vitreous reaction, but culture was negative.

Figure 25: Surgical management of firecracker injury

Table C: Surgical management of closed globe and open globe injuries (some of the eyes had more than one type of surgery)

<table>
<thead>
<tr>
<th>Surgery</th>
<th>Closed Globe; N=114 (Number of eyes)</th>
<th>Open Globe ; N=8 (Number of eyes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lid Tear Repair</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Foreign body removal (Cornea &amp; anterior chamber)</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Pars Plana Vitrectomy(PPV)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Intra Ocular Lens Implantation</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>4(primary),1(secondary)</td>
<td>(secondary)</td>
</tr>
<tr>
<td>Procedure</td>
<td>Column 1</td>
<td>Column 2</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>Lens matter aspiration</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Wound Exploration</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Corneal Tear Repair</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Scleral Tear Repair</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
### Table D: Children (1-5 years old) who were excluded

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Class</th>
<th>Type</th>
<th>Zone</th>
<th>Grade</th>
<th>Final Vn (Cardiff/Kay)</th>
<th>Both eye</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>3</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>PL(4)</td>
<td>6/9</td>
<td>No</td>
</tr>
<tr>
<td>2.</td>
<td>2</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>PL(4)</td>
<td>6/9</td>
<td>No</td>
</tr>
<tr>
<td>3.</td>
<td>1</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>PL(4)</td>
<td>6/12</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>PL(4)</td>
<td>6/12</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>6/60(2)</td>
<td>6/9</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>PL(4)</td>
<td>6/9</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>CF1m(4)</td>
<td>6/9</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Table E- Patients lost to follow up

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Class</th>
<th>Type</th>
<th>Zone</th>
<th>Grade</th>
<th>Both eye</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>24</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>4</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>30</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td>10</td>
<td>8</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>4</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>10</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>4</td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>25</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>4</td>
<td>No</td>
</tr>
<tr>
<td>14</td>
<td>52</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>1</td>
<td>No</td>
</tr>
<tr>
<td>Patient</td>
<td>Age</td>
<td>Class</td>
<td>Type</td>
<td>Zone</td>
<td>Grade</td>
<td>Both eye</td>
</tr>
<tr>
<td>---------</td>
<td>-----</td>
<td>-------</td>
<td>--------</td>
<td>--------</td>
<td>------------</td>
<td>----------</td>
</tr>
<tr>
<td>15</td>
<td>75</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>1(RE)4(LE)</td>
<td>Yes</td>
</tr>
<tr>
<td>16</td>
<td>19</td>
<td>Closed</td>
<td>Contusion</td>
<td>External</td>
<td>4</td>
<td>No</td>
</tr>
</tbody>
</table>

Table F- Patients excluded because of previous loss of vision

7 patients (10 eyes) [8-14 th patient] were lost to follow up after the initial assessment in casualty, 3 eyes (15,16) had decreased vision prior to this trauma (immature senile cataract in two eyes and childhood trauma leading to subluxation of lens in one eye), 10 eyes of children in the 1-5 age group (1-7 th patient), whose ocular examination was normal and whose vision after assessment with Cardiff/Kay pictures ranged from 6/12 (4 eyes) - 6/9 (6 eyes) were also not included in this assessment.
26. FINAL VISUAL ACUITY DUE TO FIRECRACKER INJURY

The final visual acuity of 21 eyes which had decreased vision of less than 6/6 is depicted in figure 26. Of this 2 eyes had only perception of light. At the conclusion of the study, 78 eyes (78.78%) had vision of 6/6. Hence in figures 26, 30, 31, 32, results have been displayed after omitting these patients, and the calculations have been displayed based on 99 eyes.

![Final visual acuity graph](image)

Figure 26: Final Visual Acuity (*78 eyes with 6/6 vision not depicted in the graph)

27. CAUSE OF DECREASE IN VISION (last follow up)

The main cause of decrease in vision in those who were injured by firecrackers at the end of our follow up was traumatic cataract (8.08%), followed by macular and corneal scar (3.03%). There were three eyes with corneal scar, of which only one was in the visual axis (Figure 27). Three eyes were aphakic and one eye which was aphakic developed corneal ulcer.
Figure 27: Cause of decrease in vision

28. AGE (<LESS THAN 20) Vs. FINAL VISUAL ACUITY

There were 61 children below 20 years of age (≤ 19 years), 3 children (6 eyes) were lost to follow up, 7 children (10 eyes) in the 1-5 age group, whose ocular examination was normal and whose vision after assessment with Cardiff/Kay pictures ranged from 6/12(4 eyes) -6/9 (6 eyes) were also not included in this assessment. 1 teenager was excluded due to prior loss of vision, due to childhood trauma. So 51 patients below 20 years of age were finally assessed (64 eyes)

Of the 21 eyes with decreased vision less than 6/6 in this study, 8 eyes were seen in the less than 20 year age group. None of the children developed bilateral loss of vision. 2 children who developed monocular blindness were in the <5 years age group. Moderate visual impairment was noted in 2 children of which one child was in the 5-9 year age group and the other was a teenager. (Figure 28)
Visual impairment (vision < 6/18 but ≥ 3/60) was noted in 2 eyes in the closed eye injury group. Blindness occurred in 5 eyes in the open eye injury group and 2 eyes in the closed eye injury group.
**TABLE C:** Showing details of patients who had decreased vision due to firecracker injury

<table>
<thead>
<tr>
<th>Pt</th>
<th>Age</th>
<th>Vision at Presentation</th>
<th>Type of cracker</th>
<th>Cause of mishap</th>
<th>Type of Injury</th>
<th>Zone of Injury</th>
<th>Surgery</th>
<th>Final Visual Acuity</th>
<th>Cause of DV</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>32</td>
<td>CFCF</td>
<td>Bottle rocket</td>
<td>Bystander Cricket match</td>
<td>Penetrating</td>
<td>Zone 1o</td>
<td>Corneal Tear Suturing</td>
<td>CF 1m</td>
<td>Traumatic cataract</td>
</tr>
<tr>
<td>B</td>
<td>65</td>
<td>HM, CFCF (bilateral injury)</td>
<td>Bomb</td>
<td>Misuse Scare Monkeys from farm</td>
<td>Mixed</td>
<td>Mixed</td>
<td>Zone 1o</td>
<td>Corneal Tear suturing, Phacoemulsification, IOFB removal, Glue with contact lens</td>
<td>HM</td>
</tr>
<tr>
<td>C</td>
<td>29</td>
<td>PL</td>
<td>String Bomb</td>
<td>Bystander Funeral procession</td>
<td>Penetrating</td>
<td>Zone 1o</td>
<td>Corneal tear suturing with wound exploration</td>
<td>PL ,PR inaccurate</td>
<td>Retinal detachment</td>
</tr>
<tr>
<td>D</td>
<td>11</td>
<td>PL</td>
<td>Bomb</td>
<td>Bystander, Christmas celebration</td>
<td>Penetrating</td>
<td>Zone 2o</td>
<td>Corneal Tear repair, Scleral tear repair, LMA</td>
<td>6/18</td>
<td>Corneal Scar in visual axis, Surgical aphakia</td>
</tr>
<tr>
<td>E</td>
<td>28</td>
<td>HM</td>
<td>String Bomb</td>
<td>Bystander, Funeral procession</td>
<td>Mixed Zone 1o</td>
<td>Corneal tear Suturing, IOFB removal</td>
<td>6/9</td>
<td>Corneal scar not involving visual axis</td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>----</td>
<td>----</td>
<td>-------------</td>
<td>-----------------------------</td>
<td>--------------</td>
<td>----------------------------------</td>
<td>-----</td>
<td>-------------------------------------</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>2</td>
<td>PL</td>
<td>Bomb</td>
<td>Bystander, Diwali</td>
<td>Penetrating Zone 1o</td>
<td>Corneal tear repair, Lens Matter aspiration, Anterior Membranectomy, Optical Iridectomy</td>
<td>PL</td>
<td>Perforated corneal ulcer, healed with flat AC and corneal scar</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>6</td>
<td>CFCF</td>
<td>Bomb</td>
<td>Bystander, Diwali</td>
<td>Penetrating Zone 1o</td>
<td>Corneal tear suturing, LMA, IOL</td>
<td>6/12</td>
<td>Corneal scar not in visual axis</td>
<td></td>
</tr>
</tbody>
</table>

**CLOSED GLOBE INJURY**

<table>
<thead>
<tr>
<th>H</th>
<th>24</th>
<th>PL</th>
<th>String Bomb</th>
<th>Bystander Funeral procession</th>
<th>Contusion Zone 2c</th>
<th>LMA + IOL</th>
<th>6/9</th>
<th>Posterior capsule opacification</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>4</td>
<td>PL</td>
<td>Bomb</td>
<td>Bystander Diwali</td>
<td>Contusion Zone 3c</td>
<td>LMA + IOL</td>
<td>HM</td>
<td>Macular Scar</td>
</tr>
<tr>
<td>J</td>
<td>36</td>
<td>HM</td>
<td>Bottle rocket Personal failure, Diwali</td>
<td>Contusion Zone 2c</td>
<td>LMA +IOL</td>
<td>6/12</td>
<td>Epiretinal membrane</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>14</td>
<td>HM</td>
<td>Bomb</td>
<td>Misuse, Diwali</td>
<td>Contusion</td>
<td>Zone 2c</td>
<td>LMA+ IOL+ PPV</td>
<td>6/18</td>
</tr>
<tr>
<td>---</td>
<td>----</td>
<td>----</td>
<td>--------</td>
<td>---------------</td>
<td>----------</td>
<td>--------</td>
<td>---------------</td>
<td>-----</td>
</tr>
<tr>
<td>L</td>
<td>56</td>
<td>6/12</td>
<td>String Bomb</td>
<td>Bystander, Diwali</td>
<td>Contusion</td>
<td>Zone 2c</td>
<td>Refused surgery</td>
<td>CF1m</td>
</tr>
<tr>
<td>M</td>
<td>25</td>
<td>HM</td>
<td>String bomb</td>
<td>Bystander, Funeral</td>
<td>Contusion</td>
<td>Zone 2c</td>
<td>Deferred surgery</td>
<td>6/12</td>
</tr>
<tr>
<td>N</td>
<td>60</td>
<td>6/60</td>
<td>String bomb</td>
<td>Bystander, Funeral</td>
<td>Contusion</td>
<td>Zone 2c</td>
<td>Awaiting surgery</td>
<td>6/18</td>
</tr>
<tr>
<td>O</td>
<td>45</td>
<td>6/12</td>
<td>String bomb</td>
<td>Bystander, Funeral</td>
<td>Contusion</td>
<td>Zone 2c</td>
<td>Deferred surgery</td>
<td>6/9</td>
</tr>
<tr>
<td>P</td>
<td>53</td>
<td>3/60</td>
<td>String bomb</td>
<td>Bystander, Funeral</td>
<td>Contusion</td>
<td>Zone 2c</td>
<td>Awaiting surgery</td>
<td>6/18</td>
</tr>
<tr>
<td>Q</td>
<td>9</td>
<td>HM</td>
<td>Bomb</td>
<td>Device failure, Diwali</td>
<td>Contusion</td>
<td>Zone 3c</td>
<td>-</td>
<td>6/36</td>
</tr>
<tr>
<td>R</td>
<td>18</td>
<td>PL</td>
<td>Cone fountain</td>
<td>Device failure, Diwali</td>
<td>Contusion</td>
<td>Zone 3c</td>
<td>-</td>
<td>6/36</td>
</tr>
<tr>
<td>S</td>
<td>17</td>
<td>HM</td>
<td>Bomb</td>
<td>Bystander, Funeral</td>
<td>Contusion</td>
<td>Zone 2c</td>
<td>Deferred surgery</td>
<td>6/9</td>
</tr>
<tr>
<td>T</td>
<td>42</td>
<td>6/24</td>
<td>Bomb</td>
<td>Device failure, Funeral</td>
<td>Contusion</td>
<td>Zone 2c</td>
<td>Awaiting surgery</td>
<td>6/12</td>
</tr>
</tbody>
</table>
Of the 122 eyes, 3 eyes which got injured were not included in the final visual acuity, because they had prior decrease in vision due to senile immature cataract in 2 eyes, and childhood trauma leading to subluxation of lens in 1 eye.

30. TYPE OF INJURY Vs. FINAL VISUAL ACUITY

Seven eyes were noted to be blind. Blindness was due to penetrating injury in 3 eyes, mixed injury of the open globe injury group in 2 eyes and contusion in 2 eyes. Of the 21 eyes with decreased vision was noted to cause decreased vision in 13 eyes resulting in moderate visual loss in 2 eyes and blindness in 2 eyes. (Figure 30)

![Figure 30: Type of Injury Vs. Final Visual Acuity](image-url)
31. ZONE Vs. FINAL VISUAL ACUITY

Seven eyes were noted to be blind (Figure 31), 5 eyes belonged to the zone 1o group, 1 each in Zone 2c and zone 3c respectively. Moderate visual impairment was noted in 3 eyes, 1 eye in zone 2c group and 2 in zone 3c group. There were 76 eyes with vision of 6/6 in Zone 1c group.

![Zone Vs. Final Visual Acuity](image)

**Figure 31: Zone of Injury Vs. Final Visual Acuity**
32. INITIAL GRADE Vs. FINAL VISUAL ACUITY

Ten eyes which had presented with visual acuity of grade 4 (CF 1.5 m – PL) improved to 6/6, whereas 2 eyes continued to have only perception of light. (Figure 32) At the conclusion of the study 78 of the 99 eyes had visual acuity of 6/6. Seven eyes were blind. Moderate visual loss was noted in 2 eyes.

Figure 32: Grade of Injury Vs. Final Visual Acuity
DISCUSSION

Firecrackers are used across the globe to mark various celebrations. (44, 54, 58, 68) and most of them (36%) affect children between 10 to 14 years of age. (44) Judicious use of these crackers are necessary due the large number of accidents which occur while lighting them. This is an observational study which attempts to look into demographic profile of those patients who sustained ocular trauma with firecrackers and their final visual acuity after a six month follow up, or till their last intervention during the study period to improve vision.

A total of 96 patients (122 eyes) were evaluated, and the demographic profile is shown in figure 1 and 2. There were 27 patients in the retrospective and 69 in the prospective group. There were 28 patients who sustained bilateral injury. 7 patients (10 eyes) were lost to follow up.

The youth are generally at an increased risk of ocular trauma as noted in the studies by Zohar et al, Shimazaki et al, and other studies (73, 74). Information from the United States Eye Injury Registry states that from 1990-1994, the median age group injured with firecrackers was fifteen years. (55) Children have been found to be associated with firework injuries in various studies (20, 41, and 67). In this study out of 96 patients who participated, 63.5% of patients were youngsters with age less than 20 years.
31.25% were children below the age of 10 years. The mean age group was 19.88 years. (Figure 1)

An Indian study by Tandon et al in Delhi, showed that 73 % of those affected were in the age group of 5 – 30 years (77). Another study, done in Chandigarh, by Arya et al, showed that 62 % of those affected by firecrackers were between the age of 6 and 30. (77). Youngsters have been repeatedly found to be more at risk, due to their reckless behaviour, adventure seeking nature, and immature outlook towards handling situations.

In our study, the incidence of firecracker injury showed a downward curve as age increased, mostly because adults are more responsible while handling firecrackers and they are less involved in celebrations with firecrackers. Elderly population who were injured were mainly by standers and were not active participants in the celebration.

_Males_ are found to be more injured due to ocular trauma with fire crackers in studies by Smith et al (71%), Kuhn et al (79%), Knox et al (79%) (49, 61, 66). This may due to their active participation in lighting crackers. In our study, majority of the patients injured were males (78%) compared to females. (Figure 2) This result matches with the studies mentioned before on ocular trauma with fire crackers (20, 47, 53). When males and the youth are seriously injured, the economic situation in their family is worsened due to their inability to go for
work. Men were found to be more prone for injury due to reasons other than Diwali, such as temple festivals and attending funeral where firecrackers are used and women do not attend this function. A study done by See et al, also noted that, male to female ratio of those who were injured to be 2.5:1, which is similar to our study.(79)

Studies by Mansouri et al have shown that lower socio economic strata were more prone for injury (52). Residents of rural community were found to have increased rate of injury compared to urban citizens.(47) Our study also showed that upper lower (48.95%) and lower middle class (36.45%) sections of the community were found to be more affected by firecrackers than the other sections. (Figure 3).

People from lower socioeconomic strata were more affected, probably due to lack of awareness, education, and proper guidance. These crackers were burst, in crowded streets, and areas where houses are built close to each other. They also tend to use crackers meant for public display which are not suitable for use in such crowded areas such as bottle rockets (10%). Children from poor background were found to misuse firecrackers such as trying to relight them and trying to burst old unused firecrackers in this study (16%), in the absence of adult supervision.
The *other modes of injury* in this study were personal failure in 20.4% (i.e. the person who handled the cracker did not move away fast from cracker which was lit or did not use the correct device for lighting them), device failure in 11.8% (malfunctioning of the crackers even after taking adequate precautions), misuse in 10.8% (trying to relight half burnt crackers, and using unused old crackers) and others as in Figure 4.

Young adults were found to misuse firecrackers, after being under the influence of alcohol in 3% of cases in this study (Figure 4). Such behaviour caused severe injury with hyphaema, cataract and had to be rehabilitated with surgery. Hence awareness regarding responsible handling of crackers is necessary.

Studies have shown that private display of crackers occasionally have found to cause more damage due to unregulated use of dangerous crackers without proper supervision, expertise or protective gear (40,43,81). In this study we noted that homes were the usual place of occurrence of firecracker injuries in 55.02%. (Figure 5) This may be due to the custom of celebrating Diwali with family in closed groups. Though adult supervision is expected to be more at homes we found there is a higher rate of injury there. This highlights the fact that educational awareness needs to reach the family as a whole.
It was noticed that 40.62% of the injuries in this study occurred in public places. This was mostly on the roads, via where funeral procession occurs. String bombs were lighted and caused injury to passers-by. When these bombs burst they were found to travel distances more than 2 metre causing injuring to onlookers as well. Churches and temples grounds were another place for lighting crackers. Such public display of crackers are often not well organised to control the crowd, and people often mill around to watch it being burst causing injury to onlookers.

One unusual area of occurrence was in a mango farm, where the farmer tried to scare the monkeys away with a loud noise producing cracker, which burst in his hand causing severe damage to his hands, face and eyes.

Across the globe, firecrackers have been used for various celebrations such as New Year, Christmas, Independence Day celebrations, where massive numbers of firecrackers are burst. Diwali, or the festival of lights marked the event in which maximum number of injuries occurred in this study (59.37%), followed by funeral processions (20.83%). (Figure 6). To the best of our knowledge, this is the only study in which firecracker injuries have been recorded during funeral processions. This is due to the local custom existing in south India where crackers are burst often recklessly during funeral processions.
Other occasions in which crackers were seen to be used in this study were when cricket matches were won, political victory during elections and while sweeping away unused firecracker debris. Sweeping unlit, or half burnt crackers have to be done carefully, since such crackers have a propensity to suddenly burst, causing unprecedented injury as seen in this study.

In a retrospective study on 1373 patients done in Delhi by Tandon et al over 8 years during Diwali period – the type of firecracker causing injury was found to flower pots in 64% of injuries were caused by flower pots and bombs 13% of injuries. The visual outcome with each firecracker was not evaluated. (77) In a study done by Vinita et al, most of the injury was caused by flare/fountain (39%).

Most of the injuries in this study were caused by bombs (25%) cone fountain (25%), followed by string bombs (21.87%) as shown in figure 7. The more severe injuries (7%) were caused by bombs, as it consists of small particles which travel at high velocity causing penetrating and blunt injury, leading to decrease in vision. String bombs caused injury mainly during funeral processions on the road, causing traumatic cataract in 5%, corneal tear and retinal detachment in one patient. The more severe injuries (7%) were caused by bombs.
2 % of the injuries in this study were caused by other causes such as while sweeping away unlit cracker debris, children manipulating and lighting the combined gunpowder of unused or half burnt firecrackers.

Puri et al have noted the sparklers to be a dangerous mode of lighting the crackers since it lights the crackers at various points at the same time. The main mode of lighting the firecrackers as seen in this study was with match stick (43.75%) followed by sparkler (28.12%)(Figure 8). More injuries were associated with usage of matchstick, when used to light firecrackers. (Figure 8) This may be because as the match sticks are smaller than sparklers and incense sticks the patient has to bend down closer toward the firecracker to light them, and there can be a delay in getting away from the lighted cracker.

In a study of 65 cases by Bagri et al, half of the injuries were caused by misuse (i.e. holding the cracker in hand and lighting them) followed by device failure. Majority of the patients who got injured in this study were due to negligence (76.04%) and not due to intervention, such as manipulation or misuse (Figure 9). Attempt to reignite the fire cracker resulted in injury in 4.16% of the cases. (Figure 10) Children from higher socio economic status were not involved in misuse or firecrackers as much as those from lower socio economic status.
Studies from abroad and India have shown large number of bystanders being involved in fireworks related injuries. (54, 69) In the study by Patel et al, almost equal number of bystanders (48.9%) and active participants were found to be injured. (54) In our study injury has occurred to the person himself in 41.66% of the cases and to the bystander in 57.29%. (Figure 10) This is noteworthy as the innocent bystander or the passers-by are seen to have got injured in the majority of the cases. Hence bystanders also have to be alerted about the dangers of watching firecrackers without adequate eye protection. Other than this the passers-by on the road, while fire crackers are lit during funeral processions have also been found to be injured in this study. There should be strict legislation regarding the use of fireworks in crowded places and roads to prevent injury to these innocent victims. Individuals who sleep by the road side away from the celebration were also seen to be injured. This denotes the importance of public awareness as it is not only injurious to the person who handles it but also to the people in the vicinity as well. Hence it is necessary to restrict fire cracker usage within an enclosed ground and not on public roads, where innocent bystanders can get injured.

Firecrackers are found to cause less injury when they are kept on the ground and lit rather than trying to light them holding it in the hand. (69) In our study most of the injuries (41.66%) were seen when the fire crackers were very close to the face while being lit and was mostly due to negligence. (Figure12) This
can be avoided to a large extent by public awareness of the problem, by having a trained person lighting the fireworks and by adult supervision when children are involved. Some firecrackers were found to cause injury even more than 2 m away, (14%) due to the high velocity of the particles within the cracker mostly with bombs. Bombs were found to cause missile injuries in children causing significant loss of vision in this study. (Figure 1)

Around 90% of all ocular trauma can be avoided by proper eye protection and adult supervision. (Figure 13)(18) Most of the Indian studies have showed that more than 85% of firecracker injuries occurred while children were unsupervised by adults. (41, 69, 73) In our study we found that 66.10% of children who were injured lacked supervision by the adults while they were dealing with fire crackers. In spite of being supervised injuries were noted in 33.89% of children below the age of 18 and this may be due to the laxity in seriousness among parents while children were handling firecrackers. (Figure 13) This may also be because of the lack of knowledge about safety measures amongst parents and not following them as majority of the injuries (87%) occurred in children belonging to the lower middle and the upper lower income group. It is also difficult to keep a watch on children always while they are playing.

Commonly injured sites in firecracker injury are hands, face and eyes as seen in various studies. (43, 71, 73). The closer the patient is to the firecrackers,
there are more chances for *facial injury*. (Figure 14) In a study done at a tertiary eye care centre in India it was noted that associated facial injuries were noted in 38.5% of the patients which included burns, lacerations which required suturing and abrasions. Facial injuries were noted in 13 patients in our study and consisted of lacerations (76.92%), contusions (23.07%) and hematoma (7.69%) (Figure 14) One patient had upper lid tear involving the margin, and required suturing. Patel et al observed lid and facial burns in 16% of the patients in his study (54) Many patients presented with burns on the lid (57.30%) and on the face due to the heat produced by the crackers which burst close to the face. Almost all were first degree burns. They also presented with lid oedema (41%) and charred eye lashes (25%). None of the patients developed contractures, entropion or ectropion on long term follow up.

Trauma can be *classified as open and closed globe injury*. In a systematic review of firecracker injury compiling 17 articles by Wisse et al, 18% of the injuries were open globe injuries.(58) Study by Malik et al showed 17% to be open globe injuries and 83% to be closed globe injuries (42) In the study by Mansouri et al 12.3% had sustained open globe injury.(52) In this study, of the 122 eyes which were injured, 114 (93.44%) eyes had sustained closed globe injury. This was similar to the previous studies where we noted closed globe injuries to be more common. But the percentage of open globe injuries in our study was only 6.55% which was slightly lesser than the studies mentioned above. (Figure 16).
One patient had sustained bilateral open globe injury and another patient had sustained open globe injury of one eye and closed globe injury of the other. Bilateral open globe consisted of corneal tear with multiple intraocular foreign body and anterior capsule breach in both the eyes. Another patient had one eye open globe (full thickness corneal tear with iris prolapse) and one eye closed globe injury (Figure 16).

Injuries can be classified based on various types, in both open and closed globe injury. Various studies have shown that firecracker injury has been associated with rupture, penetrating, perforating, intraocular foreign body, and mixed trauma. Within these types the ocular structures damaged has also been enumerated in the above studies which include corneal tear, scleral tear, traumatic cataract, lens dislocation, retinal detachment, macular scar. In case of closed globe injury, contusion, superficial foreign body, lamellar laceration have been found in these studies (41, 54, 59–61) (Figure 16).

Of the closed globe injury contusion was noted in 81.96 %, and superficial foreign body in 11.40%. (Figure 17) Contusion of the eye had caused epithelial defect of cornea, traumatic uveitis, hyphaema, traumatic cataract, even macular hole.
Among the open globe injury, penetrating injury alone was seen in 6% and mixed (penetrating injury + intraocular foreign body) injury in 2% (Figure 17). Penetrating injury consisted of corneal tear, corneo scleral tear, anterior capsular breach, vitreous loss. Mixed open globe injury consisted of corneal tear, anterior capsule breach and intraocular foreign body in anterior chamber in both the eyes of a patient and corneal tear with intraocular foreign body in anterior chamber in another patient’s eye.

Depending on zones affected, injuries can be classified in both open and closed globe injury. In a study by Singh et al, 23% of the total injuries were due to open globe injuries, {Open globe, Zone 1 (11.35%) and Zone 3(11.53%)} whereas in closed globe injuries, majority were in zone 3(42.30%). {Closed globe zone 1 constituted 4%, zone 2 comprised 30.76%, and zone 3 had 42.30% of injuries. (41) Although our study had mostly closed globe injuries like the study by Singh et al we noted most of the injuries in zone 1 in contrast to the study by Singh et al where they found mostly zone 3 closed globe injuries. In this study most of the injuries 87% were through zone 1 in both open and closed globe injury. Of the 122 eyes zone 1 closed globe trauma was the commonest of all injuries (81%), comprising of corneal epithelial defect, superficial foreign body on the cornea and conjunctiva. Zone 2 closed globe (anterior segment) injuries consisted of 10%, which included traumatic cataract. Zone 3 injury in closed globe trauma (posterior segment injuries) on
presentation was noted in 2% and was characterised macular hole, commotio retina and berlins oedema. (Figure 17) Most of the patients had hazy view to the posterior segment due to epithelial defect, corneal abrasions, and multiple intra stromal foreign body. Among the open globe injury only one eye had a zone 2 injury. In a study by Singh et al, in open globe, Zone 1 (11.35%) and Zone 3(11.53%) injuries consisted of 23% of the total injuries, whereas in closed globe injuries, zone 1 consisted of only 4%, zone 2 -30.76%, and the majority were in zone 3: 42.30%. (41)

The presenting vision of patients with ocular trauma are used to classify them in to various grades. Kumar et al noted that most of the injured eyes (41%) had vision more than 6/12 on presentation. 15.6% of the patients had vision ranging from 6/60 to counting fingers and 3.9% had only perception of light. (68) Singh et al’s study showed very poor vision of CF1.5m to PL in 80.7% of patients due to traumatic cataract, subluxation of lens, vitreous haemorrhage, retinal detachment etc. Most of the eyes (51.63%) which were injured in our study had vision of grade 1 (visual acuity of 6/12 or better) which was similar to the study by Kumar et al. (Figure 18).It is to be noted that 34.42% of the eyes had only grade 4 vision (ranging from CF 1.5m to perception of light) at presentation. The initial poor vision was attributed to large epithelial defect, punctuate epithelial erosion, dispersed and layered hyphaema, and children whose vision could not be assessed due to poor cooperation especially in the initial period. (Figure 19). In a study by Kumar et al. 2 patients of the 51
patients had no perception of light, 8 patients had vision ranging from 6/60 to counting fingers, on initial assessment. (68) Similar to our study, most of the injured eyes (41%) had vision more than 6/12, on presentation. Singh et al’s study showed that of 26 patients, 21 had vision ranging from CF1.5m to PL(41)(Figure 19)

Presence of **Relative afferent pupillary defect (RAPD)** was found to be associated with poor visual prognosis by Singh et al (41). Another prospective study done in India of 26 patients who were injured with fireworks and followed up for a period of six months noted that a better visual acuity at presentation, absence of RAPD and endophthalmitis had a better visual outcome at the end of the follow up period. (41) In our study, of 122 eyes, only 4 eyes had (RAPD) at presentation. Three of them were due to closed globe injury with, macular hole (3 eyes) and vitreous in anterior chamber. Another patient had sustained open globe injury, and had retinal detachment. RAPD was a factor which indicated poor visual prognosis in all the patients except one, who had raised IOP due to pupillary block secondary to vitreous in anterior chamber, and RAPD resolved with control of intra ocular pressure. Two patients had raised intra ocular pressure of which only one had RAPD (Figure 20).

**External injuries**: Burns on the eyelid were the most common injury seen in 57.30% and almost all of them were first degree burns. (Figure 15) One patient
had multiple small foreign bodies on the face, conjunctiva, cornea and the anterior chamber. Other injuries noted were conjunctival tear (8%), sub conjunctival foreign bodies (3%) which were removed after localised wound exploration. (Figure 15).

In a study by Patel et al the common anterior segment injury was hyphaema (34.69%), followed by traumatic cataract (28.57%) and corneal epithelial defect and abrasions(28.57%).(54) Kong et al noted hyphaema in 42% of patients, corneal/scleral/corneo scleral tear in 33% and traumatic cataract in 29%. (50) In a study by Lin et al, of the 53 eyes, 42(79.3%) eyes had open globe injury, foreign bodies in 34% of the eyes.(80)

Among the anterior segment injuries, we observed that, more than half of the injured eyes had corneal epithelial defect (51.63%) with hyphaema in 20.49% and intra stromal corneal foreign body in 9.80%. (Figure 22). Corneal epithelial defect was due to the blunt trauma, multiple superficial foreign body and thermal injury caused by the crackers. Patients also had traumatic cataract (14.75%) which caused decrease in vision. Traumatic cataract consisted of both posterior sub capsular cataract as well as those which became intumescent due to the breach in the anterior capsule (4.09%). Of the two patients who presented with subluxated lens, one patient had previous subluxation of the lens due to childhood trauma. Full thickness corneal tear was seen in 6.55 % of
the eyes. Foreign body was also seen embedded within the iris in 2.45% of the eyes injured.

Among the closed globe injuries corneal epithelial defect (53.50%) followed by hyphaema (18.42%) was the most common anterior segment injury while cataract (75%) followed by hyphaema (50%) were the common injuries among the open globe group. (Table B)

Firecrackers can also cause posterior segment injuries, as seen in various studies. In a case series report by Wang et al, 7 patients were noted to have retinal detachment. In spite of successful reattachment, they had poor visual outcome. (81) In the study by Sundelin et al posterior segment injuries were observed in 23.61%, which consisted of vitreous haemorrhage (8.33%), retinal damage (11.11%) and choroidal damage (2%) (60). Vitreous haemorrhage was the most common posterior segment injury (20.40%) in the study by Patel et al followed by traumatic endophthalmitis (3%) and retinal detachment (2%) (54)

In this study, of the 122 eyes that were injured with firecrackers, 23.77% had posterior segment injuries. This is similar to the study by Sundelin et al who noted posterior segment injury to be around 23.61%. Among the eyes which had posterior segment injuries, commotio retinae was seen in 13% of the eyes while traumatic macular hole was seen in 2.4% (3) of eyes. These 3 macular holes was caused due to a closed globe injury. One patient who initially presented with corneal tear, hyphaema and relative afferent pupillary defect, on
follow up was found to have retinal detachment. In our study, none of the patients had endophthalmitis, due to trauma. (Figure 23)

Ocular trauma due to fireworks are managed either conservatively or by surgery as required. 8 eyes which had sustained open globe injury, and 7 eyes with closed globe injury underwent surgical management. Conservative management was given for 87.77% of the closed globe injuries. (Figure 24) Medical management consisted of thorough irrigation of the affected eyes with normal saline or ringer lactate solution, with double eversion of the lids, to remove any loose external debris of firecracker material. Following this patient was started on topical lubricants, antibiotics, steroids and cycloplegics as necessary. Patient was admitted or followed up in the outpatient department till the healing of epithelial defect. Patients with hyphaema, raised intraocular pressures were admitted for monitoring of any rebleed and control of intraocular pressure.

Surgical management includes lid tear repair, orbital fracture repair, corneal/scleral/corneo scleral tear repair, intraocular foreign body removal, lens matter aspiration/ cataract extraction, intraocular lens implantation, vitreo retinal surgery, evisceration/enucleation for non-salvageable globe rupture. (Figure 25). In study by Knox et al, of the 47 patients who got injured, 15 underwent suturing of lid laceration and 7 underwent repair of the penetrating injury, 8 patients underwent enucleation/evisceration. (61) In the study by Patel
et al, 22 patients of 49 had to undergo surgical intervention, 4 underwent evisceration, because the globe was beyond repair, to salvage vision.

In this study, 7% of the eyes underwent corneal tear repair, lens matter aspiration in 8%, intraocular lens implantation in 5% and corneoscleral tear repair in one patient. Lid tear repair was done for a patient who had presented with full thickness lid tear involving the margin of the upper lid. Foreign body removal was done for 4% of eyes from the cornea, subconjunctival space and anterior chamber. None of our patient required enucleation or evisceration. Lens matter aspiration was the common surgery done in both the open and closed eye groups other than the primary repair in the open eye group. In closed globe injury 4.38% of eyes underwent lens matter aspiration.

In the study by Patel et al, 36.7% patients had final visual acuity of less than 6/12, with 8 patients out of 49 having no perception of light in the injured eye. (54) In another study by Kumar et al out of 51 patients, 3 patients had no perception of light after scleral tear repair, and 2 patients had only perception of light after corneoscleral tear repair, exact mechanism/reason for low vision has not been mentioned in the study. (68) At the end of the study, once the patients who were lost to follow up, patients who had prior decreased vision in the injured eye and the children whose eyes were normal but proper visual assessment was not possible were excluded there were 99 eyes. The final visual acuity was calculated only for these eyes. Of these 7 eyes were blind,
(two eyes had only perception of light, one due to corneal ulcer following corneal tear repair, and the other due to retinal detachment following penetrating injury, 3 eyes had vision of hand movements due to corneal ulcer, corneal and macular scar, 2 eyes had vision of counting fingers due to traumatic cataract and were awaiting surgery. 78.78% of eyes had vision of 6/6 in the injured eye on follow up.

Cause of decreased vision as seen in other studies were penetrating corneal and scleral trauma, traumatic cataract, optic nerve damage, (59) retinal detachment globe perforation(60), macular scar (61), traumatic endophthalmitis (54). In our study, we found that the main cause of decrease in vision at the end of follow up was traumatic cataract (8.08%), followed by macular and corneal scar (3.03%). (Figure 27) Of the 8 eyes with traumatic cataract, surgery was being planned for 3 eyes, surgery was refused in 1 eye by the patients and 3 eyes had vision of 6/12 or better, and hence wanted surgery later. There were 3 eyes which were aphakic, one eye developed corneal ulcer and was still on treatment and was awaiting visual rehabilitation surgery. Other two eyes with aphakia had corneal scar and corneal sutures with glue and bandage contact lens.

In a study by Knox et al, of 47 patients studied 13 were less than 18 years old and 2 children had vision<6/60 due to macular scar, retinal and optic nerve damage.(61) In our study there were 61 children (64 eyes) below 20 years of
age. None of the children developed bilateral loss of vision. Of the 21 eyes with decreased vision less than 6/6 in this study, 8 eyes were from the less than 20 year age group. This was due to open globe injury in 3 eyes and closed globe injury in the rest. All of them underwent primary repair of the corneal /and scleral wound and LMA and in addition had IOL implantation/membranectomy/optical iridectomy. Of the 8 eyes which were injured the injury was caused due to bombs in 7 of them and in one of them it was due to cone fountain. Five of the eyes which sustained injury were innocent bystanders and were not actively involved in lighting the crackers. In the other 3 eyes it was either due to misuse or device failure.

Two eyes which developed mono ocular blindness were below the age of 5 years and was due to a corneal ulcer which developed on a sutured full thickness corneal tear and a macular hole following closed globe injury. (Figure 28) The 5 eyes which sustained closed globe injury were in zone 2 and 3 and the vision was more severely involved in those with zone 3 injury.

On comparing, open and closed globe injury in this study, open globe injury was associated with poor vision than closed globe injury. In a study by Malik et al with 101 patients and 17 open globe injury, permanent blindness was seen in three patients, with open globe injury. Mean log MAR visual acuity for closed globe injury was 0.09 [6/7 (20/24)] and for open globe injury was 0.58 [6/20 (20/76)] (42).
In our study, of the seven eyes which had become blind, 5 eyes had sustained an open globe injury, whereas 2 eyes had sustained a closed globe injury. 2 eyes with open globe injury had vision of 6/12 or better (Figure 29). Of these 7 eyes were blind, two patients had only perception of light, one due to corneal ulcer following corneal tear repair, and the other due to retinal detachment following penetrating injury. 3 eyes had, vision of hand movements due to corneal and macular scar. 2 eyes had vision of counting fingers due to traumatic cataract and are awaiting surgery.

Penetrating injury was found to cause blindness more than contusion. Of the 21 eyes with decreased vision contusion was noted to cause decreased vision in 13 eyes resulting in moderate visual loss in 2 eyes and blindness in 2 eyes (Figure 30) All the contusions which led to decrease in vision were when the injury was in zone 2 or 3. In this study all the patients who sustained penetrating /mixed injury had sustained it in zone 1 other than 1 patient who sustained it in zone 2. Hence comparison between zones cannot be made in the open eye injury group. [Due to corneal ulcer, retinal detachment, and corneal scar] Traumatic cataract had caused moderate decrease in vision in 4 eyes, and blindness in one eye. These eyes were yet to have cataract surgery. (Figure 31). Grade 4 presenting vision was associated with poor visual outcome in this study. 5 eyes who had presented with decreased vision due to firecrackers, continued to have poor vision at the end of the study. (Figure31)
Of the 8 eyes with traumatic cataract, surgery was being planned for 3 eyes, surgery was refused in 1 eye by the patients and 3 eyes had vision of 6/12 or better, and hence wanted surgery later. There were 3 eyes which were aphakic, one eye developed corneal ulcer and was still on treatment and awaiting visual rehabilitation surgery once the ulcer healed. Other two eyes with aphakia had corneal scar and corneal sutures with glue and bandage contact lens. 78.78% of patients had vision of 6/6 in the injured eye on follow up.(Figure 26) In Patel et al’s study, 36.7% patients had vision less than 20/40, with 8 patients having no perception of light in the injured eye.(54) In Kumar et al’s study, 3 patients had no perception of light after scleral tear repair, 2 patients had only perception of light after corneo scleral tear repair. (68)

7 patients (10 injured eyes) were lost to follow up after the initial assessment in casualty, 3 eyes had decreased vision prior to this trauma (immature senile cataract in two eyes and childhood trauma leading to subluxation of lens in one eye), 10 eyes of children in the 1-5 age group, whose ocular examination was normal and whose vision after assessment with Cardiff/Kay pictures ranged from 6/12(4 eyes) -6/9 (6 eyes) were also not included in this assessment.

There were 61 children below 20 years of age, who had got injured with fireworks, out of which 2 are below the age of 5 who developed mono ocular blindness due to trauma. One had sustained full thickness corneal tear, which
was sutured, and then developed corneal ulcer, which perforated. Another child had developed macular hole following closed globe injury. One child in the age group 5-9 years sustained moderate vision loss due to macular hole, following contusion. One teenager had monocular blindness (HM) prior to the fire cracker injury itself, due to childhood trauma. (Figure 28) In a study by Knox et al, 2 children had vision<6/60 due to macular scar, retinal and optic nerve damage.(61)

On comparing, open and closed globe injury in this study, open globe injury was associated with more poor vision than closed globe injury. In open globe injury, 5 eyes sustained blindness, whereas 2 eyes had blindness in closed globe injury. In spite of being open globe injury, 1 eye each had vision of 6/9, 6/12, and 6/18. (Figure 29) In a study by Malik et al, permanent blindness was seen in three patients, with open globe injury. Mean visual acuity for closed globe injury was 6/7 (20/24) and for open globe injury was 6/20 (20/76).(42)

Of the 21 eyes which had decreased vision less than 6/6, 7 eyes were noted to be blind. Penetrating injury was found to cause blindness more than contusion. Contusion largely caused moderate visual loss (11 eyes <6/60), Mixed injury in open globe, was found to cause both blindness in 2 eyes, as well as mild loss of vision in 1 eye. (Figure 30)
Zone of injury which lead to blindness was Zone 1 in open globe (4 eyes) [Due to corneal ulcer, retinal detachment, and corneal scar] Traumatic cataract had caused moderate decrease in vision in 4 eyes, and blindness in one eye. These eyes were yet to have cataract surgery. (Figure 31).

Grade 4 presenting vision was associated with poor visual outcome in this study. 5 eyes who had presented with decreased vision due to firecrackers, continued to have poor vision at the end of the study. There were 61 eyes with grade 1 vision initially on presentation, of which 3 eyes were lost to follow up, 1 eye had blindness in the affected eye due to traumatic cataract. In 18 eyes with grade 2 vision initially, 2 eyes were lost to follow up. In 43 eyes with grade 4 vision, 5 eyes were lost to follow up.

Factors which led to poor visual acuity in our study were open globe injury (p<0.001) and grade 4 injury (p=0.046). In Malik et al’s study, poor visual outcome was associated with initial presentation poor visual acuity, open globe injury, intra ocular foreign body, traumatic endophthalmitis, and retinal detachment.(42) In Singh et al’s study the factors which determined better visual outcome were, good presenting visual acuity, absence of relative afferent pupillary defect, traumatic endophthalmitis, IOFB.(41)

Out of 21 patients who had decreased vision due to fire cracker injury, (<6/6), 8 were below the age of 20 years (8%) Men were also affected more in the
severity of damage caused by the cracker (80%) and also had residual severe visual loss 30% at the end of this study. Here, 6% of the patients who had developed mono ocular blindness, were from the upper lower socio economic strata. Out of 122 eyes which got injured, 5% of eyes became blind, and 4% were those of bystanders. Mostly, because bystanders were caught unaware about the trajectory of the flying pieces of burst cracker, and unable to move away in time. Also, they were not wearing any protective gear, which increased the chances of more damage. Mansouri et al had similar results in which severe injury was caused by grenades, seen in bystanders, lower socio economic class, male gender.(52)

In this study, 28 patients out of 96 [i.e.56 of 122 eyes (46%)] had bilateral injury of which, one patient had sustained bilateral open globe injury, and another patient sustained one eye open and other eye closed globe injury. All the rest of the patients had sustained bilateral closed globe injury. Patient who had sustained bilateral open globe injury had only hand movements’ vision in both eyes vision due to surgical aphakia in both eyes, corneal ulcer in one eye and corneal tear sutured and glue placed in the other eye. In a study by Mansouri et al 18.5 % of the ocular trauma was bilateral(52). In a study by Sudesh et al, 5% of the injuries are bilateral.(70) In a study by Rashid et al, 13% had bilateral injuries.(57)
CONCLUSION

According to this study, young males, upper lower class and bystanders formed the major proportion of those who were injured. Injuries happened more often at home during Diwali. Bombs and cone fountain caused most of the injuries and ground spinner being the least. Adult supervision was absent in more than half of the cases. Closed globe injuries caused majority of the trauma, of which zone 1 was the most common. Corneal epithelial defect was the most common injury among closed globe whereas corneal tear in open globe. The most common posterior segment injury was commotio retinae in both open and closed globe injury. Surgical management was undertaken for 15 eyes, and conservative management for the rest. 7 eyes had blindness due to firecracker injury. Based on this study, it was concluded that factors for poor visual outcome after firecracker injury were poor initial visual acuity (p=0.046) and open globe injury (p<0.001)
RECOMMENDATIONS

In India firecrackers are available for use by the common public. The fact that so many youngsters were injured highlights the importance of regulating firecracker use and enforcing safety precautions. Though there are many legislations by government and non-governmental, such as the one which was brought by the Supreme Court of India in July 2005 which directed the Pollution Control Board to prohibit the use of loud speakers between 10 pm and 6 am with a special clause inclusive of fire crackers in the ban. This hasn’t been strictly enforced, hence hasn’t brought down the usage of firecrackers in the night. Strict legislation has brought down the number of firecracker injuries as shown in a study done in UK\(^{(61)}\). This will be possible only if the public is taken into confidence and they are involved in its implementation. Governmental regulation on the quality of firecrackers is a move in the positive direction.

The single most effective measure may be to restrict fireworks to public open spaces (parks or playgrounds) and maintain a distance between the on looker and the area where the firecrackers are lit and avoiding use of it on the roads. Public education promoting safe use of firecrackers via schools, media will have a positive impact. Protective polycarbonate glasses should be worn while lighting and watching fireworks as simple glasses do not protect against high velocity injuries. Posters, banners, TV serials, websites with information on
firecrackers and their risks can be used for dissemination of knowledge and prevention of accidents. Mobile phones are a popular mode of communication in rural and urban areas of the country. The dos and don’ts in the form of messages can be sent to the public during the festive season. Safety precautions include not to let little children handle firecrackers, to douse used and half lit crackers in water, to educate children on the dangers of using illegal or homemade crackers, to handle crackers responsibly and to never use firecrackers under the influence of alcohol.
REFERENCES


ANNEXURES
November 10, 2014

Dr. Neethu Ann Kurien
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Department of Ophthalmology
Christian Medical College, Vellore 632004

Sub: Fluid Research Grant Project:
Ocular trauma due to flyspeck: an observational study in a tertiary eye care centre.
Dr. Neethu Ann Kurien, PG Registrar, Dr. Sarada David, Dr. Pushpa Jacob, Dr. Jayanthi Peter, Ophthalmology, CMC, Vellore.

Ref: IRB Reg No 5003 (OBSE) dated 08.08.2014

Dear Dr. Neethu Ann Kurien,

I enclose the following documents:

1. Institutional Review Board approval

Could you please sign the agreement and send it to Dr. Nihal Thomas, Addl. Vice Principal (Research), so that the grant money can be released.

With best wishes,

Dr. Nihal Thomas
Secretary (Ethics Committee)
Institutional Review Board

Dr. Nihal Thomas
MD, MNAMS, DNB (Endo), FRACP (Endo), FRCP (Edin), FRCP (Glasg)
Secretary - Ethics Committee
Institutional Review Board,
Christian Medical College, Vellore - 632 002.
Cc: Dr. Sarada David, Ophthalmology, CMC, Vellore, CMC, Vellore.
November 10, 2014

Dr. Neethu Ann Kurien
PG Registrar
Department of Ophthalmology
Christian Medical College, Vellore 632004

Sub: Fluid Research Grant Project:
Ocular trauma due to fireworks: an observational study in a tertiary eye care centre.
Dr. Neethu Ann Kurien, PG Registrar, Dr. Sarada David, Dr. Pushpa Jacob,
Dr. Jayanthi Peter, Ophthalmology, CMC, Vellore.

Ref: IRB Min NO 2003 Q/RESERVE dated 04.06.2014

Dear Dr. Neethu Ann Kurien,

The Institutional Review Board (IRB, Research & Ethics Committee) of the Christian Medical College, Vellore, reviewed and documented a project entitled, Ocular trauma due to fireworks: an observational study in a tertiary eye care centre on August 4th, 2014.

The Committee reviewed the following documents:

1. IRB Application format
2. Curriculum Vitae of Drs. Neethu Ann Kurien, Sarada David, Pushpa Jacob,
   Jayanthi Peter.
3. Proforma
4. Informed Consent form (English & Tamil)
5. Information Sheet (English & Tamil)
6. No of documents 1-5

The following Institutional Review Board (IRB, Research & Ethics Committee) members were present at the meeting held on August 4th, 2014 in the CREST/ASCN Conference Room, Christian Medical College, Bagayam, Vellore 632002.
<table>
<thead>
<tr>
<th>Name</th>
<th>Qualification</th>
<th>Designation</th>
<th>Other Affiliations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Benjamin Perakath</td>
<td>MBBS, MS, FRCS</td>
<td>Professor, Colorectal Surgery, CMC, Vellore</td>
<td>Internal, Clinician</td>
</tr>
<tr>
<td>Dr. Rajesh Kannangai</td>
<td>MD, Ph.D.</td>
<td>Professor &amp; In-charge Retrovirus Laboratory (NRL under NACO), Department of Clinical Virology, CMC, Vellore</td>
<td>Internal, Clinician</td>
</tr>
<tr>
<td>Dr. Anup Ramachandran</td>
<td>Ph. D</td>
<td>The Wellcome Trust Research Laboratory for Gene-Specific Science, CMC, Vellore</td>
<td>Internal, Basic Medical Scientist</td>
</tr>
<tr>
<td>Dr. Simon Pavamani</td>
<td>MBBS, MD</td>
<td>Professor, Radiology, CMC, Vellore</td>
<td>Internal, Clinician</td>
</tr>
<tr>
<td>Dr. Vivek Mathew</td>
<td>MD, G.G. Med. D.M. (Neuro)</td>
<td>Professor, Neurology, CMC, Vellore</td>
<td>Internal, Clinician</td>
</tr>
<tr>
<td>Dr. Mathew Joseph</td>
<td>MBBS, MCh</td>
<td>Professor, Neurosurgery, CMC, Vellore</td>
<td>Internal, Clinician</td>
</tr>
<tr>
<td>Dr. Bobby John</td>
<td>MBBS, MD, DM, Ph.D, MAMS</td>
<td>Professor, Cardiology, CMC, Vellore</td>
<td>Internal, Clinician</td>
</tr>
<tr>
<td>Dr. Chandrasekhar</td>
<td>MS, MCh, DMB</td>
<td>Professor, Urology, CMC, Vellore</td>
<td>Internal, Clinician</td>
</tr>
<tr>
<td>Dr. Visalakshi J</td>
<td>MPH, PhD</td>
<td>Lecturer, Dept of Biostatistics</td>
<td>Internal, Statistician</td>
</tr>
<tr>
<td>Dr. Iniyan Saran</td>
<td>MS, FRCS, FRACS</td>
<td>Professor, Surgery, CMC, Vellore</td>
<td>Internal, Clinician</td>
</tr>
<tr>
<td>Name</td>
<td>Position and Qualifications</td>
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</tr>
<tr>
<td>Dr. B. J. Prashantham</td>
<td>MA (Counselling Psychology), MA (Theology), Dr. Min (Clinical Counselling), Chairperson, Ethics Committee, Vellore</td>
<td></td>
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</tr>
<tr>
<td>Mrs. Pattubiraman</td>
<td>B. Sc, DSSA, Social Worker, Vellore</td>
<td></td>
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</tr>
<tr>
<td>Dr. Jayaprakash Malaiy</td>
<td>B. Sc, MBBS, MD, MPH, Dr PH (Epid), DMIHC, Retired Professor, GMC, Vellore</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr. Denise H. Fleming</td>
<td>B. Sc (Hons), PhD, Honorary Professor, Clinical Pharmacology, GMC, Vellore</td>
<td></td>
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</tr>
<tr>
<td>Mrs. Emily Daniel</td>
<td>MSc, Nursing, Professor, Medical Surgical Nursing, GMC, Vellore</td>
<td></td>
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<tr>
<td>Mrs. Sheda Durai</td>
<td>MSc, Nursing, Professor, Medical Surgical Nursing, GMC, Vellore</td>
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<tr>
<td>Mr. C. Sampath</td>
<td>BSc, BL, Legal Expert, Vellore</td>
<td></td>
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<tr>
<td>Dr. Anuradha Rose</td>
<td>MBBS, MD, Assistant Professor, Community Health, GMC, Vellore</td>
<td></td>
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</tr>
<tr>
<td>Dr. Nihal Thomas,</td>
<td>MD, MNAMS, DNB (Endo), FRACP (Endo), FRCP (Edin), FRCP (Glasg), Professor &amp; Head, Endocrinology, Additional Vice Principal (Research), Deputy Chairperson, IRB, Member, Secretary (Ethics Committee), IRB</td>
<td></td>
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</tbody>
</table>

IRB Min No: 9003 [OBSERVE] dated 04.08.2014
OFFICE OF RESEARCH
INSTITUTIONAL REVIEW BOARD (IRB)
CHRISTIAN MEDICAL COLLEGE, VELLORE, INDIA.

Dr. R.J. Prakashanth, M.A., M.A., Dr. Min (Clinical)
Director, Christian Counseling Center,
Chairperson, Ethics Committee.

Dr. Alfred Job Daniel, D Ortho, MS Ortho, DNB Ortho
Chairperson, Research Committee & Principal

Dr. Nikhil Thomas,
MD., MNAMS., DNB (Endo), FRACP (Endo), FRCP (Edin), FRCP (Glasg)
Deputy Chairperson
Secretary, Ethics Committee, IRB
Additional Viz Principal (Research)

We approve the project to be conducted as presented.

The Institutional Ethics Committee expects to be informed about the progress of the project, any adverse events occurring in the course of the project, any amendments in the protocol and the patient information / informed consent. On completion of the study you are expected to submit a copy of the final report. Respective forms can be downloaded from the following link: http://172.16.13.136/Research/IRB_Policies.html in the CMC Intranet and in the CMC website link address: http://www.cmclvellore.edu/main/research/index.html.

Fluid Capped Abbreviation:
A sum of 3000/- INR (Repos: Your Personal copy) will be refunded for 1 year.

Yours sincerely,

Dr. Nikhil Thomas
Secretary (Ethics Committee)
Institutional Review Board

Dr. NIKHIL THOMAS
SECRETARY (ETHICS COMMITTEE)
INSTITUTIONAL REVIEW BOARD,
CHRISTIAN MEDICAL COLLEGE, VELLORE - 632 002.

Cc: Dr. Sarada David, Ophthalmology, CMC, Vellore., CMC, Vellore.

IRB Min No: 5003 [OBSERVE] dated 04.08.2014

Ethics Committee Blu, Office of Research, 1st Floor, Carman Block, Christian Medical College, Vellore, Tamil Nadu 632 002.
Tel: 0416 - 2284294, 2284202
Fax: 0416 - 2282788, 2284481
E-mail: research@cmovellore.ac.in
II-PROFORMA

Ocular Trauma Due to Fireworks

Name:           Age:     Sex: M/F     Address

Tel No:

Date and Time of presentation:          OPD / Casualty

<table>
<thead>
<tr>
<th>EDUCATIONAL QUALIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional</td>
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<table>
<thead>
<tr>
<th>OCCUPATION</th>
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<tbody>
<tr>
<td>Unemployed</td>
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<table>
<thead>
<tr>
<th>FAMILY INCOME</th>
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<tbody>
<tr>
<td>&gt;= 31,507</td>
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<table>
<thead>
<tr>
<th>SOCIOECONOMIC STATUS</th>
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<tbody>
<tr>
<td>Upper</td>
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<table>
<thead>
<tr>
<th>MODE OF INJURY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Misuse</td>
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</table>

<table>
<thead>
<tr>
<th>TIME OF INJURY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early morning</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>PLACE OF INJURY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
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<table>
<thead>
<tr>
<th>DAY OF PRESENTATION</th>
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<tr>
<td>Same day</td>
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<table>
<thead>
<tr>
<th>OCCASION</th>
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<tbody>
<tr>
<td>Diwali</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>TYPE OF FIRECRACKER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sparkler</td>
</tr>
</tbody>
</table>
**MODE OF ACQUISITION**
- Home made
- Bought from shop

**MODE OF LIGHTING**
- Sparkler
- Matchstick
- Candle
- Newspaper
- Incense stick

**INTERVENTION**
- Manipulation
- Misuse
- Nil

**HANDLING OF FIRE CRACKER**
- Patient
- Bystander
- Other

**PROXIMITY TO FIRE CRACKER**
- Close to face
- Half to 1 metre
- Less than 2 metres
- More than 2 metres

**PROTECTIVE EYE WEAR**
- Yes
- No

**KNOWLEDGE OF PROTECTIVE EYE WEAR**
- Yes
- No

**ADULT SUPERVISION**
- Present
- Absent
- Not applicable

**LIKELY CAUSE OF MISHAP**
- Negligence
- Device malfunction
- Attempt to reignite
- Recover a failed device

**FIRST AID TAKEN**
- Yes
- No

**PAST OCULAR HISTORY**
- Glasses
- Glaucoma
- Cataract

**SYSTEMIC ILLNESS**
- Diabetes
- Hypertension
- IHD
- Asthma
- Others

**EXAMINATION**

<table>
<thead>
<tr>
<th>Right eye</th>
<th>Left eye</th>
</tr>
</thead>
</table>

**SYSTEMIC INJURY:**

**FACIAL INJURY**
- Laceration
- Contusion
- Hematoma
- Crepitus
## CLASSIFICATION

### OPEN GLOBE

<table>
<thead>
<tr>
<th>Type</th>
<th>Grade</th>
<th>Pupil</th>
<th>Zone</th>
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</thead>
</table>

### CLOSED GLOBE

<table>
<thead>
<tr>
<th>Type</th>
<th>Grade</th>
<th>Pupil</th>
<th>Zone</th>
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</table>

## SYMPTOMS

<table>
<thead>
<tr>
<th>Decreased vision</th>
<th>Pain</th>
<th>Redness</th>
<th>Watering</th>
<th>Foreign body sensation</th>
<th>Irritation</th>
<th>Burning Sensation</th>
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</thead>
</table>

## VISUAL ACUITY

Right eye:  
Left eye:

## ORBITAL RIM

<table>
<thead>
<tr>
<th>Normal</th>
<th>Tender</th>
<th>Ecchymosis</th>
<th>Crepitus</th>
<th>Blow out fracture</th>
<th>IOFB</th>
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## LIDS AND ADNEXA

<table>
<thead>
<tr>
<th>Skin burns</th>
<th>Charred eye lashes</th>
<th>Contusions/ hematoma</th>
<th>Lacerations</th>
<th>Enema</th>
<th>Discharge</th>
<th>Normal</th>
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</table>

## BURNS

<table>
<thead>
<tr>
<th>First degree</th>
<th>Second Degree</th>
<th>Third degree</th>
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## CONJUNCTIVA

<table>
<thead>
<tr>
<th>Normal</th>
<th>Congestion</th>
<th>Tear</th>
<th>Chemosis</th>
<th>Subconjunctival haemorrhage</th>
<th>Limbal ischaemia</th>
<th>Foreign body</th>
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</thead>
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## SCLERA

<table>
<thead>
<tr>
<th>Normal</th>
<th>Tear</th>
<th>Posterior scleral rupture</th>
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## CORNEA

<table>
<thead>
<tr>
<th>Normal</th>
<th>Epithelial defect</th>
<th>PEES</th>
<th>SPKS</th>
<th>Partial Thickness tear</th>
<th>Full thickness tear</th>
<th>IOFB</th>
<th>Corneal edema</th>
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## SEIDELS TEST

<table>
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<tr>
<th>POSITIVE</th>
<th>NEGATIVE</th>
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## ANTERIOR CHAMBER

<table>
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<tr>
<th>Normal</th>
<th>deep</th>
<th>Shallow</th>
<th>Flat</th>
<th>uveitis</th>
<th>hyphaema</th>
<th>hypopyon</th>
<th>IOFB</th>
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</table>

## IRIS

<table>
<thead>
<tr>
<th>Normal</th>
<th>Iridodialysis</th>
<th>Foreign body</th>
<th>Sphincter tear</th>
<th>No View</th>
<th>Iris incarceration</th>
<th>Cyclodialysis</th>
</tr>
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<tbody>
<tr>
<td>PUPIL</td>
<td>Normal</td>
<td>Dilated and fixed</td>
<td>Pharmacologically dilated</td>
<td>Irregular</td>
<td>Sluggishly reacting to light</td>
<td>RAPD</td>
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<tr>
<td>LENS</td>
<td>Normal</td>
<td>Cataract</td>
<td>Subluxated lens</td>
<td>Dislocated lens</td>
<td>Ant cap breach</td>
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<tr>
<td>IOP</td>
<td>Normal</td>
<td>Abnormal</td>
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<td></td>
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<tr>
<td>VITREOUS</td>
<td>Normal</td>
<td>Haemorrhage</td>
<td>Inflammation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RETINA</td>
<td>Normal</td>
<td>RD</td>
<td>Choroidal haemorrhage</td>
<td>Choroidal rupture</td>
<td>Berlins edema</td>
<td></td>
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<tr>
<td></td>
<td>Macular hole</td>
<td>Choroidal detachment</td>
<td>IOFB</td>
<td>Extrusion</td>
<td>TON</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SURGERY</td>
<td>Corneal Tear</td>
<td>Scleral Tear</td>
<td>Wound exploration</td>
<td>Lens Matter Aspiration</td>
<td>PCIOL at a later date</td>
<td>Vitrectomy proceed</td>
</tr>
<tr>
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</tbody>
</table>


2. Investigation: a. Xray  b. CT Scan c. MRI

3. Conservative: a. topical steroid b. mydriatic c. cycloplegic d. lubricants e. antibiotic

4. Intra vitreal antibiotic given a. yes b. no

5. No. of surgical procedures required: a. 1 b. 2 c. 3 d. >3


7. Total no. of OPD attendance: a. 1-3 b. 4-7 c. 8-12 d. more than 12

8. Total No. of IP days: a. 1 day b. 2 days c. 3 days d. up to 1 week. More than 1 week

.. Visual acuity on follow up
   1st visit: RE : LE :

6 months follow up visit:

Last definitive follow up:

Likely reason for decrease in visual acuity (specify)
III-CONSENT FORMS

Patient Information Sheet

Christian Medical College, Vellore
Department of Ophthalmology

Ocular trauma due to fireworks: An observational study in a tertiary eye care centre

You are being requested to participate in a study to see, the nature and type of eye injuries caused due to fireworks and to determine the type of people and how they are injured due to this. After thorough examination and management in the inpatient/outpatient department, you will be followed up for six months minimum or till the last surgery to attain the best corrected vision and to identify the factors which play a role in the visual outcome at the end of the study. Fireworks are used across the world during celebrations. However, it can be dangerous if it is used without adequate precautions. Fireworks cause burns, lacerations, soft tissue losses and bony injuries. It can also cause facial burns, of which ocular injuries are the commonest.

There can be injury to the eyelid, cornea, bleeding, infection, loss of vision and disfiguration.

If you agree to participate in this study, you will undergo a complete ophthalmic examination and the appropriate management will be undertaken either as in patient or out patient just like any other patient attending OPD or A&E will have. You will be followed up in the out patient department after discharge for further management and details of your ocular findings including vision will be recorded for a minimum of six months or till the last surgery. There will not be any additional costs if you participate in the study. Your participation in this study is voluntary and you are also free to decide to withdraw permission to participate in this study. If you do so, this will not affect your treatment in this hospital.

After the study is over the results of the study will be published in scientific journals. The names or identity of the participants will not be published. The hospital records will be kept in the Department of Ophthalmology. Interested patients can be briefed about the results of the study.

The results of this study will be published in a medical journal but you will not be identified by name in any publication or presentation of results. However, your medical notes may be reviewed by people associated with the study, without your additional permission, should you decide to participate in this study.

If you have any further questions, please ask Dr Neethu Ann Kurien (Tel: 0416 3071201/ 3071205) or email: neethuann@gmail.com
Informed Consent Form for Subjects to participate in the study

Study Title: Ocular trauma due to fireworks: An observational study in a tertiary eye care centre

Study Number: __________  Hospital Number: ______________

Subject’s Initials: __________  Subject’s Name: ____________________________

Date of Birth / Age: ___________________

(Subject)

(i) I confirm that I have read and understood the information sheet dated ________ for the above study and have had the opportunity to ask questions.

(ii) I understand that my participation in the study is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected.

(iii) I understand that the Sponsor of the clinical trial, others working on the Sponsor’s behalf, the Ethics Committee and the regulatory authorities will not need my permission to look at my health records both in respect of the current study and any further research that may be conducted in relation to it, even if I withdraw from the trial. I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published.

(iv) I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s).

(v) I agree to take part in the above study.

Signature (or Thumb impression) of the Subject/Legally Acceptable

Date: ___/___/____

Signatory’s Name: ____________________________  Signature:

Or

________________________
Childs Assent Form to participate in the study

Study Title: Ocular trauma due to fireworks: An observational study in a tertiary eye care centre

Study Number: ___________ Hospital Number: ________________
Subject’s Initials: ________________ Subject’s Name: _______________________

Date of Birth / Age: __________________

CHILD’s ASSENT

Name of Child:
Date:
Oral assent: Given / Not Given

Thumb impression: Signature:

Signature of the Investigator: _________________
Date: ___/___/____
Study Investigator’s Name: _________________

Signature of the Witness: _________________
Date: ___/___/____
Name & Address of the Witness: _________________
TAMIL CONSENT FORM

தமிழ் பிறந்த

தமிழ் பிறந்த விளக்க வகுப்பு அவர்களின் மக்களின் வரலாற்றுக்கு அடுத்து பிறந்த வகுப்பு. பள்ளிக் கல்வி பள்ளிக்கு முன்னர் பள்ளிக் கல்வி பள்ளிக்கு முன்னர் வகுப்பு.


என்னுடைய பிறந்த வகுப்பு முதல் உயர்ந்த வகுப்பு முதல் பள்ளிக் கல்வி பள்ளிக்கு முன்னர் வகுப்பு?

2. என்னுடைய பிறந்த வகுப்பு முதல் உயர்ந்த வகுப்பு முதல் பள்ளிக் கல்வி பள்ளிக்கு முன்னர் வகுப்பு?

3. என்னுடைய பிறந்த வகுப்பு முதல் உயர்ந்த வகுப்பு முதல் பள்ளிக் கல்வி பள்ளிக்கு முன்னர் வகுப்பு?

4. என்னுடைய பிறந்த வகுப்பு முதல் உயர்ந்த வகுப்பு முதல் பள்ளிக் கல்வி பள்ளிக்கு முன்னர் வகுப்பு?

5. என்னுடைய பிறந்த வகுப்பு முதல் உயர்ந்த வகுப்பு முதல் பள்ளிக் கல்வி பள்ளிக்கு முன்னர் வகுப்பு?

6. என்னுடைய பிறந்த வகுப்பு முதல் உயர்ந்த வகுப்பு முதல் பள்ளிக் கல்வி பள்ளிக்கு முன்னர் வகுப்பு?
இன்று பங்கு வகைப்படுத்தப்பட்டுள்ளதா சோட்டாம் தேன்காரம்?

இன்று புதிய எழுத்து பங்கு வகைப்படுத்தப்பட்டுள்ளதா சோட்டாம் தேன்காரம். இன்று புதிய எழுத்து பங்கு வகைப்படுத்தப்பட்டுள்ளதா சோட்டாம் தேன்காரம்.

ஆனால் என்றும் புதிய எழுத்து வகைப்படுத்தப்பட்டுள்ளதா சோட்டாம் தேன்காரம்?

இன்று புதிய எழுத்து பங்கு வகைப்படுத்தப்பட்டுள்ளதா சோட்டாம் தேன்காரம். இன்று புதிய எழுத்து பங்கு வகைப்படுத்தப்பட்டுள்ளதா சோட்டாம் தேன்காரம். இன்று புதிய எழுத்து பங்கு வகைப்படுத்தப்பட்டுள்ளதா சோட்டாம் தேன்காரம்.

இன்று குற்றாம்பு சோட்டாம் தேன்காரம் சோட்டாம் தேன்கார என்று வேண்டும்?

இன்று குற்றாம்பு சோட்டாம் தேன்காரம் சோட்டாம் தேன்காரம். இன்று குற்றாம்பு சோட்டாம் தேன்காரம் சோட்டாம் தேன்காரம். இன்று குற்றாம்பு சோட்டாம் தேன்காரம் சோட்டாம் தேன்காரம்.

இன்று குற்றாம்பு சோட்டாம் தேன்காரம் என்று வேண்டும்?

இன்று குற்றாம்பு சோட்டாம் தேன்காரம் சோட்டாம் தேன்காரம். இன்று குற்றாம்பு சோட்டாம் தேன்காரம் சோட்டாம் தேன்காரம்.
வாழ்க்கையை குறிப்பிட்டு விளக்கும் வழியாக உள்ளூரகத்தில் வருமாறு என்ன உண்டு?

இது அம்மவேளை வரும் மாநிலத்தில் உள்ளூரகத் தொடர்பு விளக்கின் மூலமாக அளிக்கப்பட்டது. அதன் பின்னர் உள்ளூரகத் தொடர்பு அம்மவேளைக் கொண்டு விளக்கம் வைக்கப்பட்டது.

மூடாயின் வழியாக விளக்கும் வழியாக உள்ளூரகத்தில் சென்று வருமாறு உள்ளூரகத் தொடர்பு அம்மவேளை பல்லாக கேரளத்தில் வெளியீடாக முடிக்கும் உள்ளூரகத்தில்.

இது அம்மவேளை வரும் மாநிலத்தில் வருமாறு உள்ளூரகத்தில் வருமாறு உள்ளூரை வளர்மைப்படுத்தும் அம்மவேளை வருமாறு உள்ளூரகத்திலிருந்து அங்கு நீர் மாற்றமாறும். அங்கு நீரும் வளர்ப்பேற்றுகிறது. அங்கு நீரும் வளர்ப்பேற்றுகிறது. அங்கு நீரும் வளர்ப்பேற்றுகிறது. அங்கு நீரும் வளர்ப்பேற்றுகிறது.

அங்கு நீரும் வளர்ப்பேற்றுகிறது. அங்கு நீரும் வளர்ப்பேற்றுகிறது.

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அங்கு நீரும் வளர்ப்பேற்று�í
அலுவல் கோட்டையில்: சேவுப்பாதை மைசர் பங்குகளில் வளர்ந்து கொண்டு (i) ப்ளாம் தொடர்ந்து பாதுகாப்பான்களுக்கு ஆதிக்கப்படும் புதிய விளக்கம்.

அம்மா கோட்டையில்:

பாதுகாப்பான்கள் தொடர்ந்து:

பாதுகாப்பான்கள் விடுமுறை:

i. ________ விளக்க ஆக்கத்திற்கு சேவுப்பாதை அம்மான் பாதுகாப்பான்கள் அமைக்கப்பட்டு வருகிறது. ஏற்காட்டு அம்மான் சேவுப்பாதை அமைக்கப்பட்டு வருகிறது. எனவே அம்மான் பாதுகாப்பான்கள் அமைக்கப்பட்டுத் தொடர்ந்து வருகிறது.

ii. இந்த விளக்கம் பாதுகாப்பான்கள் தொடர்ந்து வளர்ந்து கொண்டு வருகிறது. உயர்ந்த விளக்கம் பாதுகாப்பான்கள் தொடர்ந்து வளர்ந்து வருகிறது. எனவே அம்மான் பாதுகாப்பான்கள் தொடர்ந்து வளர்ந்து வருகிறது.

iii. இந்த விளக்கம் பாதுகாப்பான்கள் தொடர்ந்து வளர்ந்து கொண்டு வருகிறது. ஊரிய விளக்கம் பாதுகாப்பான்கள் தொடர்ந்து வளர்ந்து வருகிறது. உயர்ந்த விளக்கம் பாதுகாப்பான்கள் தொடர்ந்து வளர்ந்து வருகிறது. எனவே அம்மான் பாதுகாப்பான்கள் தொடர்ந்து வளர்ந்து வருகிறது.

சொந்த ஆுருவாள் சேவாப்பாதையில் (ii) மேற்கொள்ளும் விளக்கத்திற்கு உயர்ந்த விளக்கங்கள் எழுக்குவது தொடர்ந்து பாதுகாப்பான்கள் கொண்டு வருகிறது. எனவே விளக்கம் பாதுகாப்பான்கள் அமைக்கப்பட்டு வருகிறது. எனவே விளக்கம் பாதுகாப்பான்கள் அமைக்கப்பட்டு வருகிறது. எனவே விளக்கம் பாதுகாப்பான்கள் அமைக்கப்பட்டு வருகிறது.
பல்வேளாமாற்றத்திற்கு காரணம்

பல்வேளாமாற்றத்தை (அ) நிற்பாயிற்று வலாச்சியின் கல்வியம்பதியை (ஆ) நிலை மூட்டி விளக்கம்:

கல்வியம்பதி விளக்கம் பாடல்

அல்லது என்னுடைய மொழிகளில் குறிப்பிட்டு

கல்வியம்பதியும் விளக்கம்:

அல்லது என்னுடைய மொழிகளில் குறிப்பிட்டு

கல்வியம்பதி விளக்கம்:

அல்லது என்னுடைய மொழிகளில் குறிப்பிட்டு

கல்வியம்பதி விளக்கம்:

அல்லது என்னுடைய மொழிகளில் குறிப்பிட்டு

கல்வியம்பதி விளக்கம்:

அல்லது என்னுடைய மொழிகளில் குறிப்பிட்டு
IV- COLOUR PLATES

PICTURE 1: Open globe injury with full thickness corneal tear, iris and vitreous prolapse

PICTURE 2: Closed globe injury with superior iridodialysis and layered hyphaema
PICTURE 4: Bilateral open globe injury, facial burns and facial abrasion due to foreign bodies.

PICTURE 4: Bilateral mixed closed globe injury with facial burns, abrasions and multiple foreign body in the facial subcutaneous tissue.
PICTURE 5: Closed globe injury with traumatic cataract and posterior synechiae in a child.

PICTURE 6: Traumatic macular hole with subretinal haemorrhage following closed globe injury
V- DATA