Original Research Article

Clinico-Demographic Profile and Visual Outcome of Ocular Chemical Injuries in a Rural Center

Dr. Rashmi Jalihal[1], Dr. Tanmaya S.[2], Dr. Jeevitha R.[3]

[1]Junior Resident, Department of Ophthalmology, Adichunchangiri Institute of Medical Sciences, B.G. Nagara, Karnataka, India.
[2]Junior Resident, Department of Ophthalmology, Adichunchangiri Institute of Medical Sciences, B.G. Nagara, Karnataka, India.
[3]Senior Resident, Department of Ophthalmology, Adichunchangiri Institute of Medical Sciences, B.G. Nagara, Karnataka, India.

Corresponding Author
Dr. Jeevitha R., Senior Resident, Department of Ophthalmology, Adichunchangiri Institute of Medical Sciences, B.G. Nagara, Karnataka, India.

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ABSTRACT

Background
Chemical eye injuries are a critical ophthalmic emergency requiring urgent treatment. This study aims to examine the demographic and clinical profile and evaluate the visual outcomes of patients with ocular chemical injuries in a rural medical setting.

Methods
A hospital-based cross-sectional observational study was conducted at a tertiary rural medical hospital from June 2022 to May 2023. The study included 24 patients with chemical ocular injuries. Data were collected on demographics, clinical presentation, type of chemical involved, and visual outcomes. Injuries were classified using the Roper-Hall classification system. Statistical analysis was performed using SPSS 17.0.

Results
Of the 24 patients, 71% were males, with a mean age of 40.29 years. The majority of injuries were unilateral (71%) and occurred at home (41.66%) and construction sites (33.33%). Alkali injuries were the most common (58.33%), followed by acid injuries (33.33%). According to the Roper-Hall classification, 50% of injuries were Grade I, 38% were Grade II, 8% were Grade III, and 4% were Grade IV. At presentation, 29% of patients had mild or no visual impairment, 54% had moderate impairment, 13% had severe impairment, and 4% were blind. Post-treatment, 88% of patients achieved mild or no impairment, 8% had moderate impairment, 4% had severe impairment, and none remained blind.

Conclusion
Chemical ocular injuries pose a major risk of visual impairment, particularly in occupational settings. Early intervention and preventive measures are crucial for improving visual outcomes and reducing the incidence of these injuries. Public health initiatives focusing on safety protocols and awareness campaigns are essential to mitigate the risks associated with chemical eye injuries.

Keywords: Ocular chemical injuries, Visual outcomes, Roper-Hall classification, Alkali injuries, Rural medical center.

INTRODUCTION

Ocular chemical injuries represent a critical ophthalmic emergency requiring prompt and appropriate management to mitigate the risk of permanent visual impairment or blindness. These injuries can occur due to exposure to various chemical agents, often found in household products, industrial environments, and agricultural settings. The severity of chemical injuries to the eye can range from mild epithelial disruption to extensive damage involving the cornea, limbus, and deeper intraocular structures, depending on the nature and concentration of the chemical involved.
Chemical injuries to the eye are relatively common, particularly in developing countries where safety regulations and protective measures may not be as stringent or widely enforced. The incidence of ocular chemical injuries ranges from 1.25% to 4% in these regions, highlighting a significant public health concern.[1] The majority of these injuries occur in adult males, which is attributed to their higher likelihood of working in occupations with greater exposure to hazardous chemicals.[2] Studies have consistently shown a male predominance in the demographic profile of patients with ocular chemical injuries, with ratios as high as 2.42:1.[3] This gender disparity underscores the need for targeted interventions and safety education in high-risk occupational settings.
The pathophysiology of chemical injuries to the eye depends on the nature of the chemical agent involved. Chemical injuries can be broadly classified into alkali and acid injuries, each having distinct mechanisms of action and clinical outcomes.
Alkali agents, such as ammonia, lye, and lime, are particularly hazardous to ocular tissues due to their ability to penetrate the corneal stroma rapidly. Alkalis saponify the fatty acids in cell membranes, leading to cellular destruction and deeper tissue penetration. This process results in extensive damage to the cornea, limbus, and potentially intraocular structures, causing a significant inflammatory response and risk of neovascularization and fibrosis.[4] The extent of damage in alkali injuries is often more severe than acid injuries due to this deep tissue penetration and the resultant cascade of inflammatory and reparative processes that can lead to permanent scarring and vision loss.
Acidic agents, such as sulfuric acid and hydrochloric acid, cause coagulation necrosis of the superficial ocular tissues. This coagulative effect tends to limit deeper penetration compared to alkalis, often resulting in less extensive damage. However, severe acid injuries can still cause significant corneal opacification and limbal stem cell deficiency, leading to chronic complications such as persistent epithelial defects and secondary infections.[5] Despite their generally more localized effects, acid injuries still require urgent intervention to prevent lasting visual impairment.
Patients with ocular chemical injuries typically present with sudden onset of pain, redness, tearing, and photophobia. The severity of symptoms correlates with the extent of tissue damage and the type of chemical involved. A thorough clinical history, including the nature of the chemical agent, duration of exposure, and any initial first aid measures taken, is crucial for guiding immediate management and treatment strategies.
The initial ophthalmic examination includes an assessment of visual acuity, detailed slit-lamp biomicroscopy of the anterior segment, and evaluation of the extent of limbal ischemia and corneal involvement. The Roper-Hall classification is commonly used to grade the severity of chemical injuries based on these clinical findings.[6] This classification system categorizes injuries from Grade I (mild epithelial damage with no limbal ischemia) to Grade IV (total epithelial loss

with more than 50% limbal ischemia and poor prognosis). Accurate grading is essential for predicting visual outcomes and determining the appropriate treatment course.

The management of ocular chemical injuries involves both immediate and long-term interventions aimed at minimizing tissue damage, controlling inflammation, and promoting healing. The initial management focuses on rapid and copious irrigation of the affected eye to remove the chemical agent and dilute its concentration. This step is critical and should be performed as soon as possible, preferably within the first few minutes of exposure. Normal saline or balanced salt solution is commonly used for irrigation, although tap water can be utilized if other solutions are not available.[7]

Following initial irrigation, specific treatments are tailored based on the severity of the injury. For mild to moderate injuries (Grades I and II), topical corticosteroids are often prescribed to reduce inflammation, along with antibiotic prophylaxis to prevent secondary infections. Cycloplegic agents may be used to alleviate pain and prevent synechiae formation. For more severe injuries (Grades III and IV), additional interventions such as topical or systemic ascorbate, autologous serum drops, and amniotic membrane transplantation may be necessary to support corneal epithelial healing and reduce the risk of scarring.[8]

The visual prognosis of patients with ocular chemical injuries depends largely on the initial severity of the injury and the promptness of treatment. Lower-grade injuries generally have a good prognosis with appropriate management, often resulting in minimal or no permanent visual impairment. In contrast, higher-grade injuries are associated with a guarded prognosis, with significant risks of chronic complications such as corneal opacification, limbal stem cell deficiency, and secondary glaucoma.[9]

Studies have shown that early and aggressive treatment can significantly improve visual outcomes even in severe cases. The use of advanced surgical techniques, such as limbal stem cell transplantation and keratoprosthesis, has provided new avenues for visual rehabilitation in patients with extensive ocular surface damage.[10] However, these procedures require specialized expertise and resources, which may not be readily available in all settings, particularly in rural and under-resourced areas.

The high incidence of ocular chemical injuries, particularly in occupational settings, underscores the need for robust public health initiatives aimed at prevention and education. Implementing safety protocols, such as mandatory use of protective eyewear and proper handling of hazardous chemicals, is crucial for reducing the risk of these injuries. Additionally, public awareness campaigns highlighting the importance of immediate first aid measures, such as eye irrigation, can improve outcomes by ensuring timely intervention.[11]

MATERIALS & METHODS

Study Design

This study was a hospital-based cross-sectional observational study. It was designed to evaluate the clinico-demographic profile and visual outcomes of patients presenting with ocular chemical injuries. The observational nature of the study allowed for the comprehensive recording of patient data without the need for intervention. This design was chosen to accurately reflect the real-world clinical scenario in a rural medical setting.

Study Setting

The study was conducted at a tertiary rural medical hospital. This setting was selected because it provides a comprehensive environment for treating a wide range of ocular conditions, including chemical injuries. The rural location offered a unique opportunity to study the impact of chemical injuries in a population that may have different exposure risks and healthcare access compared to urban centers. The hospital's facilities and staff were well-equipped to manage and document these cases.

Study Duration
The study spanned one year, from June 2022 to May 2023. This duration was chosen to ensure an adequate sample size and to observe any seasonal variations in the incidence of ocular chemical injuries. The year-long timeframe provided a comprehensive overview of the types and outcomes of injuries treated at the hospital. This period was sufficient to follow up on the visual outcomes of the patients after treatment.

Inclusion Criteria
Participants included all patients who presented with chemical injuries to the eyes.

Exclusion Criteria
Patients with trauma caused by vegetative matter, road traffic accidents, or pre-existing ocular pathology were excluded. These criteria ensured a homogeneous study population focusing solely on chemical injuries. Including only chemical injury cases allowed for a more accurate analysis of the specific impact and treatment outcomes of these injuries.

Study Sampling
A convenience sampling method was used to include all patients who met the inclusion criteria during the study period. This method was practical given the hospital setting and ensured that all relevant cases were captured. The approach allowed for the rapid collection of data from patients as they presented. This method ensured a comprehensive dataset within the specified study duration.

Study Sample Size
The study included 24 patients who presented with ocular chemical injuries over the one-year period. This sample size was considered sufficient to provide meaningful insights into the demographic and clinical characteristics of these injuries. The number of cases was appropriate for statistical analysis to draw reliable conclusions. This sample size also allowed for the observation of trends and patterns within the patient population.

Study Groups (if applicable)
No distinct study groups were formed within this research. All patients were treated as a single cohort to analyze the overall clinico-demographic profile and visual outcomes. This approach ensured that the study remained focused on the main objectives without the complexity of subgroup analysis. By treating all patients as a single group, the study could uniformly assess and report the outcomes of ocular chemical injuries.

Study Parameters
The study evaluated several parameters, including demographic data (age, gender), type of chemical involved (acid, alkali, unknown), laterality of the injury (unilateral, bilateral), and location of the injury (home, construction site, office, fields, roadside). The severity of the injury was graded using the Roper-Hall classification, and visual outcomes were assessed at presentation and after treatment using Best Corrected Visual Acuity (BCVA). These parameters provided a comprehensive overview of the impact and treatment outcomes of ocular chemical injuries.

Study Procedure
Each patient underwent a thorough clinical history-taking to document the type of chemical involved, duration of exposure, and initial first aid measures. Ophthalmic examinations included visual acuity assessments with the Snellen chart and detailed anterior segment examinations using slit-lamp biomicroscopy. Injuries were graded according to the Roper-Hall classification, and treatment outcomes were recorded. This procedure ensured a systematic approach to data collection and analysis.

Study Data Collection
Data were collected through structured patient interviews and clinical examinations. Demographic information, details of the injury, and visual outcomes were systematically recorded. The structured format ensured consistency and completeness in data collection. This approach facilitated accurate and reliable analysis of the collected data, contributing to the study's overall validity.

Data Analysis
Statistical analysis was conducted using SPSS version 17.0. Descriptive statistics such as mean, standard deviation, frequencies, and percentages were used to summarize the data. Visual outcomes before and after treatment were compared using appropriate statistical tests to determine the significance of improvements. This analysis provided insights into the effectiveness of treatments and identified patterns within the data.

Ethical Considerations
The study was conducted following the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the hospital's ethics committee prior to the commencement of the study. Informed consent was obtained from all participants or their legal guardians, ensuring they were fully aware of the study's purpose, procedures, potential risks, and benefits. Confidentiality and anonymity of the participants were maintained throughout the study, adhering to ethical standards in research.

RESULTS AND ANALYSIS
Demographic Distribution
Out of the 24 patients, 17 (71%) were male and 7 (29%) were female. The mean age at presentation was 40.29 years. The age-wise distribution of patients is shown in Table 1.

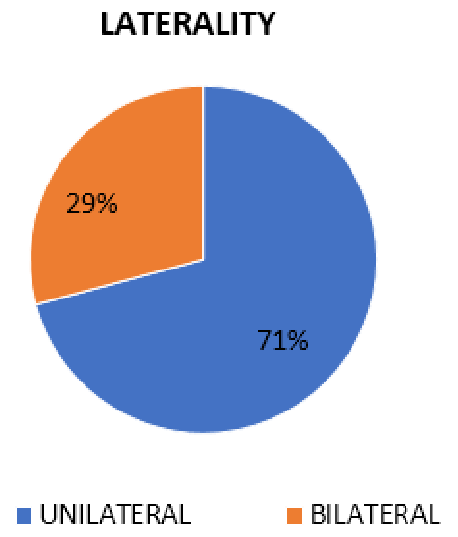
Age Group	Number of Patients	Percentage
< 15 years	1	4%
16 - 30 years	5	21%
31 - 45 years	10	42%
> 45 years	8	33%

Table 1: Age-Wise Distribution of Patients

Laterality Distribution
The majority of the patients (71%) presented with unilateral injuries, while 29% had bilateral injuries. This distribution is presented in Table 2.

Laterality	Number of Patients	Percentage
Unilateral	17	71%
Bilateral	7	29%

Table 2: Laterality Distribution of Injuries



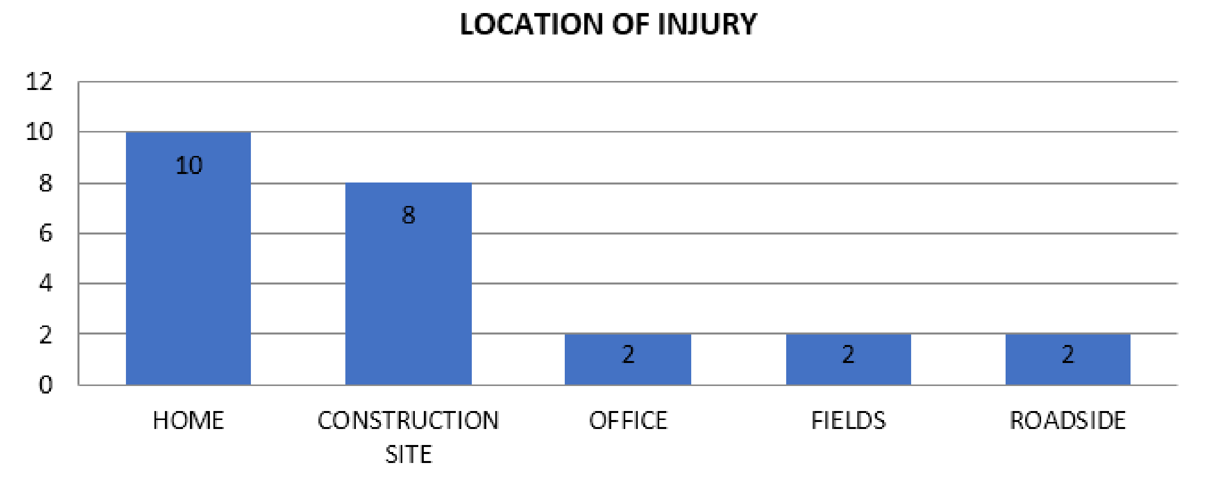
Graph 1

Location of Injury

The most common location for ocular chemical injuries was at home (41.66%), followed by construction sites (33.33%). Other locations included offices, fields, and roadside incidents, each accounting for 8.33% of the injuries. The distribution of injury locations is detailed in Table 3.

Location of Injury	Number of Patients	Percentage
Home	10	41.66%
Construction Site	8	33.33%
Office	2	8.33%
Fields	2	8.33%
Roadside	2	8.33%

Table 3: Location of Injury



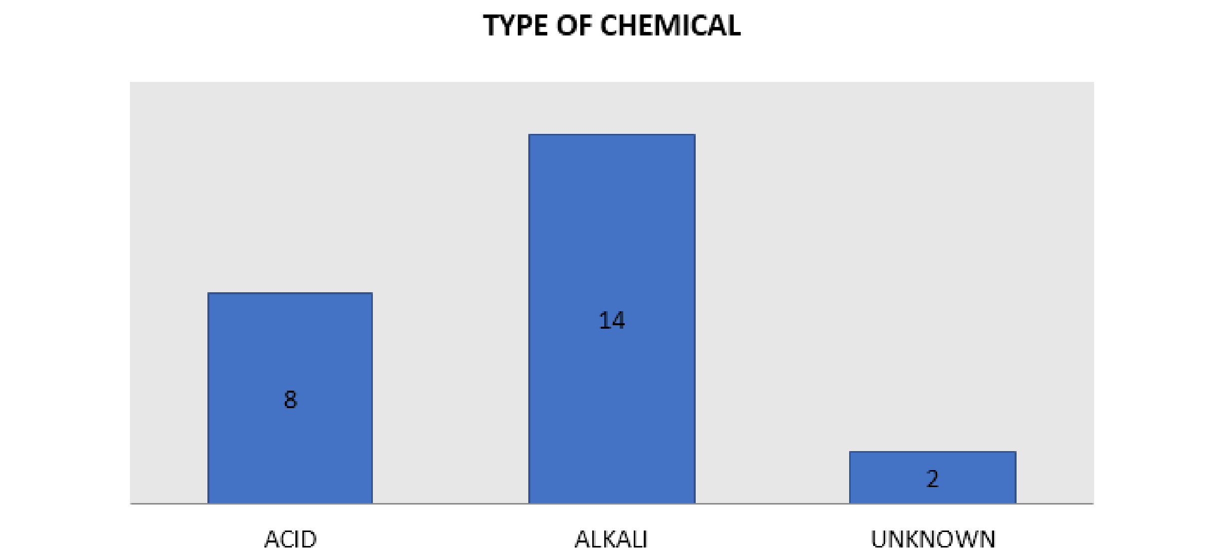
Graph 2

Type of Chemical Injury

Alkali injuries were the most prevalent, accounting for 58.33% of the cases, followed by acid injuries at 33.33%, and injuries from unknown chemicals at 8.33%. The breakdown of chemical injury types is shown in Table 4.

Type of Chemical	Number of Patients	Percentage
Alkali	14	58.33%
Acid	8	33.33%
Unknown	2	8.33%

Table 4: Type of Chemical Injury



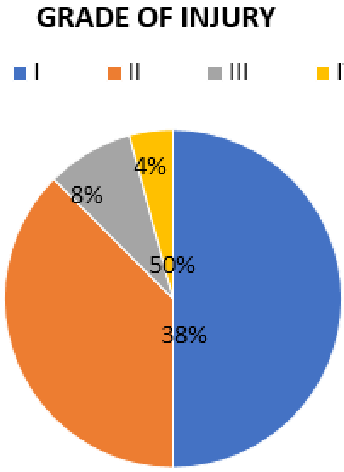
Graph 3

Grade of Injury

According to the Roper-Hall classification, the distribution of injury grades is presented in Table 5. The most common grade was Grade I (50%), followed by Grade II (38%), Grade III (8%), and Grade IV (4%).

Grade of Injury	Number of Patients	Percentage
I	12	50%
II	9	38%
III	2	8%
IV	1	4%

Table 5: Grade of Injury According to Roper-Hall Classification



Graph 4

Visual Outcomes at Presentation and After Treatment

The visual outcomes of the patients were assessed using Best Corrected Visual Acuity (BCVA) at presentation and after treatment. The detailed outcomes are shown in Table 6.

BCVA (Snellen's)	At Presentation	Percentage	After Treatment	Percentage
Mild or no impairment (6/6 - 6/12)	7	29%	22	88%
Moderate impairment (6/18 - 6/60)	13	54%	2	8%
Severe impairment (5/60 - 3/60)	3	13%	1	4%
Blind (<3/60)	1	4%	0	0%

Table 6: Visual Outcomes at Presentation and After Treatment

DISCUSSION

In the present study, the mean age at presentation for ocular chemical injuries was 40.29 years, with a male predominance, evidenced by a male-to-female ratio of 2.42:1. This aligns with findings from other studies, where males were more frequently affected due to their higher likelihood of engaging in occupations that involve exposure to hazardous chemicals. The demographic profile underscores the necessity of implementing stringent safety measures in workplaces, especially in industries where the use of chemicals is prevalent.

The majority of patients (71%) presented with unilateral injuries, while 29% had bilateral injuries. The most common locations for these injuries were at home (41.66%) and construction sites (33.33%), followed by offices, fields, and roadside incidents (each accounting for 8.33%). The high incidence of home-based injuries suggests a significant lack of awareness regarding the potential hazards of household chemicals and the importance of safety practices at home. Similarly, the notable occurrence of injuries at construction sites highlights the occupational risks associated with this sector and the critical need for protective eyewear and proper handling procedures.

Alkali injuries were the most prevalent, accounting for 58.33% of cases, followed by acid injuries (33.33%) and injuries from unknown chemicals (8.33%). Alkali agents, such as ammonia and lime, are known for their deep penetration into ocular tissues, leading to more severe and extensive damage compared to acid agents, which cause more superficial coagulative necrosis. This finding is consistent with previous studies, reinforcing the understanding that alkali injuries require more aggressive and immediate treatment to mitigate long-term visual impairment.

According to the Roper-Hall classification, Grade I injuries (corneal epithelial damage with no limbal ischemia) were the most common, affecting 50% of patients, followed by Grade II injuries (38%), Grade III injuries (8%), and Grade IV injuries (4%). The predominance of lower-grade injuries with better prognostic outcomes indicates that timely and effective management can significantly improve visual outcomes. However, the presence of severe injuries (Grade III and IV) in a small percentage of patients underscores the potential for serious long-term complications and the importance of early intervention.

The visual outcomes were assessed using the Best Corrected Visual Acuity (BCVA) at presentation and after treatment. At presentation, 29% of patients had mild or no impairment (BCVA 6/6 - 6/12), while 54% had moderate impairment (BCVA 6/18 - 6/60), 13% had severe impairment (BCVA 5/60 - 3/60), and 4% were blind (BCVA <3/60). Post-treatment, there was a significant improvement in visual outcomes, with 88% of patients achieving mild or no impairment, 8% with moderate impairment, 4% with severe impairment, and none remaining blind. This significant improvement highlights the effectiveness of prompt and appropriate treatment in reducing the impact of chemical injuries on vision.

Our study's findings are consistent with those of Sourabh et al.,[12] who reported a male predominance (60%) and a high incidence of unilateral injuries (52%) in their study of 110 eyes affected by chemical injuries. Similarly, Li et al.,[1] found that males constituted 85% of their study population, with the majority of injuries resulting from alkali agents. Poojitha et al. and Aditi et al.,[13,14] also observed similar demographic trends and injury profiles in their respective studies, reinforcing the commonality of these findings across different populations and settings. Given the high incidence of chemical ocular injuries, particularly in occupational settings, several recommendations can be made to mitigate the risks:

1. **Workplace Safety Measures**: Implementing stringent safety protocols, including the mandatory use of protective eyewear and proper chemical handling procedures, can significantly reduce the occurrence of these injuries.
2. **Public Awareness Campaigns**: Raising awareness about the potential hazards of household chemicals and the importance of first aid measures, such as immediate eye irrigation, can help prevent and minimize the impact of chemical injuries.
3. **Training and Education**: Providing regular training and education to workers in high-risk industries on the proper use of protective equipment and emergency response procedures can enhance safety and reduce the incidence of injuries.
4. **Policy and Regulation**: Enforcing regulations that mandate safety measures in workplaces and ensuring compliance through regular inspections and penalties for non-compliance can create safer working environments.

CONCLUSION

Chemical ocular injuries remain a significant public health concern due to their potential to cause severe and permanent visual impairment. The study highlights the importance of early intervention, appropriate treatment, and preventive measures in improving visual outcomes and reducing the incidence of these injuries. Continued research and public health efforts are essential to enhance safety practices and awareness, ultimately protecting individuals from the devastating effects of chemical ocular injuries.

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