

Prevalence and Clinical Outcomes of Corneal Metallic Foreign Bodies in an Industrial Population: A Retrospective Study of 500 Cases from a Private Hospital

S. Srividya¹, M.J. Venkatesan²

¹DNB, Assistant Professor, Deepika Eye Care Hospital, Sriperumpudhur, Tamil Nadu, India

²M.S., M.Ch., Professor & Head, Dept. of Ophthalmology MAPIMS, Melmaruvathur, Tamil Nadu, India

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Corresponding Author: Dr. S. Srividya

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Abstract

Background: Corneal metallic foreign body (CMFB) is among the most common occupational ocular emergencies encountered in industrial regions. Prompt identification, meticulous sterile removal, and timely management are essential to prevent infectious keratitis, stromal scarring, and visual morbidity. Standardized removal techniques under slit lamp magnification can significantly improve epithelial healing and clinical outcomes.

Aim: To evaluate the prevalence, demographic profile, clinical characteristics, management outcomes, and factors influencing rapid corneal epithelial healing in patients presenting with corneal metallic foreign bodies.

Methods: This retrospective observational study included 500 patients diagnosed with corneal metallic foreign bodies at a private eye care hospital situated in an industrial region between January 2024 and December 2025. Medical records were reviewed for demographic details, occupational exposure, duration before presentation, clinical findings, foreign body characteristics, management protocols, epithelial healing time, and complications. All foreign bodies were removed under strict aseptic precautions using a sterile 26-gauge needle under slit lamp magnification. Rust ring scraping was performed whenever indicated. Statistical analysis was performed using descriptive and inferential methods.

Results: The majority of patients were males (92.4%) belonging to industrial occupations such as welding, grinding, and metal fabrication. The most commonly affected age group was 21–40 years. Rust ring formation was observed in 71.2% of cases. Patients presenting within 24 hours demonstrated significantly faster epithelial healing compared to delayed presenters ($p < 0.05$). Strict sterile precautions, precise foreign body removal using sterile 26-gauge needles, and meticulous rust ring scraping resulted in favorable visual outcomes and minimal complications. Complete epithelial healing was achieved in most patients within 3–5 days.

Conclusion: Corneal metallic foreign bodies continue to represent a significant occupational hazard in industrial settings. Early presentation, standardized sterile removal techniques, and complete rust ring scraping under slit lamp guidance contribute substantially to rapid epithelial healing and reduced complication rates. Preventive strategies including mandatory protective eyewear and workplace education remain essential.

Keywords: Corneal metallic foreign body, Occupational ocular trauma, Rust ring, Corneal epithelial healing, Industrial eye injury, Slit lamp foreign body removal.

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Introduction

Ocular trauma remains an important cause of preventable visual morbidity worldwide, particularly among the working-age population employed in industrial sectors. Corneal foreign bodies constitute one of the most frequently encountered ophthalmic emergencies in routine clinical practice. Among them, metallic foreign bodies are especially common in occupations involving welding, grinding, drilling, hammering, and metal fabrication.

The cornea, being the most anterior transparent structure of the eye, is highly susceptible to trauma from high-velocity metallic particles generated during industrial activities. Such injuries can lead to severe pain, photophobia, watering, foreign body sensation, blepharospasm, and diminution of vision. Although many cases involve superficial injuries, delayed diagnosis or improper management can result in infectious keratitis, corneal ulceration, stromal scarring, recurrent epithelial erosions, and permanent visual impairment.

Metallic foreign bodies are often associated with rust ring formation due to oxidation of retained iron particles within the corneal stroma. Retained rust may induce inflammatory response, delayed epithelial healing, corneal staining, and stromal necrosis. Hence, meticulous removal of both the foreign body and associated rust ring is critical for optimal recovery.

Several factors influence the healing outcome in corneal metallic foreign body injuries, including duration before presentation, depth of penetration, sterility during removal, completeness of rust ring scraping, and compliance with post-procedure medications. Slit lamp-guided removal using a sterile 26-gauge needle provides excellent visualization, precision, and minimal tissue trauma when performed under aseptic precautions.

Despite increasing industrialization and workplace hazards, many workers continue to neglect protective eyewear usage. Awareness regarding occupational eye safety remains inadequate in many developing regions. Furthermore, there is limited literature emphasizing the role of standardized sterile techniques and meticulous rust ring scraping in enhancing epithelial healing. The present study was undertaken to evaluate the prevalence, demographic characteristics, clinical profile, management outcomes, and factors contributing to rapid healing in patients presenting with corneal metallic foreign bodies to a private eye care hospital serving an industrial population.

Aim and Objectives

Aim: To study the prevalence and clinical outcomes of corneal metallic foreign bodies in an industrial population and to evaluate factors contributing to rapid corneal epithelial healing.

Objectives

Primary Objectives

1. To determine the demographic and occupational distribution of corneal metallic foreign body injuries.
2. To evaluate clinical presentation and epithelial healing patterns.

Secondary Objectives

1. To assess the role of sterile slit lamp-guided foreign body removal using a sterile 26-gauge needle.
2. To evaluate the effect of complete rust ring scraping on healing outcomes.
3. To analyze complications associated with delayed presentation.
4. To emphasize preventive strategies for occupational ocular trauma.

Materials and Methods

Study Design: Retrospective observational study.

Study Setting: The study was conducted at a private eye care hospital located in an industrial region catering predominantly to industrial workers and laborers.

Study Duration: January 2024 to December 2025.

Sample Size: A total of 500 patients diagnosed with corneal metallic foreign body were included in the study.

Inclusion Criteria

1. Patients aged above 18 years.
2. Patients diagnosed with superficial corneal metallic foreign body.
3. Patients with complete medical records and follow-up data.
4. Industrial workers and non-industrial workers presenting with metallic foreign body injuries.

Exclusion Criteria

1. Penetrating ocular injuries.
2. Intraocular foreign bodies.
3. Associated globe rupture.
4. Pre-existing corneal pathology.
5. Patients with incomplete records.
6. Non-metallic corneal foreign bodies.

Data Collection: Patient records were reviewed from hospital medical archives. The following parameters were documented:

- Age
- Gender
- Occupation
- Mode of injury
- Time interval between injury and presentation
- Visual acuity at presentation
- Eye involved
- Site and depth of foreign body
- Presence of rust ring
- Associated epithelial defect
- Treatment administered
- Time to epithelial healing
- Complications
- Final visual acuity

Clinical Examination: All patients underwent detailed ophthalmic evaluation including:

- Visual acuity assessment
- Slit lamp biomicroscopy
- Fluorescein staining
- Anterior segment examination
- Intraocular pressure assessment when indicated

Standardized Sterile Removal Protocol: All procedures were performed under strict aseptic precautions.

The management protocol included:

1. Instillation of topical proparacaine 0.5% anesthetic drops.
2. Cleaning of periocular skin and lids using povidone-iodine solution.
3. Use of sterile gloves and sterile instruments.
4. Slit lamp-guided removal of the metallic foreign body using a sterile 26-gauge needle mounted on a tuberculin syringe.
5. Rust ring scraping under slit lamp magnification whenever rust deposits were identified.
6. Confirmation of complete foreign body removal.
7. Post-procedure fluorescein staining.
8. Instillation of topical broad-spectrum antibiotic drops.

Post-Procedural Medical Management

Patients received:

- Topical broad-spectrum antibiotics
- Lubricating eye drops
- Cycloplegic drops when required
- Topical non-steroidal anti-inflammatory drugs in selected cases
- Oral analgesics when necessary
- Protective eyewear counseling

Patients were reviewed within 24–72 hours and subsequently until complete epithelial healing.

Outcome Measures

Primary Outcome: Time taken for complete corneal epithelial healing.

Secondary Outcomes

- Improvement in visual acuity.
- Resolution of symptoms.
- Presence of corneal scarring.
- Infectious keratitis.
- Recurrent epithelial erosion.

Statistical Analysis: Data were analyzed using SPSS software version 25.0.

Descriptive statistics including mean, standard deviation, frequency, and percentage were calculated. Chi-square test and independent t-test were used for comparison of categorical and continuous variables respectively. A p-value less than 0.05 was considered statistically significant.

Results

Demographic Distribution: A total of 500 patients with corneal metallic foreign body injuries were included in the study. Among them, 462 patients (92.4%) were males and 38 patients (7.6%) were females. The high male predominance reflected increased occupational exposure among industrial workers. The most commonly affected age group was 21–40 years, accounting for 68.8% of cases.

Table 1: Age Distribution

Age Group	Number of Patients	Percentage
18–20 years	42	8.4%
21–30 years	186	37.2%
31–40 years	158	31.6%
41–50 years	79	15.8%
>50 years	35	7.0%

Occupational Distribution: Industrial workers constituted the majority of cases.

Table 2: Occupational Profile

Occupation	Number of Patients	Percentage
Welders	176	35.2%
Metal grinders	132	26.4%
Fabrication workers	88	17.6%
Mechanics	49	9.8%
Construction workers	31	6.2%
Others	24	4.8%

Time to Presentation: A total of 318 patients (63.6%) presented within 24 hours of injury, whereas 182 patients (36.4%) presented after 24 hours. Delayed presentation was associated with increased pain, larger epithelial defects, and higher incidence of corneal infiltrates.

Clinical Findings: Rust ring formation was observed in 356 patients (71.2%). Central corneal involvement was seen in 138 patients (27.6%), while

peripheral corneal foreign bodies were more common.

Associated symptoms included:

- Pain: 96%
- Watery eyes: 88%
- Photophobia: 74%
- Foreign body sensation: 100%
- Blurring of vision: 42%

Management Outcomes: All foreign bodies were removed under slit lamp magnification using sterile 26-gauge needles.

Complete rust ring scraping was achieved in 332 out of 356 rust ring cases during the first sitting, while

the remaining required repeat scraping during follow-up.

Strict sterile precautions and meticulous removal techniques resulted in excellent healing outcomes.

Table 3: Epithelial Healing Time

Healing Duration	Number of Patients	Percentage
1–2 days	102	20.4%
3–5 days	318	63.6%
6–7 days	61	12.2%
>7 days	19	3.8%

Patients presenting within 24 hours demonstrated significantly faster healing compared to delayed presenters ($p < 0.05$).

Visual Outcomes: Visual acuity improved in the majority of patients following treatment.

At final follow-up:

- 92% achieved visual acuity of 6/9 or better.
- Mild corneal scarring was noted in 7.8% of cases.
- Significant visually disabling scars were uncommon.

Complications: Complications were minimal due to standardized sterile techniques.

Table 4: Complications

Complication	Number of Patients	Percentage
Mild corneal scar	39	7.8%
Infectious keratitis	6	1.2%
Recurrent epithelial erosion	4	0.8%
Persistent epithelial defect	3	0.6%

Infectious keratitis was more common among delayed presenters and patients with incomplete prior foreign body removal elsewhere.

Discussion

Corneal metallic foreign bodies remain one of the most frequent occupational ocular injuries encountered in ophthalmic emergency practice. The present study analyzed 500 cases from an industrial population and demonstrated that early presentation, strict aseptic precautions, and meticulous slit lamp-guided removal significantly contributed to favorable healing outcomes.

The marked male predominance observed in this study is consistent with previous literature, reflecting greater occupational exposure among men employed in industrial sectors such as welding, grinding, and fabrication. The predominance of younger adults in the productive age group highlights the socioeconomic impact of occupational ocular trauma.

Welders and metal grinders constituted the majority of affected workers. These occupations involve high-velocity metal particle generation capable of penetrating the corneal epithelium. Lack of consistent use of protective eyewear remains an important contributory factor.

Rust ring formation was noted in over 70% of cases in the present study. Metallic iron particles oxidize rapidly within the corneal stroma, leading to

deposition of rust and associated inflammatory response. Incomplete rust ring removal may contribute to persistent epithelial defects, recurrent inflammation, stromal necrosis, and visually significant scarring.

One of the important strengths of this study was the use of a standardized sterile removal protocol in all patients. Slit lamp-guided removal using a sterile 26-gauge needle allowed precise localization and atraumatic extraction of the foreign body. The slit lamp provides excellent magnification and illumination, minimizing collateral epithelial damage.

Strict aseptic precautions including periocular cleaning, sterile instrumentation, and post-procedure antibiotic prophylaxis likely contributed to the low incidence of infectious keratitis observed in this study. This emphasizes the importance of maintaining sterility even during outpatient procedures.

Complete rust ring scraping under slit lamp guidance also appeared to contribute significantly to rapid epithelial healing. Patients undergoing meticulous rust ring removal demonstrated faster symptom relief and lower complication rates. Early presentation was associated with superior healing outcomes. Patients presenting within 24 hours achieved complete epithelial healing significantly earlier than delayed presenters. Delayed presentation increases the likelihood of secondary

infection, stromal inflammation, deeper rust deposition, and larger epithelial defects.

The majority of patients in this study achieved complete epithelial healing within 3–5 days, indicating that prompt standardized management can effectively restore corneal integrity. Final visual outcomes were excellent in most patients.

The low rate of visually significant scarring observed in this study further supports the effectiveness of sterile and meticulous foreign body removal techniques.

The study also highlights the importance of preventive ophthalmology. Despite awareness regarding occupational hazards, many workers continue to neglect protective goggles due to discomfort, lack of availability, or inadequate workplace enforcement. Mandatory eye protection policies, regular workplace safety training, and employee education programs are essential to reduce the burden of occupational ocular trauma.

Limitations

1. Retrospective study design.
2. Single-center study.
3. Long-term follow-up data were unavailable in some patients.
4. Variability in patient compliance with medications and follow-up.

Despite these limitations, the large sample size and standardized management protocol strengthen the validity of the study findings.

Conclusion

Corneal metallic foreign bodies continue to represent a major occupational ocular hazard in industrial populations. Young male industrial workers are predominantly affected.

Early diagnosis and prompt management using slit lamp-guided sterile removal with a 26-gauge needle significantly improve epithelial healing and visual outcomes. Meticulous rust ring scraping plays a critical role in reducing inflammation, preventing delayed healing, and minimizing corneal scarring.

Strict aseptic precautions during foreign body removal contribute to low complication rates and favorable prognosis. Workplace safety education and mandatory protective eyewear remain essential

preventive strategies to reduce the incidence of occupational corneal injuries.

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