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Review

Corneal foreign body: Management and clinical simulation training

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ABSTRACT

For patients with eye injuries, especially corneal foreign bodies, care pathways may vary depending on many circumstances. Mild cases can progress rapidly within hours and threaten the functional prognosis. Various clinical practitioners may be consulted for urgent care in this context. Each provider will propose specific care according to their resources and level of specialization. A well-codified management strategy and adequate training of healthcare providers might ensure improved standards of care for patients. Several classification tools for corneal foreign bodies are available. Removal is the mainstay of treatment, and several techniques are described, particularly in cases of metallic foreign bodies. The use of slit-lamp magnification should be considered in most cases. Various clinical simulation models have already been tested. We present herein an original model that takes advantage of affordability and realistic visual and tactile feedback, as well as innovative early recognition of iatrogenic corneal perforation and realistic interference from the upper eyelid.

Background

Ocular affections are seldom life-threatening. Nevertheless, they can be severe enough to result in permanent visual loss [1]. According to a Swedish study, the incidence of eye injuries accounts for 8.1 per 1000, including 40% corneal or conjunctival foreign bodies. These accidents have numerous causes, mainly work-related [2–4].

Managing an unscheduled demand for care involves prior triage to assess the severity and emergency then thorough medical history and patient examination to provide the appropriate initial therapy steps and allow adequate orientation [1,5,6].

In clinical practice, various practitioners may face the challenge of corneal foreign body removal (emergency physicians, general practitioners and ophthalmologists, among others), and several circumstances impact referral to a specific health-care service [7–13].

In this review, we aim to report current recommendations regarding corneal foreign body removal and propose a simple and accessible clinical simulation training to improve medical doctors' skills in managing this condition.

Classification tools

The first step to appropriate management is to adequately classify ocular foreign bodies in terms of location and severity. In clinical medicine, a classification based on location can help to define the treatment. According to the classification of Shukla, ocular foreign bodies might be divided into three major groups: global foreign bodies (GFB), adnexal foreign bodies and mixed foreign bodies.

Global foreign bodies located outside the eyeball are called extra-global foreign bodies (EGF) whereas global foreign bodies located within the corneoscleral coat are named intramural foreign bodies (IMF). Extra global foreign bodies may lie on the surface of the cornea (EGC). Intramural foreign bodies can be located within the cornea (IMC). In case of open globe injury, global foreign bodies can be found inside the eyeball. They are called intraglobal foreign bodies (IGF). They can stand in the anterior chamber (IGA), the iris (IGI), the lens (IGL), the vitreous (IGV), the choroid (IGC) or the retina (IGR) [14,15].

Furthermore, a classification based on severity can assist with triage and the downstream care. Hence, according to *Bourges et al.* in the "Consensus on Severity for Ocular Emergency" [BaSe SCOrE], corneal foreign bodies located outside the visual axis obtain median weight rating severity of 2 whereas corneal foreign bodies on the visual axis obtain median weight rating severity of 3 on a scale from 0 to 6 [5].

Clinical presentation of corneal foreign bodies

The main clinical presentation of corneal foreign bodies is represented by sudden discomfort, rarely accompanied by obviously decreased visual acuity [2,16]. However, the related inflammatory response can induce several symptoms and signs including red eye, pain,

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photophobia, blinking, tearing or blurred vision. Sometimes, a foreign body located at the surface of the cornea can progressively migrate through the cornea into the anterior chamber [2].

Baseline treatment

Pain control represents the priority. Analgesia can be given topically, orally, by intramuscular or intravenous injection.

Administration of tetracaine eye drops is the most effective treatment but overuse can lead to disabling corneal wounds or delayed healing [2,17]. In the absence of medical contraindications, local cycloplegic agents or ketorolac collyrium are also adequate. Care must be taken to remove contact lenses.

It is advisable to protect the eye from further harm with an eye shield especially in children. Ocular patches are, however, not recommended for the affected eye. If the patient experiences difficulties in coping with the clinical examination, systemic analgesia may be necessary knowing the nonnegligible risk of dependence or overuse [2].

Clinical ocular examination

The clinical examination must be accurate and careful. It needs to quantify monocular and binocular visual acuity. Intraocular pressure measurement may be skipped if an open globe injury is suspected to avoid a discharge of intraocular content by applying inappropriate force on the globe.

A slit lamp examination should be carried out. The first step is a basic examination without fluorescein followed by a second step with the use of fluorescein and cobalt blue light to detect corneal disruption signs by a technique of staining. The aim of the assessment is to identify all foreign bodies potentially involved and rule out an open globe injury.

The conjunctiva, sclera, eyelids, and lashes need to be examined. The upper eyelids must be turned inside out to search for potential hidden foreign bodies.

Clinical signs such as red eye, chemosis, corneal abrasions, anterior chamber inflammation (cells, flare) and Seidel test (aqueous humor leakage from the anterior chamber) should also be sought [2].

Additional tests

Depending on the clinical context, additional tests should be considered. Practitioners should always consider them based on their own clinical judgment. In some cases, it will be necessary to refer the patient to a more specialized physician with access to more comprehensive equipment.

Dilated-pupil fundus examination will allow us to identify intraglobal foreign bodies (IGF) [2].

B-scan ultrasonography is a performant imaging test to detect intraglobal foreign bodies in the anterior chamber (IGA), especially when located near the posterior lens capsule. However, extreme caution is advised given that the slightest pressure on the eyeball can cause the extrusion of intraocular content in cases of open globe injury [2,18,19].

Computed tomography can recognize both intraglobal foreign bodies (IGF) and intracranial foreign bodies [2,20–22].

Anterior segment optical coherence tomography (AS-OCT) helps to check or clarify clinical findings in cases of intramural foreign bodies within the cornea (IMC), including their depth and exact position. This test is therefore beneficial to determine the most appropriate method of treatment and keep watch on its results. Accessibility 24/7 of AS-OCT could impact clinical management as well as improve patient satisfaction and the practitioner comfort [23,24].

Removal of corneal foreign bodies

Removal of corneal foreign bodies is the major line of treatment considering that patients are at risk of developing necrosis and infection. Extra global foreign bodies on the cornea (EGC) have the potential to become embedded within the stroma over a period of 24 h. More aggressive removal attempts can then cause scar formation or perforation of the cornea [2,25].

Inert corneal foreign bodies could be observed periodically but metallic corneal foreign bodies should be taken out regardless of depth to avoid the formation of rust rings in the stroma [2]. A stepwise approach to the removal seems appropriate. For recent and superficial extra global foreign bodies on the cornea (EGC), a simple irrigation or a moist cotton swab sliding on the corneal surface can be successful [2]. In cases of failure or embedded foreign bodies, the use of equipment under magnification and slit lamp guidance should be considered. Two dominant techniques are described: the needle-bevel approach and the burr procedure [2,26]. Most authors suggest the use of a 25–30 Gauge needle (possibly connected to a tuberculin syringe to ensure better control) [2]. Bending the needle bevel appears more competitive than keeping it straight. It requires a needle holder, forceps or another needle. In the latter case a 25-gauge needle is inserted into the tip of a larger needle (e.g., 21 gauge) and the bevel of the smaller needle is bent to 90 degrees. With bent needles, the risk of accidental globe perforation becomes almost insignificant [27,28]. An ophthalmic corneal burr can flick out foreign bodies and above all remove rust rings. However, it can result in large corneal damage and additional infection risk [2,27]. Small rust rings usually disappear spontaneously. In other cases, rust rings should be removed as soon as possible with a needle or a burr. They can also be limed serially as the stroma regenerates. Inadequate removal of rust rings can result in permanent staining of the cornea or anterior acute uveitis ([BaSe SCOrE] median weight rating severity 2) [2,5,29]. Intramural corneal foreign bodies (IMC), intraglobal foreign bodies ([BaSe SCOrE] median weight severity 5) and corneal ulcer ensuing from foreign bodies ([BaSe SCOrE] median weight severity 2 to 5 when perforating) necessitate urgent referral to an ophthalmologist [2,5,30]. After successful removal of extra global corneal foreign bodies (EGC), pain control, prophylactic antibiotics and follow-up should be considered [2]. More often than not, oral analgesia is sufficient [31]. Ketorolac eye drops do not compromise corneal healing. Cycloplegic agents are a possible option except atropine owing to their long duration of action. Lubricating eye drops are also suitable [2]. Extra global corneal foreign bodies (EGC) are significant contaminant vectors of bacteria. In one study, 19.8% of corneal foreign bodies revealed a positive bacteriological analysis [32]. Antibiotics should therefore be given to patients with extra global corneal foreign bodies (EGC) combined with uncomplicated corneal abrasions, especially contact lens wearers. In the latter case, anti-pseudomonal antibiotics need to be considered [30].

Ocular patches failed to demonstrate benefit in terms of corneal healing or comfort. They are furthermore contraindicated for contact lens wearers and organic foreign bodies due to an increased risk of infection [2–31]. If whole foreign body removal is successful, the patient can be discharged. Persistent rust rings need follow-up by an ophthalmologist within 24 h as well as contact lens wearers with corneal abrasions [30]. Thereafter, in cases of worsening eye pain, red eye or decreased visual acuity, an urgent medical reassessment is recommended [33].

Clinical simulation training

In emergency departments (ED), eye injuries are common conditions, and ophthalmic affections account for up to 6% of admissions [1,34–36]. Likewise, primary care physicians may also have to address this condition.

In several studies and surveys carried out in the United States, the skills for the diagnosis and the management of common ocular conditions and ocular emergencies appeared to be incomplete among medical students [37,38]. In the United Kingdom, a national survey of the management of eye emergencies in EDs by foundation doctors highlighted the major role of nonophthalmologists in the effective

Fig. 1. Simulation model for corneal foreign body removal made up of an inflated latex balloon and a modelling clay disc.

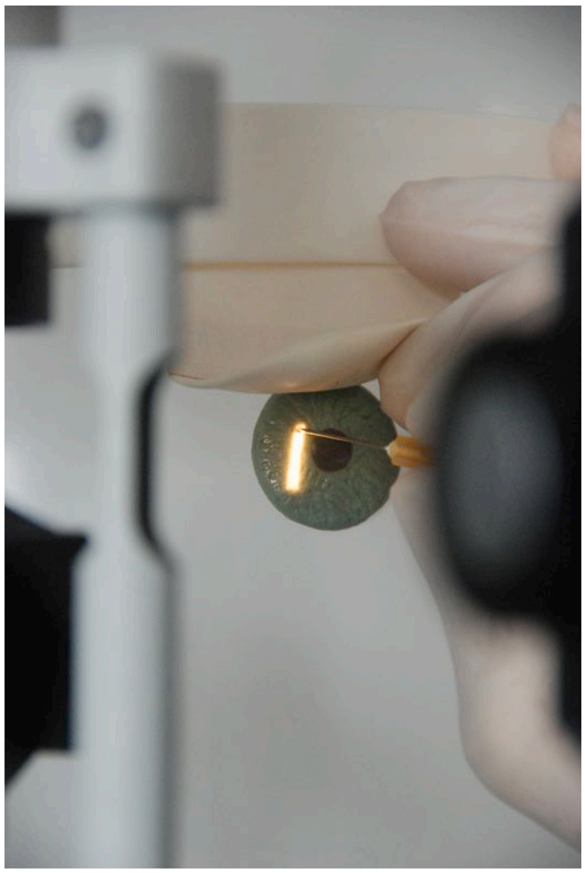

Fig. 2. The trainee needs to lift the upper uninflated balloon to reach a foreign body.

management of ophthalmic emergencies but signaled a concerning decline in basic ophthalmic training for junior doctors, mentioning an urgent need to improve that situation [35]. In France, there is a constantly increasing demand for emergency eye care [39]. In contrast, the growing shortage of working ophthalmologists makes it difficult for patients to access an ophthalmologist in emergency situations. Hence, patients tend to go to the emergency departments for ophthalmologic emergencies [8]. However, disparities occur in the training of emergency physicians about eye emergencies [36].

Irrespective of the patient outcome, several studies have already established that simulation training improves procedural assurance and skills for metallic corneal foreign body removal [25,40,41]. To date, quite a few simulation concepts have been studied, made from animal cadaveric eyes, liquid latex, silicon, grape, cardboard, agar, gelatin, or paraffin wax [25,42–48].

In addition to the quest for realism, the main challenges are to acquire adequate coordination of the movements under high magnification and to learn how to control the pressure exerted on the prototype with a needle while simulating the very slight depression of the cornea. We present here an original model that could offer some benefit from those previously described.

After checking all contraindications such as allergies, a medium latex balloon is inflated until the dimensions of a human head are obtained. A small ball of modelling clay is then compressed between two object-carrying slides to create a flat disc approximately 0,5 mm thick and 12 mm in diameter. This flat disc is then coated with colorless nail polish and stuck on the inflated balloon with liquid paper glue. An optional second uninflated balloon can be incompletely fixed just above to overlap the disc.

After a reasonable drying time, foreign bodies and rust are drawn on the disc using the tip of a permanent marker pen. Possibly, any small foreign body could also be put in place. The balloon is then stably fixed on a slit lamp with adhesive plaster or tape. The disc should be in front of the optic section of the slit lamp, approximately 3 cm below the lower edge of a forehead support. A trainee wearing medical safety glasses and hearing protection is then requested to remove the ink accurately with a needle or a burr while lifting the edge of the upper uninflated balloon (Fig. 1). An inappropriate perforation of the modelling clay disc or an awkward gesture can evidently cause the rupture of the balloon.

Subject to comparative analysis, this simulation model could be an improved combination of affordability, realistic feeling and innovative obvious identification of iatrogenic corneal perforation. Another key point of this model is the simulation of an overlapping upper eyelid (Fig. 2).

Conclusion

Ocular foreign bodies are a common condition that should never be neglected due to potential serious complications. Patients with corneal foreign bodies require thorough care consisting of initial triage, accurate classification, initial therapy, clinical examination, and appropriate additional tests. The removal strategy is based on a stepwise approach including potential patient referral or downstream care depending on the foreign body type, location, and severity along with the clinician's resources. Clinical skills could be improved using simulation models. The model we put forwards takes advantage of affordability and realistic feeling but also of an innovative early recognition of iatrogenic corneal perforation as well as upper eyelid overlapping.

CRediT authorship contribution statement

All authors attest that they meet the current International Committee

of Medical Journal Editors (ICMJE) criteria for Authorship.

Individual author contributions are as follows:

Gilles Terlonge: Conceptualization, Methodology, Writing-Original draft.

Allison Gilbert: Methodology, Writing-Reviewing and Editing.

Alexandre Ghuysen: Conceptualization, Writing-Reviewing and Editing, Supervision.

Informed consent and patient details

The authors declare that the work described does not involve patients or volunteers.

Human and animal rights

The authors declare that the work described has not involved experimentation on humans or animals.

Reported guidelines

This review is a narrative review, and standard guidelines do not exist for this type of review.

Declaration of competing interest

The authors declare that they have no link of interest concerning this article

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