

## Chemical Injuries of the Ocular Surface

**Miss Melanie C Corbett, MD FRCS FRCOphth**  
**Consultant Ophthalmologist**

**Mr Mukhtar Bizrah, FRCOphth**  
**Ophthalmic Specialty Trainee**

**The Western Eye Hospital, Imperial NHS Trust**

Ocular chemical injuries vary in severity, with the more severe end of the spectrum having drastic consequences for both the ocular surface and vision. Appropriate management in the first minutes and days can greatly improve the long-term outcome. It is therefore essential that the public, emergency teams and ophthalmologists are able to manage these patients effectively, and ophthalmologists also have a role in the education of these other groups.

The incidence is highest in men (ratio 3-8:1) of working age (typically 20-30 years), with two-thirds occurring at work. However, there is poor use of protective eye wear and education in first aid management, even if first aid kits with irrigating fluids are available. Assault accounts for one-third of severe injuries and causes more permanent damage due to the toxic nature of the chemicals used (e.g. ammonia) and reduced access to emergency treatment.

Alkalis account for two-thirds of injuries, with the resultant damage related to the rate of penetration of the ocular surface due to cell membrane disruption (ammonia > sodium hydroxide > potassium hydroxide > calcium hydroxide > lime > acid). Formation of calcium soaps (lime) or coagulated protein (acids) in the superficial layers can limit penetration into the eye.

### First aid treatment

First aid treatment could be initiated immediately at the site of the incident by members of the general public. Copious amounts of water or saline should be applied to the eyes and face from a tap, hose pipe or water bottle. Contaminated clothing should be removed, and clinical care accessed through the emergency services. There should be a low threshold for referral to ophthalmologists, as it is easy to underestimate the severity of the injury.

### Emergency management

In the emergency department, irrigation of both eyes should be started immediately using an intravenous giving set. It should not be delayed for comprehensive assessment, nor for acquiring a particular irrigating fluid or set. If no set is available, water may be used directly from a tap or poured from a container. There are no robust clinical trials comparing irrigating fluids, and the evidence for use of one irrigating fluid over others is not yet substantiated.

### Immediate Management of Chemical Injury

1. Check pH with universal indicator paper (without delaying irrigation)
2. Administer topical anaesthetic and remove any contact lenses
3. Immediate irrigation with at least 1L of saline, retracting the lids
4. Re-check pH, and continue irrigation until pH of 7.0 achieved
5. Evert the upper lids, with double eversion using forceps if possible
6. Sweep deep into upper and lower fornices with cotton bud to remove particles
7. Re-check pH every 15 mins for >1 hour (including under the lids) and irrigate again if not pH 7.

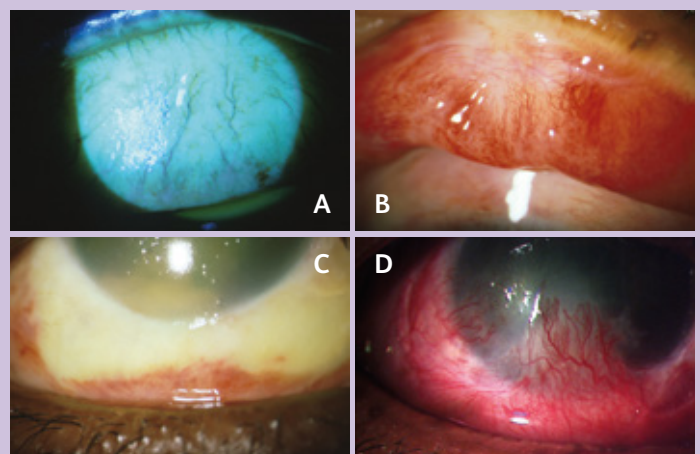
8. Document history and examination (see acute assessment), and grade
9. Obtain imaging of the ocular surface
10. Consider admission for severe ocular injuries, especially bilateral
11. Urgent referral to burns unit for oral/facial burns or airway compromise
12. Urgent referral to corneal specialist if moderate or severe injury

### Acute Assessment

Accurate observation and recording of the ocular surface immediately, and frequently in the first couple of weeks, is essential. Assessment of the severity of the various pathological processes helps predict the likely pattern of healing and informs long-term management decisions. The general ophthalmologist involved in the acute management should therefore understand the specialist treatment options that may be required later, and the questions that need to be answered.

### How Severe is the Injury?

Several grading systems relate the severity of the initial injury to the long-term outcome (e.g. Roper-Hall, Dua). These are based on the location and extent of epithelial loss (fluorescein staining of the cornea, limbus and conjunctiva) and limbal ischaemia (intravascular coagulation or vessel closure, **Figure 1**). Later, ischaemia may be masked by haemorrhage or revascularisation. More severe injuries can be associated with deeper damage: corneal haze, anterior chamber activity, and low or high intraocular pressure from injury to the ciliary body or trabecular meshwork. Meticulous drawings with annotation are important as a baseline from which to record healing and make future decisions, and in criminal cases. The full extent of the epithelial loss on both the cornea and conjunctiva should be drawn.



**Figure 1**

### What is the Limbal Stem Cell Viability?

Limbal stem cells are situated deep in the Palisades of Vogt in the far periphery of the cornea. They may be relatively protected if there is only epithelial loss at the limbus, but damaged if there is ischaemia affecting the deeper layers.

### Which epithelial cells are resurfacing the cornea?

The stem cells divide to produce corneal epithelial cells that rise to the surface then migrate centrally to cover the cornea. Corneal

epithelial cells at the limbus provide contact inhibition on the conjunctival epithelial cells, preventing them spreading across the corneal surface (corneal conjunctivalisation) and loss of vision.

As healing occurs, daily observation of the limbus will distinguish the origin of the epithelial cells. Cells of corneal phenotype emerge from the palisades at the limbus (Figure 2), with a staining area persisting more peripherally. By contrast, conjunctivalisation can be identified by the healing edge migrating onto the cornea from beyond the limbus: the leading edge is in continuity across the limbus from the tenons to the cornea.

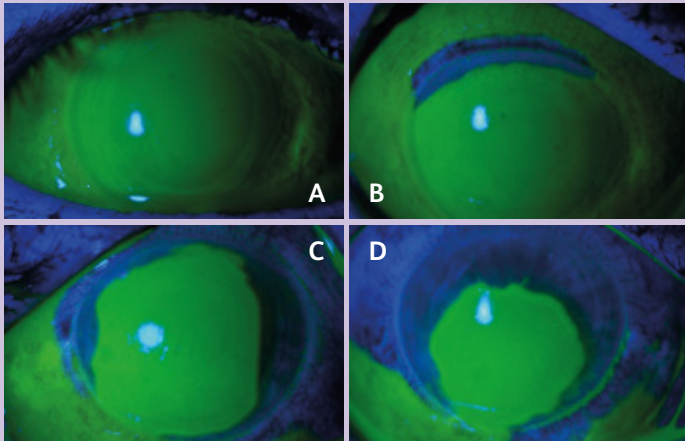


Figure 2

### Acute Treatment

Any chemical injuries other than the mildest require intensive treatment and follow up. This can be facilitated by admission to hospital and referral to a corneal team once acute treatment has been initiated. Tissue injury and necrosis results in profound inflammation with release of lytic enzymes and free radicals, which can lead to a vicious cycle of further ocular tissue damage and stromal melting. Intensive topical, and sometimes systemic, corticosteroids are essential to control both ocular surface and intraocular inflammation.

Ascorbic acid (vitamin C) is a free radical scavenger normally secreted by the ciliary body and present in high concentrations in the anterior chamber. Its levels drop rapidly after chemical injury, so need to be replaced by both topical application (which stings but has high penetration), and systemic administration (which can be continued for longer). Additionally, ascorbic acid promotes collagen synthesis and has anti-lytic activity. Citrate and tetracyclines have also been demonstrated to have anti-lytic effect.

### Acute Treatment of Moderate & Severe Chemical Injury

- G Dexamethasone 0.1% preservative free 1-2 hourly, ± systemic if severe
- G Sodium Ascorbate 1-2 hourly for 2-3 days
- Ascorbate 1g 2x/day orally
- G Sodium Citrate 1-2 hourly, if available, for 2-3 days
- Antibiotic drops preservative free 4x/day, until epithelium healed
- Cycloplegic drops (e.g. G Cyclopentolate 1% 3x/day)
- Consider: Doxycycline 100mg x1/day, topical serum drops
- Debride conjunctival epithelium from corneal surface
- Amniotic membrane transplant
- Conformer – to prevent conjunctival contraction

Daily review will determine whether conjunctival epithelium is migrating centrally across the limbus. If this occurs, debridement back to just beyond the limbus should be considered, to allow corneal epithelial cell migration. Debridement can be performed at the slit lamp under topical anaesthetic using the bevel of a sterile needle. If no corneal epithelium is apparent by 1-2 weeks, conjunctivalisation could be allowed to occur to prevent stromal

melting and can be addressed by surgery later. In some cases, amniotic membrane transplant may be valuable.

### Long-term Management

Patients with long-term sequelae usually benefit from management by a corneal team, but it is useful for general ophthalmologists to know of the options available. Identifying the cell type on the cornea is key to planning further management.

Once the cornea is epithelialized it can be difficult to tell whether the cells are of corneal or conjunctival phenotype if this has not been determined during healing. However, it is preferable to do so prior to the ingrowth of substantia propria and vessels beneath conjunctival cells. The persistence of a healing line may show the junction of the two cell types. Conjunctival epithelium tends to appear slightly more granular and matt compared to the shiny surface of the corneal epithelium. Fluorescein over the conjunctival epithelium tends to appear a slightly darker green. In cases of doubt, impression cytology using a cellulose acetate filter collects the superficial layer of cells for immunohistochemical staining of cytokeratins specific to each type of cell. Epithelial biopsy shows goblet cells if conjunctival epithelium is present.

### Long-term Management Options

- Artificial tears preservative free frequently
- Serum drops – autologous, umbilical cord serum, platelet rich plasma
- Bandage contact lens or botulinum ptosis – for persistent epithelial defects
- Lid hygiene ± lid eversion surgery
- Anti-glaucoma medication or surgery (stent or tube, not trabeculectomy)
- Limbal stem cell transplantation + systemic immunosuppression if cadaveric
- Keratoplasty – penetrating or deep anterior lamellar
- Keratoprosthesis

The evolution of treatment strategies, particularly limbal stem cell transplantation, has revolutionised the visual and cosmetic outcomes of chronic disease. In light of this, ophthalmologists are encouraged to consider referral of even advanced pathology to tertiary specialised centres. Ophthalmologists also have an important role in ensuring that both their local ophthalmology and A&E departments have up to date protocols for the immediate and acute management of ocular chemical injuries.

The Royal College is starting work to raise awareness and promote guidance for the immediate and acute management of chemical injuries of the ocular surface.

### Further Reading

- Dua HS, King AJ, Joseph A. A new classification of ocular surface burns. *Br J Ophthalmol* 2001; 85: 1379-83.
- Tandon R, Gupta N, Kalaivani M, et al. Amniotic membrane transplantation as an adjunct to medical therapy in acute ocular burns. *Br J Ophthalmol* 2011; 95: 199-204.
- Tsubota K, Satake Y, Kaido M, et al. Treatment of severe ocular surface disorders with corneal epithelial stem-cell transplantation. *N Engl J Med* 1000; 340: 1697-1703.

### Figures

**Figure 1.** A severe chemical injury showing acute intravascular coagulation in the superior tarsal plate (A) with subsequent cicatrization (B); and ischaemia of the inferior limbus (C) with subsequent conjunctivalisation of the cornea (D) due to limbal stem cell insufficiency.

**Figure 2.** Stages of re-epithelialisation of a chemical injury affecting much of the ocular surface (A). Corneal epithelial cells emerge from the palisades at the superior limbus (B) and migrate over the peripheral (C) then central (D) cornea.