Corneal trauma, although generally superficial can also be an intensely painful and distressing experience. This article will show how accurate assessment and careful consideration of the available treatment options can maximise patient comfort and optimise healing.

THE CORNEA
The cornea is a transparent avascular structure which covers the anterior one sixth of the outer coating of the eye. It is the major refracting surface of the eye, starting the process in which light eventually focuses on the retina. At the limbus, the cornea's junction with the sclera, the corneal epithelium is continuous with that of the conjunctiva. The cornea is normally described as having five layers. The outermost layer is the epithelium (five to ten cells thick) whose basement membrane is attached to Bowman's membrane, the outer consolidation of the main part of the cornea, the stroma. Underneath the stroma is the basement membrane (Descemet's membrane) of the single celled endothelial layer, the innermost layer of the cornea. The arrangement of cells within the cornea, its avascularity and its relative dehydration along with the integrity of the epithelium and endothelium ensure the cornea's transparency. The cornea is innervated by fibres from both the ophthalmic and maxillary branches of the trigeminal nerve. At its periphery, the cornea is around 1 mm thick and around 0.5 mm thick at its centre.

EFFECTS OF INJURY ON THE CORNEA
Corneal epithelial cells originate in the deep basal layers of the epithelium, become progressively flatter as they displace anteriorly and shed from the outermost layer, seven to ten days later in a continuous process (Newell 1996). The epithelium regenerates at the limbus and spreads quickly across the cornea (Forrester et al 1996). The basement membrane of the cornea is attached to Bowman's membrane by anchoring filaments which may take up to six weeks to be re-established after injury. Bowman's membrane does not regenerate after injury and damage will result in a corneal scar. Stroma consists of lamellae of collagen arranged to ensure the clarity of the cornea. Disruption to this structure, for example by injury, results in corneal scarring. Within the cornea, nerve fibres are not myelinated and most are concentrated in the stroma immediately below Bowman's membrane and send branches forward into the epithelium.

The cornea is one of the most sensitive tissues in the body with the highest density of sensory neurones per mm² which are within and just below the epithelium; any disruption of the epithelium will disrupt or expose nerve fibres and result in pain.

IDENTIFYING THE EXTENT OF TRAUMA
A light source and single use fluorescein minims or impregnated strips are the crucial elements in identifying the extent of corneal trauma. Both white and cobalt blue filtered light are necessary and magnification enables much more comprehensive assessment. The tools used may range therefore from a pen torch or ophthalmoscope, a head loupe or ring light with integral magnification or in the best case, a slit lamp and a clinician with the skills to use it. Fluorescein stains damaged epithelial cells and shows a bright green/yellow stain under cobalt blue light. It is therefore used to show the extent of epithelial loss. It is relatively non toxic to ocular tissue so may be used even where there is a suspicion of perforation. The two main components of the corneal injury are extent and depth and both must be assessed (figs 1 and 2). Extent may...
be assessed using simple direct illumination from a pen torch or ophthalmoscope. Depth is better assessed using a slit lamp but may be considered by using a slightly angled view of the cornea, rather than considering the injury from a ‘straight on’ view only. The degree of epithelial loss is not a good indicator of the severity of injury and as pain is associated with epithelial loss, a high level of pain may not indicate a severe injury.

Findings should be documented, generally by illustrating the location and extent of the injury on a diagram. It is possible, when using a slit lamp to measure the extent of injury but otherwise, as accurate an interpretation as possible should be drawn. This is useful for identifying the progress of healing at any subsequent review visits.

Fluorescein may be used in identifying perforation of the cornea (or sclera) in cases where the eye appears to be intact but there is suspicion of deep penetration (fig 2). A drop of fluorescein instilled into the lower fornix will spread over the cornea as the patient blinks. If there is corneal or scleral perforation, aqueous fluid will tend to leak out of the perforation and wash away the fluorescein film. If the eye is illuminated by a cobalt blue light, the observer will see black streaks appearing in the fluorescein film under the site of the injury. This will indicate an aqueous leak and is confirmation of perforation. Any injury which is more than superficial, a corneal laceration or perforation should be referred to an ophthalmic specialist unit as soon as possible.

Having identified the extent of trauma there are a number of decisions to be made about treatment. Treatment decisions will affect patient comfort and the patient’s experience of corneal trauma. It is important that care is optimised for each patient. The three main areas which need consideration are the treatment of pain, the prevention of infection and the optimisation of healing.

**PREVENTION OF INFECTION**

One of the eye’s major innate defence mechanisms against pathogens is the integrity of the corneal epithelium. The eye normally has a population of commensal bacteria (diphtheroids, staphylococcus, streptococcus) which prevent colonisation with pathogenic bacteria (Forrester et al 1996, Newell 1996). Disruption of the corneal epithelium allows penetration of the outer coat of the eye by these and any other opportunistic pathogens which can result in infection of the cornea itself (infective keratitis) or infection of the interior structures of the eye (endophthalmitis) which can be catastrophic to ocular tissues and any prognosis for useful vision.

It can be seen that any breach in the corneal epithelium requires treatment with topical prophylactic antibiotic. As the antibiotic is for prophylaxis, the choice is limited to one with a broad spectrum of activity and in practice, in acute cares settings, this means either chloramphenicol or fucidic acid preparations (Fucidin).

Contrary to some popular opinion, short courses of topical chloramphenicol do not appear to cause systemic side effects (Besamusca and Basteinsen 1986, Gardiner 1991, Drugs and Therapeutics Bulletin 1997). It is considered to be a very safe drug, widely used throughout ophthalmology in

<table>
<thead>
<tr>
<th>TOPICAL ANTIBIOTIC</th>
<th>THINK ABOUT</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>We’ve only got one</td>
<td>Give it</td>
<td></td>
</tr>
<tr>
<td>We’ve got everything</td>
<td>Eye pad?</td>
<td>Ointment (chloramphenicol)</td>
</tr>
<tr>
<td>Significant pain?</td>
<td>Ointment</td>
<td></td>
</tr>
<tr>
<td>Perforation?</td>
<td>Chloramphenicol minim</td>
<td></td>
</tr>
<tr>
<td>Mild pain/needs to drive or work?</td>
<td>Drop or ointment</td>
<td></td>
</tr>
<tr>
<td>Difficulty instilling medication</td>
<td>Fucithalmic (BD)</td>
<td></td>
</tr>
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Chloramphenicol is available in both drop and ointment form and Fucidic acid as a viscous drop which becomes clear and liquid on hitting the tear film of the eye. Chloramphenicol is usually prescribed four times daily and Fucidic acid twice daily. This regime should be continued until the epithelium is healed. Usually, a five day course is prescribed.

Either of these drugs and regimes are acceptable for treating corneal trauma. The choice is often limited by what is available but consideration must also be given to the vehicle, whether a drop or an ointment form is preferable (see Table 1). Fechner and Teichmann (1998) prefer ointment and Rhee and Pyfer (1999) suggest that both are as effective. Practitioner experience suggests, however, that ointment provides much more comfort, as a greasy surface between injured cornea and lids. Certainly, if an eye pad is used, ointment should be used as the antibiotic will be present on the eye for much longer than a drop underneath the eye pad.

Ointment does tend to blur vision for a few minutes but this can be minimised by advising the patient to instil only a couple of millimetres of the ointment. Patients should be informed that chloramphenicol has an unpleasant taste and, as the lacrimal drainage system eventually drains down the back of the throat, chloramphenicol drops or ointment will be tasted for some while after instillation.

If perforation is suspected or confirmed, a single drop of unpreserved, single dose chloramphenicol (in minic form) may be instilled before transfer to the ophthalmic unit. Preservatives and ointment are toxic to intraocular tissues and should not be used.

DEALING WITH CORNEAL PAIN

Any breach in the corneal epithelium will cause a degree of discomfort or pain as corneal nerves are damaged and exposed and the extent of epithelial loss is likely to be related to the degree of pain experienced by the patient. Corneal pain is difficult to treat but a number of strategies can be used and accurate assessment of the degree of pain is required and the pain experienced by the patient treated (Table 2).

**Topical anaesthesia** For examination purposes only, and to obtain an accurate visual acuity assessment, topical anaesthesia may be used in the department.

Repeated instillation will result in dose related toxicity to the corneal epithelium and delay in healing due to inhibition of cell division (Fechner and Teichmann 1998). This means in practice that if patients are given topical anaesthetic drops to take home, their pain will be relieved but the corneal epithelial loss will not recover and may get worse.

**Pupillary dilation** A component of the pain experienced is likely to be due to ciliary spasm where there is more than a very small area of epithelial loss. This can be seen as the pupil of the affected eye reacts more slowly than that of the uninjured eye. Relief of the spasm and therefore a component of the pain may be achieved through instillation of a drop such as Tropicamide 1 per cent, Cyclopentolate 1 per cent, Homatropine 2 per cent, to dilate the pupil. Of these, Homatropine lasts the longest (around 24 hours). Patients should be warned that these drops paralyse the ciliary muscle; accommodation and the patient’s near vision will be blurred as focusing is impossible. Atropine should never be used as it is completely irreversible and lasts from ten to 14 days.

**Topical analgesia** Prostaglandins play a major role in pain sensation and non steroidal anti inflammatory drugs (NSAIs) are

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**Table 2. Decision making guide for pain control**

<table>
<thead>
<tr>
<th>THINK ABOUT</th>
<th>ACTION</th>
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<tbody>
<tr>
<td>Topical anaesthesia?</td>
<td>The effect on corneal healing</td>
</tr>
<tr>
<td>Mild pain</td>
<td>Analgesia</td>
</tr>
<tr>
<td>Moderate and severe pain</td>
<td>Ciliary spasm present?</td>
</tr>
<tr>
<td>Padding?</td>
<td>Instill medication and pad. If it is uncomfortable, the patient may remove it and commence medication</td>
</tr>
</tbody>
</table>

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For examination purposes only. There is no need to pad just because of topical anaesthesia.

Ointment works well

Probably not but depends on extent of injury

Topical NSAI is indicated

Review

Yes
used systemically as analgesics to inhibit the enzyme cycloxygenase and therefore decrease the synthesis of prostaglandins (Fechner and Teichmann 1998). Topical NSAIs have been evaluated for us in corneal pain (Brahma et al. 1996) and found to be extremely effective. Their use does not appear to delay healing and no adverse effects have been found. For patients with corneal pain therefore, topical NSAIs provide a significant degree of effective pain relief and are usually prescribed four times daily. (Brahma et al. 1996, Fechner and Teichmann 1998, Rhee and Pyfer 1999). Three NSAIs are also available in eye drop form, Diclofenac Sodium (Voltarol ophtha) and Flurbiprofen sodium (Ocufen) in single dose units and Ketorolac Trometamol (Acular) as a 5ml bottle which is rather more cost effective.

**SYSTEMIC ANALGESIA** Use of topical analgesia should almost remove the need for systemic analgesia. Pain associated with other branches of the trigeminal nerve are notoriously difficult to treat. Practitioner experience suggests that many common analgesics provide little relief for corneal pain and other strategies, those discussed have a better effect. If systemic analgesia is suggested, the analgesic which the patient normally takes is as likely to be effective as anything else.

**TO PAD OR NOT TO PAD** Studies have been undertaken which address the question of eyepads and there have been equivocal results, ranging from faster to slower healing and suggesting overall, little effect on pain. Interpretation of these results suggests that there will be a number of patients below and a number above this mean conclusion. It is clear that for some patients padding will make their situation better, while for others, their level of pain will increase. If the decision is to pad nobody, a significant number of patients will be denied effective pain relief. A strategy might be devised to pad those patients who have significant pain while telling them that this is for comfort only and that if the pad makes the pain worse, they should remove it.

A double eye pad should always be used, one pad folded over the closed lids and the other open on top of it. The whole taped firmly to the face so that the patient cannot open the eye underneath the pad. Medication (dilating drops, analgesia, antibiotic) should be instilled prior to patching and antibiotic ointment should be used as it will be present on the cornea for longer than in drop form. If comfortable, the pad should be left intact for 24 hours and then removed and instillation of medication commenced. If the pad is uncomfortable, it may be removed and medication commenced. There is no need to pad the eye just because a topical anaesthetic has been instilled.

**OPTIMISATION OF HEALING**

Educating the patient on the importance of continuing to use prescribed medication to avoid corneal infection is essential. Decisions whether to review simple corneal abrasions depend on the individual clinician. It is useful to review large abrasions to ensure healing is taking place and that there is no loose epithelium which needs debridering. Recurrent erosion syndrome is a distinct possibility for those patients who have an animal or vegetable cause for their corneal trauma (Plant or fingernail for example). The filament which anchor the epithelium to Bowman’s membrane may take even longer to heal and until this happens, the epithelium is unstable and is easily damaged. It is helpful to explain this to the patient and also that the time that they are most vulnerable to epithelial loss is at night as the epithelium sticks to the conjunctiva of the eyelid rather than to its basement membrane while the eye is relatively dry, overnight, and may be peeled off by the mechanical action of the lid opening on waking. This can be prevented until the epithelium is stable by using ointment at night before sleeping to keep the eye lubricated. ‘Simple’ ointment, or ‘Lubri tears’ or ‘Lacrilube’ (ointment base without drugs) should be used for a period of up to three months to prevent this happening.

**REFERRAL**

Where there is suspicion that corneal trauma is anything other than superficial, and certainly in the case of corneal laceration or perforation, the patient should be referred to an eye unit. At review visits, the clinician should consider whether the cornea is healed, whether there is any loose epithelium visible or any sign of infection, increase in pain or reduction in visual acuity. In any of these circumstances it is safer to refer the patient for an ophthalmic opinion.

**References**

Besamusca F, Bastiensen L(1986) Blood dyscrasias and topically applied chloramphenicol in ophthalmology. Documenta Ophthalmologica 64:87-95


Slack New Jersey

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