MAJOR REVIEW

The Management of Eyelid Burns

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Abstract. Eyelid involvement is common in facial burns. Ocular sequelae, including corneal ulceration, are usually preventable and secondary to the development of eyelid deformities, exposure keratopathy, and rarely, orbital compartment syndrome. Early ophthalmic review and prophylactic ocular lubrication is mandatory in burns involving the eyelids. Early surgical intervention, often requiring repeat procedures, is indicated if eyelid retraction causing corneal exposure occurs. Permanent visual impairment is rare with such prompt management. No binding aphorisms exist regarding the tissue used for eyelid reconstruction, with each case requiring an individual approach based on available skin. This review article covers the principles of ophthalmic management in addition to intermediate and long-term management of eyelid burns. (Surv Ophthalmol 54:356–371, 2009. © 2009 Elsevier Inc. All rights reserved.)

Key words. burns of ocular adnexa • eyelid burns • eyelid grafting • lagophthalmos • masquerade procedure • tarsorrhaphy • thermal eyelid burns

I. Introduction

Facial burns are a common sequelae of thermal trauma, and ocular involvement is relatively common, occurring between 7.5% and 27% of patients admitted to burn units. The loss of an eye primarily from a thermal injury is rare. This is due to protective mechanisms such as the blink reflex, Bell phenomenon, and protective movements of the head and arms to avoid the source of a burn. The initial corneal or ocular surface injury can be quite trivial compared to the injury sustained to the eyelids. Most ocular sequelae, including corneal ulceration, occur secondary to the development of eyelid deformities after the initial burn injury. Secondary complications such as exposure keratopathy, secondary infection, and orbital compartment syndrome are potentially preventable by appropriate early and sustained management.

II. Epidemiology

The authors manage the surgical care of patients at the regional Burns Centre at the Queen Victoria Hospital, East Grinstead, UK. By far the most common thermal burn is the scald burn from hot water and the most common place to sustain this is at home. Children, the elderly, and the disabled are
most prone to burn injury as the result of their impaired mobility and immature or impaired mental function. Seizures and unconsciousness secondary to cardiac or vascular events are also major causes of thermal burns.

Flame injuries in the UK occur both in the domestic environment and at work. Most flame injuries occur in men of working age, but the elderly and those with mental health problems are also affected. In the latter group these may be self-inflicted. Flame injury is more likely to cause a deeper burn and resultant ocular sequelae. Flash flame injury occur in people working with arcing electrical current that produces an intense, short-lived flame.

In patients admitted to burn units, ocular injuries such as conjunctival burns (3–11%), corneal abrasions (7–22%), corneal burns (5%), corneal perforations (1–2%) and cataracts (2%) are found less frequently than eyelid burns (50–85%) and eyelid contractures (30–65%). In one series of 143 burns patients with ocular injuries, 2 were left blind, 2 had impaired vision, and 3 underwent enucleation.

III. Pathophysiology of Thermal Burns

Burn injury results in the release of multiple inflammatory mediators that result in vasodilatation, pain, and edema. Exudation from the wound is greatest in the first 24 hours, although this may continue for days. The associated edema may also take days to resolve.

The depth of burn depends on the intensity of heat exposure, the duration of exposure, and the thickness of epidermis and dermis. Periocular skin is thin with no subcutaneous fat, resulting in deeper burns than a similar exposure to skin elsewhere.

Work by Moritz and Henrique on time–temperature exposure relationship to depth of injury showed that as exposure temperature increases, time to produce a burn decreases. At temperatures below 44°C, a burn is unlikely to occur, even if exposed for several hours, but exposure for more than one second at 60°C (140°F) will cause epidermal sloughing (partial-thickness burn). A temperature of greater than 70°C (158°F) will cause dermal protein denaturation, producing full-thickness burns.

The pattern of burn injury is rarely uniform and depends on the time and temperature of exposure to that particular area of skin. The burn is also dynamic as demonstrated by Jackson’s burn wound model. The center of injury, usually the site of greatest heat transfer, is known as the “zone of coagulation.” It consists of dead and dying cells as the result of coagulation necrosis with no blood flow. It appears white and leathery and is insensate (full-thickness burn).

Surrounding this is the “zone of stasis,” characterized by a pronounced inflammation. Here the microvasculature is engorged with heat-injured erythrocytes (dermal burn). This potentially salvageable area can be converted to full thickness injury by infection, ischemia, or drying of the wound. The outermost “zone of hyperemia” (inflammation) is the site of minimal cell involvement and undergoes early spontaneous recovery. It is characterized by minor cell damage, but prominent vasodilation. The increased blood flow brings with it nutrients needed to support the zone of stasis and the cells necessary to continue the inflammatory process within the zones of stasis and coagulation.

Thus, burns that initially appear dermal/partial thickness in nature may progress to full thickness injury if appropriate and timely measures are not taken.

The necrotic tissue resulting from a burn is known as eschar and is a good substrate for microorganisms. If left untreated it becomes colonized, contaminated, and eventually infected.

IV. Classification of Thermal Eyelid Burns

A. EPIDERMAL BURNS (FIRST-DEGREE BURNS)

This corresponds to the zone of hyperemia in Jackson’s model. Severe sunburn is the most common first-degree burn. By definition, this affects only the epidermis, and blistering is not common. Pain is due to local vasodilator prostaglandins, and healing is usually complete within a week. Undamaged keratinocytes regenerations within skin adnexae, and scarring does not occur.

B. PARTIAL-THICKNESS BURNS (SECOND-DEGREE BURNS)

Partial-thickness burns involve the dermis and epidermis. This corresponds to the zone of stasis in Jackson’s model. Dermal burn injury is a continuum, but is commonly divided into superficial and deep dermal injury.

C. SUPERFICIAL PARTIAL-THICKNESS BURNS

Injury to the epidermis and superficial papillary dermis results in thin-walled, fluid-filled blisters with a moist red base. The exposure of superficial nerves makes these injuries painful. A burn of this depth heals within 2 weeks by regeneration of epidermis
from keratinocytes within sweat glands and hair follicles with minimal scarring. The rate of regeneration therefore is partly dependent on the density of these adenexae: thin, hairless eyelid skin may take longer to heal than thick or hairy skin (e.g., back, scalp, face) and, although progression to a deeper burn is unlikely, it may occur if the wound dries out or becomes infected, or the patient becomes systemically unwell or hypotensive.\textsuperscript{25}

### D. DEEP PARTIAL-THICKNESS BURNS

These burns can be difficult to assess and have a pale white or mottled base beneath the blisters. They may initially appear superficial, with Blanching on pressure, but have fixed capillary staining if reassessed at 48 hours. There are fewer viable skin adenexae (islands of regeneration) at this depth, and healing is slower, taking three or more weeks, and is accompanied by scarring and contraction. These injuries are therefore particularly consequential in the eyelid region, often necessitating early surgery for contraction and eyelid retraction.

### E. FULL-THICKNESS BURNS (THIRD-DEGREE BURNS)

These destroy epidermis, dermis, and all regenerative elements and correspond to the zone of coagulation in Jackson’s burn wound model. The skin is dry, leathery, and as a result of heat coagulation of dermal blood vessels, the affected tissue is avascular and white. Such burns are usually painless because of loss of sensation in the involved area. Healing only occurs from edges and is associated with significant contraction. Early excision of affected tissue and skin grafting is almost always required to resurface the burnt area and prevent secondary corneal complications.\textsuperscript{5}

### F. DEEP (FOURTH-DEGREE BURNS)

These are full-thickness burns with destruction of the underlying muscle, bone and vital structures. Such burns require extensive and complex management and invariably result in severe contracture and prolonged disability.

Based on these definitions and the likelihood of surgery, eyelid burns may be classified as minimal, moderate, or major.\textsuperscript{15} Minimal burns describe superficial partial-thickness burns that usually heal without the need for surgery. Moderate burns refer to deeper partial-thickness burns that are delayed in healing but may not require surgery. Major eyelid burns are deep-partial or full-thickness and invariably require early surgery with skin grafts.

### V. Principles of Ophthalmic Management

Most ocular sequelae, including corneal ulceration are potentially preventable and are secondary to the development of eyelid deformities because of inadequate or delayed treatment of the initial burn injury. The role of the ophthalmic and oculoplastic surgeon is therefore vital in the early management of these patients.

#### A. EARLY EVALUATION

Patients with facial burns should be seen by an ophthalmologist as soon as possible to assess the extent of injury and to exclude the possibility of an ocular, intoacroar, intraorbital foreign body, especially in the context or industrial explosions. If any doubt exists as to the presence of a foreign body, then a plain x-ray is mandatory and computed tomography (CT) should be considered.\textsuperscript{29} A common foreign body often overlooked is the contact lens. This assessment should be made, if possible, in the emergency room before significant conjunctival and eyelid edema prevents a thorough exam. Studies have shown that cases referred early for ophthalmic assessment require less subsequent ophthalmic surgery.\textsuperscript{42}

Early ophthalmic referral with some urgency identifies ocular sequelae, offers a broader range of treatment options to the burns unit, and institutes those treatments before the development of secondary complications. Patients at particular risk of sight loss following burns are those being ventilated and those immunosuppressed as a result of their injuries. This may reflect the fact that this group of patients are more likely to have had a severe injury. In addition, conjunctival and eyelid edema following fluid resuscitation and positive pressure ventilation can further exacerbate lagophthalmos and compromise ocular surface wetting. Furthermore, a paralyzed patient may not be aware of and cannot communicate symptoms and is dependent upon the ophthalmologist’s care.\textsuperscript{29} Use of opiates makes pupil assessment difficult.

Ocular injury in the absence of burns to the eyelids may also occur in an enclosed space fire from convection energy heat transfer while the eyes remain open as the victim is looking for a means to escape.\textsuperscript{17} It is recommended that patients exposed to fumes, intense heat, or smoke, particularly in an enclosed space, should also receive ophthalmic consultation to exclude unrecognized injuries.\textsuperscript{6} Clearly all patients with subjective complaints or lagophthalmos should receive a formal evaluation.

Because of the risk of secondary bacterial infection of a corneal epithelial defect, this should be considered an ophthalmic emergency in the patient with eyelid burns.\textsuperscript{29}
B. OPHTHALMIC AND EYELID EVALUATION

As perhaps the most critical issue for the ophthalmologist is the integrity of the corneal surface, fluorescein strips and a cobalt blue light should be available in the burn unit. In addition, a portable slit lamp allows a more detailed examination than would otherwise be possible. Corneal thinning, usually the result of lagophthalmos, is often only detectable by a portable slit-lamp. We also include a Tono-pen, direct ophthalmoscope, near vision chart, and eyelid speculum in our kit in order to minimize repeated visits, as such patients are often barrier-nursed and the examiner is required to be gowned and gloved to prevent transfer of infection.

The depth and extent of burns in the eyelid and facial area should be initially assessed, and photography is now a standard tool. The presence of eyebrow hairs and eyelashes should also be documented, as loss of these is usually associated with a deep partial-thickness or full-thickness burn (Fig. 1A). Furthermore, the presence of eyelashes indicates sparing of the eyelid margin.

 Conjunctival edema is produced by a combination of fluid resuscitation, positive pressure ventilation, and mild exposure, but may also be a consequence of conjunctival burn, an indicator of a severity. In the presence of a partial-thickness burn, eyelid contracture producing progressive lagophthalmos and corneal exposure is likely. Therefore, the presence or absence of a Bell’s phenomenon should be documented. A good Bell’s phenomenon can help prevent a corneal epithelial defect even in the presence of significant lagophthalmos (Figs. 1B and 1C). This reflex may be temporarily absent in a heavily sedated or paralyzed patient. With an absent Bell’s phenomenon and concern regarding lagophthalmos, daily ophthalmic review or close communication between the ophthalmologist and burn unit staff is required to monitor signs of increased conjunctival redness or chemosis, mucus discharge, or corneal exposure as their presence would prompt earlier surgery if Bell’s phenomenon is absent. Foreign bodies should be removed with irrigation and cotton swabs, including careful sweeping of conjunctival fornices, where appropriate.

Globe perforation as a result of corneal melt or microbial keratitis is thankfully rare, but corneal thinning leading to perforation can occur silently (silent perforations) in the absence of significant inflammation or conjunctival chemosis in paralyzed/sedated patients, especially those with poor Bell’s phenomenon and lagophthalmos.

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Fig. 1. A: Loss of eyebrow hair and lashes following a deep partial-thickness burn. B and C: Same patient shown with lagophthalmos 1 month later.
Portable slit-lamp examination allows a detailed examination of anterior segment structures, including the lens. We have observed intraocular inflammation following a severe ocular surface burn, resulting in a hypopyon and traumatic cataract, in the absence of penetrating injury, melt, or perforation. However, this is usually following severe facial chemical rather than thermal burns (Fig. 2A).

Within 2 weeks of the injury, lagophthalmos from contracture of the eyelids may develop (Figs. 1B and 1C). It is at this point that the ocular surface needs daily observation not only to identify corneal epithelial defects, but also for evidence of conjunctival injection as this should raise suspicion of an inflamed eye.

1. Orbital Compartment Syndrome

It has been suggested that intraocular pressure (IOP) monitoring may be important in the patient who receives intravenous fluid resuscitation, as elevation may occur within 72 hours of large shifts from the intravascular compartment to the extravascular compartment. Elevated IOP in this context is usually an indirect measure of elevated orbital pressure, which may arise from capillary leakage in an enclosed compartment limited by the eyelids, orbital septum, and orbital walls. There have been several reports of ischemic optic neuropathy as the result of to elevated IOP and orbital pressure. Patients at risk of orbital compartment syndrome are those with large burn injuries requiring fluid volumes in excess of those predicted by the Baxter formula of 3.74.3 cc/kg per percentage total body surface area burned (% TBSA). Sullivan et al reported the occurrence of orbital compartment syndrome (with IOP increasing greater than 30 mm Hg and requiring lateral canthotomy and cantholysis to successfully reduce IOP) in 5 out of 13 patients with burn sizes greater than 25% TBSA. All 13 patients received average fluid volumes of 24 liters in the first 24 hours (7.1 cc/kg/%TBSA) and those who subsequently developed orbital compartment syndrome had received even larger volumes of fluid resuscitation (9.0 cc/kg/%TBSA). Two of the 13 patients in this series died following failed fluid resuscitation.

It would be prudent to obtain an IOP reading in any patient with a history of glaucoma and daily readings for 72 hours in patients with burn sizes greater than 25% TBSA or those receiving large volumes of fluid resuscitation. In the presence of orbital compartment syndrome with raised orbital pressure and IOP, topical medication may decrease IOP only. An urgent lateral canthotomy and inferior cantholysis is therefore indicated.

C. INITIAL MANAGEMENT

Head elevation may be helpful in preventing further swelling around the eyelids. Topical steroids should be avoided due to the risk of secondary infection.

1. Prophylactic Ocular Lubrication

Prophylactic ocular lubrication within 24 hours of admission, with a minimum of three applications a day, is particularly important as burn patients often have reduced tear production, blink reflex, and eyelid mobility or excursion. Our preferred first-line choice is guttae carboxymethyl cellulose sodium 1.0% (Celluvisc, Allergan, Irvine, CA) for a minimum of four times daily and white petrolatum ointment (Lacrilube, Allergan) at night. Artificial tears are less effective than ointment. Prompt prophylactic lubrication also appears to have a beneficial effect in reducing the need for either ocular or eyelid surgical intervention by preventing exposure keratitis. Although not reaching statistical significance, perhaps because of the small number of patients, Spencer et al showed in their series of 66 patients with eyelid burns that, where prophylactic ocular surface lubri-
2. Scorched Eyelashes

Singed or scorched eyelashes are usually present in a thermal eyelid burn and, although the management of burned eyelashes has largely been neglected in the literature, it is generally recommended that these be removed to avoid the possibility of char falling into the eye and prolonging ocular surface discomfort. In a controlled study trimming eyelashes with fine scissors, the blades of which were covered with an ophthalmic ointment in order to prevent the cut lashes from falling into the conjunctival sac, both symptoms of foreign body sensation and discomfort as well as conjunctival hyperemia were shown to be reduced.

3. Moisture Chambers

Moisture chambers, such as commercially available bubbles or those made from cellophane wrap, are useful when the pre-septal eyelid skin is in good health. However they do not tend to adhere well to severely burned eyelid skin. In this instance, a temporary suture tarsorrhaphy may be preferred.

4. Dressings and Wound Management

The principles of wound management for eyelid burns are those for any burn: assessment, cleansing, and protection followed by re-surfacing for deeper burns.

The eyelids should be cleaned of any debris as soon as possible using saline-soaked gauze. There is a vast range of available dressings, and our preference is tulle gras, silicone covered nylon mesh, or an alginate dressing. An alternative is to use liquid paraffin, although this is particularly difficult around the eyes and requires frequent re-application. Dressings are favored over the traditional exposure method which often desiccates the burn and may extend the depth of the burn.

5. Temporary “Draw-string” Suture Tarsorrhaphy

In the presence of lagophthalmos with a severe burn of the eyelid skin, a suture tarsorrhaphy is useful and effective in aiding closure. A tarsorrhaphy is recommend in the presence of an epithelial defect due to lagophthalmos and a poor Bell’s phenomenon, if there has been failure to improve over 24 hours, or with a large defect. Our technique is based in principle on the technique described by Hollsten. Either a 3–0 prolene double armed suture (or two single-armed 3–0 prolene sutures with ends tied) is passed through the lower eyelid skin 1 cm apart emerging through the gray line of the lower eyelid. These sutures are then passed through the gray line of the upper eyelid to emerge just below the brow approximately 1 cm apart. A bolster is used to support the lower eyelid to help prevent cheese wiring, and the sutures may be passed so that they emerge at the pre-tarsal upper eyelid (rather than below the brow) if no upper eyelid burn exists. It is also important to avoid passing sutures posterior to the gray line to avoid corneal abrasions. The two suture ends can either be tied to the level of the brow or taped to the forehead using a Steristrip. This provides improved closure yet allows any examination of the eye as well as installation of topical medication not possible with the tarsorrhaphy closed. This type of “draw-string” suture tarsorrhaphy lasts approximately 2 weeks in severe eyelid burns before cheese wiring occurs and the sutures need replacement. A variation of this technique to help prevent lower eyelid cheese-wiring, provide anchorage to the lower lid, and avoid any trauma to the upper eyelid levator complex is to pass a double-armed suture through the pre-tarsal skin of the upper eyelid emerging at the grey line. Each needle is then passed through the gray line of the lower eyelid, and finally through the periosteum of the inferior orbital rim, before emerging through the skin inferiorly. It has been suggested that, if daily ophthalmic examination is not possible or practical, then a useful instruction to the burn unit staff is to notify the ophthalmologist immediately if (1) the patient’s conjunctiva becomes more chemotic or injected or an increase in mucus discharge occurs and/or (2) the tarsorrhaphy sutures do not secure close the eyelids.

In those situations where there is no significant facial burn, a moisture chamber may also be of benefit. In deeper burns an allograft can be used as a dressing without surgical debridement to provide protection and aid healing. This is especially useful in the mixed depth burn, as the use of allograft may avoid the need further surgery in such cases.
Another and perhaps simpler option in the presence of developing epithelial defect and poor closure or poor Bell’s phenomenon is the use of a simple Frost suture. This is particularly useful if there is healthy skin on the brow or the cheek to which the frost suture can be taped. This is technically easier than the draw-string tarsorrhaphy described previously and still allows easy access for examination and treatment. A further useful technique in patients who do not have significant pre-tarsal burns yet demonstrate exposure due to lagophthalmos is to splint the upper lid into a closed position with a strip of 1-inch-wide tape applied horizontally.29

6. Surgical Tarsorrhaphy

A surgical tarsorrhaphy would theoretically seem ideal at the 2-week stage when eyelid contracture occurs, overcoming any suture tarsorrhaphy and producing ectropion. However, tarsorrhaphy in facial burns has generated more controversy than any other procedure and has largely been abandoned as routine practice. Tarsorrhaphy does not appear to prevent wound contraction where cictricial ectropion is present, and the basic principle of tissue replacement should preside.15,28,32 The argument is that tarsorrhaphy is not necessary in the early stages where eyelid edema is present, is difficult to perform on edematous and friable lid margins, and can permanently damage or deform the lid margin and lash line.15,49 This is particularly true for permanent types, including the “tongue-in-groove” tarsorrhaphy, which should be avoided.2,28 Certain extreme situations may warrant tarsorrhaphy, or suturing of the eyelids together, for example following destruction of the eyelid margins where there is sufficient tissue remaining to avoid the need for the masquerade procedure (see subsequent discussion).1

Although uncertain whether combined tarsorrhaphy with skin grafting may help reduce the need for further skin grafting or recurrent ectropion, in certain circumstances we would perform a small lateral tarsorrhaphy at the same time as definitive ectropion repair. This maintains lateral elevation and provides further blood supply to the lower eyelid if horizontal shortening has been performed at the same time. Following a gray-line incision at the lateral eyelid margin, the intra-marginal posterior lamella skin is removed, and upper and lower eyelid tarsoconjunctival flaps are sutured using 6-0 vicryl mattress sutures through the cut tarsal edge on the margin. The anterior lamellar (skin and muscle layer) is closed with vertical mattress silk sutures evertting the eyelashes away for the globe and supported with bolters.

As the risk for ectropion persists for months due to persistent eyelid shrinkage, a tarsorrhaphy would need to remain in place until facial scars mature.

7. Masquerade Procedure

In severely damaged eyelids where sloughing due to necrosis has occurred and no viable adjacent skin or tissue exists, the masquerade procedure can be carried out as a viable method of closing the eye until further reconstruction can be accomplished. In this procedure all necrotic tissue including orbicularis and eyelid margins are excised, a conjunctival flap from the remaining upper and lower eyelid (often bulbar conjunctiva) are mobilized and sutured together. This covers the anterior surface of the globe with the epithelial surface of tarsal (or bulbar) conjunctiva. A skin graft (usually split-thickness, as a full-thickness graft is likely to undergo necrosis in areas due to poor vascularity of the underlying bed) is then applied to cover the entire eyelid area, leaving a small gap nasally and temporarily for drainage of tears (Fig. 3). The full-thickness flap is divided horizontally approximately 1–3 months later to create new eyelid margins. Slight eyelid eversion may develop, along with problems of stiffness, ptosis, and variable lagophthalmos; however, the eyelids generally function normally and, more importantly, are able to cover the ocular surface.29

In repairing the entire loss of an upper and part of the lower eyelid, Marrone28 described the use of advancing the levator muscle after incising the horns. This was covered by a full-thickness skin graft (FTSG) and provided a healthy vascular bed with good coverage. After flap division, a functioning lid was observed, at least initially.

8. Split-thickness Dermal Grafts

In the presence of large corneal and scleral defects, where conjunctival flaps may be difficult to fashion, alternatives include split-thickness dermal grafts or tenonplasty (see subsequent discussion). The use of a split-thickness dermal graft was reported by Mauriello30 in 10 cases with multiple defects. The graft was harvested from the thigh after raising a superiorly hinged, thin epidermal flap. A thin dermal graft may then be harvested from the exposed dermal bed, taking care to maintain surface orientation of the graft. The epidermis flap is then perforated and closed. Remaining corneal epithelium is removed with a blade, and the graft is placed on the defect following a limbal peritomy, with or without undermining of adjacent conjunctiva, depending on the site of the defect. It is sutured with 10-0 nylon sutures to healthy sclera and 7–0 polyglactin to conjunctiva. Grafts may require postoperative thinning.
9. Tenonplasty

An alternative globe-preserving procedure in the absence of nearby conjunctival flaps involves dissection of the Tenon’s layer and anterior advancement of Tenon’s in a flap-like fashion and suturing to the globe at the limbus in order to provide a vascular supply and promote corneal epithelialisation. Kuckelkorn et al. reported the use of this technique for 75 eyelid burns in 59 patients. Epithelialization of advanced Tenon’s was complete within 21 days in 80% of the cases and in all eyes within 54 days, resulting in prevention or healing of scleral ulceration in all cases. Primary epithelialization of the burned cornea was achieved in approximately 30% of cases. Fornices were sufficiently deep in about 74%, and severe symblepharon formation was reported in 26% of cases.

Fig. 3. Masquerade procedure. The bulbar and fornical conjunctiva is mobilized (A), sutured together (B), and covered by a split-thickness skin graft (C).

D. INTERMEDIATE MANAGEMENT

1. Lower Eyelid Ectropion and Upper Eyelid Retraction

It is generally agreed that progressive contracture and recurrent cicatricial ectropion is the norm, necessitating repeated eyelid grafting during the early stages to protect the cornea and, subsequently, to relieve eyelid traction. This is considered one of the most important operations in the entire surgical rehabilitation of the facial burn and should be carried out before any other facial surgery.

The timing of deep eyelid burn debridement is controversial. Clinical priorities may mean burns elsewhere are treated first and there may little available skin graft in a large burn. In addition, good blood supply, redundant eyelid skin, and viable skin intermixed with deep burn may help avoid contracture in the first 2–3 weeks. The judicious use of dressings or allograft will also be of benefit.

In general therefore, eyelid burn debridement is performed at a later time compared to burns elsewhere. The timing of surgery is often dictated by the emergence of eyelid contracture or lagophthalmos with tissue destruction having become demarcated, often at 2–3 weeks post injury.

At the time of surgery it is important to release the eyelids as fully as possible. Again there is controversy in how this is managed. Huang recommends incision and release only suggesting that eschar need not be excised. It is suggested that this approach avoids damage to any viable orbicularis oculi. However, we and others consider escharctomy to viable tissue essential to prevent further contracture while also providing a healthy wound for skin graft take.

Early surgery has only been shown help reduce the risk of exposure keratopathy and no evidence exists to support the suggestion that it reduces the number of further eyelid procedures required in the long-term. Barrow et al. showed in their retrospective study of 57 children with third-degree eyelid burns, that early release and grafting of the upper and lower eyelids within 7 days of injury in 17 patients, resulted in 2 corneal ulcers compared to 25 ulcers in the 40 patients who underwent delayed releases (more than 7 days after injury). This latter figure is clearly higher than the incidence of corneal ulcers based on our experience and also that reported by other centers. The authors did not specify whether other measures including prophylactic ocular lubricants, for example, that have been shown to be of benefit in reducing ocular complications were used.

Release (with or without excision of eschar) and grafting should be delayed until lagophthalmos with
either symptoms or signs of corneal exposure, or conjunctival injection or chemosis, or failure to secure the eyelids closed with draw-string tarsorrhaphy sutures.

2. Incision and Technique for Eyelid Release and Grafting

Although it has been advocated that when grafting upper eyelid skin for indications other than eyelid burns (for example, post-blepharoplasty lagophthalmos) a subciliary upper eyelid skin incision be used so that the graft may be placed pretarsally,40 when grafting for post-burns contracture this is not usually possible or practical. An upper eyelid skin crease incision is used as the lower border of the graft.

A subciliary incision is recommended and is generally possible for the lower eyelid. For both upper and lower eyelids, dissection should be “canthus-to-canthus”49 and extend up to 2 cm beyond the lateral canthus, angulated very slightly upwards for lower eyelid incisions and well into the nose at the inner canthus (Fig. 4A).

The eyelid margin is stretched on a gray-line silk traction suture, often overlapping the eyelids as much as possible to account for future graft shrinkage. The anterior lamella is then recessed with layered dissection and wide release of contracture and any cicatrix excised until complete eyelid release is achieved. After release of all cicatrix with layered dissection, the resulting defect may be as large as 8 cm × 6 cm.32

A full-thickness graft is fashioned to fit the recipient bed. The graft is cleaned of subcutaneous tissue and is sutured into the recipient bed with 6/0 sutures using the technique of “epithelial outlay” so that the skin edges of the recipient bed overlap the graft, thus permitting the introduction of an excess of skin graft to compensate in part for subsequent contraction.11,32,39 A petrolatum gauze is placed over the graft and a bolster is tied in place, ensuring donor-recipient apposition. Eyelid margin traction sutures and pressure dressing are maintained for 5–7 days and then removed. Patients often look as though they are peering through what has traditionally been described as “port-holes” following this surgery, but are once again able to close their eyes and sleep in comfort (Fig. 4B).32

3. Full-thickness or Split-thickness Skin Grafting

Whether FTSG or split-thickness skin grafts (STSG) are ideal for eyelid burn reconstruction is a much-debated subject. Traditionally, STSG was recommended for upper and FTSG for lower eyelid grafting. One of the earliest proponents of this was Schofield,39 who reported a series of 144 patients treated from 1940–1950 at our institution. Burns were not excised unless the eschar did not separate and STSG (with no mention of thickness) were applied. The subsequent incidence of ectropion was

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Fig. 4. A: Lower eyelid release of burn contracture “canthus-to-canthus” extending well beyond lateral canthus and medially into the nose. B: Two weeks following upper and lower eyelid full-thickness grafts, “port-holes”. C: 1 year following initial skin grafting procedure and 3 months following revision medial canthus five-flap Z-plasty and repeat skin grafts. Hair transplantation to eyebrows as well as the use of eyebrow pencil has helped create eyebrows, and the patient is using camouflage make-up 4 weeks post upper lid anterior lamellar repositioning.
not stated; however, Schofield recommended (1) FTSG from unburned eyelids for either upper or lower eyelids, (2) post-auricular or supraclavicular FTSG for lower eyelid defects only (due to their “lack of suppleness rendering them unsuitable for use in the upper lid”), and (3) thin STSGs for the majority of upper or lower eyelids. The report indicates that 463 STSGs and only 14 FTSGs were used, with 14% excellent, 61% satisfactory and 25% fair (based on the author’s definition of excellent, satisfactory, or fair) results and concludes that thick STSG have no advantage over thin ones and therefore thick STSG were rarely used.

Sloan et al11 later reported 283 consecutive patients with facial burns over 8 years, 11% (32/283) of whom developed lower eyelid ectropion, requiring surgical correction using 24 FTSG and 32 STSG. Ectropion recurred in 11 patients, 25% (6) of the FTSG group and 16% (5) of the STSG group. Twelve patients (4%) developed upper eyelid ectropion requiring 14 STSG and 6 FTSG. Six of these failed with no data as to the nature of the failed graft. Without any further data to substantiate their conclusion, the authors advocated that FTSG were too bulky for the upper eyelid and stated their preference for 0.018- to 0.02-inch STSG.

Falvey et al14 later challenged this approach when they reported the use of postauricular and supraclavicular FTSG for upper and lower eyelid reconstruction and the use of STSG if these sites were burned. They reported FTSG to be “quite supple” in the upper eyelid with no impairment to eyelid mobility, with possibly a lower propensity for late contracture in comparison to STSG.

Parkash36 used FTSG from the prepuc to reconstruct ectropion in two patients (one acute and one reconstruction) with good results except for graft hyperpigmentation. This may result in unhappy patients and is not considered the site of choice for harvesting grafts to eyelid burns.126

Lille et al30 recently showed that FTSG to both upper and lower eyelids appear to reduce the incidence of ectropion in comparison to STSG, presumably due to less graft contraction. They also commented that upper eyelid FTSG gave an equivalent and possibly even better appearance and function in comparison to STSG. They reviewed the treatment of 50 eyelids in 18 patients, 10 of whom received FTSG and 8 STSG. Thirty percent of patients (3/10) receiving FTSG and 88% (7/8) who received STSG developed ectropion requiring repeat surgery. Full-thickness donor sites used included post-auricular, supra-clavicular, upper arm, chest, groin, and foot.

The present authors prefer to use post- or pre-auricular FTSG whenever possible. If this is not available, then supra-clavicular or, if necessary, inner arm or groin skin is used. It should be noted, however, that using full-thickness skin may stimulate hair growth in the skin graft, resulting in a less than acceptable aesthetic result (Figs. 4B and 4C).

The capacity of a skin graft to inhibit wound contraction is directly proportional to the amount of structurally intact dermal collagen present. It follows that, due to the presence of more dermis, FTSG subsequently contract less than STSG. Thin, but full-thickness skin grafts from unaffected areas are generally recommended for both upper and lower eyelid grafting as they contract less than STSG and do not appear to compromise mobility or appearance. However, in extensive burns, if viable skin is limited, then this is often reserved for later repair and STSG are used instead.28,29 During eyelid grafting, whether for upper or lower eyelids, full-thickness grafts from sites of thicker skin, for example the groin, require thinning, often effectively rendering them thick split-thickness grafts. It is also known that a FTSG contracts by at least a third, particularly so in the periocular region or in the presence of infection.43 It is therefore important to oversize any graft whether full- or split-thickness as these will invariably contract over time.

The issue of color-matching is particularly important if the entire face needs to be grafted. Under such circumstances the eyelid skin should be taken from the same area as the remainder of the face if at all possible.

4. Staging of Eyelid Grafting

If both upper and lower eyelids require grafting then in order to avoid insufficient skin being introduced to each, and therefore to maximize the stretched graft-bed for each eyelid, it is best to perform grafting at separate sessions. Some feel that the lower eyelids should be operated on first.32 We usually carry out lower eyelid grafting first (with the lower eyelids placed on traction and padded) followed by upper eyelid grafting, once again with traction, 5–7 days later. In bilateral surgery this may require both eyes to be closed for up to 2 weeks, but any concern with regards to infection or corneal ulceration (increased discharge or pain) should prompt removal of the pad or bolster to allow examination.

E. LONG-TERM MANAGEMENT

1. Lower Eyelid Sling

The use of lower eyelid fascial slings have been reported in correcting recalcitrant burn ectropion,12 utilizing either temporalis fascia or fascia lata. A strip of fascia can be passed, using either a Wright’s fascia needle or a suture loop in the pretarsal, sub-orbicularis plane. It is secured to the
medial canthal tendon and either to the lateral periosteum or the lateral orbital rim via a drilled-hole.\textsuperscript{50} We use this mainly in patients with facial palsy-lower eyelid ectropion, as this simply provides a vertical support and does not overcome contraction or tissue deficit, which requires release and tissue replacement, respectively.

2. Horizontal Eyelid Shortening

It seems logical that in the management of cicatricial ectropion, at the time of full-thickness skin grafting, horizontal eyelid tightening should be considered, but in the presence of severe eyelid burns causing progressive ischemic scarring, any further interruption of the marginal arcade vessels by wedge excision or a lateral tarsal strip procedure may increase the risk of eyelid necrosis. Infarct of the central tarsal plate following cantholysis in a patient has been described.\textsuperscript{18} It is therefore suggested that, if eyelid shortening is indeed required, then in the lower eyelid, this be carried out at the lateral canthus to avoid central eyelid necrosis perhaps in combination with a lateral tarsorrhaphy to supplement the blood supply via the upper eyelid tarsconjunctival flap.\textsuperscript{29} Lateral tarsal strip procedures in isolation should be carried out without removing skin. In fact, it is nearly always necessary to add further skin at the time.

3. Reconstructive Flaps in the Eyelid Region

Reconstructive flaps in the eyelid region in the treatment of burns contracture are limited because of the lack of normal adjacent skin.\textsuperscript{21,29} Although orbicularis oculi myocutaneous flaps have the advantage of additional support and possible lower eyelid suspension in the repair of lower eyelid burn- ectropion,\textsuperscript{24} they are obviously indicated only in the rare circumstance where the upper eyelid is unaffected and available for harvesting.

Severe full-thickness eyelid burns are notoriously difficult to reconstruct if the tarsal plate itself has been destroyed (Fig 2B), and reconstruction is challenging as the remaining eyelid tissue is often ischemic and scarred. The height and length need to be restored, and grafting of the posterior lamellae in isolation is inadequate as a result of the ischemic scarred tissue in the residual eyelid bed. At least one lamella, either anterior or posterior, requires a flap for a viable blood supply, and it is often our preferred practice to use flaps for posterior lamellae—for example a forehead periosteal flap for the posterior lamella—if a Hughes flap is not possible. Another potential source of vascularized tissue may be an island pedicle flap, and a free-flap for total eyelid reconstruction following deep facial burn has also been reported.\textsuperscript{48}

4. Trichiasis

Trichiasis commonly occurs after eyelid malposition is corrected. It is often noted at the time of correcting long-standing or tarsal ectropion and if present, should be initially managed at the time of ectropion surgery with epilation. Repeat epilation and focal electrolysis is often required. Fine hair can recur despite repeat epilation and electrolysis. Under such circumstances, cryotherapy may be considered.

5. Medial and Lateral Canthal Deformities

Eyelid burns associated with deep nasal burns often give rise to severe webbing of the medial canthus with hypertrophic folds with vertical contracture. This may even result in forward displacement of the punctum, causing epiphora.\textsuperscript{1,28,49} Multiple Z-plasties may be useful in correcting linear contractions if the wounds are relatively soft and not densely scarred (Fig. 5, A–E).

Otherwise, better results have been reported by excising the scar web, releasing the canthus, and replacing the defect with an FTSG.\textsuperscript{1,48} Local transposition flaps have also been described to correct scar bands at the lateral canthus (Fig. 6, A–D).\textsuperscript{1,47}

6. Palpebral Aperture Stenosis

Cicatricial eyelid margin adhesion, exaggerated by scar contracture, is thought to be the reason for stenotic palpebral apertures occasionally seen in patients following full-thickness eyelid burns. Spherical contraction causes the typical “port-hole” deformity that is also seen following extensive eyelid grafting for contracture and lagophthalmos.\textsuperscript{32} Before any attempt is made to widen the palpebral aperture, all upper and lower eyelid tissue deficit should be corrected. A simple incisional release is usually adequate and should include the entire horizontal aperture length in order to reposition the medial canthus.\textsuperscript{19} This should be avoided if eyelid vascularity is a concern as infarction of the central eyelid following cantholysis in a patient with a severe eyelid burn has been described.\textsuperscript{18}

7. Eyebrow Deformities

Loss of eyebrow hair can vary from partial to complete alopecia, depending on the depth of the burn. McIndoe\textsuperscript{32} advocated the use of a full-thickness composite skin graft of hair-bearing skin from the temporo-parietal region (due to the thinness of the skin in this region compared to hair-bearing skin elsewhere) from each side so that hair would grow naturally and in the correct direction. Composite hair-bearing scalp grafts require optimum conditions for complete take. In
order for them to undergo satisfactory vascularisation in a recipient site already scarred, they should be narrow, not exceeding 5 mm. An alternative may be to use 1-mm strips in a staged manner.19,49 The graft should be cautiously thinned so as not to damage the hair follicles, placed on a dry bed, and kept under a pressure-dressing for a week. It is said the hair tends to fall out in 3 weeks but returns in 3 months, with 60–70% of the follicles surviving.32 Partial failure often occurs, resulting in hairless areas, either within or at the edge of the graft and, in one series, hair loss was an issue in 5 out of 10 patients, requiring re-grafting in 3 cases.41

The use of temporal pedicle-flaps, although discouraged by some as being too heavy and time-consuming,32 is advocated by others as offering a better cosmetic result than free grafts.19,31,49 An appropriate branch of the superficial temporal artery is traced on the scalp and the flap outlined, ensuring the direction of hair is similar to the brow hair. A subcutaneous pedicle including temporal artery and vein (along with some soft tissue), obtained through a single incision extending from the pre-auricular area to the edge of the proposed graft. This is then placed on the recipient site prepared with a single brow incision in the desired location. The eyebrow should be placed more medially, anticipating subsequent contraction that often pulls the graft laterally. Venous congestion during the first 36 hours postoperatively is treated by head elevation, frequent “milking” or rolling of the graft with a cotton-tipped applicator, and possibly removal of sutures at the recipient site to facilitate drainage.19,31

One of the authors (RM) has used a skin transposition flap to reconstruct a post-burn eyebrow defect. Closure of the secondary defect helps placement of the hair-bearing flap into the recipient bed without tension. The procedure was carried out for a patient while on an overseas visit to a rural hospital in India, and long-term follow-up was not possible (Fig. 7).

Recent advances in micrograft techniques of hair transplantation have had some success and said to produce a natural eyebrow profile that compares favorably with traditional techniques. However the technique is time consuming and may require repeated procedures.10,16,53

The patient’s gender also influences the choice of procedure. In female patients, in particular, make-up and an eyebrow pencil can camouflage a missing eyebrow, especially in the lateral-half of the brow (Fig 4C). In men, who require a thick bushy eyebrow, a flap procedure may be preferable.19,49

**Fig. 5.** Five-flap Z-plasty to correct medial canthus deformity.
8. Canalicular Obstruction

Lacrimal damage following eyelid burns is rare; however, burns around the medial canthus may involve the puncta and canaliculi. In a study of 283 facial burns, 52 (2%) had significant adenexal deformities, of which symptomatic punctal and canalicular obstruction was found in one case (2%).

Meyer et al. reported early punctal dilation, punctoplasty, one-snip canaliculoplasty, and intubation within 5 days of injury in seven patients. Based on their experience the authors recommended early punctal probing with re-evaluation every 1–2 days, with the fluorescein dye disappearance test and repeat punctal dilation if necessary during the first 10 days of injury. One of these procedures was advised if the puncta cannot be identified or the canaliculi not easily probed. This is clearly an intensive regime, particularly in the setting of a burns unit. Furthermore, it remains uncertain as to the incidence of asymptomatic punctal or canalicular stenosis, in the presence of a severe ocular surface injury and dry eye may in fact be of benefit in reducing tear outflow.

9. Scar Control

In areas where dermis was lost, the skin is thinner than normal and never regains normal durability and texture. Increased redness and palpable thickening of skin are signs of hypertrophic scars. Scar contracture can lead to late deformity. This contracture may arise from skin grafts, scars directly related to the eyelids, or more commonly from adjacent tissues such as the cheek or forehead.

Control of scarring directly around the eyelids can be difficult and require intralesional steroid injection. Adjacent tissues may be better controlled by the use of compression techniques. Currently, pressure garments and rigid orthoses are commonly used to provide a pressure effect on scarred tissue.

![Fig. 6. Transposition flap to correct lateral canthus webbing.](image-url)
Pressure is an effective way of reducing scar hypertrophy and subsequent scar contracture and can be used in conjunction with intralesional steroid injection. In our opinion a rigid orthosis can provide a more consistent and evenly spread pressure to the affected areas; however, we acknowledge that very little evidence exists in the form of randomized trials to support the use of either rigid orthosis or intralesional steroid.

10. Burn Scar Malignancy
The development of carcinomas within burn scars is well described and usually follows delayed healing with prolonged wound ulceration or irritation. Although squamous cell carcinoma (SCC) represents 90% of burn scar malignancies in the head and neck region and extremities, Pratt et al.37 reviewed the literature regarding eyelid cases and reported eight basal cell carcinomas (BCC) arising within 2 years of injury, often from burn wounds that never healed. In these cases, the initial burn was often brief, superficial, and isolated to a small area. This is in contrast to the more extensive tissue damage associated with SCC developing within burn scars elsewhere. Furthermore it also remains uncertain as to whether sun exposure may have been a significant co-existing predisposing risk factor for eyelid BCC in these patients.

VI. Conclusion
Eyelid involvement is common in facial burns. Most ocular sequelae, including corneal ulceration, are thought to be preventable. Prompt ophthalmic consultation and prophylactic ocular lubrication are mandatory in burns involving the eyelids. Early surgical intervention, often requiring repeat procedures, is indicated if eyelid retraction causing corneal exposure occurs. There are no hard and fast rules regarding the tissue used for eyelid reconstruction, and each case needs an individual approach based on what skin is available.

VII. Method of Literature Search
Literature search was based on a Medline search with Pubmed (Embase, ophthalmic literature) including the keywords thermal eyelid burn, eyelid burn, burns of ocular adenexae, masquerade procedure, eyelid grafting, lagophthalmos, tarsorrhaphy. There was limitation by date from 1940 to 2006. Articles were restricted to those in English and other-language publications with English abstracts. References within these articles were also obtained for review.

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