Techniques of Upper Eyelid Reconstruction

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Abstract. Reconstruction of the upper eyelid is one of the greatest challenges facing the orbitofacial surgeon. This comprehensive review outlines the principles of reconstruction and the range of techniques available. Methods of assessing upper eyelid defects are discussed, and an algorithm for reconstruction based on defect size and lamellar involvement is given. The review contains numerous detailed examples of reconstructive techniques, including secondary intention healing, local flaps, distal flaps, simple and composite grafts, occlusive and non-occlusive methods, and canthal fixation. Eyebrow and eyelash reconstruction is also covered. (Surv Ophthalmol 55:256–271, 2010. © 2010 Elsevier Inc. All rights reserved.)

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Upper eyelid defects are caused by trauma, tumor excision, or, occasionally, congenital colobomas. Reconstruction of such defects poses a significant challenge to orbitofacial surgeons as a result of the highly specialized function of the upper eyelid that must be restored. Ideally, any reconstruction must allow the eyelid to protect the ocular surface by apposing a mucosal surface to it; the eyelid must be mobile, however, so it can wipe the cornea and refresh the tear film and clear the visual axis. It must also have a stable eyelid margin that prevents stratified squamous epithelium, lashes, or hairs from abrading the cornea. Finally, as the upper eyelid forms one of the most significant landmarks of the human face; there should be an acceptable cosmetic appearance in relation to the other eye, with regards to symmetry of eyelid height, contour, tarsal show, and skin fold.

These features make upper eyelid reconstruction far more complex than that of the lower eyelid. For example, a stiff, immobile eyelid, although tolerable in the lower eyelid, fails to meet the functional requirements of the upper eyelid. Similarly, full-thickness suture material or tissues without mucosal lining can both be used in lower eyelid reconstruction, but may cause corneal complications in the upper eyelid.
Basic Principles

Upper eyelid reconstruction can be simplified by adhering to a few basic principles. First is the concept of lamellar reconstruction. The tarsal upper eyelid is divided into two lamellae and the septal upper eyelid into three. Both have an anterior lamella consisting of skin and orbicularis muscle and a posterior lamella consisting of mucosa. In the tarsal region this posterior lamella also contains tarsus. In the septal region there is an additional middle lamella between the anterior and posterior ones that consists of septum, fat, and upper eyelid retractors.

Each tissue has its specific function. Thus, the mucosa protects the underlying cornea, the tarsus offers stability to the eyelid, the orbicularis enables eyelid closure, the loose preseptal skin allows mobility, the tight pretarsal skin and lid margin prevent occlusion or irritation of the cornea by preseptal skin, and the fat acts as a lubricant over the upper lid retractors. Any upper eyelid reconstruction must endeavor to restore these layers, replacing “like-for-like” tissues, each with their differing properties. This also applies to the pretarsal and preseptal units of the upper eyelid, whose different functional and esthetic properties should be respected. Finally, one must adhere to the basic principles relating to the viability of flaps and grafts. These dictate that a graft can be laid on a flap, and vice versa, but a flap cannot be laid on a flap because of the lack of a secure blood supply. The last can only be circumvented by the use of a “sandwich flap” in between the two grafts.17,58,65

Assessment of the Defect

Thorough assessment of the defect is essential for effective upper eyelid reconstruction. The horizontal and vertical extent of the lesion should be measured and photographed. The amount of tissue required for reconstruction is then determined by placing the medial and lateral wound edges under gentle tension to demonstrate the reduced defect size. Careful assessment must also be made of the lamellar planes and functional units involved to enable “like-for-like” replacement of tissue. Particular attention must be made to the configuration and amount of residual tarsus, as this will have a pivotal influence on the type of reconstruction performed. Finally, the presence or absence of structures for canthal fixation must be noted. Based on this information, the appropriate reconstruction technique can be selected. A simple guide is given in Fig. 1, but it is obviously influenced by the patient’s exact circumstances and desires.

Isolated Anterior Lamellar Defects

The upper eyelid skin is both the thinnest skin of the body and is hairless. These properties are important as they allow rapid eyelid movement while preventing mechanical ptosis, corneal irritation, or impaired vision from a heavy upper eyelid with long upper eyelid hairs. It is therefore essential to try and match “like-for-like” when reconstructing the anterior lamella.

HEALING BY SECONDARY INTENTION

Small, isolated anterior lamellar defects in the pretarsal and medial canthal areas may be left alone to heal. The tarsus offers a good scaffold for epithelialization and prevents contraction of the wound, giving a good result, and the concavity and bony support of the medial canthus perform a similar role. In addition, skin grafts and flaps to the medial canthus often have a poor aesthetic outcome. Laissez-faire can be especially useful in patients who are post-radiotherapy or have primary skin precancerous conditions, such as xeroderma pigmentosa, in which skin may be of poor quality. Similarly it can be used in patients with ill-health who would not tolerate further surgery.12,48,73,95

LOCAL SKIN FLAPS

Most other upper eyelid anterior lamellar defects will require the use of a skin flap or graft. Where possible, flaps offer the best outcome because of their identical tissue match and minimal contraction. Small preseptal skin defects are ideally closed by local skin flaps, either taken from adjacent horizontal or superior skin, with adequate undermining. Such flaps should respect the skin crease as far as possible, as this greatly improves cosmesis. Advancement flaps are therefore commonly used in the upper eyelid, as one of the borders can be made to coincide with the crease (Fig. 2, images 1–4). A novel alternative for medial skin loss is the hinged blepharoplasty flap, commonly used for reconstruction following excision of large xanthelasma.84 This involves creation of a skin flap with classic skin crease and lateral blepharoplasty incisions, the latter acting as an effective “back-cut” to allow medial advancement of the flap into the defect (Fig. 2, images 5 and 6; and Fig. 4, images 1 and 2).
SKIN GRAFTS

Unfortunately, the amount of upper eyelid skin available for mobilization into a flap is limited because it changes into thick, hair-bearing skin at the orbital rim. Larger isolated anterior lamellar defects therefore do better with a skin graft. Where possible, full-thickness skin is superior, offering the best aesthetic result with least contracture, as well as increased convenience and less donor-site morbidity. The best match for thin upper eyelid skin is the contralateral upper eyelid, although alternatives include the hairless skin of the pre- and postauricular area, the supraclavicular fossa, or the inner upper arm. Only in rare circumstances, such as burns, are alternative sources or partial thickness (split skin) grafts necessary. In all cases, the grafts should be cleared of any subcutaneous fat prior to placement.

As a general principle, skin grafts are best placed pretarsally and are the authors’ preferred option for predominant pretarsal anterior lamellar defects. This may involve undermining any existing pretarsal skin as a flap, moving it preseptally and inserting the graft on the exposed tarsus. In doing so, care must be taken not to elevate the natural skin crease, which is formed at the highest point of attachment between the levator aponeurosis fibers and the skin–orbicularis complex. This is best achieved by extensive superior undermining of the mobilized skin so as to clear any such attachments.

The tarsus offers a stable bed for the graft, reducing contraction and improving cosmesis. In such situations, the graft does not have to be oversized and should be placed at the supraciliary, rather than skin-crease site, of the pretarsal upper eyelid. A skin fold tends to form at the upper border of an upper eyelid skin graft, and this is least conspicuous when it coincides with the natural upper eyelid skin crease. If pretarsal placement is not possible, care must be taken to respect the tarsal/septal boundary and avoid crossing this with a single skin graft. If both subunits are involved, it is often advisable to make a skin crease incision and treat the two defects separately, undermining the borders of each independently. Where preseptal skin is needed, the graft should be oversized by 30% to anticipate contracture and avoid lagophthalmos.

The underlying orbicularis provides an excellent vascular bed for the graft and, if it is absent, muscle should be moved in from around the defect. However, its constant shearing forces in the preseptal area can inhibit vascularization of the base of

![Fig. 1. Schematic overview of the management of upper eyelid reconstruction.](image-url)
the graft. As such, the graft should be immobilized as much as possible during the first week, using a firm pressure dressing or even tie-over bolsters. Quilting sutures may aid graft adhesion, and the graft may also be fenestrated to prevent hematoma formation. Placement of a Frost-type traction suture in the upper eyelid margin, taped to the lower cheek, also helps to immobilize the upper lid and serves to stretch the bed of the graft. This improves graft apposition and reduces premature contraction. It is important to remember that any immediate post-operative ptosis will resolve with subsequent contraction of the tissues and is preferable to recalcitrant eyelid retraction.

Host site complications of periocular full-thickness skin grafts have been reported to occur in approximately 15% of cases. Graft hypertrophy, partial graft failure and graft contraction, potentially leading to retraction or ectropion, are the most likely problems. Management options for such complications are outside the scope of this review but include ocular lubricants, eyelid massage, intrallesional steroid injection, dermabrasion, and laser resurfacing.
CUTANEOMARGINAL GRAFTS

Anterior lamellar defects involving a minimal amount of eyelid margin can either be converted to a full-thickness defect and closed directly (see subsequent discussion) or be repaired with a cutaneomarginal composite graft. This technique is particularly useful for lateral defects for which direct closure can be difficult. The graft is harvested as a pentagon wedge excised from one of the other eyelids, usually from the lateral aspect, and the donor site is closed directly. The cutaneomarginal graft is then fashioned from the wedge by excising the tarsal plate and orbicularis to leave only the eyelid margin and skin (Fig. 5, images 4, 5, 7). This composite graft is positioned in the upper eyelid defect and secured in a bi-lamellar fashion. One advantage of this technique is the preservation of a stable eyelid margin, which reduces both corneal irritation and the redness often seen in reconstructed eyelid margins. Significant lash loss is reported to occur in the grafted tissue.

Posterior Lamellar (Full-thickness) Defects

Most frequently upper eyelid defects are full-thickness, involving both anterior and posterior...
lamellae. In general, a hierarchical approach to reconstruction is used, based on the size of the reduced defect.

**SMALL DEFECTS (LESS THAN ONE-THIRD OF EYELID LENGTH)**

**Direct Closure**

For defects up to one-third of the horizontal length of the eyelid, direct closure is preferable. This may require excision of a small superior residual bridge of tarsus to allow both sections of the otherwise divided tarsus to be opposed. Direct closure can be augmented with a lateral canthotomy and superior cantholysis if necessary. As in any eyelid margin repair, care must be taken to ensure correct alignment of opposing edges by using the meibomian orifices, gray line, and lash line as a guide. A vertical mattress suture, placed along the gray line or meibomian orifices, helps to evert the edges and avoid notching. This can be placed as a buried absorbable suture. Tarsal sutures should be checked to avoid full-thickness bites, and the knots should be placed anteriorly to avoid corneal abrasions. Pull-through non-absorbable sutures may also be used for the tarsus, with the advantage of producing minimal reaction in the healing phase and allowing suture removal at a desired time after surgery.

When repairing these full thickness defects, it is important to respect the preseptal and pretarsal subunits for a good aesthetic outcome. As such we recommend making a skin crease incision to separate the septal and tarsal sections of the lid. This allows the septum and superior attachments of the levator to remain intact. The tarsal portion of

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Fig. 4. Composite of line drawings illustrating techniques used in upper eyelid reconstruction. 1-2 = Hinged upper eyelid blepharoplasty flap [1 = left medial upper eyelid anterior lamellar defect with flap marked; 2 = flap advanced medially, inferior border trimmed and flap secured in position]. 3-4 = Inverse Tenzel myocutaneous advancement flap with direct closure [3 = left full thickness upper eyelid defect with inverse Tenzel flap incised; 4 = direct closure of central eyelid defect, reformation of lateral canthus, and closure of flap donor site]. 5-6 = Inverse McGregor myocutaneous advancement flap with direct closure [5 = left full thickness upper eyelid defect with inverse McGregor flap marked out; 6 = Z plasty flaps reversed and secured into position. Lid closed directly]. 7-8 = V-Y myocutaneous advancement flap with direct closure [7 = left full thickness upper eyelid defect with V flap incised. The superior border is in line with the skin crease and the flap is mobilized on a superiorly-based orbicularis pedicle; 8 = medial transposition of flap with closure of lateral border in a Y formation. Central upper eyelid closed directly]. 9-12 = Advancement tarsoconjunctival flap [9 = central upper eyelid full thickness defect involving the eyelid margin but with residual superior tarsus; 10 = residual central tarsus mobilized caudally on a conjunctival fornix-based pedicle after freeing of the upper eyelid retractors; 11 = tarsus secured to edges of defect; 12 = reconstruction of the anterior lamella using a full thickness skin graft]. 13-16 = Sliding tarsoconjunctival flap [13 = lateral full thickness upper eyelid defect with residual medial and central tarsus; 14 = oblique incision through residual tarsus with freeing of the upper eyelid retractors; 15 = sliding of superior residual tarsus laterally to close defect; 16 = trimming of prominent tarsus to reform lid margin].
the lid is then closed directly and the skin crease reformed (Fig. 2, images 7 and 8).

MEDIUM-SIZED DEFECTS (ONE-THIRD TO ONE-HALF OF EYELID LENGTH)

Direct Closure under Tension

Direct closure has also been described for defects up to one-half of the length of the eyelid. These produce significant tension and result in eyelid lengthening through the phenomena of mechanical and biological creep. Wound dehiscence and secondary mechanical ptosis, however, are a concern when using this technique for upper eyelid repair. It is therefore perhaps preferable to recruit additional tissue when closing defects greater than one-third of the horizontal length of the eyelid.

Direct Closure with Lateral Myocutaneous Flaps

Defects up to half of the eyelid length have good residual tarsus, so a local myocutaneous flap, without any additional stiffener, can be used to augment the length of the upper eyelid. The conjunctiva from the lateral fornix migrates to give this transposed skin–muscle flap its posterior mucosal layer. Such skin–muscle tissue is best recruited from the lateral canthal and zygomatic area, following superior lateral canthal release and subsequent advancement. This will involve division of

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Fig. 5. Composite of line drawings illustrating techniques used in upper eyelid reconstruction. 1–3 = Free tarsal graft from contralateral upper eyelid [1 = harvesting graft from contralateral superior upper eyelid tarsus, ensuring that a 4-mm strip of tarsus is left along the lid margin; 2 = tarsal graft placed in upper eyelid defect; 3 = graft secured to residual medial and lateral tarsal edges]. 4–7 = Composite grafting [4 = pentagon wedge harvested from medial or lateral upper eyelid; 5 = dissection of wedge to leave solely the eyelid margin and tarsocconjunctival surface (tarsomarginal graft, medial) or the eyelid margin and skin (cutaneomarginal graft, lateral). The area highlighted in gray is that which is excised; 6 = tarsomarginal graft; 7 = cutaneomarginal graft]. 8–11 = Cutler-Beard flap [8 = extensive full thickness upper eyelid defect; 9 = full thickness inferiorly based pedicled flap of lower eyelid tissue mobilized 4-mm beneath lower eyelid margin; 10 = flap passed beneath residual "bridge" of lower eyelid tissue and secured into the upper eyelid defect; 11 = flap divided after 4–8 weeks to form new upper eyelid margin and base of flap secured back into the lower eyelid defect]. 12–15 = Lid switch flap [12 = extensive full thickness upper eyelid defect with full thickness, pedicled flap of lower eyelid; 13 = flap secured in upper eyelid by bi-lamellar direct closure, leaving pedicle connected; 14 = division of flap after 2–4 weeks; 15 = repair of lower eyelid defect with secondary reconstructive procedure (e.g., Tenzel flap)].
the conjunctiva and attachments of the superior orbital septum. Care should be taken to avoid damaging the lacrimal gland and its secretory ductules.

The most commonly used flap is the inverted semicircular “Tenzel” flap that follows the downward curve of the lateral eyelid towards the orbital rim and then gently curves upward (Fig. 2, images 9 and 10; Fig. 4, images 3 and 4). It should not be curved too steeply as this can lead to a retracted lateral eyelid when the flap is positioned. The flap is elevated in a suborbicularis plane up to the orbital rim and subcutaneously beyond this so as to avoid the zygomatic branches of the facial nerve. If further translation of the flap is required, the flap can be further extended and a back-cut can be utilized (Fig. 2, images 11 and 12; Fig. 4, images 5 and 6). The resultant angled posterior edge of the flap can then be placed in a superior relieving incision, extending from the original flap line. Once the wound edges can be apposed with minimal tension, the flap is secured by its deep tissues to the periosteum of the lateral orbital rim. This important step prevents the flap from sagging under its own weight, exacerbated by the temporary loss of muscle tone. The primary full-thickness eyelid defect is then closed directly, and the lateral canthus is reformed with a buried absorbable suture. The marginal edge of the flap need not be sutured to the mobilized conjunctiva.

An alternative lateral myocutaneous flap is the V-Y flap. Here, the upper margin of the flap is placed in the line of the superior eyelid skin crease, extending laterally, and the lower margin in a lateral canthal wrinkle which meets it. The flap extends to the edge of the upper eyelid defect and contains any residual lateral tarsus and conjunctiva. The lateral upper eyelid is released and the skin and muscle freed along the incision lines. This allows the flap to be mobilized medially on a pedicle of orbicularis arising beyond the orbital rim.

**Composite Grafts**

A composite free graft containing conjunctiva, tarsus, and eyelid margin skin may also be used to repair a medium sized full-thickness defect. Full-thickness composite eyelid grafting was first described by Callahan and Fox, but resulted in poor tissue viability because neither the anterior or posterior lamellae had sufficient vascularity.

A viable alternative was later proposed in the form of the tarsomarginal graft which contained the lid margin and adjacent tarsus only, and which required a vascularized anterior lamella. Cutanemarginal grafts, discussed earlier, are based on a similar concept.

A tarsomarginal graft is typically harvested as a full-thickness wedge from the contralateral upper eyelid. In general, a temporal eyelid defect is reconstructed with a graft taken from the nasal aspect of the contralateral eyelid, and vice versa, to give the best match in tarsal contour. The wedge is dissected to leave solely the eyelid margin and tarsococonjunctival surface, which is then secured into the upper eyelid defect and covered with a local anterior lamellar flap (Fig. 5, images 4–6). It is recommended that tarsomarginal grafts be used for defects only up to a maximum of one-half of the relaxed eyelid length to ensure direct closure of the donor site. Tarsomarginal grafts may also be harvested from the lower eyelids, particularly where there is significant lower eyelid laxity. As for cutanemarginal grafts, the presence of a formed eyelid margin reduces corneal irritation from lanugo hairs and also prevents eyelid margin conjunctivalization. Cosmetic results of tarsomarginal grafts are highly acceptable to patients. They are often ideal for lateral defects because of their potential for providing eyelashes, even though only 20% are expected to survive.

Viable composite grafting has also been described using a flap of vascularized orbicularis placed in between the anterior and posterior lamella of the graft. This converts it into a sandwich flap (see later) and provides adequate vascularity to the composite.

**LARGE DEFECTS (OVER ONE-HALF OF EYELID LENGTH) WITH RESIDUAL TARSUS**

**Local Tarsoconjunctival Flaps**

Defects over 50% of the horizontal length of the eyelid must be carefully examined to determine the amount of residual tarsus. Eyelid eversion is therefore mandatory (Fig. 2, images 13 and 14). The upper eyelid requires 4 mm of tarsus along the eyelid margin to ensure stability. This allows us to recruit any excess superior tarsus beyond 4 mm into a defect. Where possible, this tarsus should be mobilized in the form of a conjunctival fornix-based pedicled flap, allowing the anterior lamella to be reconstructed using a free skin graft. Depending on the configuration of the defect, a variety of local flaps can be devised. Central defects involving the inferior tarsus and eyelid margin are easily closed using an advancement tarsoconjunctival flap, raised from the residual central superior tarsus. Ideally, this should be 3–4 mm high to ensure resultant eyelid margin stability. Vertical incisions are made superiorly from the edges of the defect up through the residual tarsus and conjunctiva, and the...
flap is freed from the overlying upper eyelid retractors (levator and Müller’s muscle) in a similar fashion to harvesting a Hughes flap. The flap is then advanced to the eyelid margin on its conjunctival pedicle, where it is secured to the remaining medial and lateral tarsal edges (Fig. 2, images 13–16; Fig. 4, images 9–12).

Tarsocconjunctival flaps can also be fashioned using transposition, horizontal advancement, and sliding techniques. The latter involves making an oblique incision from one margin of the defect superiorly through the remaining tarsus, extended into the upper eyelid retractors. The superior flap is then freed from levator and Müller’s muscle and is slid obliquely towards the defect on its conjunctival pedicle. It is secured to the remaining medial and lateral tarsal edges with an absorbable suture (6-0 vicryl). Any excess tarsus protruding below the newly reconstructed eyelid margin is excised (Fig. 3, images 1–4; Fig. 4, images 13–16). Transposed tarsal flaps are harvested as vertical strips of tarsus and rotated through 90° on their pedicle.

In all of these cases, where the posterior lamella has been reconstructed using a local tarsal flap, the anterior lamella may be reconstructed with either a skin graft or local skin–muscle flap. As the anterior lamellar defects may be large, local skin flaps run the risk of leaving the upper eyelid with a shortage of skin, resulting in lagophthalmos. Larger, more distal pedicled flaps are a poor skin match as the result of the thickness of the peri-orbital skin, which results in a bulky immobile eyelid. Consequently, skin grafts are preferred in this situation, particularly if the anterior lamellar defect is predominantly pretarsal.

Complete Upper Eyelid Defects

In more extensive defects of the upper eyelid there is insufficient eyelid tissue for local advancement flaps of either the anterior or posterior lamella. Traditional approaches therefore required at least one lamella to be obtained from outside the affected upper eyelid area as a distal pedicled flap. The ipsilateral lower eyelid was the preferred source for such flaps and is the only option for a posterior lamellar flap. Such eyelid sharing, or bridging, techniques involve occlusion of the eyelid until the pedicle of the flap is divided. We, however, prefer non-bridging, non-occlusive techniques. These frequently involve the use of posterior lamellar grafts in combination with orbicularis mobilization and an anterior lamella graft.

Bridging (Occlusive) Eyelid-sharing Techniques

Eyelid-sharing techniques involve mobilizing tissue layers in a composite manner from the ipsilateral lower eyelid into the upper eyelid defect. The pedicle of the flap can be inferiorly, laterally, or medially based. A second stage is required to divide the flap and restore the palpebral aperture and eyelids.

Inferior Pedicle

The classic eyelid sharing procedure is the Cutler-Beard flap (“bridge flap”) described in 1955. The principle of this is to bring full-thickness lower eyelid tissue, harvested from 4 mm below the lower eyelid margin, underneath this remaining “bridge” of tissue and over the cornea to fill the upper eyelid defect (Fig. 3, image 7). By commencing the flap 4 mm below the eyelid margin, the vascular supply to the margin is preserved. Conjunctiva remains in contact with the cornea throughout, avoiding keratopathy. The full-thickness flap is traditionally divided 4–8 weeks after surgery at the level of the newly reconstructed upper eyelid margin. The pedicle slides back and is sutured to the distal border of the bridge (Fig. 3, images 5–8; Fig. 5, images 8–11). Although the Cutler-Beard flap does have good donor–recipient skin match, it has several limitations. These include prolonged occlusion of one eye, persistent lower eyelid instability (due to disruption of the lower eyelid retractors, scarring, and unaddressed lower eyelid laxity), and upper eyelid entropion (due to a lack of upper eyelid rigidity). Several modifications have therefore been made to the Cutler-Beard procedure to address these problems, including the implantation of a stiffener such as donor sclera, ear cartilage, and Achilles tendon between the skin–muscle layer and the septoconjunctival layer of the lower eyelid. Other authors have suggested including the distal border of the lower tarsus in the advancement flap. However, this can threaten the marginal artery, which runs 1.8–3.4 mm distal to the lower eyelid border, and can also further destabilize the lower eyelid.

An alternative approach has been to raise flaps of only anterior or posterior lamellae from the lower eyelid and to use a free graft to reconstruct the other lamella. Tarsocconjunctival flaps can be raised from the lower eyelid as a reverse of the upper eyelid modified Hughes procedure. In this case, however, the incision is made 1.5–2 mm from the lower eyelid margin to compensate for the shorter height of the lower eyelid tarsus. Once again, care must be taken to avoid the marginal artery. Alternatively, a free tarsal graft may be used for the posterior lamella and only the skin-muscle component of the lower eyelid flap advanced as a vascularised anterior lamella flap (Fig. 3, images 5–8). In this situation, the flap may be brought anteriorly
over the marginal eyelid and lashes, thus preserving the lower eyelid retractors and minimizing post-operative lower eyelid complications. However, this does leave the cornea potentially exposed to the undersurface of a muscular flap, which tends to slough and keratinize if left undivided. Earlier flap division at 2 weeks is widely advocated with these single lamella techniques.32

Medial/Lateral Pedicle

The Mustarde “lid switch” procedure, based on the Abbe-flap for lip reconstruction, is another full-thickness lower eyelid flap, but one that is based on a medial or lateral pedicle.57,79 It is a transposition flap as opposed to an advancement flap. The traditional flap is at least 4 mm wide, to incorporate the marginal arcade, and is one-half to two-thirds of the length of the upper eyelid defect, to leave the eyelid under some tension and to allow for stretching of the flap. The pedicle of the flap is placed on the same side as any residual upper eyelid tissue. If the defect is central, then the pedicle is based laterally to allow more prompt return of lymphatic drainage. The flap is secured in the upper eyelid by bi-lamellar direct closure, leaving the pedicle connected. The flap is usually divided after 2 to 4 weeks, and the recipient site closed directly. The lower eyelid defect is then repaired by a secondary reconstructive procedure (Fig. 5, images 12–15). Often this involves a lateral cantholysis and myocutaneous advancement flap, such as a Tenzol or cheek rotation flap, but it may be closed directly or even left to heal.

As tarsus is included in the switch flap, the reconstructed upper eyelid has more stability than that in the classic Cutler-Beard procedure. In addition, the upper eyelid margin is intact, including lashes. Disadvantages of the switch flap include the potential irritation of the cornea by the pedicle, the need for full-thickness lower eyelid reconstruction, and potentially poor cosmesis of the lower eyelid and lateral canthus. As with all eyelid-sharing bridging procedures, the patient has to endure occlusion of the visual axis for a few weeks, which may not be practical in all cases.

The two lamellae harvested in a switch flap do not necessarily have to be of the same size. This can be useful for upper eyelid defects with differing lamellar defects or to preserve additional posterior lamella and eyelid margin in the lower eyelid. Donor site closure also respects these two lamellae, such that frequently the small lower eyelid posterior lamellar defect is closed directly and the larger anterior lamellar defect requires a flap or graft. Such a “split lamella switch flap” can permit primary closure of the lower eyelid at the time of flap harvesting, reducing morbidity.39

Bipedicled lower eyelid anterior lamellar (Tripier) flaps have also been reported with buccal mucous membrane lining.87 However, the lack of tissue to replace tarsus results in a lack of rigidity in the reconstructed upper eyelid, making it prone to entropion.

Non-bridging, Non-occlusive Techniques

If occluding the eye with a lower eyelid flap is to be avoided, vascularized tissue must be recruited from the peri-ocular region to support both lamellae. This may be in the form of an anterior lamellar flap in conjunction with a posterior lamellar graft or bi-lamellar grafts supported by orbicularis mobilization (“sandwich flap”).17,58,65 Autologous grafts for upper eyelid posterior lamellar reconstruction include tarsoconjunctiva,77,80 hard palate chondromucosa,11,76 and nasal chondromucosa.7 Buccal mucous membrane is another alternative, although this lacks rigidity.56

Tarsoconjunctival Grafts

Contralateral upper eyelid tarsoconjunctival grafts provide the most similar tissue. In the donor eyelid, the marginal 4 mm of tarsus is spared to preserve the marginal vessels and to retain the donor eyelid’s marginal stability. The necessary width of tarsus is marked out, based on the reduced defect size, with a further 2 mm subtracted to avoid eyelid laxity following reconstruction. The graft is outlined using a scalpel blade, elevated, and dissected free of the overlying tissues. It is then freed of Müller’s muscle and levator attachments. The free graft is placed in the defect and secured to the remaining tarsus or medial and lateral canthal tendons. (Fig. 3, images 5 and 6; Fig. 5, images 1–3). Disadvantages of free tarsoconjunctival grafts include alterations to the donor eyelid, as well as the burning of “reconstructive bridges” by using all the remaining contralateral tarsoconjunctiva available for harvesting.28,66 A recent large prospective study suggests that donor site morbidity is minimal, being limited to mild contour peaking (2%), lash ptosis (4%), donor site infection (1%), transient discomfort (4%), and future unpredictability of surgery to alter eyelid height.32

Tarsoconjunctival Substitutes

Where there is concern about operating on another eyelid, hard palate mucoperiosteum provides a suitable substitute for the posterior lamella, as it contains similar fibrous and mucosal elements to tarsus.30 It is harvested from the area between the
median raphe and the gingival mucosa by dissecting in the submucosal plane using a long-handled blade or pocket knife (Fig. 3, images 9 and 10). The graft usually requires thinning by removing fatty submucosa with scissors. The hard palate can provide enough tissue to reconstruct the entire upper eyelid, and donor site complications are generally limited to bleeding (7–10%). Complications in the recipient upper eyelid include ocular irritation (20%), transient keratopathy (13%), partial graft dehiscence (13.4%), upper eyelid retraction (13%), and necrosis of the overlying skin flap (7%). Corneal irritation is thought to be caused by patches of keratin present in the stratified squamous epithelium of the hard palate. This may improve over time, possibly reflecting differentiation of the epithelium into a less keratinized form, but the speed at which this occurs is disputed. Mucous production from minor salivary glands located in the graft has also been reported.

Nasal septal chondromucosa is another alternative for rigid, mucosalized composite graft material and can be readily harvested from the nasal septum. This is traditionally done endonasally, but is also described using an external peri-alar approach, where the ala is reflected. It may be necessary to thin the cartilage or perforate it for upper eyelid use. Nasal septal chondromucosa offers abundant material and consists of a non-keratinized epithelium that is well tolerated. Although it has been postulated that mucous production from nasal mucosa may contribute to tear production, recent histological studies suggest that almost all submucosal glands are lost following grafting. Our opinion is that nasal septal chondromucosa may be preferable as an option for lower eyelid rather than upper eyelid reconstruction as the result of its rigidity and less potential for corneal epitheliopathy.

Nasal chondromucosa can also be harvested as a distal pedicled flap, based on the dorsal nasal artery. The flap of chondromucosa is taken from the cranial portion of the upper lateral nasal cartilage with a pedicle of subcutaneous tissues, including periosteum, along the path of this artery lateral to the bridge of the nose. The flap is then tunnelled subcutaneously around the medial canthus to fill the upper eyelid defect. The chondromucosal flap allows the placement of an anterior lamellar free graft.

Despite its increased pliability, auricular cartilage is not commonly used for full thickness upper eyelid reconstruction because of its lack of a mucosal covering and the ensuing risk of corneal damage. Some feel that this can be overcome by either mobilizing a bipedicled conjunctival flap from the superior fornix to cover the inner surface or by using an inferiorly based orbital septal flap that is reflected down and onto which the auricular cartilage is placed. This latter flap has the added theoretical advantage of acting as an extension of the levator aponeurosis and conveying some levator function to the eyelid. It is reported to epithelialize within 14 postoperative days. Many techniques exist for harvesting auricular cartilage including both anterior and posterior approaches.

A typical anterior approach involves making an incision in the skin along the anterior edge of the helix, elevating the skin and perichondrium and harvesting the required strip of cartilage from the anterior aspect of the scapha. The skin is then closed with interrupted absorbable sutures. Complications of auricular grafts are reportedly minor, with no significant donor site morbidity.

Artificial tarsal substitutes are also available, although, once again, their lack of mucosal lining makes them better suited to lower eyelid reconstructions or for use as upper eyelid spacers where the conjunctiva remains intact. Examples include processed allografts such as AlloDerm (LifeCell Corporation, Branchburg, New Jersey, USA), composed of heat-treated human cadaveric acellular dermis, and xenografts, such as Enduragen (Tissue Science Laboratories, Aldershot, UK), composed of a porcine acellular collagen matrix. AlloDerm has been widely used for lower eyelid reconstruction, but has been found to have a high absorbency rate, with graft shrinkage in the region of 70%. Nevertheless, there are reports of its use as an upper eyelid spacer in burn patients where there is residual conjunctival lining. Short-term results for the peri-ocular use of Enduragen are encouraging, with a recent study confirming structural integrity and ease of application. No complications were reported in the eight eyes for which Enduragen was used as an upper eyelid spacer, although there was a 10% complication rate in lower eyelid use, largely relating to the need for additional graft material, infection or graft exposure. In cases of lower eyelid reconstruction where the posterior surface of the Enduragen was left exposed, re-epithelialization occurred over 6–8 weeks. As yet,
however, long-term studies are not available on this product.

**Distal Anterior Lamellar Flaps**

Posterior lamellar grafts require a vascularized anterior lamella. This can be a challenge in the case of large full-thickness defects, as there is little remaining upper eyelid skin to use as a local vascularised flap. As such, more distant sources of skin and muscle are required. The secondary defects caused by harvesting of these flaps are commonly closed directly, although skin grafts can be used if necessary.

A multitude of distal peri-ocular flaps have been described. Sub-brow or suprabrow skin and muscle may be recruited and brought down as a unipedicled (Fricke) or bipedicled (bucket handle/Tripier) flap (Fig. 3, images 10–12).\(^{66,92}\) Paramedian unipedicled myocutaneous flaps may also be created, supported by the supraorbital vessels.\(^{68}\) Islanded pedicled myocutaneous flaps based on the superficial temporal artery are an alternative if extensive upper eyelid defects exist and can be subcutaneous or rotating.\(^{64,70}\) These require isolation of an island of skin and muscle together with its arterial supply. The island of tissue is passed subcutaneously to the upper eyelid, still attached to its vascular pedicle that remains subcutaneous. Such flaps have a wide arc of rotation, but frequently recruit hair bearing skin and are prone to postoperative venous or lymphatic congestion.\(^{49}\) Skin and muscle can also be recruited from the paranasal and cheek area via pedicle transposition flaps such as the orbitonasal-jugal flap (modified Tessier flap).\(^{3,61}\) The range of commonly used distal pedicled flaps is illustrated schematically in Fig. 6.

Intraoperative tissue expansion techniques may be used adjunctively to increase the amount of skin available for grafting and assist in closure of the donor site.\(^{22,92}\) This technique exploits the skin’s viscoelastic properties of creep and stress relaxation. Descriptions include stretching of the skin perioperatively by inflating a subcutaneous 10-cm\(^2\) balloon on a modified no. 14 French Foley’s catheter.\(^{92}\)

Unfortunately, by recruiting thick skin outside the orbital rim such flaps tend to be bulky and often require secondary thinning or division of the pedicle. The esthetic result can be poor and corneal irritation can occur from the lanugo hairs present on the skin. If this is a concern, one alternative is to use lower eyelid anterior lamella in an eyelid-sharing bridging procedure, as discussed previously. This technique has the advantage of recruiting thinner skin, but its limitations include occlusion of the visual axis and compromising lower eyelid integrity and stability. Such lower eyelid anterior lamella flaps include an inferiorly based bridge flap\(^{32}\) (Fig. 3, images 7 and 8), which is usually divided at 2 weeks, or a uni- or bipedicled switch flap.\(^{87}\)

**Orbicularis Sandwich Flaps**

Another option is solely to mobilize adjacent orbicularis as a pedicled flap, undermined and freed from the overlying skin.\(^{17,58,65}\) The orbicularis must maintain a vascular supply either superiorly or medially and laterally. The vascularized muscle flap is placed over a posterior lamella graft and covered with a thin skin graft, serving as the vascular supply to both (Fig. 3, images 13–16). Such sandwich flaps have the advantage of using thinner skin for reconstructing the upper eyelid, which improves eyelid closure, mobility, and cosmesis. Orbicularis is also easier to harvest than a skin–muscle flap, as it can be readily stretched and requires minimal donor site closure. In addition, the upper eyelid reconstruction can be completed in a single-staged procedure. The excellent vascularity of the orbicularis muscle enables both grafts to remain viable.\(^{65}\) Such orbicularis flaps have also been used to replace the orbicularis in a full-thickness composite eyelid graft, essentially converting it into a sandwich...
flap, as well as in conjunction with myocutaneous grafts.¹

**Canthal Fixation**

The medial and lateral canthal tendons provide firm fixation for the eyelids. Such anchoring is essential for normal eyelid closure as it translates the circular pull of the oribcularis into a vertical vector, preventing migration of the canthi towards the pupil and consequent fishmouthing of the eyelids.³² In most cases of upper eyelid reconstruction, some soft tissue canthal structures remain and can be used for fixation of the reconstructed posterior lamella. This may not be the case where there has been significant canthal involvement. Under such circumstances, more distal periosteal tissue, from the orbital rim or beyond, can be elevated as a flap and mobilized into the orbital cavity to act as an anchoring point.¹⁸ This technique is particularly applicable to the lateral orbital rim due to its relative ease of exposure, its large size and good quality periosteum, and both horizontal and oblique flaps have been described.²⁴,⁴⁵ Such periosteal flaps can be several millimeters in length, allowing them to form part of the reconstructed posterior lamella, thus reducing the size of the posterior lamella graft required. If insufficient healthy periosteum is available to form a flap, direct anchoring to the bone of the internal orbital rim is possible with the use of drill holes.²¹,⁵¹ Commonly, an inwardly directed single drill hole is made in the anterior lateral orbital rim at the desired canthal position. Sutures can then be passed from the reconstructed posterior lamella of the upper eyelid, through the drill hole, and into the deep temporal fascia where they are secured.⁵¹

Medial periosteal flaps can be elevated based on the posterior lacrimal crest or alternatively, sutures can be placed directly into the periosteum at this point.⁴¹ If there is insufficient periosteum in the medial canthal region, screws or plates are the preferred mode of fixation. Titanium microplates and miniplates can be fixed to the anterior lacrimal crest and sutures attached to them from the reconstructed upper eyelid.³⁰ Both resorbable and non-resorbable screws have also been used as modes of medial canthal fixation.⁸,⁶³,⁷⁴

**Eyebrow and Eyelash Loss**

Major reconstructions of the upper eyelid frequently result in the lack of eyelashes and occasionally eyebrows. This can be a cosmetic concern for patients as well as increasing the exposure of the globe to perspiration and dust. Conservative treatments for eyebrow loss include tattooing or the implantation of nylon threads. However, many people prefer surgical grafting of hair.⁵⁴ This was traditionally done by transplanting strip grafts or islanded pedicled flaps, but lately this has been superseded by the transplantation of hair follicles.²⁵ For eyebrows, this is done by harvesting a 1 × 4 cm ellipse of hair-bearing scalp, often from the mid-occipital region, which is then carefully dissected to reveal the individual follicular units. Multiple small incisions are then made in the eyebrow region into which the individual hair follicles are grafted. Usually about 100 hair follicles are grafted during one procedure, which can be repeated at a later point if necessary.

Eyelash harvesting is similar except that the donor hair is left long prior to harvesting and individual hair follicles are dissected from the dermis side using a microscope.²⁵ The entire hair shaft is pulled out through the dermis with its attached follicle and inserted into a French needle, like a suture. The needle is passed anteriorly into the tarsus and out at the lash line, placing the follicle in its path.⁹ The hairs fall out over the next few weeks, but grow back again within three months. Up to 90% of grafted eyebrow hairs, but usually only 50% of lash hairs, return, as a result of to the increased manipulation.²⁵ However, the procedure can be repeated as required.

**Summary**

Upper eyelid defects form one of the most challenging areas of reconstruction because of the highly specialized anatomy and function of the upper eyelid. Isolated anterior lamellar defects have the advantage of a vascularised bed and are therefore amenable to a range of reconstruction techniques including, flaps, grafts and, in specific cases, secondary intention healing. The reconstruction of full-thickness eyelid defects is best approached using an algorithm of techniques based on defect size. This requires careful assessment of the defect, including horizontal measurement under gentle tension and eversion of the eyelid to assess residual tarsus. Small defects can be closed directly, with lateral cantholysis if necessary. Larger defects, up to half of the length of the eyelid, will require recruitment of additional lateral tissue in the form of a myocutaneous flap or a tarsomarginal graft. Once more than half of the eyelid has been lost, significant additional tarsus is required and is best harvested as a tarsoconjunctival flap from the involved eyelid. This can be covered with an anterior lamellar graft. Defects involving almost the entire upper eyelid require the recruitment of more distal tissue such as lower eyelid flaps or eyelid sharing techniques. These have the disadvantage of...
occluding one eye, which can be circumvented by the use of tars Conjunctival grafts or substitutes to reconstruct the posterior lamella. The latter require a vascularized anterior lamella in the form of a distal pedicled flap of skin and muscle or possible a sandwich flap of orbicularis with placement of an overlying skin graft. Finally, adequate canthal fixation is essential to good eyelid closure and may require periosteal flaps, Burr holes, plates or screws in cases of significant canthal destruction.

This algorithm of management of upper eyelid defects serves as a guide for reconstruction, but not a protocol. Each case must be carefully assessed, including the health, expectations and needs of the individual patient. By adhering to the principles of a bi-lamellar reconstruction—with like-for-like tissue replacement and the sourcing of vascular supply—a viable reconstruction can be achieved. The details will depend on the creativity of the reconstructive surgeon.

Method of Literature Search

The authors conducted a Medline database searched, using the PubMed interface, through to August 2008. Key words used in searches included upper eyelid, pericoronal, flap and graft in conjunction with reconstruction, skin, anterior lamella, posterior lamella, local, distal, pedicled, myocutaneous, tarsocan- junctival, composite, cutaneous marginal, tarsomarginal, secondary intention, hard palate, nasolabial chondromucosa, auricular cartilage, orbicularis sandwich, periosteal, canthal fixation, eyelash, and eyebrow. In addition specific named reconstructive flaps were searched including Cutler-Beard, Mustarde lid switch, Tenzol, McGregur, Tessier, and Tripier. The search was confined to articles written in English and other-language publications with an English abstract. Due to the fact that large clinical controlled trials were not available, small patient series and relevant case reports were included. Cross-references cited in the reference list of retrieved articles, as well as from the PubMed link “related articles”, were utilized. Pertinent articles from our own reprints were retrieved and added if they had been missed by the previous sources. Inclusion and exclusion of articles from the review was based on their relevance to the subject, as judged by the authors.

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