EYELID AND CANTHAL RECONSTRUCTION

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INTRODUCTION

Considering the highly specialised multifunctional characteristics of the eyelids as well as their aesthetic and emotional qualities, eyelid reconstruction does have profound implications.
In depth understanding of the anatomy together with the specific functional aspects and aesthetic qualities of the eyelid is a prerequisite to adequately choose from an array of reconstructive surgical options.

ANATOMY

The eyelids consist of various tissues layers (Fig. 1). At the level of the eyelid margin, the various layers from superficial to deep consist of skin, orbicularis, tarsus and conjunctiva. Outside the tarsal level, from superior to deep, additional tissue layers can be recognised, skin, orbicularis, orbital septum, periorbital fat, eyelid retractors and conjunctiva.
Skin and orbicularis compose what is called the *anterior lamella*, while conjunctiva, lid retractors and tarsus are considered the *posterior lamella*[24]. The tarsus consists not of cartilage, but of dense, fibrous tissue and functions as stiffener. The height of the tarsal plate differs from upper and lower eyelid. In the upper eyelid the vertical dimension ranges from 9-12 mm, in the lower eyelid from 3-5 mm. The retractors attach to the free border and slightly anterior portion of the tarsus. The retractors of the upper eyelid consist of the levator aponeurosis and Muller's muscle. The capsulo-palpabral fascia in the lower eyelid is analogous to the levator aponeurosis of the upper eyelid but contains no muscle fibres. The capsulo-palpabral fascia transmits contractions of the inferior rectus muscle while stabilising the tarsus of the lower eyelid[16]. Thus, the retractors provide function, opposing the sphincteric action of the orbicularis muscle, as well as lid margin stability. The orbital septum is a fascial membrane separating the eyelids from the deeper orbital structures including periorbital fat.

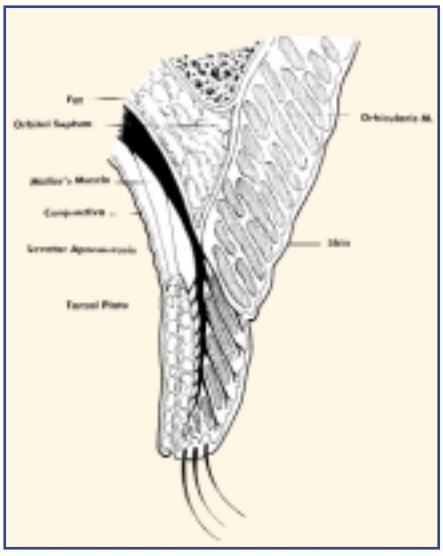

Fig. 1. Anatomic layers of the eyelids.

The medial canthal complex constitutes the bony attachment of the eyelids, as well as the lacrimal collecting and drainage system. Specifically the part of the medial canthal tendon which inserts posteriorly into the orbit helps maintain apposition of the eyelids to the globe.

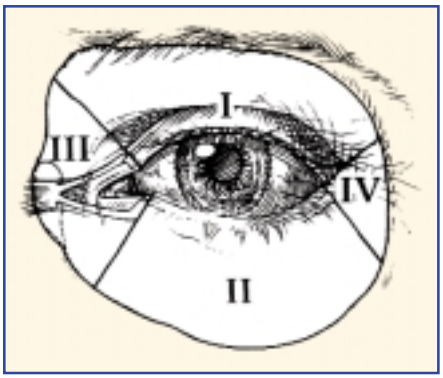

Fig. 2. Periorbital zones
Zone I upper eyelid
Zone II lower eyelid
Zone III medial canthal region
Zone IV lateral canthal region
(Spinelli H.M. (1994) Periauricular reconstruction: a systematic approach. Plast. Reconstr. Surg. 1:1017.

The lateral canthal area consists of 4 structures, including the lateral canthal tendon, Lockwood's ligament, check ligaments of the lateral rectus muscle, and the lateral horn of the levator aponeurosis. Addionally, it encompasses the palpabral lobe of the lacrimal gland[11]. The lateral canthal tendon attaches to Whitnall's tubercle, a bony promontory just within the bony rim. The lateral canthal tendon draws the eyelid laterally, superiorly and posteriorly.

To conceptualise eyelid reconstruction the periorbital region is usually divided in 4 zones. These zones are the following: Zone I – upper eyelid; Zone II – lower eyelid; Zone III - medial canthus; Zone IV – lateral canthus[7,11,17] (Fig. 2).

FUNCTION

The eyelids are a distinct facial feature that contribute to individual facial expression. The overall main purpose of the upper and lower eyelid and medial/lateral canthal complex, is support of adequate global function. More specifically, the eyelids protect the eyes from debris, excess light and exposure[29]. The upper eyelid is vastly more important to the function of corneal coverage than the lower eyelid[33]. Moreover, the upper eyelid provides lubrication by means of accessory lacrimal glands and ducts of the lacrimal gland. Untreated or inadequately treated defects of the upper eyelid will lead to severe dry eyes, resulting in corneal injury and visual loss. The lower eyelid with its relatively stable margin, retains periglobal moisture, while blinking clears and redistributes the tearfilm. Both medial and canthal tendon complex provide support for the eyelid and prevents malposition (entropion/ectropion) while maintaining adequate horizontal width of the palpable aperture. The medial canthal tendinous complex is part of the lacrimal drainage and tear pump system. If necessary, the lacrimal drainage is probed and intubated for a long period to assure competence in medial canthal defect reconstruction. In its ideal position, both eyelids cover 1-2 mm of the limbus. On eyelid closure the upper eyelid must cover the cornea completely[18,32].

TUMOUR CONTROL

Eyelid skin is prone to skin cancer, and because it is so thin, most basal cell and squamous cell carcinomas invade the underlying orbicularis muscle[28].

Surgical management of malignant tumours aim at disease eradication coupled with preservation of adjacent normal tissue. In the periorbital region, functional and cosmetic sequelae of removal of excessive normal tissue may have far-reaching consequences[6]. The tumour ablative surgeon who is unfamiliar with the periorbital anatomy and reconstructive options, may compromise margins of resection because of the unwillingness to sacrifice vital structures in the area[7].
Mohs micrographic surgery offers highest cure rates (< 98%) while preserving maximum amount of normal tissue in an area where excess tissue for reconstruction is scarce[1,4,6,23]. Orbital invasion of basal cell carcinoma is rare but calls for extensive preoperative evaluation and multidisciplinary team management[11].

RECONSTRUCTION PRINCIPLES AND GUIDELINES

Most resections and reconstructions are performed under local anaesthesia, sometimes supplemented with i.v. dissociative anaesthesia for enhanced patient comfort. Local anaesthetic BMX® drops are used in the conjunctival sac, while lidocaine 2% with adrenaline 1 : 100.000 is injected with a 30 G needle. For longer operations 0.5% bupivacaine with epinephrine 1 : 200.000 is added to the mixture.

Periorbital defects are generally categorized according to location (zone I-IV), depth and size. In anterior lamellar defects, part of the eyelid thickness remains. In full thickness defects, both the anterior and posterior lamella must be reconstituted. The larger the percentage of the full thickness eyelid which is missing (0-25% / 25-50%/ > 50%) the more complex the reconstruction.

The ideal goal of reconstruction is to provide global protection and normal aesthetics[24].
Prerequisites to attain this goal may be the following:
1. Lining maintaining lubrication while avoiding corneal irritation
2. Lid rigidity while allowig direct global apposition
3. Lid stability and orientation with proper medial and lateral canthal support
4. Opening and closing ability facilitated by adequate muscle power and tone, allowed by subtle skin covering.

To attain these goals, reconstruction should ideally replace the delicate, thin, pliable, well vascularised and innervated tissues of the eyelids with kind. In general, adjacent eyelid structures may act as reservoirs for tissue harvesting and flap or graft transfer[9,21,28,29,31]. Distraction forces, such as gravity, edema and wound retraction may lead to complications, such as eyelid malposition (ectropion) and corneal exposure[29].

Anterior lamellar defects consisting of partial eyelid thickness are generally accomplished with local flaps or full thickness grafts[28]. Most local flaps consist of skin and muscularis to enhance vascularity, replace bulk and possibly provide active muscle tonus to support the eyelid function. The tissue reservoirs to be considered for flap harvesting are upper eyelid, temple/cheek and glabella region for lower eyelid defects and temple/suprabrow and glabellar region for upper eyelid[5]. Alternatively, grafts from the ipsilateral or contralateral eyelid or composite skin-perichondrium grafts of the periauricular region may be applied in both upper and lower eyelid reconstruction[28,30].

The upper eyelid presents an obvious reservoir of redundant skin and muscle to be harvested for skin-muscle flaps.
Full thickness composite skin-orbicularis-fascia grafts from the upper eyelid may be versatile in reconstruction anterior lower and upper eyelid defects[28]. For mobilising skin muscle flaps aesthetic blepharoplasty techniques can be applied to project lower incision in the lid crease while preserving subbrow skin and subcuticular tissues. Blepharoplasty may be performed on the contralateral eyelid to maintain symmetry unless there is concern about the needs for future skin graft[26].
Alternatively composite skin-perichondrial grafts taken from the conchal bowl are available in relatively large quantities[30]. The main advantage being minimal tendency for shrinkage compared to other full thickness skin grafts taken from the preauricular or postauricular donor sites. The conchal bowl donor site will heal by secondary intention if cartilage holes are punched out. Postauricular donor skin closely matches eyelid skin. Both post- and preauricular skin must be thinned to an appropriate thickness. Both donor sites are usually easily closed primarily.

In posterior lamella defects usually tarsus and conjunctiva are missing. For posterior lamellar reconstruction, either a graft or conjunctical flap may replace both conjunctiva and tarsus. A large series with a variety of grafts described for reconstruction include autogenous composite mucosa-cartilage from the nasal septum[14], auricular chonchal cartilage graft[20], homologous tarsal grafts, scleral grafts, buccal mucosa[21], and hard palate mucosa grafts[25,27]. Nasal septum and auricular chonchal cartilage grafts are obviously easily obtained, but frequently cause cosmetic inacceptable contour changes when used in the upper eyelid[12]. Moreover, composite cartilage grafts may risk inadequate graft take. Buccal mucosa is too soft and shrinks substantially in the postoperative period. Nowadays, lateral hard palate mucosal grafts are favoured for posterior lamella reconstruction[25,27].
Alternatively, tarsal-conjunctival advancement or transposition flaps can be applied from the upper to the lower lid. The anterior lamella is reconstructed separately along the guidelines described above. Remember, in reconstruction of both anterior and posterior lamellae, that at least one layer must carry its own blood supply.

REGIONAL RECONSTRUCTIVE OPTIONS

Anterior lamella defects

Only very small defects (< 0.5 cm) are amandable to secondary intention healing. Anterior lamella defects of less than 50% of the eyelid are usually closed with local muscular cutaneous sliding flaps from witin the eyelid itself. The orbicularis is included in the flap for enhanced vascularity and bulk. These local flaps are most often designed as uni- or bipedicled advancement flaps. The maximal tension is oriented in a plane parallel to the free border of the eyelid to prevent ectropion, while the incisions lie within the RSTL's (Fig.3). Alternatively, O-Z plasty involves two opposing sliding rotation flaps. However, tension factors and incision orientation are less than ideal. Excessive tension must be prevented because of the risk of lagophthalmus or ectropion.

In case of anterior lamellar defects of *more than 50%* additional tissue may be brought into the defect for proper reconstruction. As a first choice, either free grafts or regional skin muscle flaps from upper to lower eyelid may be used.

An orbicularis muscular cutaneous flap can be taken from the upper eyelid and transferred into the lower eyelid as a laterally or medially based uni- or bipedicled transposition flap. These flaps may be either directly inset or interpolated as a two stage procedure. They provide coverage for anterior lamellar defects or in case of full thickness defects, provide blood supply for a free graft which is used for reconstruction of the posterior lamella[21,25,27].

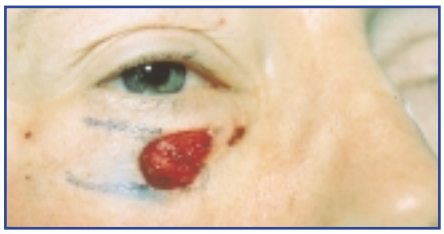

Fig. 3a. Anterior lamellar lower eyelid defect, unilateral skin muscle advancement flap outlined.

Fig. 3b. Flap advanced and set in the defect.

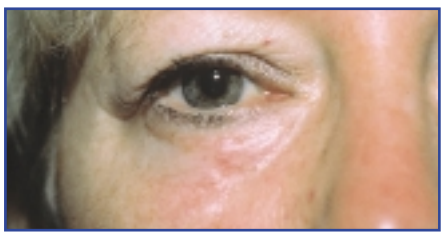

Fig. 3c. Final result.

A large quantity of additional skin covering may be obtained for lower eyelid defects, by mobilising cheek tissue and sliding a flap from lateral to medial in a rotational movement[12]. To develop the large, broad-based, subcutaneous rotation flap an incision is started from the lateral canthus upward with an apex of the rotation as high as possible. The resulting healing vector force from low medial to high lateral aims to harnass scar tissue to support the lid. However, even with temporal suspension sutures to avoid tension on the lid margin and a direct postoperative slit-like narrow palpable fissure, these types of flaps may lead to lid malposition (ectropion) in a significant percentage of patients[2].

For anterior lamella reconstruction of the upper eyelid, most often local skin muscular advancement flaps or composite skin muscular fascia grafts from the contralateral eyelid are used. Furthermore, temple, suprabrow or glabella/forehead flaps may be brought in but are usually only applied in full thickness defects. It must be noted that glabellar/forehead skin does not match the pliable thin skin of the eyelids to be reconstructed and thus is secondary choice.

Full thickness defects

Full thickness upper and lower eyelid defects must be reconstructed in multiple layers to optimise functional and aesthetic results. Reconstruction of full thickness defects range from simple to complex parallelling the percentage of eyelid tissue which is missing[7].

Defects up to 25% of both upper and lower eyelid can be closed primarily in a single stage repair. Normal anatomy including eyelid lashes are maintained. Even larger defects may be closed primarily if adequate tissue laxity exists.
The incision should be perpendicular to the free eyelid border and encompass the total width of the tarsus while being finalised in a pentagon shape to include a burrow triangle. Exact vertical alignement of the tarsus is imparative for satisfactory lid margin repair. Only the anterior tarsus is included in suture repair to avoid corneal irritation. The lid margin itself is closed with moderate eversion using 3 mattress sutures, which are left long. The orbicularis muscle and skin are separately repaired. The 3 long marginal sutures are tied away after being incorporated in the most distal skin sutures.
A formal lateral canthotomy with cantholysis substantially increases the ability of a layered primary closure[12]. After a horizontal cut through the skin and muscle, the lateral canthal tendon is palpated and put on stretch. Subsequently the inferior or superior crus (depending on lower or upper eyelid to be reconstructed) of the lateral canthal tendon is divided vertically with scissors.

Defects up to as much as 50%

Of the horizontal dimension of the upper and lower eyelid may be closed by developing a semicircular flap on the lateral canthal area. A skin-muscle flap is developed opposite the side of the eyelid defect to be reconstructed. For the lower lid the semicircular flap is kept within the confines of the line that would be an inferior continuation of the eyebrow[17]. The semicircle is approximately 20 mm in diameter beginning at the lateral canthal angle, extending no further than the lateral extent of the brow. A skin muscle incision is made onto the periosteum to develop the flap. Subsequently wide undermining allows medial mobilisation of the flap[31]. Furthermore, a lateral canthotomy is performed beneath the flap and the inferior portion of the lateral canthal tendon is cut (Fig.4). Further mobilisation and medialisation of the full thickness eyelid composite flap is possible if the attachment of the orbital septum at the inferior orbital rim is cut[22]. In extreme cases even the retractors may be divided at the inferior tarsal border[19]. The composite flap is medialised so that the residual fragment of lateral tarsus is incorporated in the medial part of the repair. The remainder of the reconstructed lateral part of the lid is composed of the muscular cutaneous flap without any tarsal or conjunctival substitute. The defect is closed primarily in layers while the secondary donor defect of the semicircular flap is closed by the method of halving.

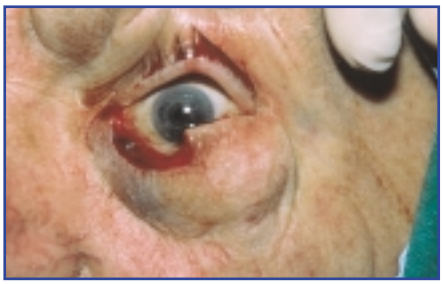

Fig. 4a. Full thickness defect.

Fig. 4b. Tenzel flap including lateral canthal lysis and lateral rotation flap outlined.

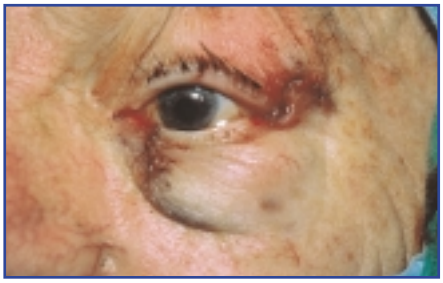

Fig. 4c. Flap transposed. Primary defect closed in layers.

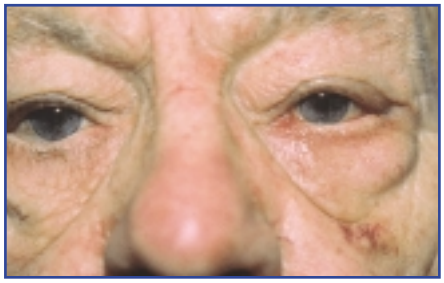

Fig. 4d. Three weeks postoperative result.

The best cosmetic results are achieved with the semicircular flap when the surgical defect is located centrally, allowing the cut edges of the tarsus to be joined directly to each other. Although a versatile and frequently used flap, complications such as lateral canthal webbing, ectropion, lid notching, and symblepharon formation are associated if the flap is inappropriately applied in too large defects[22].

***Defects of half or more of the eyelid** (> 50%)*

In larger full thichness defects, the replacement of a posterior lamella to support eyelid position becomes increasingly important. For posterior lamellar reconstruction, either a graft or conjunctival flap may be used.

Nowadays most authors favour autogenous lateral hard palate mucosal grafts[25,27]. The collagen of the mucosal palatal graft has enough support together with a degree of compliance that enables close adaptation to the globe. The palatal mucosal graft is both moist and stiff, so that in one layer it can serve quite nicely as a replacement of both tarsus and conjunctiva[27] (Fig.5). Palatal mucosal grafts are obtained from an abundant supply with minimal problems in terms of donor morbidity and discomfort. Graft harvesting can be done under local anaesthesia. Incisions are made into mucosa and periosteum on the lateral hard palate. The periosteum need not be included in the graft, allowing decreased postoperative pain and faster healing of the donor site, while simplifying the thinning of the graft. The donor site is simply treated with a plastic stent or the patient's own dentures[8].

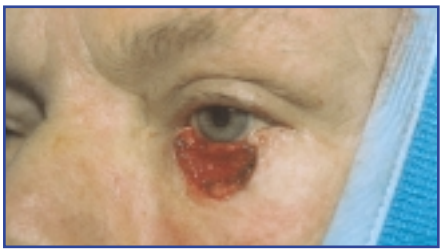

Fig. 5a. Full thickness defect including a large part of the anterior lamella of the lower eyelid.

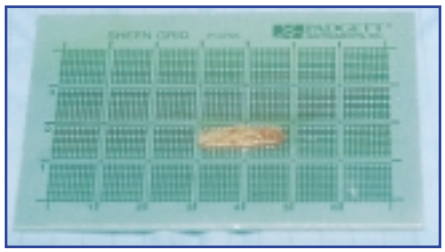

Fig. 5b. Palatal mucosal graft harvested.

Fig. 5c. Donor site demonstrated.

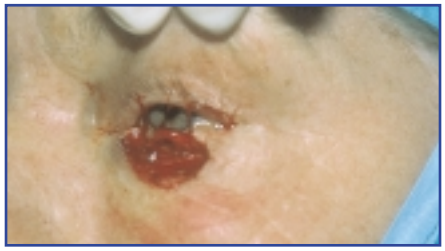

Fig. 5d. Mucosal graft sutured in defect for posterior lamellar replacement.

Fig. 5e. Bipedicled skin muscle flap for upper eyelid outlined.

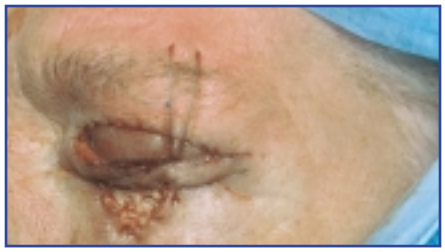

Fig. 5f. Skin muscle flap transposed to provide skin to the eyelid margin and blood supply for the palatal mucosal graft. The remaining anterior lamellar defect of the lower eyelid is closed with a composite skin perichondrial graft of the conchal bowl.

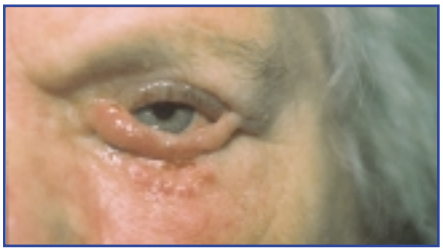

Fig. 5g. Just before pedicle division of the interpolated bipedicled upper lateral skin muscle flap.

Fig. 5h. Final result.

To reconstruct the posterior lamellar defect of the lower eyelid defects, one may also consider tarsal conjunctival composite flaps obtained from the upper eyelid[10,13]. Most often an advancement flap is developed after horizontally incising the conjunctiva and tarsus 3 mm above the eyelid-free margin in order to preserve the margin of the arterial arcade and to preserve the levator aponeurosis attachement to the tarsus below the cut[9] (Fig. 6). Incision and dissection are carried upward, Muller's muscle is usually not included in the flap[9,17]. Including Muller's muscle in the flap improves blood supply but risks delayed eyelid retraction[24]. The tarsal conjunctival flap is set in to the lower eyelid posterior lamellar defect, so that the upper border of the tarsus contained in the flap is in alignment with the remaning lower lid margin. The inferior edge of the tarsus included in the flap is sutured into the inferior conjunctiva and retractors. The anterior lamella is reconstructed as previously described with local pedicled skin flaps or skin grafts. After 6 weeks the palpabral fissure is recreated in a second stage with division of the conjunctival pedicle and insetting of the lid margin. If the defect includes the lower eyelid and the lateral canthus, instead of a superior conjunctival tarsal advancement flap, a temporarily based flap may be developed[10,17].
One should note that full thickness upper eyelid defects are the greatest challenge to reconstruct. In upper eyelid reconstruction the effect of both horizontal and vertical tension of closure must be appreciated[26]. Excessive horizontal tension may result in ptosis, excessive vertical tension will cause lagopthalmus, both must be avoided. Full thickness defects up to as much as 25% of the upper eyelid may be closed primarily. A semicircular flap is used for up to 50% for upper eyelid defects, similar to the lower eyelid defects.

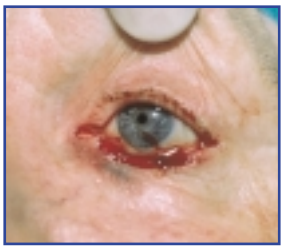

Fig. 6a. Full thickness lower eyelid defect.

Fig. 6b. Hughes' tarsal conjunctival flap outlined on the upper eyelid.

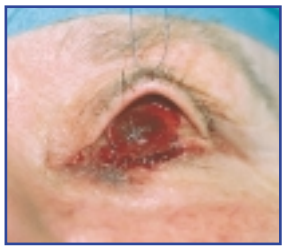

Fig. 6c. Hughes' flap set in lower eye-lid defect to reconstruct lower eyelid posterior lamella.

Fig. 6d. A small lower eyelid advancement flap is developed and folded down on cheek for demonstration purposes.

Fig. 6e. Both flaps are sutured in place and will remain in position for 6 weeks.

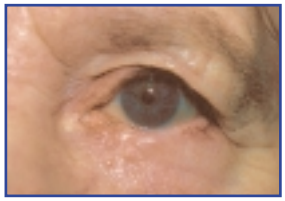

Fig. 6f. Result after pedicle division.

Defects involving 50% or more of the upper eyelid may be reconstructed with various types of full thickness lower lid sharing procedures, or combined flap and graft reconstruction, such as described below. The Cutler-Beard procedure is a lid-sharing technique in which a skin-muscle-conjunctival flap from the lower lid is advanced into the defect of the upper lid[24]. This two staged procedure is indicated for full thickness large defects < 50% of the eyelid. Practically, a full thickness flap including skin retractors and conjunctiva is developed from the opposing lower lid, while leaving the margin of the inferior donor lid in place. The flap is pulled into place under the intact lower tarsal bridge. The flap is inset and divided in a second stage. After 6-8 weeks the flap is incised at the level of the intended upper eyelid margin and the pedicled flap repositioned in the donor eyelid[3]. The major disadvantage of the Cutler-Beard procedure is that the tarsus is not replaced with a rigid structure, leading to possible instability of the reconstructed lid margin[3]. Autogenous cartilage may be incorporated in the composite lower eyelid advancement flap in the first stage of the procedure to enhance lid stability.
Alternatively, a pedicled full thickness composite flap from the lower eyelid, including eyelid free margin, may be set into the upper eyelid defect as a two-staged lid-sharing procedure[14,15,33]. The depleted donor lower lid is subsequently reconstructed.

The level of surgical involvement is considerable with these lid-sharing procedures. By reconstructing the posterior and anterior lamella of the upper eyelid separately one may simplify the surgery while possibly decreasing the risk of complications. Posterior lining may relatively easily be reconstructed by hard palate mucosal graft as a moisturing layer and stabiliser of the upper eyelid. Skin coverage may be obtained by a laterally based suprabrow transposition flap which has a relatively large length-width ratio (4 : 1). Favourable donor site does provide adequate blood supply. Obviously neither the Cutler-Beard procedure nor the above described temporal skin flap/palatal mucosal graft procedure does reconstitute the normal eye lashes of the upper eyelid.

Medial canthal area

In the medial canthal area primary closure is rarely possible. But if performed, a Z-plasty may be incorporated in the closure to prevent webbing in this concave area. Because of its concavity, the medial canthal zone lends itself well to secondary intention healing[34]. If defects are centered around the medial canthal ligament, scar tissue contraction forces are equal on upper and lower eyelid preventing tissue distorsion. If defects are asymmetrically placed toward the upper or lower eyelid, unfavourable scar tissue contraction and ectropion may occur. Distorsion can be prevented to a certain degree by guiding sutures. The defect is reduced and the remaining defects symmetrically positioned around the medial canthal area (Fig. 7).
Larger defects may be reconstructed with full thickness skin grafts (FTSG) if the recipient site does provide vascular support for the graft (Fig.8). When vascular support is decreased, by removal of periosteum an upper eyelid transposition flap or for larger defects a rotation or transposition flap from the glabella may be useful. Glabellar flaps must be aggressively thinned for proper contour and skin thickness match in this region.

Fig. 7a. Asymmetrically medial canthal lower eyelid defect.

Fig. 7b. Anterior lamella mobilised towards the medial canthal by suturing to prevent asymmetric scar rectal forces and ectropion.

Fig. 7c. Final result.

Fig. 8a. Medial canthal defect including a small part of the upper and lower eyelid.

Fig. 8b. Medial canthopexy performed. Upper eyelid advancement flap outlined.

Fig. 8c. Advancement flap in place. Retroauricular skin graft applied.

If medial canthal support is lost and not reconstituted, canthal dystonia will result. Specifically, the posterior arm of the medial canthal tendon and its attachment to the posterior lacrimal crest must be reconstructed to properly oppose the reconstructed eyelid to the globe[22]. Medial canthal reconstitution is difficult because of global proximity and thin lacrimal fossa periosteum. Alternatively a transnasal canthopexy or microplate fixation may be considered[12].

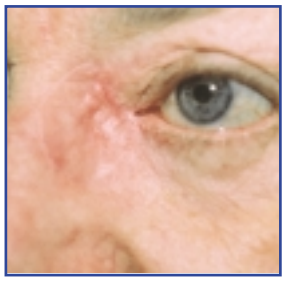

Fig. 8d. Final one year result.

Lateral canthal area

Restoration of this area is the least challenging of the periocular reconstruction. Skin defects are generally reconstructed with inferior based cheek rotation flaps tailored to the individual defect and donor site characteristics. Various rotational shapes and sizes of flaps may be applied. If the lower eyelid is involved a canthopexy such as used in traditional blepharoplasty surgery should be considered to enhance lid tonus and pre-

vent ectropion (Fig.9). More extensive defects of the lateral canthal ligament may also involve loss of lateral tarsal tissue and may require the development of a periosteal strip off the zygomatic arch, based on the lateral border of the orbital wall [18,32]. The strip must be at least 1 cm wide. The developmental angle of the periosteal flap differs between upper and lower eyelid defect but should possibly mimic the original lateral canthal support. The periosteal strip may be split to reconstruct both upper and lower lid canthal supports. When the lateral canthal and the posterior lamella is reconstructed with a thin periosteal strip, the coverage and bulk is provided by a skin muscle flap.

Fig. 9a. Lateral canthal lower eyelid full thickness defect.

Fig. 9b. Canthopexy closes the full thickness lower eyelid defect. Rotation flap defect to reconstruct anterior lamella defect.

Fig. 9c. Flap in place. The superiorly arched rotation flap will harness scar forces to support lower eyelid.

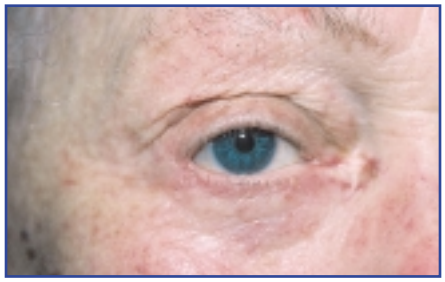

Fig. 9d. Final result.

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