EYELID RECONSTRUCTION

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INTRODUCTION
When performing eyelid reconstruction, a thorough understanding of periorbital anatomy is critical. It is important to understand the function of each structure and its interplay. One must approach eyelid reconstruction with the goal of restoring the functionality of the structure while achieving an aesthetically pleasing result.

ANATOMY
In this section, we present summaries of the anatomy related to eyelid reconstruction. For further reading on eyelid anatomy, detailed descriptions can be found in the 2008 text, Eyelid & Periorbital Surgery, by McCord and Codner.

Dimensions
The palpebral fissure is the space between the upper and lower eyelid margins. Normally, the adult fissure is 27 to 30 mm horizontally and 8 to 11 mm vertically (Fig 1). Many conditions can affect the palpebral fissure measurement; it can be vertically increased in patients with Graves disease, decreased in patients with involutional ptosis, and variable in patients with myasthenia gravis. Horizontally, it can be decreased in patients with blepharophimosis and in patients with laxity or disinsertion of the lateral or medial canthal tendon.

Skin and Eyelid Crease
The eyelid skin has only six to seven cell layers and averages <1 mm thick. The thin keratinizing epithelium is loosely attached to the underlying orbicularis muscle. The levator aponeurosis extends inferiorly to join the anterior surface of the tarsal plate 3 mm superior to the lid margin, where it forms its firmest attachment.

When performing eyelid reconstruction, it is important to successfully recreate the eyelid crease for a better cosmetic result. The occidental upper eyelid crease is 8 to 9 mm superior to the eyelid margin centrally in men and 8 to 11 mm superior to the margin in women. The lid crease is a result of fascial bands from the levator aponeurosis extending anteriorly through the orbicularis oculi to the skin. The lid crease typically is higher in involutional ptosis and in levator dehiscence.

In the Asian eyelid, the upper eyelid crease is 2 to 3 mm superior to the margin and usually poorly defined. Three morphological types of Asian upper
eyelids have been identified:
1. Single eyelid: no lid crease with puffiness
2. Low eyelid crease: low-seated, nasally tapered, inside-fold type of crease
3. Double eyelid: lid crease parallel to the lid margin

Jeong et al. found that there are three reasons for the absent or lower crease in the Asian upper eyelid:
1. The orbital septum fuses to the levator aponeurosis at variable distances below the superior tarsal border.
2. Preaponeurotic fat pad protrusion and a thick subcutaneous fat layer prevent levator fibers from extending toward the skin near the superior tarsal border.
3. The primary insertion of the levator aponeurosis into the orbicularis muscle and into the upper eyelid skin occurs closer to the eyelid margin in Asians.

The lower eyelid crease is formed by the fascial extensions of the capsulopalpebral fascia, which also pass through the orbicularis oculi muscle and insert onto the skin. Lim et al. reported that in Asians, these fascial extensions do not extend to the skin; therefore, a palpebral crease is not found. Kakizaki et al. stated that the reason for the indistinct lower lid crease in Asians is the higher or indistinct septum fusion, the anterior and superior orbital fat projection, and the overriding of the preseptal orbicularis muscle.

Eyelid Margin and Lacrimal Pump
The eyelid margin has several significant structures. Both the upper and lower eyelid margins have a punctum medially. The punctum opens into the canaliculus of the lacrimal system. Tears drain via the canaliculi and into the nasolacrimal sac and then to the lacrimal duct by both an active and a passive mechanism. The lacrimal pump actively sucks tears into the lacrimal sac with each blink. The contraction of the orbicularis muscle brings the lower punctum medially, closes the ampulla, and displaces the lateral wall of the lacrimal sac laterally, creating a negative pressure in the sac. This draws the tears from the common canaliculus into the sac. The loss of the active component of tear drainage is partially responsible for epiphora in cases of facial nerve palsy. Malpositions of the lower eyelid and the puncti can also lead to epiphora.

Along the length of the eyelid margin is the gray line, corresponding histologically to the most superficial portion of the orbicularis muscle, the muscle of Riolan, and to the avascular plane of the lid. Anterior to the gray line, the eyelashes or cilia arise. Posterior to the gray line are the orifices to the meibomian glands. Meibomian glands are modified holocrine sebaceous glands that produce lipid secretions. Oil from the openings forms a reservoir on the skin of the lid margin and is supplied to the tear film with each blink. Other glands found on the skin of the eyelids are the sweat eccrine glands of Zeis and holocrine glands of Moll.

Orbicularis Oculi Muscle
The orbicularis muscle is arranged in concentric bands and is the main protractor of the eyelid. It can be separated into orbital and palpebral portions. It is innervated by cranial nerve VII. Its antagonist, the levator, is innervated by cranial nerve III. The orbital portion is involved in forced eyelid closure. The palpebral portion can be divided into pretarsal and preseptal parts (Fig. 2). The palpebral portions are involved in involuntary lid movements, such as blinking.

The pretarsal orbicularis attaches medially to the anterior and posterior arms of the medial canthal ligament to surround the lacrimal sac, and the superior and inferior lacrimal canaliculi are found within its muscle fibers. It plays a vital part in the lacrimal pump mechanism. Laterally, the pretarsal orbicularis joins the lateral canthal ligament at the Whitnall tubercle. The preseptal and orbital components attach medially to the medial canthal ligament and laterally to the zygoma, lateral to the orbital rim. In addition to the formerly mentioned attachments, the orbital orbicularis attaches medially to the maxillary and frontal bones and extends peripherally to overlie the orbital rims. A small segment of the orbicularis oculi muscle,
Figure 1. Landmarks of the external eye. The palpebral fissure is approximately 27 to 30 mm wide and 8 to 11 mm high in the adult. (Reprinted with permission from Cibis.)

Figure 2. Upper eyelid anatomy. (Reprinted with permission from Kersten.)
called the muscle of Riolan, is separated from the pretarsal component by the eyelash follicles and forms the gray line along the eyelid margins.\textsuperscript{14,15}

Muzaffar et al.\textsuperscript{16} reported that the orbicularis-retaining ligament is a bilaminar septum-like structure attaching the orbicularis oculi to the inferior orbital rim. The attachment is weakest centrally and tightest over the inferolateral orbital rim.

Ghavami et al.\textsuperscript{17} further clarified that the orbicularis-retaining ligament is a circumferential, periorbital structure and that the orbicularis retaining ligament of the superior orbit arises 2 to 3 mm above the orbital rim in the mid orbit.

Anterior and Posterior Lamellae
The eyelid is divided into two lamellae (Fig. 3).\textsuperscript{13} The anterior lamella consists of skin and the orbicularis oculi muscle, and the posterior lamella consists of the tarsal plate and conjunctiva.\textsuperscript{15}

Tarsus
The tarsal plates act as the skeleton of the eyelids, providing semirigid support.\textsuperscript{18} The tarsus is composed of dense regular connective tissue and contains the Meibomian glands.\textsuperscript{4} The superior tarsus is 10 to 12 mm at its greatest vertical dimension, and the inferior tarsus is 3 to 5 mm.\textsuperscript{18} The upper and lower tarsal plates are similar in length (29 mm) and thickness (1 mm).\textsuperscript{2} The Meibomian glands are modified holocrine sebaceous glands and are oriented vertically in parallel rows through the tarsus. The upper lid contains 25 meibomian glands, and the lower lid contains 20.\textsuperscript{13}

Conjunctiva
The palpebral conjunctiva lines the inner surface of the eyelids and is covered by a non-keratinized epithelium. Holocrine glands known as goblet cells secrete mucous and are located throughout the conjunctiva. The goblet cells are mainly concentrated in the conjunctival fornices and at the caruncle. The palpebral conjunctiva is continuous with the conjunctival fornices and merges with the bulbar conjunctiva overlying the globe. The conjunctiva becomes freely mobile in the fornices. The bulbar conjunctiva lines the sclera and terminates at the limbus.

Orbital Septum
The orbital septum lies beneath the orbicularis muscle and consists of a thin sheet of connective tissue. It encircles the orbit as an extension of the periosteum of the roof and the floor of the orbit.\textsuperscript{2} The orbital septum acts as a barrier of the orbital contents, and the orbital fat can be found posterior to it. It extends from the arcus marginalis, where the periosteum and periorbita fuse, toward the tarsus.\textsuperscript{3} In the upper eyelid the septum inserts at the levator, approximately 2 to 3 mm above the superior edge of the tarsus. In the lower eyelid, the septum inserts to the inferior edge of the tarsus.\textsuperscript{19} The septum attaches medially to the lower end of the anterior lacrimal crest, called the lacrimal tubercle. It continues from the lower to upper eyelid by passing under the medial orbicularis muscle.\textsuperscript{3} Putterman\textsuperscript{19} noted that the septum is difficult to trace laterally because it blends with the lateral canthal tendon and the lateral horn of the levator. The septum also takes the shape of an arch under the supraorbital notch and around the supratrochlear and infratrochlear nerves and vessels. Weakness in the orbital septum contributes to herniation of the orbital fat.

Reid et al.\textsuperscript{20} described a distinct fibrous anatomic layer, which extends from the orbital septum to cover the tarsus. They named the fibrous structure the \textit{septal extension}. They described the preaponeurotic fat layer covered by the septal extension, which extends to cover the tarsus along its anterior border to the ciliary margin. The septal extension was found between the orbicularis oculi and the levator aponeurosis, distinct from the levator tissue. Fibrous connections extending from the levator aponeurosis penetrate the septal extension and the orbicularis muscle, connecting the levator-dermal link to the septal extension. Tension placed on the orbital septum leads to referred tension on the septal extension and secondary lagophthalmos. The authors stated that the findings
might help avoid relapse and complications associated with aesthetic and functional upper eyelid surgery.

**Upper Eyelid Retractors and Müller Muscle**
The upper and lower eyelids are analogous structures with their main difference being their respective retractors. In the upper eyelid, the levator palpebrae superioris and its aponeurosis comprise a distinct entity that evolved from the superior rectus muscle. The lower eyelid retractor is a fascial extension of the inferior rectus, which divides to encircle the inferior oblique muscle, called the capsulopalpebral fascia.

The levator muscle palpebrae originates under the lesser wing of the sphenoid just anterior to the optic foramen. It extends anteriorly for 40 to 45 mm and becomes tendinous in front of Whitnall ligament (Fig. 4). Whitnall ligament is a transverse band of fibrous condensation that attaches superiorly to the widening levator. It is the condensed fascial sheath of the levator muscle approximately 18 to 20 mm above the superior border of the tarsus. Medially, it attaches to the connective tissue around the trochlea and superior oblique tendon. Laterally, it attaches to the inner aspect of the lateral orbital wall, approximately 10 mm superior to the lateral orbital tubercle. It
functions to convert the anterior-posterior pulling force of the levator to a superior-inferior direction, which raises and lowers the eyelid.\textsuperscript{21-23} The levator aponeurosis joins the orbital septum above the superior border of the tarsus and sends fibrous strands between the orbicularis oculi muscle septa to the skin to make the lid crease.\textsuperscript{22} The normal excursion of the levator muscle is 15 mm.\textsuperscript{3}

Müller muscle is a smooth, sympathetically innervated muscle in the upper eyelid. It originates from the undersurface of the levator muscle 8 to 10 mm above the superior tarsal border and attaches to the superior edge of the tarsus.\textsuperscript{22} It functions to provide 2 mm of lid retraction, and its interruption in Horner syndrome causes mild ptosis.\textsuperscript{24}

Kakizaki et al.\textsuperscript{25} found that the levator aponeurosis has doubly stratified layers that include smooth muscle. The authors suggested that the levator aponeurosis regulates tension in the anterior lamella of the upper eyelid as the Müller muscle regulates the tension of the posterior lamella of the upper eyelid.\textsuperscript{26} The structures lead to ordered movement in the upper eyelid.

Lower Eyelid Retractors

In the lower eyelid, the retractors originate from the capsulopalpebral head of the inferior rectus muscle. The capsulopalpebral fascia is analogous to the levator in the lower eyelid. The capsulopalpebral head splits around the inferior oblique muscle and fuses again to form Lockwood ligament (similar to Whitnall ligament in the upper lid). The inferior tarsal muscle is a sympathetically innervated muscle analogous to Müller muscle of the upper lid. It originates on the posterior surface of capsulopalpebral fascia. The inferior tarsal muscle, capsulopalpebral fascia, and orbital septum insert at a fusion point into the anterior and inferior surface and base of the tarsus.\textsuperscript{22} The capsulopalpebral fascia sends anterior projections that penetrate through the orbicularis to the skin to create a transverse crease.\textsuperscript{3}

Preaponeurotic Fat

The preaponeurotic fat serves as an important structure in eyelid anatomy. It is a crucial surgical landmark. The levator aponeurosis lies just posterior to the preaponeurotic fat, and the septum lies just anteriorly. In the upper eyelid, two fat pads are found: the nasal and middle fat pads (Fig. 5). The nasal fat pad lies beneath the trochlea. The lower eyelid has three fat pads. The nasal fat pad is separated posteriorly from the central fat pad by the inferior oblique muscle. The central and lateral fat pads are connected in deeper layers but anteriorly are divided into two pads by a dense septal partition.\textsuperscript{22} The nasal fat pads are distinctly whiter in color in both the upper and lower eyelids when compared with the yellow color of the more lateral fat pads.

Medial Canthus

The medial canthus provides a support point for the eyelids, helps provide its normal angular shape, and assists the lacrimal pump apparatus.\textsuperscript{27} It is rigidly fixed to the orbital wall.

McCord et al.\textsuperscript{22} illustrated the structure of the medial canthus and reported that medially, the pretarsal orbicularis produces two heads that pass superficial and deep to the canaliculi. The anterior, more superficial, pretarsal orbicularis muscle forms the anterior crus of the medial canthal tendon that inserts into the frontal process of the maxillary bone. The posterior, deeper, pretarsal orbicularis inserts into the posterior lacrimal crest. The muscle is known as Horner muscle. The deep pretarsal orbicularis inserts on the posterior lacrimal crest and the lacrimal fascia. The deep preseptal fibers insert mainly on the lacrimal fascia, and this is known as Jones muscle. The preseptal muscle forms the horizontal raphe laterally, and medially, it inserts into the anterior crus of the medial canthal tendon.

Lateral Canthus

The lateral canthal tendon resembles the medial canthal tendon in that it supports the lids by supplying a tendinous attachment of pretarsal orbicularis oculi muscle and ligamentous attachment of the tarsal plates to the periosteum of the lateral orbital tubercle. It also allows
Figure 4. Anterior view of the levator palpebrae superioris shows the relationship to the tarsal plate and Whitnall ligament.

Figure 5. Fat compartments and lacrimal gland in the upper and lower eyelids.
movement of the canthal angle by its posterior fibrous attachments to the check ligament of the lateral rectus muscle. In contrast to the medial canthus, the lateral canthus is mobile, possessing up to 6 mm of vertical movement and 2 mm of lateral movement.\textsuperscript{28,29} The lateral canthal tendon is a fibrous structure that joins the upper and lower tarsal plates to Whitnall tubercle inside the orbital rim, deep to the septum. Whitnall tubercle is an area that is not easily found intraoperatively and must be estimated clinically. It forms a prominence approximately 5 mm posterior to the lateral orbital rim.\textsuperscript{30} Rosenstein et al.\textsuperscript{31} described the lateral canthal tendon:

“Superiorly, it is in continuity with the lateral horn of the levator aponeurosis. Inferiorly, it receives fibrous contributions from Lockwood’s suspensory ligament and then curves posteriorly to attach to Whitnall’s tubercle. Anteriorly, the lateral extensions of the preseptal and pretarsal orbicularis oculi muscles coalesce. Posteriorly, contributions from the check ligaments of the lateral rectus muscle complete the formation of the lateral canthal tendon.”

The lateral canthus is located approximately 2 mm higher than the medial canthus. The measurement is the same for both sexes and does not change with increasing age.\textsuperscript{28,32}

**Vascular Supply of the Eyelids**

The eyelids receive their vascular supply from the facial system, which is made from the branches off the internal and external carotid arteries. Off of the internal carotid artery comes the ophthalmic artery, which branches into the supraorbital, supratrochlear, dorsal nasal, and lacrimal arteries. The external carotid artery contributes the facial artery (angular artery) and superficial temporal artery (transverse facial artery, median temporal artery, and frontal and parietal branches). The arterial network of the upper eyelid is composed of anastomoses between the collateral branches of the ophthalmic artery (supraorbital artery, supratrochlear artery, and dorsal nasal artery), a branch of the facial artery (angular artery), and the superficial temporal artery.\textsuperscript{33,34}

The lateral region of the upper eyelid also receives further blood supply from the branches of the superficial temporal artery and the lacrimal artery.\textsuperscript{34} Erdogmus and Govsa\textsuperscript{33} described the connection of the vascular supply and its location:

“The dissection showed that the main blood supplies of the upper and lower lids were provided by the arterial arcades; the marginal, peripheral, superficial, and the deep ones. The marginal and peripheral arcades consisted of the anastomosis of medial and lateral palpebral arteries. The marginal arcade coursed just anterior to the lower margin of the tarsal plate and gave off small perforating branches that ascended tortuously on both sides of the orbicularis oculi muscle and the tarsal plate. These branches extend to the skin, the muscle and the tarsal plate. The perforating branches running over the orbicularis oculi traversed obliquely, in contrast to the perforating vessels, with a descending diameter and became part of the vascular plexus and lower palpebrae in all cases. The peripheral arcade coursed along the upper border of the tarsal plate. It was positioned along the surface of the Muller muscle at the superior border of the tarsus. The peripheral arcade gave off perforating branches that descended on both sides of the tarsal plate. The descending branches running over the tarsal plate connected with the ascending branches arising from the marginal arcade, whereas the descending branches coursing under the tarsal plate fanned out fine vessels and formed a vascular network with the ascending branches arising from the marginal arcade.”

The authors observed arterial arcades near the orbital rim and perforating vessels running on the superficial and deep surfaces of the orbicularis oculi.
muscle, rather than intramuscular vessels, which suggests that the orbicularis oculi muscle. Their observation indicated that the orbicularis oculi muscle is not a tissue with a large vascular network but is instead supplied by the surrounding vascular network.

The venous system for the eyelids was described by McCord et al., who reported that the anterior facial vein is the main superficial venous structure. It follows approximately the same course as that of the facial artery but is superficial and more lateral to it. The facial vein is called the angular vein near the medial canthus; it then becomes the supratrochlear vein and forms deep anastomosis superomedially in the orbit with the superior ophthalmic vein via the supraorbital vein. The angular vein lies temporal to the angular artery over the insertion of the medial canthal tendon. Laterally, the supraorbital vein runs below the orbicularis oculi muscle on the frontalis muscle to communicate with the frontal branches of the superficial temporal vein. Medially, the supraorbital vein runs horizontally beneath the orbicularis and does not surface to join the frontal vein until it communicates with the superior ophthalmic vein of the orbit. A confluence of angular, supraorbital, and supratrochlear veins forms the superior ophthalmic vein. The superior ophthalmic vein acquires venous drainage from the globe and travels to the cavernous sinus. Because of the direct passage to the cavernous sinus, infection of the facial area can cause a superficial sepsis to spread to the cavernous sinus.

Lymphatics of Eyelids
Lymphatic vessels are found in the eyelids and parallel the course of the veins. The medial lymphatics drain to the submandibular lymph nodes. The lateral lymph vessels drain into the preauricular lymph nodes (Fig. 6).

Lacrimal System
Under ordinary conditions, a tear film is continuously produced. It protects the cornea and provides some refractive power for the eye. Basic or baseline secretion is produced by approximately 50 small accessory glands of the Krause and Wolfring glands, mucin-secreting goblet cells of the conjunctiva, and oil-secreting meibomian glands and the glands of Zeiss at the eyelid margin. The main lacrimal gland is actually a reflex secretor and acts in response to physical and emotional triggers (i.e., from emotional or foreign body stimulus).

The main lacrimal gland is divided into two parts by the lateral horn of the levator aponeurosis and is found superotemporally in the orbit. The upper or orbital lobe conforms to the space between the orbital wall and the globe, extending from the lateral border of the levator aponeurosis on which it rests, down to the frontozygomatic suture. The lower or palpebral lobe is located under the levator aponeurosis in the subaponeurotic space. This inferior lobe is mobile and often can be prolapsed into view in the conjunctival sac.

Figure 6. Lymphatic drainage of the upper and lower eyelids with drainage to the submandibular and preauricular lymph nodes.
The vascular supply to the lacrimal gland is via the lacrimal branch of the ophthalmic artery. It receives its innervation by way of cranial nerves V and VII and from sympathetics of the superior cervical ganglion. The secondary and accessory lacrimal glands are responsible for tearing under ordinary circumstances, providing baseline tear secretion.

The excretory system is made up of the upper and lower puncta, canaliculi, the tear sac, and the nasolacrimal duct. They work in conjunction with pretarsal orbicularis oculi, which drives the tears from the tear meniscus in the conjunctival cul-de-sac down to the inferior meatus of the nose.

Jones described its structure. The author reported that the canaliculi are approximately 10 mm long, consisting of a vertical portion 2 mm long and a horizontal portion 8 mm long. The vertical component of each canaliculus begins with the punctum, which lies in the apex of the lacrimal papilla. It is approximately 0.3 mm in diameter and is surrounded by a ring of connective and elastic tissue and a constrictor muscle. It is unique in that it is the only part of the passages with walls rigid enough to produce capillary attraction. The lumen widens to form the ampulla, which is 2 to 3 mm at its longest diameter. The ampulla, in turn, gives rise to the horizontal section, which is ≥0.5 mm in diameter. In 90% of cases, both canaliculi join to form a single common duct, which opens into the tear sac just posterior and superior to the center of its lateral wall.

Jones noted that the tear sac and nasolacrimal duct are anatomically a single structure. The upper end is the fundus, which extends 3 to 5 mm above the level of the medial commissure. The combined length of the tear sac and nasolacrimal duct is approximately 30 mm. The upper 12 mm of the nasolacrimal duct lies in the nasolacrimal canal and is known as the interosseous part. The meatal portion of the duct usually opens 5 mm below the vault of the anterior end of the inferior meatus.

The lacrimal pump begins in the conjunctival sac, where a tear strip is forced medially by the movement of the lids during blinking. The superficial and deep heads of the pretarsal orbicularis muscle close the ampullae and shorten the canaliculi. The preseptal orbicularis creates a negative pressure in the tear sac as the lacrimal diaphragm produces alternating negative and positive pressures to pull the tears into the sac and out of the nose.

**EYELID RECONSTRUCTION.**

Techniques for eyelid laceration repair or eyelid defects after tumor removal range from allowing wounds to heal via secondary intention to the use of complex flaps and grafts. Those without loss of tissue should undergo minimal débridement and be closed primarily. When repairing eyelid lacerations or defects, one must take great care to address proper alignment of the lamellae. Structural repair of the anterior lamella affords a skin covering and blood supply to the eyelid. The posterior lamella provides semirigid support to the eyelid and a nonabrasive mucosal surface for normal blinking, which helps keep the ocular surface moist to protect the cornea from drying. Functional restoration of the upper eyelid acts to protect the cornea, and that of the lower eyelid allows it to oppose the globe and furnish stability, aiding in the normal flow of tears.

In addition to proper alignment of the wound edges, the suture knots should be positioned away from the globe to prevent corneal abrasions from the suture ends.

Granulation or healing via secondary intention is an option in the repair of certain defects. The defects tend to be small and/or superficial and to involve such concave surfaces as the medial canthus or upper nasal side wall.

Full-thickness eyelid defects ≤25% of eyelid length can be transformed into a pentagonal excision and directly closed in younger patients with less eyelid laxity. In older patients with more eyelid laxity, defects up to 40% of the length of the eyelid margin can be closed directly in the same manner. One must ensure that the skin excision involved in a pentagonal excision does not extend beyond the lid crease, if possible. If necessary, the anterior lamella
can be excised as a pentagon and the posterior lamella can be excised as a rectangle to avoid extending the skin incision across the lid crease.\textsuperscript{15} The full-thickness defect is directly closed with the use of the buried vertical mattress technique, as first described by Burroughs et al.\textsuperscript{40} The buried vertical mattress technique uses a single 6-0 or 7-0 polyglactin 910 suture pass, which is begun and completed in the tarsus with the knot tied deep within the eyelid tissue.

Ahmad et al.\textsuperscript{15} described the buried vertical mattress suture in detail:

“The buried vertical mattress suture is performed using a 6-0 Vicryl suture on an S-29 needle (Ethicon, Inc., Somerville, NJ) in a ‘far-far-near-near-near-near-far-far’ pattern” (Fig. 7).\textsuperscript{15} “The suture is first passed through the tarsus at one of the wound edges far from the eyelid margin and out of the tarsus at the eyelid margin far from the wound edge. The suture is then passed back through the same tarsus at the eyelid margin near the wound edge and out of the tarsus at the wound edge near the eyelid margin. The suture is then passed through the tarsus of the opposite wound edge, near the eyelid margin and out of the tarsus at the eyelid margin near the wound edge. The suture is then passed back through the same tarsus at the eyelid margin far from the wound edge and out of the tarsus at the wound edge far from the eyelid margin. The suture is then tied and buried deep to the orbicularis oculi muscle evertting the wound edges at the eyelid margin. Simple interrupted 6-0 Vicryl sutures are performed along the anterior aspect of the tarsus to approximate the remainder of the tarsus. Another simple interrupted 6-0 Vicryl suture is used to align the lash line. It is crucial to align the lash line for a good cosmetic outcome. The skin is closed using simple, interrupted 6-0 nylon sutures.”

The orbicularis muscle can be closed as a separate layer. The septum should not be closed because closure of the septum can lead to eyelid retraction and lagophthalmos, which can lead to significant corneal morbidity.

Burroughs et al.\textsuperscript{40} reported that in 90 patients undergoing the buried vertical mattress technique, no cases of wound dehiscence and only five cases of minimal notch formation occurred within follow-up ranging from 3 to 12 months.

**Free Tissue Grafts**

Free tissue grafts should be coordinated to match both cosmetically and functionally. They should have little or no shrinkage or absorption and be associated with a minimal rate of infection or rejection. Typically, autogenous tissue grafts are better at meeting the requirements than are homologous tissue grafts or alloplastic materials.
Skin
Full-thickness skin grafts contain both an epidermal and a dermal component. Preferred donor sites for full-thickness skin grafts used in eyelid reconstruction have traditionally included the upper eyelid, retroauricular or preauricular areas, and the supraclavicular region, with the best match being from the contralateral eyelid.\textsuperscript{22,41,42} The inner arm and groin are also possible donor sites, but they should not be considered first because they do not provide as suitable a match.\textsuperscript{22} For those patients who have undergone previous facial surgery (i.e., blepharoplasty or rhytidectomy) or for whom large skin grafts are needed, Custer and Harvey\textsuperscript{41} described using the skin of the inner arm as an alternative. A large amount of suitable skin might be obtained from the arm for grafting purposes. In their study, 52 procedures were performed on 42 patients. Partial graft necrosis occurred in two patients, and mild asymptomatic graft contracture developed in four. Steroid injections were administered to two patients with more marked graft contracture. Chronic graft shrinkage occurred in three cases and involved the repair of ichthyosis-related cicatricial ectropion, and abnormal hairs appeared in four grafts.

A split-thickness skin graft is composed of epidermis only, and the standard donor site is the anterior thigh. The split-thickness grafts from the thigh generally have deficient texture, color match, and a tendency to become pigmented. The graft is obtained by a power-driven dermatome. The main application in ophthalmic plastic and reconstructive surgery is for lining anophthalmic sockets and orbital cavities. Only in severe burn cases should this method be a viable choice.\textsuperscript{22}

Conjunctiva
The conjunctiva provides a smooth moist surface of contact for the cornea. A similar material is needed when replacing conjunctiva to prevent corneal irritation. Defects of the conjunctiva that cannot be repaired by advancement require a free graft.

Free conjunctival grafts from the same or opposite eye undergo significant contraction and are difficult to handle. One must take care to avoid compromising the donor fornix.\textsuperscript{3} Mucous membrane grafts in an anophthalmic socket contract rapidly. A conformer is therefore to be kept in the socket at all times for many weeks to prevent socket contracture. Skin cannot be used to replace conjunctiva because the hairs on skin and the squamous layer of epidermis are highly irritating and potentially damaging to the cornea.\textsuperscript{3,43}

Oral or buccal mucosa is the tissue of choice for many plastic surgeons in need of a mucous membrane graft. It is the most readily available of mucous membranes that can be grafted in place of posterior lamellae or eyelid margin resurfacing, but it tends to contract to approximately 50% of pre-graft volume.\textsuperscript{3,43} It can be cut fairly thin and is pliable. The graft donor site typically is the inner surface of the lower lip, but additional grafts can be taken from the inner cheek or upper lip if needed. Because mucosal grafts tend to contract, they must be prepared slightly larger than the size of the proposed graft site. One must take care to avoid the vermillion margin of the lips, the gum, and Stenson duct inside the cheek when obtaining the graft.\textsuperscript{22} The harvesting site is outlined with methylene blue and subsequently incised with a number 15 Bard-Parker blade (BD, Franklin Lakes, NJ). The graft is removed with sharp and blunt scissor dissection and then thinned with scissors. The graft is then placed in an antibiotic solution until needed to replace the eyelid defect. Alternatively, a mucotome can be used to harvest oral mucosa at preset thicknesses varying between 0.2 and 0.5 mm.

Bowen Jones and Nunes\textsuperscript{44} followed patients with oral mucosal grafts to the orbit for more than 3.5 years. Fourteen of the study population were anophthalmic and suffered from contracted socket. Three patients had eyes but were in need of additional conjunctiva. In those patients with eyes who were short of conjunctiva, the defect and fornices were covered with oral mucosa and a soft curved-shell conformer was fitted to maintain the depth of the fornices for 2 weeks. Satisfactory functional results were obtained. The authors concluded that the use of the soft shell to cover the
globe and stretch the graft was essential to maintain the full extent of the fornices for several weeks. They reported using palatal mucosa and nasal septal mucosa for lining eyelids with less resulting contraction, but less material was available for harvesting and the grafts were less pliable.

Ang and Tan described the use of autologous serum-free cultivated conjunctival sheets in a 10-year-old patient with extensive recurrent viral papillomata involving the superior and inferior tarsal, forniscal, and bulbar conjunctiva. The patient underwent surgical excision of all diseased areas and double freeze-thaw cryotherapy. The conjunctival equivalents were used to reconstruct the ocular surface and conjunctival fornices. Almost complete epithelialization was achieved by 5 days postoperatively. The transplanted epithelium remained intact, and good cosmetic and functional results were achieved. Despite the extensive surgery, no significant cicatricial complications, such as forniscal shortening, symblepharon formation, or ocular motility restriction, occurred. Twelve months postoperatively, the eye remained disease-free with no recurrence of the viral papilloma.

The amniotic membrane is anatomically the innermost layer of the placenta and consists of a thick basement membrane and an avascular stroma. It commonly is used to replace damaged mucosal surfaces and has been effectively and extensively used for reconstructing corneal and conjunctival surfaces damaged by a variety of insults and in different ocular surface disorders. Solomon et al. showed that amniotic membrane transplant maintained a deep fornix and scar-free environment with complete or partial success in 14 of 17 eyes. In that study, preserved human amniotic membrane was obtained from Bio-Tissue, Inc. (Miami, FL). After thawing, the membrane was trimmed to correspond with the conjunctival defect, including the bulbar surface of the fornix and the deeper portion of the palpebral aspect of the fornix. The membrane was then secured to the recessed conjunctival edge. Alternatively, the membrane can be stabilized with tissue glue such as Tisseel tissue sealant (Baxter Corp., Mississauga, ON). The authors noted that the reconstructed area can be very large provided that the underlying bed is not ischemic and the adjacent host conjunctiva remains normal. Amniotic membrane grafts have several advantages over oral mucosa. They are readily available, can be trimmed to the required sizes, and entail no donor site morbidity. They also have therapeutic effects, such as promoting epithelial healing and reducing inflammation and pain.

Solomon et al. reported that the therapeutic effect of the amniotic membrane involves synergistic actions that suppress fibrosis, reduce inflammation, and promote epithelialization. The amniotic membrane suppresses transforming growth factor-β signaling and prevents differentiation of normal human corneal and limbal fibroblasts. It also suppresses the expression of certain inflammatory cytokines that originate from the ocular surface epithelia. The inhibition of inflammation is a major factor in the prevention of further fibrovascular proliferation and scar formation in the conjunctiva. Additionally, amniotic membrane transplants maintain a normal conjunctival epithelium with goblet cell differentiation in vivo. In that regard, it is superior to buccal or nasal mucous membrane grafts, the epithelia of which are dissimilar from that of the conjunctiva.

Tarsal Plate
For cases of eyelid reconstruction in which the posterior lamella has been lost, it is critical to use a material that simulates the tarsal-conjunctival complex in thickness, surface quality, and resilience. A wide variety of materials have been used, including autogenous, homologous, and synthetic grafts. Autogenous grafts that have been used include hard palate, ear cartilage, temporalis fascia, fascia lata, nasal septal cartilage, tarsus, dermis, and periosteum. Homologous donor sclera and synthetic polytetrafluoroethylene grafts have also been used. Some materials do not lend a permanent solution, and late problems can arise.

Hard palate grafts and free tarsal grafts are commonly used as posterior lamella alternatives in
eyelid reconstruction. They each provide a mucosal surface. A free tarsal graft is a suitable material in that it provides flexibility, rigidity, and shape. A hard palate graft also provides rigidity, flexibility, and thickness. The hard palate graft is also readily available and is not associated with any morbidity to the contralateral eyelid. The dense concentration of collagen fibers in the lamina propria of the hard palate provides this tissue with stability and firmness, but at the same time, it has enough flexibility to allow it to maintain its contour and act as replacement for the tarsus with excellent eyelid appearance and function, unlike ear or nasal cartilage. However, harvesting the hard palate graft requires a second surgical site that is not sterile and that must heal by secondary intention. Donor site morbidity and patient discomfort both discourage the use of hard palate grafts.

Leibovitch et al. retrospectively evaluated 15 patients who were treated with autogenous hard palate grafts and 16 who were treated with autogenous free tarsal grafts. The authors described the free tarsus and hard palate graft harvesting. For free tarsal graft harvesting, the authors described the following technique: "Local anesthetic was injected beneath the pretarsal upper eyelid skin before eversion of the eyelid using a Desmarres retractor for subconjunctival injection of additional anesthetic above the superior tarsal margin. The tarsus was incised 4 to 5 mm above the lid margin, parallel to the eyelid margin, with the length of the horizontal incision up to 16 mm, depending on the available upper eyelid tarsus. This was followed by 2 vertical incisions at each end of the horizontal incision, towards the upper border of the tarsus. The graft was then dissected from the loosely attached levator aponeurosis, Müller’s muscle, and conjunctiva."

In the study by Leibovitch et al., hard palate harvesting involved local anesthetic injection into the hard palate mucosa and mucoperiosteum, including the area around the greater palatine and incisive foramina. After the required graft size was marked, two parallel incisions were made between the median raphe and the gingival mucosa using a number 15 Bard-Parker blade. An edge of the graft was lifted, and dissection was continued in the submucosal plane. Hemostasis was achieved using pressure, minimal cautery, or an absorbable gelatin sponge soaked in thrombin. A surgical stent was used in some cases. The harvested hard palate graft was carefully thinned by removing fatty submucosa with scissors.

Leibovitch et al. explained that the hard palate grafts were preferred in cases with insufficient height of the contralateral tarsal plate to enable harvesting of adequate free tarsal graft with preservation of 4 mm of residual tarsus, to avoid morbidity to the contralateral eye, and also per the patient’s preference. The complications for the hard palate group included ocular irritation or discomfort in three patients, corneal edema or transient keratopathy in two, partial graft dehiscence in two, upper lid retraction in two, and necrosis of the overlying skin flap in one. Donor site complications included only one case of excessive bleeding from the hard palate site in the recovery room, which required packing. No significant complications occurred in the patients treated with free tarsal plate grafts. The donor upper lid complications were two cases of mild upper lid retraction and central peaking from a fibrous band.

The presence of keratinized epithelium often discourages the use of hard palate grafts in the upper lid because of the possible adverse effects on the cornea. The authors found this side effect to be temporary in all cases, resolving after several weeks to a non-keratinized type, possibly in correlation with the gradual metaplasia of the epithelium. An ear cartilage graft furnishes rigid support similar to that of the tarsus and has the ability to epithelialize over a period of weeks. Ear cartilage is also resistant to contraction and is thus an ideal material to act as a spacer. It lacks the malleability needed to conform to the curved surface of the eye but remains a valuable material for repairing tarsus. It can be thinned, rendering it more malleable when
using a mucotome. McCord et al.\textsuperscript{75} described the technique for harvesting autogenous ear cartilage. The authors described skin hooks used to expose the posterior surface of the ear. They marked a curvilinear line parallel to the edge of the helix, keeping 4 mm from the edge of the helix. They incised the skin and continued dissection down to the ear cartilage, which they then marked. The authors incised the cartilage with a scalpel and used scissors to complete the full-thickness incision and to cut the graft off at its base.

Hashikawa et al.\textsuperscript{76} described the use of ear cartilage as a support for the lower lid instead of a spacer. The authors reasoned that the long and wide plane of the auricular cartilage can enable the lower lid to make contact naturally and closely with the globe. Ear cartilage is generally sutured to the eyelid remnants on either side of the defect, if any, otherwise to the lateral orbital rim periosteum. Hashikawa et al. did not fix the grafted cartilage to the tarsal plate but to the medial canthal ligament and lateral orbital rim without resting on the bony rim. The procedure was applied to various lower lid deformities, including anophthalmic orbits, facial paralyses, reconstructed lids, and deformities secondary to trauma, maxillectomy, infection, burns, and neurofibromatosis. The authors described the technique used in the study:

\begin{quote}
“The auricular cartilage strip is harvested from the anterior side of the ear. From an incision made along the ridge of the antihelix and its superior crus, the subcutaneous plane is dissected, the perichondrium is incised, and then a 4.5 \times 1\text{-cm} strip of the auricular cartilage is harvested. The donor site is subsequently simply closed layer by layer.

“Small skin incisions are made at the medial and lateral canthal regions. A submuscular or a subcutaneous tunnel (depending on whether the orbicularis oculi muscle is lost at previous surgery or trauma) is bluntly dissected from the medial canthal ligament to the lateral orbital rim and made wide enough for the cartilage strip to go in, with its upper edge as close as possible to the lid margin. The auricular cartilage strip is then inserted into the tunnel. The tension of the lower lid is properly adjusted, then one end of the strip is fixed to the medial canthal ligament with nonabsorbable suture and the other is fixed to the periosteum at the level of the insertion of the lateral canthal ligament, ascertaining that the lacrimal canaliculi is not ligated. There is no need to fix the cartilage to the tarsus. Thus, the total lower lid is supported by the plane of the cartilage strip. Finally, the two incisions made at the medial and the lateral canthal regions are simply closed.”
\end{quote}

Because the procedure is simple and conducive to restoring a stable and long-lasting lower lid support, the authors claimed that it is widely applicable to various deformities of the lower lid. Although the grafted cartilage was slightly visible in some cases, none required removal.

Two of the 34 cases required secondary operations during the early postoperative period because of detachment of the grafted cartilage from the point of fixation. This was considered the only complication of the technique; otherwise, there was good lid position during a follow-up period of as long as 15 years. Warping of the cartilage did not occur in any of the cases. A disadvantage of this procedure is that the lower lid becomes fixed postoperatively, and patients might experience partial disturbance in the visual field at the extreme down-gaze. Therefore, the authors recommend the procedure for patients with anophthalmic orbit or severe deformity. Patients with poor vision in the eye undergoing eyelid repair might not be bothered by the possible complication of the down-gaze disturbance and might therefore also be suitable candidates for the procedure.

Scuderi et al.\textsuperscript{77} published the results of their 10-year experience with the nasal chondromucosal flap for large upper eyelid full-thickness defects.
Fifteen patients underwent reconstruction of at least three-fourths of the eyelid. The procedure was derived from a description by Micali et al. of a full-thickness mucosal-chondrocutaneous flap harvested from the lateral side of the nose, including part of the triangular and sesamoid cartilages. Scuderi et al. modified the method by using an ipsilateral axial chondromucosal flap to recreate the posterior lamella. They initially used a local skin flap for cutaneous coverage and later changed to using a skin graft because of the bulkiness of the flap. Scuderi et al. described the surgical technique as follows:

“After the skin is incised for 2.5 cm along the border between the lateral nasal wall and the cheek from the inner canthus to the ala nasi, the periosteum is dissected from lateral to medial, up to and beyond the midline of the nose. Dissection is extended superiorly to the inner canthus and glabella and inferiorly to the lower margin of the nasal bones. Then, the subcutaneous tissue is dissected, always from lateral to medial, onto a line beyond the midline of the nose, where it joins the subperiosteal plane. The subcutaneous dissection is extended superiorly to the glabellar area and inferiorly to or beyond the lower margin of the upper lateral cartilages. Distally, the flap is harvested including the cranial portion of the upper lateral cartilage, depending on the size of the defect to repair, and the corresponding nasal mucosa. The flap is then transposed to reconstruct the posterior lamella of the missing eyelid, flap mucosa is sutured to the conjunctival margin (separating it from the fornix if necessary), and the levator muscle stump is inserted into the cartilaginous portion of the flap. This simulates insertion of the levator muscle into the tarsal plate.”

With this technique, a skin graft is used for the anterior lamella. The nasal lining donor defect is repaired with direct closure using absorbable sutures or can be left to heal spontaneously, and the skin is closed with fine nylon. The procedure modified by Scuderi et al. resulted in a viable flap in every patient, without total or partial necrosis. Static parameters were within normal ranges: levator function was 8 to 18 mm (mean, 13 mm), and eyelid length was 25 to 30 mm (mean, 29.2 mm). Patients were generally pleased with the results. Complications included lagophthalmos in one case, orbital emphysema in one, and corneal abrasions in three.

Acellular human dermis (AlloDerm; LifeCell Corporation, Branchburg, NJ), is a cadaveric dermal graft that has been enzymatically processed to remove all cellular material to leave only an acellular and immunologically inert collagen matrix. The dermal framework promotes fibroblast immigration, neovascularization, and collagen deposition. In postoperative animal studies, the matrix is replaced by host cells. Li et al. compared 35 patients undergoing AlloDerm grafting with 25 patients undergoing hard palate grafting of the lower eyelid after postoperative cicatricial changes. The lower eyelid heights were measured. No statistically significant difference was found between the AlloDerm and hard palate groups, although a trend was observed that hard palate grafts resulted in both better elevation and a lower failure rate. Female patients in both groups were found to experience significantly greater eyelid elevation than male patients.

Taban et al. evaluated the long-term efficacy of a thick AlloDerm graft in lower eyelid reconstruction compared with previous results for thin AlloDerm and hard palate grafts. The results showed similar rates of success and final eyelid height position.

An alternative material that can be used in place of tarsus is a product known as Enduragen, which is a porcine acellular dermal collagen matrix manufactured by Tissue Science Laboratories (Aldershot, United Kingdom). McCord et al. described the first experiences with Enduragen as a spacer graft in 69 patients and 129 eyelids.
for both reconstructive and aesthetic procedures as a substitute for autogenous ear cartilage and fascia. In eight procedures, a spacer was placed in the upper lid. One hundred four procedures were performed for spacers in the lower lid and 17 for lateral canthal reinforcement. In the upper eyelid, Enduragen typically was used as a spacer graft between the levator-Müller muscle and tarsal plate for upper lid advancement procedures used to treat Graves lagophthalmos or overcorrected ptosis repairs. All upper lid procedures were accomplished using an anterior transcutaneous approach. After release of the levator attachment to the tarsal plate, an Enduragen spacer graft, of varying height depending on needs (generally 3–5 mm), was then secured to the superior edge of the tarsal plate and the distal fibers of the levator aponeurosis using absorbable sutures. In the lower eyelid, the procedures were performed either to insert spacer material in the lower lid in patients with prominent eyes or to counteract scarring in retracted lids. Either an anterior approach through a subciliary incision or a posterior approach including a cantholysis and transconjunctival incision was used. Thirteen eyelid complications occurred in the series presented by McCord et al., with a resulting complication rate of 10%. Nine cases required surgical revision. Four cases of infection occurred, and all were successfully treated with oral and topical antibiotics. Many of the cases that needed revision were extreme cases that had undergone multiple eyelid procedures before the operation in the series by McCord et al. In those cases, extreme scar contractures, previously placed grafts, and other problems were encountered. The authors noted that Enduragen is slightly more rigid than other tissue products; therefore, all edges and corners should be trimmed and tapered before closure. Enduragen is described as having superior uniformity and predictability of thickness, structural integrity, ease of use (it does not require soaking), and better durability.

Barbera et al. described using a venous wall graft to reconstruct the posterior lamellae. The walls of propulsive veins were harvested from the forearm in six patients and from the leg in one patient to replace the tarsal-conjunctival complex. No complications occurred at any of the donor sites or the eyelid area. No graft or flap suffered vascular failure. Cosmetic and functional results were judged to be good to outstanding by both patients and physicians. The authors reported that the reconstructed eyelids had congruous thinness and that the fornices were adequately deep. The venous wall was found to be useful in that it is thin and permits reconstruction of the entire height of the upper eyelid (approximately 15 mm) when using a vein with a 5-mm diameter. The elastic properties, smoothness, and concavity of the venous graft allow it to conform to the globe without inducing a chronic inflammatory reaction on the bulbar conjunctiva or on the cornea. Autogenous dermis can also be used as a replacement for tarsus and is discussed below.

**Composite Grafts**

Composite grafts provide multiple tissue requirements for eyelid reconstruction in one stage. Composite grafting is a simple, safe, less invasive, and time-saving method for eyelid repair.

Korn et al. reported their experience with autologous dermis fat grafts as a posterior lamellar spacer graft in repair of eyelid malpositions. The use of dermis fat as a composite graft in anophthalmic orbits has been well described. The authors argued that several features make autologous dermis fat a suitable spacer graft, including the ability to supply both posterior lamella on the dermis face, volume replacement with fat, no risk of a transmissible agent, and low incidence of tissue rejection. Eleven patients with lower eyelid malpositions from various causes were treated with dermis fat grafting to the lower eyelid. The source of dermis fat was the hip, inferior and posterior to the superior iliac crest. After marking an ellipse of skin, the epithelium can be removed with either sharp dissection or with a diamond burr. The dermis with the needed fat is then excised, and the composite graft is sutured into the eyelid defect with the dermis side toward the globe. The donor site is then
closed primarily. After 1 year of follow-up, all 11 patients reported marked cosmetic improvement and high satisfaction after the reconstructive surgery.

The main concerns regarding the use of dermis fat grafting are surface keratinization and growth of hairs leading to ocular surface irritation and complications. Korn et al. performed mechanical débridement of the epithelium and found that this step necessary to prevent graft complications. With that approach, the authors did not note any postoperative hair growth, surface keratinization, or any major complications. Furthermore, the authors noted that meticulous end-to-end approximation of the dermis side of the graft with the conjunctival edge allows for uniform migration of the conjunctival epithelial cells over the dermal graft surface. Finally, the authors placed the graft deep in the fornix, where corneal apposition is minimal.

Lee et al. treated 13 patients with sunken and/or multiply folded upper eyelids using fascia-fat composite grafts from the mons pubis, temporal, and preauricular areas. The technique was used in patients who had undergone Oriental upper blepharoplasty, which often results in excessive fat removal and can be associated with injury to the orbital septum. Adhesions of the skin to underlying tissues down to the septum can develop. To remedy such deformities, local tissue transfer can be used to return a more desirable volume to the eyelids and can solve the adhesion problem. The authors argue that dermis fat grafts might be too heavy, might affect upper eyelid motion, and might also produce a visible mass. By contrast, the fascia-fat composite has a rich vascular fascial component; it is therefore expected to achieve vascularity earlier and to survive better than free fat alone. In addition, it is lighter than the dermis-fat composite, provides a closer anatomic match to the damaged orbital fat and septum, and is abundant throughout the body. All 13 patients were satisfied with the appearance of the final results. Deformities resulting from volume depletion and adhesion disappeared immediately after the operation. Six-month results were maintained throughout the follow-up period (average follow-up duration, 2.5 years after surgery) without development of any complications.

Yildirim et al. used composite sandwich grafts containing skin-cartilage-skin for the reconstruction of full-thickness defects of the eyelid margin. Composite grafts were removed from the upper third of the auricular helix. Thirteen patients were followed monthly for up to 6 months. Graft loss resulted in three patients who had marginal necrosis of the outer skin layer of the composite graft. All of the marginal losses were successfully treated with daily dressings, without the need for additional surgery. No corneal irritation or injury from the use of helical skin for reconstruction of conjunctiva at the eyelid margin was observed. The authors stated that an advantage of using this composite graft technique is that the helical cartilage is thinner than that of the nasal septum and is therefore more similar to tarsus. Helical cartilage also has a better curvature than does septal cartilage for the globe.

Reconstructive Flaps
A wound or surgical defect that cannot be closed primarily might require a flap for successful reconstruction. A flap maintains its own blood supply from a pedicle or base attachment from adjacent tissue, so it is useful for reconstructing sites with poor vascularity that cannot sustain a skin graft. This feature also leads to less contraction and a more cosmetically appealing result than those achieved with grafts.

Upper Eyelid
Direct Closure
Most upper eyelid defects are caused by the removal of tumors, trauma, or congenital abnormalities. As discussed earlier, direct closure of a full-thickness eyelid defect that is ≤25% of the eyelid length can be successfully accomplished with a pentagonal excision approach in a younger patient with less eyelid laxity. Older patients have increased lid laxity; thus, defects up to 40% of the length of the eyelid margin can be closed directly. For direct closure, the buried vertical mattress technique is preferred to
the classically taught three-suture technique.

Canthotomy and Cantholysis

If direct eyelid closure causes excessive tension on the eyelid, further mobilization of tissue is needed and performing a lateral canthotomy and cantholysis is a suitable solution. The lateral canthal area is injected with lidocaine with epinephrine to achieve both anesthesia and hemostasis. A number 15 Bard-Parker blade is used to make a horizontal incision for 5 mm, starting at the lateral canthus. The incision is continued down to the orbital rim. The superior ramus of the lateral canthal tendon should then be identified. The superior and inferior rami are more easily palpated with scissors than visualized. With Westcott scissors pointed superoposteriorly toward the lateral orbital rim, the superior arm of the lateral canthal tendon can be detached from the orbital rim, causing significant mobilization of the upper eyelid.

Holds and Anderson described the use of combined medial canthotomy and cantholysis as a single-stage reconstructive technique for use in the reconstruction of the upper or lower eyelid. That technique sacrifices one lacrimal canaliculus and can provide up to 20% of the horizontal eyelid length for closure. The authors recommended that the patient be under general anesthesia for this procedure. It involves transection of one lacrimal canaliculus, lysis of one crus of the medial canthal tendon, and lateral advancement of the medial eyelid stump. Adequate reconstructive results were achieved by using this technique to correct 29 eyelid defects (21 upper eyelids and eight lower eyelids) during a 12-year period. Eleven of the patients underwent simultaneous lateral canthotomy and cantholysis. Complications included anterior displacement of the medial portion of the eyelid, epiphora, notching of the medial portion of the eyelid, medial ectropion, and blepharoptosis.

Tenzel Rotational Flap

Central upper eyelid defects involving approximately 40% of the lid margin can be closed with a semicircular flap, which is rotated into the defect, as described by Tenzel. An inferior arching semicircular line is marked from the lateral canthus extending temporally (Fig. 8). The diameter of the flap is approximately 20 mm. The flap is incised with a number 15 Bard-Parker blade, and a Bovie cutting needle (Bovie Medical Corp., Clearwater, FL) can be used to incise through muscle and to achieve hemostasis. A lateral canthotomy is made beneath the semicircular skin incision, and dissection is carried out to the lateral orbital rim. A superior cantholysis is performed as described above, and the lateral portion of the upper lid is advanced medially to be attached to the lateral orbital rim. The flap is then undermined and rotated inward. The edge of the flap should be sutured to the medial edge of the defect with a buried vertical mattress technique, as described above. Lateral fixation is obtained by suturing the edge of the flap to the periosteum at the lateral orbital rim with fixation to the inferior ramus of the lateral canthal tendon.

Cutler-Beard Flap (Bridge Flap)

The Cutler-Beard flap is a lower eyelid advancement flap that uses a full-thickness rectangular segment from the lower eyelid to repair large or total defects of the upper eyelid. It is a two-stage procedure used for reconstruction of defects involving more than one-half of the eyelid. The defect of the upper lid is fashioned in a rectangular manner in preparation for a rectangular flap from the lower eyelid. The first step involves marking the lower eyelid 1 to 2 mm below the inferior border of tarsal plate. A full-thickness horizontal incision is then made along the distal border of the lower tarsus. Vertical incisions are made next, completing a rectangular flap (Fig. 9). The flap is then advanced beneath the remaining, undisturbed lower eyelid margin bridge and is inset into the upper eyelid defect. The skin and orbicularis of the flap are split from the palpebral conjunctiva. The conjunctiva is then sutured to the remaining upper eyelid conjunctiva. The capsulopalpebral fascia just anterior to the conjunctiva is sutured to the remaining levator.
**Figure 8.** (Above) Tenzel flap for upper eyelid reconstruction. An inferior arching semicircular line is marked and incised from the lateral canthus, extending temporally. A lateral canthotomy is made, and a superior cantholysis is performed. The flap is rotated inward and sutured to the medial edge of the defect.

**Figure 9.** (Left) Classic Cutler-Beard bridge flap technique. A horizontal incision is made along the distal border of the lower tarsus. A full-thickness inferior eyelid flap is created. The remaining lower lid margin forms a bridge. After 4 to 8 weeks, the flap is cut. The pedicle slides back and is sutured to the distal border of the bridge.
The myocutaneous flap is advanced and sutured to the skin of the upper eyelid defect. Four to 8 weeks later, the second stage occurs, during which the flap is divided and the margin of the upper lid is reconstructed. The pedicle slides back and is sutured to the distal border of the bridge. To gain more rigid support of the reconstructed lid, some authors recommend recreating the upper lid tarsus by using an inlay graft of ear cartilage, fascia lata, or eye bank sclera. This graft is sutured medially and laterally to remaining tarsus and superiorly to the cut edge of the levator aponeurosis.

Hollomon and Carter described replacement of upper eyelid tarsus with Achilles tendon as part of the Cutler-Beard procedure. The Achilles tendon is composed of collagen fibril bundles with supportive cells in a dense connective tissue, similar to tarsus. It is readily available from most tissue banks. The technique was successful in four patients. The total follow-up ranged from 6 months to 4 years. Of the four patients, none experienced infection, dehiscence, or necrosis. No cases of secondary ptosis, eyelid retraction, or eyelid malposition occurred, and no case required a second procedure. The authors explained that the main advantage of using this graft is its unlimited quantity, providing sufficient length for reconstructing large areas. An additional benefit is that there is no second surgical site, reducing complications and healing time. Achilles tendon was found to be more pliable and mobile than cartilage, yet it maintained its stability over time. The disadvantages are cost, waste of excess unused tissue, and rare possibility of disease transmission present in all allografts.

Demir et al. reported a single-stage procedure for reconstructing large full-thickness upper eyelid defects using an orbicularis oculi advancement flap. The skin and muscle of the limbs are totally mobilized, leaving the base of the pedicle intact with submuscular tissue attachments. A triangular V-Y advancement myocutaneous flap is created, based on the submuscular plane. The flap includes skin, muscle, and submuscular tissue, but orbital septum is left intact. A hard palate mucoperiosteal graft is harvested for posterior lamella reconstruction. The hard palate graft is positioned in the defect and sutured to the remaining tarsus or canthal tendon stumps and conjunctiva. The myocutaneous flap is then advanced vertically to the defect and sutured to the inferior edge of the mucoperiosteal graft. The eight patients in the study by Demir et al. experienced no major complications during follow-up periods of 6 months to 4 years. The flap was viable in every patient, without total or partial necrosis, and no patient required surgical revision. The authors found that the technique allows for immediate visual rehabilitation, provides functional orbicularis muscle to preserve blinking and eyelid closure, and permits formation of natural eyelid surfaces and contours.

Irvine and McNab described a technique for large upper eyelid marginal defects with 3 to 4 mm of residual upper lid tarsus. The residual upper tarsus travels on a conjunctival pedicle after releasing the levator aponeurosis and Müller muscle. The tarsus is moved to fill the posterior lamella defect in a way similar to that of mobilizing a Hughes flap (Fig. 10). Lagophthalmos often was present to a minor degree of 1 to 2 mm, but patients were asymptomatic. The main late complication occurring in two patients was lanugo hairs from the anterior lamella causing corneal irritation and intermittent punctate epithelial keratopathy. The conditions were successfully managed with topical lubricants. After the complication occurred in the first four patients, the technique was modified by suturing the anterior lamella in a recessed position of 1 to 2 mm to avoid the complication of lanugo hairs causing corneal irritation. A full-thickness skin graft can be used in the event of insufficient anterior lamella.

Hsuan and Selva described a modified Cutler-Beard flap involving a free tarsal graft with a skin-only advancement flap from the lower eyelid, which is divided at 2 weeks. In four cases, the free tarsal graft was harvested from the contralateral upper eyelid. The authors stated that using skin
alone in the advancement flap spares dissection of the orbicularis, resulting in less disruption to the lower lid tissues. They suggested that the time required for the skin to stretch is less than that for a comparable myocutaneous flap, which is supported by their results showing the flap was divided at 2 weeks. The skin-only flap carries a sufficient blood supply, apparent during flap division at 2 weeks, which showed bleeding from the reconstructed tarsal margin and indicated good vascularity. Another advantage of this method is eye occlusion for only 2 weeks compared with the traditional 4 to 8 weeks. Only one patient developed mild ectropion and was noted to be the youngest patient needing the greatest vertical displacement to cover the upper lid defect.

Dutton and Fowler\textsuperscript{102} presented a modification of the Cutler-Beard technique, which is valuable in cases in which the upper eyelid margin is spared. The technique is helpful for patients with cicatricial upper eyelid scarring and retraction of non-marginal tumor resection. A full-thickness horizontal incision is cut just above the tarsus of the upper lid (in cases of cicatricial retraction), or the non-marginal lesion is excised, conserving the upper lid margin. The remainder of the surgery consists of the traditional Cutler-Beard technique. After 2 to 3 weeks, the flap gains adequate blood supply from above. After 3 to 4 weeks, the flap is divided. The epithelium and scar tissue along the inferior border of the lower eyelid bridge and along the superior border of the upper eyelid bridge are trimmed to expose all lamellae. The lateral and medial edges of the cheek incisions are undermined, and, if necessary, a portion of the stretched flap ends is excised. The conjunctiva and lower eyelid retractors are sutured to the inferior border of the lower tarsus with a running 6-0 fast-absorbing plain gut suture. The authors described performing the procedure in only two patients who were reported to have achieved excellent functional and cosmetic results, although a follow-up duration was not specified for the first patient described. The second patient subsequently underwent a frontalis sling procedure to correct residual ptosis 8 months postoperatively.

Another less common technique is a pentagonal composite graft from the contralateral upper eyelid. Up to 30\% of the contralateral upper eyelid can be harvested and transferred to the affected eyelid. The technique should be a last resort measure to avoid complications in the normal eye. One should consider this method if the contralateral eye is blind or has poor visual potential. A reconstructive ladder for upper eyelid defects is shown (Fig. 11).\textsuperscript{13}

**Lower Eyelid**

*Direct Closure*

Lower eyelid defects involving 25\% or less of the eyelid length in a young patient can be closed in a fashion similar to closure of the upper eyelid, with a direct end-to-end closure. In older patients
Figure 11. Reconstructive ladder for upper eyelid defect. A, Primary closure with or without lateral canthotomy or superior cantholysis. B, Semicircular flap. C, Adjacent tarsconjunctival flap and full-thickness skin graft. D, Free tarsconjunctival graft and skin flap. E, Full-thickness lower eyelid advancement flap (Cutler-Beard flap). F, Lower eyelid switch flap or median forehead flap. (Reproduced with permission from Kersten.)
with additional lid laxity, a defect consisting of up to 40% of the lower eyelid margin can also be closed directly. As revealed earlier, a pentagonal excision closure with the buried vertical mattress technique is preferred over the classically taught three-suture technique.

**Lateral Canthotomy and Inferior Cantholysis**

If direct closure causes excessive tension on the wound edges, a lateral canthotomy and inferior cantholysis can notably mobilize the lateral portion of the defect. As described earlier, a number 15 Bard-Parker blade is used to make an approximately 5-mm horizontal incision in the skin at the lateral canthus. The incision is continued down to the orbital rim. The inferior ramus of the lateral canthal tendon should then be identified with scissor tips. Using Westcott scissors pointed toward the lateral orbital rim, the inferior arm of the lateral canthal tendon is cut from the orbital rim (Fig. 12). The lower lid should easily pull away from the lateral canthus. The lateral margin of the wound can then be mobilized nasally to close the lid margin defect.

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**Tenzel Rotational Flap**

Lower eyelid defects involving 40% to 60% of the lid margin can be closed with a lateral, semicircular miniflap rotated into the lid defect. Similar to the technique used in creating a pentagonal configuration for direct closure of a lid defect, the tissue inferior to the tarsal defect is excised in a triangular shape. A superior arching line is drawn on the skin beginning from the lateral canthus extending temporally to the lateral extension of the brow line (Fig. 13). The diameter of the flap drawn is approximately 20 mm. The outline is incised with a blade, and a lateral canthotomy incision is made below the flap with subsequent dissection down to the lateral orbital rim. An inferior cantholysis is then performed. The flap is undermined and rotated nasally.

Lateral lid support must be re-established to prevent lateral drooping of the eyelid. This is accomplished by suturing the dermis of the flap tissue to the inner periosteum of the superior inner aspect of the lateral orbital rim.

The Tenzel flap can also be supplemented with periosteum or ear cartilage for slightly larger defects to create a support for the lateral eyelid. A periosteal flap is created by elevating a strip from the lateral orbital rim and keeping it hinged off the orbital rim. The flap is stretched across and attached to the inside of the advanced Tenzel flap. Alternatively, an ear cartilage graft can be used to support the lateral portion deficient of tarsus.

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**Hughes Flap**

Larger defects that involve more than 50% (depending on lid laxity) of the lower lid margin are ideally closed with a Hughes flap. In 1937, Hughes presented a method for lower eyelid reconstruction that makes use of the upper eyelid as the donor site. See also Hughes (1945) and Rohrich and Zbar (1999). A tarsoconjunctival flap was created from the ipsilateral upper eyelid, and it was advanced inferiorly into the lower eyelid defect to replace the absent posterior lamella. Hughes undermined cheek skin to elevate it, replacing absent lower lid skin without tension. The
undermined cheek skin was then brought upward and sutured onto the anterior portion of the lower half of the upper lid tarsal plate to rebuild the anterior lamella.

Macomber et al.\textsuperscript{107} later altered the Hughes flap by using a full-thickness skin graft harvested from either the postauricular, supraclavicular, or contralateral upper lid skin as an alternative to elevating cheek skin. The graft was sewn onto the advanced tarsal plate. The vascular supply for the graft came from the tarsoconjunctival flap. Macomber et al. also recommended eyelash transplantation only in the young or aesthetically minded patient after several weeks using a single row of hair follicles from the eyebrow. After 6 weeks, the lid was divided.

**Modified Hughes Flap**

Years after his original description\textsuperscript{104} was published, Hughes\textsuperscript{108} presented a modified Hughes flap in response to criticisms regarding postoperative outcomes. Cies and Bartlett\textsuperscript{109} reported methods to avoid postoperative complications with the Hughes flap. They argued to leave the inferior portion of the upper eyelid tarsal plate in situ by placing the incision above the lid margin, and they recommended removing Müller muscle from the flap at the time of original dissection. The authors stated that the maneuvers preserved upper eyelid support and decreased postoperative upper eyelid retraction and entropion. Cies and Bartlett\textsuperscript{109} and Pollock et al.\textsuperscript{110} additionally explained that preservation of at least 4 mm of tarsus vertically from the eyelid margin is necessary to avoid postoperative eyelid contour complications.

McCord et al.\textsuperscript{75} described the modified Hughes flap in detail. Per the authors, the lower extent of the lower eyelid wound is fashioned into a rectangular shape. The horizontal length of the defect is measured to determine the width of the upper lid flap. A three-sided advancement flap is marked on the conjunctiva of the upper eyelid. The horizontal margin of the flap must be 4 mm away from the lid margin. The outlined flap is incised through conjunctiva and tarsus to a level between tarsus and levator aponeurosis. The dissection is continued superiorly between Müller muscle and the levator aponeurosis. The medial and lateral edges of the tarsal flap are sutured to the edges of the lower lid tarsus. The previous upper lid superior tarsal border becomes the lower lid tarsal margin. In cases in which lower lid tarsus at the lateral margin of the defect is not available, the tarsal flap from the upper lid can be anchored to the periosteum using lateral canthal fixation. The inferior border of the flap is sutured to the remaining conjunctiva. A full-thickness skin graft is placed over the tarsoconjunctival flap, and the superior edge of the skin graft is sutured 1 to 2 mm higher than the future lower lid margin.

Various authors divided the Hughes flap after 6 to 8 weeks\textsuperscript{109} or even after 2 to 4 weeks.\textsuperscript{75,111,112}

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**Figure 13.** Tenzel flap in lower eyelid reconstruction. After a superior arching line is drawn and incised from the lateral canthus extending temporally, a lateral canthotomy incision is created and inferior cantholysis performed. The flap is then undermined, rotated nasally, and sutured.
Additionally, successful division after 1 week was reported. McNab et al. conducted a prospective randomized study comparing division of the pedicle of modified Hughes flaps at 2 and 4 weeks. Statistical analyses showed no significant difference between the two groups for upper and lower eyelid position at 3 months of follow-up or for other eyelid complications. In all cases, vascularization of the reconstructed lower eyelid was excellent in both the 2- and 4-week groups.

Bartley and Messenger reported the results of eight cases of premature traumatic dehiscence of a Hughes flap. Each case had been caused by accidental trauma that occurred between 1 and 11 days postoperatively in seven of the eight patients. One patient was unable to identify the exact day on which the flap separated. In four patients, the entire flap was involved. The eyelids were allowed to heal without immediate surgical intervention. In four patients whose dehiscence did not involve the entire pedicle, the residual tars Conjontival flap was divided after 16 to 36 days. Final cosmetic and functional outcomes were acceptable for the majority of the patients in the series. The findings suggest that elective division of the conjunctival pedicle in routine cases can conceivably be performed sooner after primary reconstructive procedures than previously thought.

Leibovitch and Selva reported the outcomes of early division of 29 eyelids of 29 patients 1 week after undergoing lower eyelid reconstructive surgery with a modified Hughes flap. The follow-up period ranged from 6 to 23 months. No cases of flap ischemia, necrosis, or retraction of the lower eyelid occurred. Lower eyelid complications occurred in two patients with margin erythema. In one of the two patients, margin hypertrophy required excision and cautery. Upper eyelid complications included three cases of lash ptosis. One patient had lateral upper eyelid retraction of 2 mm requiring an anterior approach levator recession 3 months after surgery. In two patients, biopsies were obtained from the central and distal tarsal components of the flap at the time of division. The biopsies showed viable vascularized tissue with no evidence of ischemia.

Maloof et al. described use of the Hughes flap combined with oblique medial and lateral periosteal flaps in eight patients. The use of medial and lateral periosteal flaps was noted to be the key element in the procedure, facilitating the use of the Hughes tarsal conjunctival flap to correct maximal defects of the lower eyelid in cases in which both medial and lateral canthal tendons were absent. The authors named the procedure the maximal Hughes procedure. Here is their description of the creation of the flaps:

“The periosteal flaps were elevated from the inferomedial and inferolateral orbital margins with the base of the flap located at the desired position of the medial and lateral canthal tendons. The medial periosteal flap was elevated from the anterior aspect of the inferomedial orbital rim, overlying the frontal process of the maxilla and passing inferolaterally along the orbital rim. Care was taken to ensure that the flap remained at least 4 mm wide along its entire length. Once above the level of the medial canal tendon, the margins of the flap followed an angled path from the anterior aspect of the frontal process of the maxilla to the rim of the orbit above the nasolacrimal sac, where the flap was reflected into the orbital base. The flap was constructed in this fashion to reduce the chance of medial ectropion of the lower eyelid. The average length of this medial periosteal flap was long, approximating 20 mm, to take into account the curvature at the proximal end of the flap. To produce a horizontal attachment, the periosteal flap was then folded on itself, giving a total length of approximately 15 mm. The lateral periosteal flap was created in the same fashion, by elevating an oblique strip of periosteum from the lateral orbital rim over the zygoma and passing inferomedially along the orbital rim.
rim. The peristeme was elevated above the former site of the lateral canthal tendon and reflected into the base of the orbit. Unlike the medial flap, the lateral flap did not need to follow an angled course and was not folded on itself. In all cases, the lateral periosteal flap was thicker than the medial flap. The tarsus was anchored medially and laterally to the periosteal flaps using interrupted 5-0 polyglactin sutures. The conjunctiva was sutured to the inferior border of the tarsal plate and inferior margin of the periosteal flaps using a continuous 7-0 polyglactin suture. The anterior lamella of the lower eyelid was then mobilized and sutured to the upper border of the tarsoconjunctival flap. Cases in which skin was deficient, an orbicular muscle advancement flap was mobilized and a full-thickness skin graft was used to replace the anterior lamella. The tarsoconjunctival flap was not divided for at least 8 weeks.\textsuperscript{116}

The average follow-up duration in that study was 13 months (range, 7–22 months). All flaps and grafts remained viable, and no patient experienced corneal complications or lagophthalmos. All patients had a cosmetically acceptable appearance with excellent eyelid contour. In two patients who underwent skin muscle advancements, late lower eyelid retraction developed. Medial ectropion developed in one patient at 4 months postoperatively.

Tei and Larsen\textsuperscript{117} illustrated the use of a Hughes flap with a nasolabial flap to reconstruct the lower eyelid and to cover a large accompanying skin defect in one case. The defect measured 38 mm in width and 30 mm in height and was reconstructed with the use of a subcutaneously based nasolabial flap. The tarsoconjunctival flap was divided 3 weeks postoperatively. Three months postoperatively, the patient had neither ectropion nor entropion. The vascular supply for the flap was derived from the infraorbital artery and the anastomoses between the lateral nasal artery and branches of the infraorbital artery.\textsuperscript{118} The advantages with the use of nasolabial flaps were the inconspicuous donor scar concealed in the nasolabial fold, the reliable vascularity of the flap, and use of a non-hair-bearing area.

**Mustarde Rotational Cheek Flap**

The Mustarde flap is a full-thickness rotational cheek flap that can be used for complete lower eyelid reconstruction in one operation.\textsuperscript{43,119,120} It is most valuable for correcting vertically deep defects, particularly those in which the vertical dimension is greater than the horizontal dimension, and the more nasal defects.\textsuperscript{22,75} A large, nasal, superiorly based triangle is outlined with the medial edge on the nasolabial fold (Fig. 14). A semicircular flap is then made, beginning at the lateral canthus and continuing laterally down to the area anterior to the auricular tragus. The superior edge should extend at least to the height of the brow or above. The medial triangle is excised, but its size will depend on the amount of tissue needed to rotate the flap. The semicircular flap is then undermined. Before the undermined tissue is rotated, a chondromucosal graft or autogenous ear cartilage graft is obtained for posterior lamellae reconstruction and is sutured inferiorly to the conjunctival mucosa in the inferior fornix. Alternatively, a tarsoconjunctival graft, hard palate graft, or synthetic material such as AlloDerm can be used. The cheek flap is then rotated nasally to fill the nasal triangular defect. The medial canthus is recreated by placing a 5-0 Vicryl suture through the dermis of the cheek flap and anchoring it to the posterior lamellae. The graft used for the posterior lamellae is then sutured to the posterior margin of the cheek flap at the new lid margin. Running 5-0 plain catgut suture is placed at the mucosal-epithelial border. The lateral canthus is replaced by suturing the dermis of the rotational flap to the superior, inner aspect of the lateral orbital rim with lateral canthal fixation. The skin is then closed. The lateral edge of the flap can be closed with a V-to-Y configuration or a triangular excision of redundant skin. To end with, the eyelids are sutured together with a tarsorrhaphy stitch that
provides added upward tension on the flap and everts the mucosa skin interface. The tarsorrhaphy and skin sutures can be removed after 5 days.75

Tripier Flap
In 1889, Tripier121 described the original Tripier flap for cases in which the posterior lamella is preserved but anterior lamellae lower eyelid restoration is required. It consisted of dissecting and elevating a bipedicled flap from the upper eyelid that was then transposed inferiorly into a lateral lower eyelid defect (Fig. 15).122 The flap consists of upper eyelid skin and orbicularis muscle. Tripier121 stated that for a successful flap, the number of facial nerve branches severed needed to be minimized and it was desirable to maintain the continuity of the orbicularis muscle fibers.123 He wrote that defects of one-half or even two-thirds of the lower eyelid could be reconstructed by using this technique. Adaptations of this flap have since been described.123–127

In his original manuscript, Tripier121 also described a second variation of the flap that was used to reconstruct upper eyelid defects with a myocutaneous flap based on prefrontal orbicularis oculi muscle fibers positioned superior to the eyebrow. That technique is no longer commonly used.121–123

Elliot and Britto123 described a third variation of the Tripier flap for reconstruction of marginal defects of the upper eyelid. The authors reported the design of a “bucket-handle flap” immediately inferior to the eyebrow on the upper preseptal fibers of orbicularis oculi. The flap is designed identically to the flap used by Tripier to reconstruct the lower eyelid but uses the tissues more superior and closer to the lower margin of the eyebrow.

Bickle and Bennett122 presented a fourth Tripier flap variation for reconstruction of a medial defect on the lower eyelid. A medially based myocutaneous flap (including superficial fibers of the orbicularis oculi muscle) was designed from the medial upper eyelid. The flap was intentionally made longer than necessary because, on rotation, it loses length. The lower planned incision line was placed over the pretarsal crease. An incision was made from the defect on the lower eyelid extending across the medial canthus and onto the upper eyelid; the incision was then continued laterally along the pretarsal crease and curved upward and then medially to complete the flap. The flap was elevated and transposed into the defect on the medial aspect of the lower eyelid and then sutured into place. A standing cone (dog ear) occurred at the flap base in the medial canthus, but it could not be excised at the time of flap placement because

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**Figure 14.** Mustarde rotational cheek flap. *Top, Shaded area shows inferior eyelid defect. Middle, Nasal chondromucosal graft is secured to the lateral orbital rim. The rotated flap is anchored to the external lateral orbital rim. Bottom, Defect is closed.*
doing so would compromise the vascular supply to the flap. At 5 months’ follow-up, the lacrimal system was functional, and no eyelid malposition had occurred. The authors stated that the residual dog ear would probably resolve on its own, although in some cases, if excessive, the dog ear might need to be injected with triamcinolone acetonide (10 mg/mL) or excised. Other potential problems cited by the authors were medial canthal blunting, mild pincushioning, and mild medial eyelid ectropion.

Levin and Leone\textsuperscript{128} incorporate the pedicles of the Tripier flap into the wound. The incision for flap elevation in the upper eyelid crease is lengthened medially and laterally to meet the ends of the lower eyelid defect. The donor site in the upper eyelid is primarily closed.

Vuppalapati and Niranjan\textsuperscript{125} described a modification of the Tripier myocutaneous flap, converting it into a perforator islanded flap. The feeding vessel for the flap was a branch of the zygomatico-orbital artery arising from the superficial temporal artery or transverse facial artery. Raising the flap was similar to raising a unipedicled Tripier flap with a layer of orbicularis oculi muscle. The authors stated that the essential step with this method is to identify the feeding vessel entering the flap from deeper layers of orbicularis oculi near the lateral canthus while raising the flap. The flap is then islanded once the vessel is identified, and the subcutaneous fat is preserved over the feeding vessel. The flap can be transferred to the defect either through a subcutaneous tunnel or by opening the bridge of skin. Follow-up at 1 year in the two cases reported showed stable results without ectropion.

\textit{Modified Hewes Procedure}

The modified Hewes procedure is useful for repair of lower eyelid defects not involving the entire lid margin, in particular those involving the temporal half of the lower eyelid. Hewes et al.\textsuperscript{129} described a transposition flap of tarsocconjunctiva. The flap is positioned at the lateral canthal angle and brought into the lower eyelid defect. A full-thickness skin graft or flap is then placed over it. The upper eyelid is first everted, and a rectangular block encompassing the superior tarsal border and the conjunctiva above the superior tarsal border, all based at the lateral canthal angle, is marked. With this design, the peripheral arcade at the superior tarsal edge is included and provides a vascular supply for the flap (Fig. 16). The flap is then dissected into the canthal angle, ensuring the arcade is preserved as it enters the base of the flap.

\textbf{Figure 15.} Tripier flap for repair of a lower eyelid defect.
The flap is transposed into the lower eyelid defect and secured to the tarsus and conjunctiva with absorbable sutures. The flap is then covered with a full-thickness skin graft or a musculocutaneous transposition flap from the same upper lid based at the lateral canthal angle. A reconstructive ladder for lower eyelid defects is shown (Fig. 17).

**Other Combined Techniques**

Zinkernagel et al. described repair of a large lower eyelid full-thickness defect using an autogenous free tarsal graft for the posterior lamellae and a skin rotation flap from the ipsilateral upper eyelid for the anterior lamellae. In all four of the cases presented, the skin flap provided adequate vascular support. Follow-up of 10 to 20 months showed good outcomes achieved by all patients. The authors noted that with the Hughes flap or Cutler-Beard techniques for eyelid reconstruction, a two-step approach with occlusion of the eye for at least 1 week is required, but reconstruction with a free tarsal graft is a one-stage procedure that does not necessitate eye occlusion.

Moesen and Paridaens presented a one-step technique to repair lower lid marginal full-thickness defects (Fig. 18). The posterior lamella is reconstructed by advancing residual lower lid tarsus on a conjunctival pedicle, as described by Irvine and McNab for the upper eyelid. The anterior lamella is reconstructed by orbicularis muscle advancement and a free skin graft. The authors studied five patients with lower eyelid marginal defects ranging from 8 to 9 mm in height and 12 to 22 mm in length after tumor excision. All tumors were excised with 2-mm tarsal margins to allow a residual vertical tarsus of 2 mm, which is required for the reconstruction technique. To avoid retraction of the reconstructed lower eyelid, the lower eyelid retractors are released from the conjunctival pedicle before advancement of the tarsoconjunctival flap. After a mean follow-up duration of 10 months, the outcomes were graded as good in one case and excellent in four.

Paridaens and van den Bosch described a one-stage “sandwich technique” for reconstruction of full-thickness lower eyelid defects in 12 patients and a full-thickness upper eyelid defect in one. The sandwich technique consists of an orbicularis oculi muscle advancement flap that is covered with a free tarsoconjunctival graft posteriorly and a free skin graft anteriorly. It allows for one-stage reconstruction of relatively shallow lower eyelid defects with a horizontal size of up to 70% of

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**Figure 16.** Modified Hewes procedure. *Dashed lines* represent the flap site, which includes part of the superior peripheral arcade. The upper eyelid tarsoconjunctival flap is mobilized and transposed into the lower eyelid defect. An upper eyelid musculocutaneous flap is transposed to cover the tarsoconjunctival flap.
Figure 17. Reconstructive ladder for lower eyelid defect. A, Primary closure with or without lateral canthotomy or inferior cantholysis. B, Semicircular flap. C, Adjacent tarsal conjunctival flap and full-thickness skin graft. D, Free tarsal conjunctival graft and skin flap. E, Tarsal conjunctival flap from upper eyelid and skin graft (Hughes procedure). F, Composite graft with cheek advancement flap (Mustarde flap). (Reproduced with permission from Kersten.13)
the total eyelid width and is restricted to patients with sufficiently lax lower eyelid skin. The authors argued that it might be a one-stage alternative to the modified Hughes flap. Defect sizes in the study ranged from 5 to 10 mm vertically and from 10 to 22 mm horizontally. The orbicularis muscle adjacent to the defect was mobilized, incised vertically, and advanced. The inner surface was covered with a free tarsoconjunctival graft, and the outer surface was covered with a free skin graft. The grafts were obtained from the ipsilateral or contralateral upper lid. After 5 days of patching, adequate vascularization and viability of the grafts were noted in 11 of 13 patients, whereas partial necrosis of the skin graft was noted in two. The partial necrosis healed spontaneously, but marked lower eyelid retraction developed in one of the two patients. Follow-up examinations 1 year after surgery revealed marked lower lid retraction (>2 mm) in only one patient; six patients had mild lower lid retraction of ≤2 mm. Two patients experienced ectropion and lower eyelid sagging resulting from excessive horizontal eyelid laxity. The conditions were successfully treated with additional block excision. One patient experienced adhesions between the upper and lower lid in the lateral canthus. After division of the adhesions, the results were good. The authors warned against using this technique for patients with impaired vascularity (e.g., patients who have undergone radiation treatment, smokers, diabetics, and patients with other vasculopathies). The authors have not applied this technique for reconstruction of vertical defects >10 mm because they suspect that could lead to a high rate of postoperative lid retraction because of vertical tension on the orbicularis muscle flap.

In the event of unilateral total loss of full thickness of the upper and lower eyelids with the globe remaining, preservation of vision and adequate corneal protection are the primary goals; secondarily, the eyelids need to be sufficiently mobile to open and clear the visual axis. deSousa et al. described six cases. The cause of tissue loss was traumatic avulsion in one case and tumor excision in five. In addition to loss of both upper and lower eyelids, the medial and lateral canthal tendons and canaliculi were lost. In the trauma case, primary repair was achieved by using the avulsed tissues. After tumor excision, a single anterior lamellar flap was used with planned division postoperatively in one case; the remaining four cases had separately reconstructed upper and lower eyelids. In one case, the posterior lamella was recreated by using a free tarsal graft from the contralateral upper eyelid for the upper eyelid and a hard palate graft for the lower eyelid. Bipedicled flaps of the remaining preseptal and orbital orbicularis were formed in the upper and lower eyelids to cover the posterior lamellar composite grafts. A single large free skin graft from the supraclavicular fossa was placed over the eyelids, and a central fenestration was created to form the new palpebral aperture. The remaining sub-brow defect was repaired by using a laterally based forehead flap. In another case, a large nasal septal chondromucosal graft was harvested and divided to reconstruct separate upper and lower eyelid posterior lamellae. A single midline forehead flap was used for the anterior lamella. Flap division was performed at 6 weeks, with restoration of a small palpebral aperture. In one other case, the authors created an islanded, pedicled suprabrow forehead flap based on the anterofrontal superficial temporal artery branch for the anterior lamella of the upper eyelid. The flap was elevated on its vascular pedicle and tunneled under the remaining lateral canthal skin. A free tarsal graft was used for the posterior lamella of the upper eyelid. A midline pericranial flap was raised and tunneled under the glabellar skin to form the lower eyelid posterior lamella and to provide a blood supply for an overlying free supraclavicular skin graft. The reconstructed upper and lower eyelids were secured together, leaving a small central palpebral aperture. Graft necrosis occurred in three cases. In all cases, lagophthalmos was present and the reconstructed eyelids were stiff and immobile. Ptosis and lower eyelid retraction occurred in half the cases, and ectropion resulted in two cases. Useful vision was retained in all cases.
Figure 18. Various steps of the one-stage sandwich technique for eyelid reconstruction are shown. a, Shallow lower eyelid defect after tumor excision. b, Width of the graft was 2 mm less than the horizontal defect size to ensure adequate horizontal tension. The horizontal width of the defect was measured with calipers. c, With straight Stevens scissors, the orbicularis oculi muscle was dissected from the skin anteriorly and from the orbital septum posteriorly to the orbital rim. d, Two vertical cuts were then made in the muscle to liberate it sufficiently to fill the eyelid defect without vertical traction. e, Contralateral or ipsilateral upper eyelid was everted, and a free tarsocconjunctival graft was harvested. f, Graft was sutured to the margins of the tarsal plate in the defect. g, Orbicularis oculi muscle flap was sutured to the margins of the orbicularis oculi muscle surrounding the defect. h, Free skin graft was harvested from the ipsilateral or contralateral upper eyelid. i, After careful removal of any remaining muscle fibers or subcutaneous tissue, the graft was sutured into the skin defect. (Reprinted with permission from Paridaens and van den Bosch.)
Medial Canthal Defects
Defects of the medial canthus resulting from tumor excision are commonly encountered. They are second in frequency to lower eyelid defects. Proper repair of the defects is essential to restore functionality to the eyelids and to achieve an aesthetic result to eyelid reconstructive surgery. If not appropriately addressed, the defects can lead to life-long symptoms of tearing, foreign body sensation, and poor cosmesis. Appropriateness of the repair techniques depends on the type, size, and depth of the defect and the health of the surrounding tissues. Most importantly, a combination of techniques might be necessary to achieve the most desirable surgical outcome.

Glabellar Flaps
Glabellar flaps are commonly used to repair medial canthal defects. When properly created, the flaps can be effective. Turgut et al.\textsuperscript{134} noted that a traditional glabellar flap entails creating an inverted V in the glabellar region, which is then undermined and rotated to close the medial canthal defect. Closure of the resultant wound converts the inverted V to an inverted Y (Fig. 19). The size of the flaps depends on the size of the defects and can be enough to cover a full range of medial canthal defects. Glabellar flaps offer advantages to other flaps in the region. They are relatively simple and can cover deep defects. They have sufficient blood supply from the subdermal plexus and the supratrochlear vessels.\textsuperscript{134}

One disadvantage to this technique is that it tends to draw the eyebrows closer together. Meadows and Manners\textsuperscript{135} proposed a simple modification. With the modified technique, the glabellar flap is raised and rotated to cover the defect, as described for the classic technique. The redundant skin that results from transposing the flap is then cut away and used to help close the resultant Y-shaped wound, maintaining the normal spacing of the eyebrows (Fig. 20).

Another modification of the traditional glabellar flap that helps to avoid the “bulky” appearance in the medial canthal region and the drawn-together brows is the super thinned inferior pedicled glabellar flap described by Emson and Benlier.\textsuperscript{136} With that technique, the glabellar flap is raised, as classically described.\textsuperscript{137,138} Once the forehead wound superior to the eyebrow is closed, the frontalis muscle and subcutaneous fat are removed from the flap, leaving the axial blood vessels. In their series of eight patients, Emson and Benlier found that satisfactory cosmesis was achieved in all, and the normal inter-brow distance was maintained.

\textbf{Figure 19.} Glabellar V-Y flap. Illustration on the top depicts the medial canthal defect with an inverted V originating from the apex of the defect. Incision and rotation of the flap into the defect result in an inverted Y as depicted in the illustration on the bottom.
A combination approach of glabellar and nasolabial V-Y flaps has been described to be particularly successful for large medial canthal defects.\textsuperscript{140} Yildirim et al.\textsuperscript{140} described a series of 23 patients who underwent combined glabellar and nasolabial V-Y flaps. In the reported series, the average defect size was 28 mm \(\times\) 30 mm. Because of the size of the defect, it was thought that closure with a single flap, either glabellar or nasolabial, would lead to significant deformity. The vertical dimension of the glabellar flap was planned to be approximately three times the breadth of the defect at its narrowest part, whereas the nasolabial flap was planned to be two times the longitudinal diameter of the defect. The flaps were raised and advanced into the defect and were interdigitated and sutured with 5-0 nylon. The forehead and nasolabial wounds were closed in usual fashion as an inverted V and an inverted Y. Sutures were removed on postoperative day 6. The authors reported that no patients suffered ectropion, lymphedema, or lid lag during a minimum follow-up duration of 6 months.

**Rhomboid Flap**

Another flap involving the glabellar tissue is the rhomboid flap (Fig. 21). Essentially, the flap is accomplished by conceptualizing the medial canthal defect as a rhombus with its long axis being vertical. Medial to the defect, half of the rhombus, again along the vertical axis, can be drawn. By dividing that half along its horizontal axis, the resulting rectangular flap can be advanced to fill the medial canthal defect.\textsuperscript{141} As with the traditional glabellar flaps, “bunching” might be seen medially and narrowing of the inter-brow distance can occur.

**Medial Myocutaneous Flaps**

First described in 1983 by Goldstein\textsuperscript{142} and later re-described by Jelks et al.,\textsuperscript{143} a myocutaneous flap is a versatile flap for medial canthal reconstruction. Initially, the defect is carefully measured and an appropriately sized flap is fashioned from the upper eyelid. The flap containing skin and orbicularis is raised lateral to medial, carefully leaving the vascular supply intact, which includes the

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**Figure 20.** Modified glabellar flap. Note the additional horizontal incision where excess glabellar tissue was incised, allowing the brows to rest in a more natural position.
supratrochlear, infratrochlear, and medial palpebral vessels (Fig. 22). Its attachment to the medial fat pad is kept intact, and the area acts as its pedicle, allowing rotation of the flap to cover a variety of different medial defects. As described by Jelks et al., the flap is sutured in place in layered fashion with deep 5-0 Vicryl sutures and 6-0 nylon sutures to approximate the skin. The donor site is closed primarily.

**Skin Grafts**

Full-thickness skin grafts are useful for correcting medial canthal defects that are relatively superficial. The skin can be harvested from the upper eyelid, retroauricular, supraclavicular, and inner arm areas. Dryden and Wulc described using preauricular skin, which can provide a better color match, as opposed to the traditional retroauricular grafts. Although grafts are very useful, skin color and thickness match can be cosmetically challenging. Nevertheless, skin grafts are commonly used to cover medial canthal defects. They are simple, effective, and conform well to the concave surface of the medial canthus. They should be avoided when vascular compromise of the recipient bed is suspected, such as in smokers or after radiation damage.

**Bipalpebral Sliding Flaps**

Adenis and Serra described a technique that uses a combination of flaps from the upper and lower eyelids to correct medial canthal defects. Upper eyelid incisions are made 2 mm above the cilia and 2 mm below the brow. The lower lid incisions are made 2 mm below the cilia, and the inferior incision is created in a curvilinear fashion starting at the lower edge of the defect and continuing to the inner portion of the cheek (approximately 10–20 mm below the superior incision). The flaps are undermined at the level of the orbicularis muscle and are slid into place, covering the medial defect. With a small defect, the two flaps can be approximated to each other, completely covering the defect. With larger defects, the individual flaps can be tacked down to the underlying tissue and a full thickness skin graft can be used to cover the remaining area. Because this is a sliding cutaneous flap, it is not useful in cases of deep medial canthal defects.

**Medial Pedicled Orbicularis Oculi Flap**

The medial pedicled orbicularis oculi flap, as described by Tezel et al. in 2002, combines concepts from the bipalpebral sliding flap and the myocutaneous flap. The lower edge of the flap is the lid crease. The width of the flap created depends on the size of the defect. The flap is then elevated lateral to medial and includes both skin and orbicularis. The medial portion of the flap is de-epithelialized, and the flap is tunneled to the contralateral side, allowing the de-epithelialized portion of the flap to be buried under the tunnel while the myocutaneous flap is inset to the area of the defect. The flap is sutured in place in a layered fashion, and the donor site is closed primarily.

**Mid Forehead Flaps**

Mid forehead flaps, including the median and paramedian flaps and their many variations, are useful in midfacial reconstruction, including reconstruction of medial canthal defects. Forehead skin flaps are consistently useful for reconstruction of the periorbital region in that they have a rich network of vascular structure and low donor site morbidity, are thin and pliable, and are compatible with the color of the facial skin. Per Baker, the median forehead flap was originally described in the Indian medical treatise in approximately 700 BCE and has evolved greatly over time. Baker reported that in the 1930s, Kazanjian described the procedure in detail. The technique presented by Kazanjian used a midline forehead flap that was created with a hairline incision that continued to a point immediately above the nasofrontal angle and derived its blood supply from the supratrochlear and supraorbital arteries. In the 1960s, Millard described a modification of the median forehead flap called the *seagull flap* with which lateral extensions were used to cover the nasal alae. The
Figure 21. Rhomboid flap. Note the creation of a rectangular flap that can be used to fill the medial canthal defect.

Figure 22. Medial myocutaneous flap. Note the attachment of the myocutaneous flap with the medial fat pad.

Figure 23. Medial pedicled orbicularis oculi flap. The pentagonal section represents the portion of the graft that has been de-epithelialized and will reside tunneled beneath the nasal tissue.
flap incision extended below the orbital rim to gain additional flap length. According to Baker, Labat re-designed the median forehead flap to be centered around a unilateral supratrochlear artery and Millard and Menick then modified the flap by shifting the entire vertical axis to a paramedian position and showed that the flap would survive without the central glabellar skin. The modification allowed for a narrower flap with greater freedom of tissue movement. Baker reported that in the 1980s, Burget and Menick extended the paramedian flap below the bony orbital rim, which allowed the flap to exclude hair-bearing scalp tissue.

Baker\textsuperscript{139} described, in great detail, the paramedian forehead flap based on a single supratrochlear artery. A Doppler probe often is used to assist in locating the supratrochlear artery, although Baker noted that it is not necessary. The vertical axis of the supratrochlear artery is located approximately 2 cm lateral to the midline, corresponding to the medial border of the brow, and the width of the flap is designed to be 1.5 cm and not flared. In recent Doppler studies of healthy volunteers, the supratrochlear vascular pedicle was found, at most, to be 3 mm lateral (more common in men) or medial (more common in women) to the medial canthus.\textsuperscript{150} Kelley et al.\textsuperscript{151} showed that within the paranasal and medial canthal region, an anastomotic connection exists between the supratrochlear, infraorbital, and branches of the facial arteries and branches from the contralateral side, producing a rich vascular arcade. This relationship allows a median forehead flap to be narrowly based at the level of the medial canthus.

The upper border of the flap typically is the frontal hairline unless the patient has a receding hairline or frontal balding. It is crucial to carefully measure the size of the defect and correlate it to the size of the flap that is raised. Once measured and marked, an incision is created and the flap is elevated from the underlying periosteum. To close the donor site, it is necessary to undermine the wound in a subfacial plane from one temporalis muscle to the other. Galea and frontalis muscles are completely removed from the distal tip of the flap, as is a majority of the subcutaneous fat. The flap is sutured at the recipient site with vertical mattress sutures, and the forehead donor site is closed in layers.\textsuperscript{139}

A frontal hairline flap, as described by Karşdağ et al.,\textsuperscript{152} can be used in a single-stage alternative to closing a medial canthus defect with an accompanying dorsal nasal defect. In 10 patients who were status post surgical tumor resection, Karşdağ et al. fashioned an elliptically shaped frontal island flap at the level of the frontal hairline. The flap was vascularized by the supraorbital and supratrochlear arteries. The lateral points of the pedicle were in alignment with the vertical lines crossing the medial canthus and pupillary midline, respectively. Dissection of the pedicle was confined between the lines, and a subcutaneous tunnel was formed between the defect and the flap recipient area. The island flap was transposed to the recipient area through the subcutaneous tunnel. The hairline incision was sutured intracuticularly. No major vascular damage was observed during dissection, and arterial insufficiency was not reported. Venous insufficiency and trapdoor deformity occurred in two patients and healed spontaneously. They authors stated that the venous insufficiency might have occurred secondary to the kinking of the pedicle or the inadequately narrow tunnel.

A pericranial flap composed of periosteum and subgaleal fascia is a very versatile flap used extensively in craniofacial surgery. Its use for repairing medial canthus defects is fairly new. Leatherbarrow et al.\textsuperscript{153} conducted a retrospective review of consecutive cases requiring reconstruction of medial canthal defects involving loss of periosteum or bone by a median forehead pericranial flap and full-thickness skin grafting. The authors described two different techniques of flap harvest. One is an open technique that includes a midline forehead incision, and the other is an endoscopic technique that includes two incisions behind the hairline.

With the open technique, a vertical midline incision of approximately 3 to 4 cm is made, extending superiorly from the glabella with a
remaining short bridge of skin and deeper tissue between the inferior aspect of the incision and the superior aspect of the medial canthal defect, under which the flap can later be tunneled. The tissues are dissected down to the pericranium, and the desired dimensions of the flap are outlined with a surgical marker. The flap is then cut from the pericranium with a number 15 Bard-Parker blade, keeping a length:width ratio of approximately 4:1. The pedicle is based on the opposite side of the medial canthal defect. A subcutaneous dissection of the superior aspect of the medial canthal defect is performed with Stevens scissors, and the flap is then rotated inferiorly into the defect so that the deep periosteal surface lies on the deep aspect of the defect. It is then sutured in place with interrupted with 7-0 Vicryl sutures.

With the endoscopic technique, two vertical paramedian 1-cm incisions are made behind the hairline. A straight 4-mm endoscope is inserted into one of the scalp incisions for visualization, and a plane is created between the pericranium and the frontal bone with a Freer periosteal elevator. An additional plane is then created between the pericranium and the galea with endoscopic scissors. The superior and lateral borders of the flap are cut with the endoscopic scissors. The remainder of the technique is the same as the open technique.

The average length of follow-up was 13 months for the 21 cases described by Leatherbarrow et al. Ten cases required additional oculoplastic procedures, including local periosteal flaps and mucous membrane grafts. Two patients (10%) experienced complete flap failure, one of which was caused by infection. Five patients (24%) experienced partial (<50%) skin graft necrosis. Two patients (10%) required additional surgery.

**Medial Canthal Tendon Fixation**

Transnasal wiring has commonly been used to repair medial canthus dystopia. With the technique of transnasal wiring, a stainless steel wire is passed through the nasal bridge to the opposite nasal bone. Turgut et al. described the unitransnasal canthopexy technique, which can be used in posttraumatic and tumor ablation cases. In their report of two patients, the skin located 2 mm medial to the canthus was incised vertically to avoid the lacrimal apparatus and to provide direct access to the medial canthal tendon. The periosteum corresponding to the opposite medial canthal tendon attachment point was elevated, and two holes were created 3 to 4 mm apart with a Kirchner wire. One of the free ends of two 3-0 polypropylene sutures was passed through each hole within a No. 14 Angiocath (Dogsan, Istanbul, Turkey). Both sutures were extracted by using forceps inserted in the ipsilateral nasal ostium. The free ends of the sutures were tied outside the nostril. The needles were then passed through the canthal tendon. While tying the suture ends, the tendon was repositioned to its original bony attachment point with simultaneous tightening of the tied knot inside the nostril. Follow-up of the patients was not discussed.

**Secondary Intention**

Secondary intention healing is a method that is commonly used as a means of reconstruction. However, it has been less commonly used in the periorcular region for fear of poor functional or cosmetic results. Several studies showed some success with secondary intention healing of eyelid defects, including healing in the medial and lateral canthal regions.

In 2002, Shankar et al. retrospectively studied results of the “laissez-faire” technique with which the eyelid defects were allowed to heal by secondary intention. Twenty-four patients with 25 periocular defects after tumor removal were followed, with initial skin defects ranging from 6 mm × 7 mm to 15 mm × 32 mm. Five patients had medial canthal involvement, and one had lateral canthal involvement. Twenty-three of the 25 healed defects were rated “good” or “very good” by an independent observer, and only one required a second procedure.

Lowry et al. presented a similar study in 1997, and the results were nearly the same. In that series, 83% of the 59 patients achieved satisfactory
functional and cosmetic results and only two required secondary repair. Zitelli \textsuperscript{160} divided the regions of the face into three groups—NEET, NOCH, and FAIR—and reported the results of secondary intention healing. The NEET areas are the concave areas of the face, including the nose, eye, ear, and temple, and they tend to heal with excellent cosmetic results. The NOCH areas are the convex surfaces, including the nose, oral lips, cheeks, chin, and helix of the ear, and they produce noticeable scars. The FAIR areas are the flat surfaces, including the forehead, antihelix, eye lid, and remainder of the nose, lips, and cheek, and they achieve intermediate results.

Ceilley et al. \textsuperscript{161} described the use of secondary intention healing to delay skin grafting, either full thickness or split thickness. The authors postulated that partial healing of deep wound defects by secondary intention will produce a wound that is much smaller and of more normal contour than the original wound and is therefore more amenable to skin grafting. They warned, however, that areas requiring constant protection (i.e., the central eyelid) might require immediate grafting or flap reconstruction to avoid exposure keratopathy.

Appropriate repair of medial canthal defects is crucial to ensure proper functioning of the eyelid and lacrimal system and creation of an aesthetically acceptable result. A number of approaches to this type of repair are described in the literature and have been proven to be effective. In choosing the most suitable repair, a variety of factors should be considered, including the size and depth of the defect and involvement of the lacrimal system. Additionally, it must be recognized that all the techniques described above do not exist in isolation. A combination of two or more techniques often is needed in closing medial canthal defects.

Lateral Canthal Defects
Proper repair of the lateral canthal region is an important issue in facial aesthetics. Improper repair can lead to cosmetic deformity or functional failure caused by eyelid malposition. The crucial issue in the reconstruction of the lateral canthus is its position and shape. Any tissue rearrangement around the lateral canthus should not exert undue tension on the lateral canthus. Even minor changes are noticeable and could lead to poor cosmetic results. Inadequate support to the lateral canthus can lead to blepharophimosis, rounding of the lateral canthal angle, slanting of the lateral canthal angle, ectropion, inferior scleral show, and exposure. Numerous approaches can be used to repair defects in the lateral canthal region, including primary closure, skin grafting, and regional advancement flaps. Although a majority of lateral canthal defects can be repaired by techniques previously described for the upper and lower eyelid reconstruction sections, in cases of larger or more complex defects, the following flaps have been described as being useful.

Bilobed Flap
In 2007, Mehta and Olver \textsuperscript{162} described achieving great success by using a bilobed flap for reconstructing the lateral canthal area. The flaps used in that study originated in the zygomatic or lateral cheek region. This advancement flap consists of two lobes with one common base that can be mobilized and rotated into place to cover the defect. The first lobe is slightly smaller than the defect, and the second lobe usually is one-half the width of the first lobe. The design allows the defect from the second flap to be closed primarily. To avoid skin tension, the flap should be based superiorly in a design with which the second flap is elevated from the preauricular region horizontally and the first flap is elevated in a vertical orientation. By elevating the second flap from the preauricular region with a horizontal orientation, the closure line can be placed parallel to the crow’s feet.\textsuperscript{162}

The approach provides excellent color and texture matches. Additionally, ectropion is not commonly encountered because the flap is based superiorly. However, the length of the scar is considered a disadvantage. Additionally, in male patients, the second lobe of the flap might contain some hair-bearing skin.
Superior Auricular Artery Island Flap

Kilinc et al. described using a superior auricular artery (SAA) island flap for repairing periorbital defects, including lateral canthal defects. The flap tends to have perfect color, thickness, and texture matches with the facial skin. Kilinc et al. described three types of flaps based on the pedicle. A type 1 flap is a superficial temporal vessel pedicled SAA island flap. Type 2 SAA flaps are based on the frontal branch of the superior temporal artery. Type 3 is an SAA flap based on the parietal branch of the superior temporal artery. The authors reported that the flaps they used ranged in size from 3 cm × 6 cm to 8 cm × 6 cm. In their study of 14 patients, aesthetically and functionally successful results were achieved with minimal donor site morbidity.

Mauriello emphasized the importance of adequate fixation of the reconstructed eyelid to the periosteum to avoid eyelid malposition. With small defects, direct closure usually is effective and the cut edge of the tarsus can be directly anchored to the orbital rim periosteum. For large defects, periosteal flaps can be used. A periosteal flap is raised as a rectangular strip from the outer aspect of the lateral orbital rim at the level of the pupil. The hinged flap can be reflected medially and sutured to the free edge of the tarsus with 5-0 Vicryl sutures. The periosteal flap should be covered with a sliding or advancement flap with its own blood supply. Tenzel semicircular flaps have been described to be helpful in the lateral canthal region and were discussed earlier.

Any tissues mobilized around the lateral canthus should be anchored to the lateral orbital rim, periosteum, temporalis fascia, or other solid deep tissue to ensure that no undue tension is transmitted to any component of the lateral canthus.

Complications of Eyelid Reconstruction

Reconstruction of the eyelid requires great attention to detail. Many pre- and postoperative considerations must be taken into account. Even well-planned surgical intervention for eyelid reconstruction can result in complications.

Hematoma

As with any surgery, hematoma formation is a potential complication. Meticulous hemostasis with bipolar cautery can minimize the risk. Likewise, preoperative planning regarding the discontinuation of anti-coagulation medications is prudent. Hematomas can lead to suboptimal results, including failure of grafts and excessive scarring.

Eyelid Malpositions

Entropion

Shortening of the posterior lamellae causes a cicatricial entropion, with the lid margin turning in and the lashes rubbing over the cornea. This can lead to significant ocular surface problems, including corneal abrasion and ulceration. Treatments of cicatricial entropion include tarsal fracture with rotation of the eyelid margin and posterior lamellar grafts.

Entropion can also result from horizontal laxity, disinsertion of the inferior lid retractors, and overriding of the preseptal orbicularis over the pretarsal orbicularis. Correction of such entropions should include correction of all components contributing to the occurrence of that specific entropion.

Ectropion

Shortening of the anterior lamellae leads to cicatricial ectropion, especially if horizontal lid laxity is present. This will cause corneal dryness from exposure and will also lead to epiphora from both the increased reflex tearing and from the punctum not opposing the globe. The treatment of ectropion is by horizontal tightening and by increasing the anterior lamellae, either by skin grafts or recruiting skin from the cheek.

Eyelid Retraction and Lagophthalmos

Lagophthalmos, or incomplete eyelid closure, can occur secondary to cicatricial eyelid retraction or can be paralytic. Lagophthalmos can result in exposure keratopathy and requires prompt attention. Acutely, copious lubrication of the ocular surface by means of eye drops and ointments or
a moisture chamber can help protect the cornea. Surgical intervention might be required as a definitive solution. The surgical approach depends on the cause of the lagophthalmos. If retraction occurs because of limited anterior lamellae (skin and orbicularis), repair is best accomplished with a full-thickness skin graft or adjacent advancement flap. Middle lamellar shortening can lead to eyelid retraction and inferior scleral show and can be treated with spacer grafts, such as tarsconjunctival grafts, AlloDerm, ear cartilage, or hard palate grafts.

**Notching and Contour Deformities**

When reconstructing the eyelids, care must be taken to avoid creation of irregularities along the eyelid margin and to maintain the normal curvilinear contour of the upper and lower eyelids. Failure to accomplish this can lead to a cosmetically displeasing result and loss of the normal eyelid function regarding protection of the cornea and facilitation of a functional tear drainage system.

A notching defect can occur when the eyelid margin is not adequately everted during its repair. Contraction of the wound during healing leads to a notch in the normally smooth and continuous eyelid margin. Notching is also common if wound dehiscence occurs. Such dehiscences can occur from excessive wound tension or from infections. It is a common complication if the closure of the wound does not include the tarsus in the margin or anterior surface sutures. By disrupting the normal lash line, eyelashes can be turned inward, leading to localized trichiasis. Patients encounter foreign body sensation and corneal irritation leading to epiphora, abrasion, infection, and possible perforation of the globe. Additionally, the notch formed can lead to inappropriate coverage of the cornea, leading to corneal exposure and associated complications that are discussed later in this section. Removal of the eyelid notch is typically achieved by a simple wedge resection and marginal eyelid repair. Additionally, manual epilation of the in-turned eyelashes can help temporize the situation.

Maintaining the normal curvilinear contour of the eyelid is essential not only for a cosmetically acceptable result but also to ensure proper drainage of tears. If the lateral or medial canthal tendons are not adequately fixated at the lateral and medial orbital rims, the eyelid will not have appropriate tension to allow the orbicularis muscles to exert pressure along the canaliciuli and tear sac, which is crucial for the active drainage of tears. Additionally, without proper tension on the eyelid, ectropion can result, as discussed above.

**Blepharoptosis**

Blepharoptosis occurring after eyelid reconstruction can be caused by the initial trauma or tumor or by the surgical repair itself. A ptotic eyelid, in addition to being a cosmetic concern, might interfere with the central visual axis. The complication becomes even more serious in pediatric patients when the development of amblyopia is a possibility.

The normal anatomy of the eyelid must be carefully considered when attempting eyelid reconstruction. The preaponeurotic fat serves as one of the most important surgical landmarks in eyelid reconstruction. Just posterior to the fat lies the levator aponeurosis, which can easily be severed. Additionally, extensive tissue swelling can lead to dehiscence of the levator aponeurosis from its attachment to the tarsus.

Repair of ptosis after eyelid reconstruction should be delayed at least 6 months and sometimes longer if serial examinations reveal improvement in eyelid position. Surgical repair is aimed at reattaching or advancing the levator aponeurosis along the tarsus. If reattachment is not possible, or if the levator function is poor, a brow suspension procedure might be necessary.

**Epiphora**

Excessive tearing and increased tear lake cause distorted vision by disrupting the normal tear–cornea interface. Irritation and maceration of the periocular skin occur because of the prolonged wetness.

Commonly, medial canthal defects result in injury to the canalicular system, disturbing the normal drainage of tears. Repair should include
monocanicular silicone tube intubation of the lacrimal system. In the elderly with dry eyes, a single canalicular injury might not need repair because the other canalicular system might be enough to drain the decreased tear production.

Eyelid malposition can also lead to poor tear drainage and epiphora. As discussed earlier, ectropion causes the puncta to lose contact with the lacrimal tear lake, leading to ineffective tear drainage. Likewise, if an eyelid is not adequately tight, proper tear pump function cannot be maintained.

Irritation of the cornea, caused by either direct contact with an irritant (e.g., eyelashes) or dryness, causes a reflex production of tears. Large reconstructions often involve damage to cranial nerve VII, impeding orbicularis function and hindering lid closure. A significant paralytic lagophthalmos can result. Corneal dryness results in excessive reflex tearing. Medical management is aimed at decreasing the corneal irritation and includes copious lubrication by means of ophthalmic tear drops, gels, and ointments. Surgical options include insertion of a gold weight in the upper eyelid, horizontal tightening of the lower eyelid, and tarsorrhaphy.

Reflex tearing resulting from entropion and trichiasis is common and problematic. The lashes cause corneal abrasions. Repair is aimed at addressing the underlying entropion or removing the eyelashes by manual epilation or cryotherapy.

**Exposure Keratopathy**

One of the most devastating complications of any eyelid surgery is exposure keratopathy. As described in the Anatomy section, the upper and lower eyelids serve the important functions of covering and protecting the cornea and facilitating the distribution of the tear film. Both the physical coverage of the cornea and the maintenance of an appropriate tear film are necessary to protect the delicate anterior surface of the eye, which is only 0.5 mm thick. When this coverage is hindered secondary to eyelid malpositions, consequences can be dire. Exposure of the cornea leads to a breakdown of the epithelial cells, allowing a portal of entry for infectious pathogens. This can lead to infectious keratitis, resulting in significant morbidity, including partial or complete loss of vision.

Even in the absence of corneal infection, corneal exposure and irritation can lead to vascularization and scarring of the cornea, causing visual loss. Prolonged exposure of the cornea, even when mild, can eventually lead to corneal decompensation. Patients present with irritation, pain, photophobia, and decreased vision years after periorcular or facial surgery. These signs and symptoms can occur without overt signs of eyelid malposition as a result of chronic inflammation of the ocular surface.

It is crucial for surgeons performing periorcular and facial surgical procedures to realize that even mild eyelid malpositions can lead to chronic inflammation of the ocular surface. Such inflammation can cause decreased tear production. The patients’ advancing age also contributes to further decrease in tear production. The ocular surface might withstand the initial injury caused by eyelid malpositions but will eventually decompensate. It is prudent that surgeons keep in mind the health of the ocular surface years after periorcular procedures. We will not be doing the patients or ourselves any favors if years after a reconstructive or cosmetic procedure, the patient ends up with visual loss or dysfunction.
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