Review Article

Conjunctival flaps for the treatment of advanced ocular surface disease—looking back and beyond

Richard P. Gibralter[1], Vivian S. Hawn[2,3]

[1]Department of Ophthalmology and Visual Sciences, Montefiore Medical Center, Bronx, NY, USA; [2]Albert Einstein College of Medicine, Bronx, NY, USA; [3]John A. Moran Eye Center, University of Utah, Salt Lake City, UT, USA

Contributions: (I) Conception and design: RP Gibralter; (II) Administrative support: RP Gibralter; (III) Provision of study materials or patients: None; (IV) Collection and assembly of data: VS Hawn; (V) Data analysis and interpretation: None; (VI) Manuscript writing: Both authors; (VII) Final approval of manuscript: Both authors.

Correspondence to: Richard P. Gibralter, MD. 3400 Bainbridge Avenue, Bronx, NY 10467, USA. Email: rgibralter@montefiore.org.

Abstract: Conjunctival flaps have previously proven to be effective in preserving the globe for individuals with severe ocular surface disease. Infectious keratitis, neurotrophic keratitis, nontraumatic corneal melts, descemetoceles, perforations, and corneal burns are all indications for this procedure. The flaps promote nutrition, metabolism, structure, and vascularity, as well as reduce pain, irritation, inflammation, and infection. Furthermore, patients avoid the emotional and psychological repercussions of enucleation or evisceration, while requiring fewer postoperative medications and office visits. Currently, fewer flaps are performed due to the emergence of additional therapeutic techniques, such as serum tears, bandage lenses, corneal grafting, Oxervate, amniotic membrane, and umbilical cord grafting. However, despite newer conservative medical methods, conjunctival flaps have been demonstrated to be useful and advantageous. Moreover, future technologies and approaches for globe preservation and sight restoration after prior conjunctival flaps are anticipated. Herein, we review the history, advantages, and disadvantages of various surgical techniques: Gundersen's bipedicle flap, partial limbal advancement flap, selective pedunculated conjunctival flap with or without Tenon's capsule, and Mekonnen's modified inferior palpebral-bulbar conjunctival flap. The surgical pearls and recommendations offered by the innovators are also reviewed, including restrictions and potential complications. Procedures for visual rehabilitation in selective cases after conjunctival flap are reviewed as well.

Keywords: Conjunctival flap; Gunderson flap; ocular surface reconstruction

Received: 08 June 2022; Accepted: 09 August 2022; Published: 15 December 2022.
doi: 10.21037/aes-22-36
View this article at: https://dx.doi.org/10.21037/aes-22-36

Introduction

For over a century, conjunctival flaps have spared patients the pain as well as psychological and physiologic loss associated with enucleation and evisceration. Previously, eyes with impending or frank perforations due to several disabling nontraumatic inflammatory diseases or infections were lost to infectious endophthalmitis. The early papers documenting the utility of the procedure appeared in the German literature in the late 1800s. Byers (1), Green (2), and Haik (3) furthered the understanding of the subject in the 1950s using flaps as a modality for the treatment of nonhealing corneal diseases. Trygve Gundersen's seminal report in 1958, entitled *Conjunctival Flaps in Corneal Disease* seemed to have affixed his name to the procedure as we more commonly refer to it today: the Gundersen flap (4).

The procedure and its updated modifications have salvaged many eyes for which there may have not been any alternative treatment. It provides retention of the globe for eyes that cannot be visually rehabilitated. The flap allows healing and stability for some conditions in eyes that can be visually rehabilitated later with sight-restoring surgical procedures.

The mechanism for the success of the procedure relies on it providing vascular, metabolic, and structural support to the corneal ulceration that has failed alternative treatments. The conjunctival flap provides ocular surface stability, prevents further inflammation, and results in a decrease in pain. It provides trophic protective effects while acting as a biologic reinforcement.

Conjunctival flaps and its modifications still have a place today among the more modern surgical procedures used to preserve the eye and restore vision. This procedure may be underutilized, despite the development of corneal transplantation techniques, amniotic membrane grafts, bandage contact lenses, limbal stem cell transplants, tissue adhesives, nerve growth factor, and anti-inflammatory modulators, among others. Conjunctival flaps may be especially useful in areas where transplantable tissue is unavailable at the time of perforation and when ulcerations are too large for the reasonable application of adhesives.

The indications for the procedure are usually failure of a corneal ulceration to heal with impending perforation, frank perforation, or intractable pain and discomfort from an inflammatory or infectious disease. There are numerous indications for its utility, including infectious keratitis; neurotrophic keratitis; corneal ulcers, descemetocele; nontraumatic corneal melts and perforations; chemical burns; and Herpes Zoster or Herpes Simplex involvement of the cornea with a neurotrophic component unresponsive to medical treatment. Although painful bullous keratopathy was the common indication in Gundersen's original series, it is much less of an indication today.

Our report on the topic will cover the historical development and a review of the varied techniques, including the bipedicle flap of Gundersen, partial limbal advancement flap, selective pedunculated conjunctival flap with or without Tenon's capsule, and the modified inferior palpebral-bulbar conjunctival flap reported by Mekonnen. The tips and surgical pearls will be provided from the collective wisdom of those who have developed these techniques. Potential complications and limitations will be reviewed, along with case reports gleaned from the literature. Alternative techniques for treating nonhealing corneal ulcerations will be summarized with the understanding that the flap procedure is available, should the alternatives fail to resolve the clinical situation. We will also take a brief look at sight restoration procedures after conjunctival flap in cases in which visual potential remains.

Techniques

Various types of conjunctival flaps may be differentiated by the location of the conjunctival graft, the amount of conjunctiva used, and the inclusion of Tenon's capsule. The techniques include: the bipedicle flap of Gundersen, partial limbal advancement flap, selective pedunculated conjunctival flap with or without Tenon's capsule, and the modified inferior palpebral-bulbar conjunctival flap reported by Mekonnen.

Bipedicle flap (Gundersen flap)

In 1956, Gundersen first described the surgical technique for a conjunctival flap without Tenon's capsule. A silk traction suture is placed through the superior corneal limbus, thus exposing the superior bulbar conjunctiva. The 16 to 18 mm of bulbar conjunctiva (measured vertically) between the superior limbus and the upper fornix, provides an adequate covering when repositioned over the cornea. The surgeon must take great care to avoid damaging the conjunctival tissue that will become the flap. Buttonholes must be avoided to prevent further complications. One to two cc of 2% proparacaine with epinephrine 1:50,000 is injected under the superior bulbar conjunctiva. Using scissors, the surgeon makes a 3-cm-long horizontal incision along the superior bulbar conjunctiva, anterior to the retro tarsal fold, avoiding tenon's capsule.

The flap is made by dissecting the conjunctiva from Tenon's capsule starting near the superior fornix moving towards the limbus (*Figure 1A*). Flap dissection and prevention of perforation can be aided by an assistant holding up the superior conjunctival edge with two smooth forceps to provide a view of both the anterior and posterior surfaces of the dissected conjunctiva. Once the dissection has reached the limbus, the conjunctiva can be excised from the limbus using scissors to form a peritomy. The bridge flap attachments can be visualized by lifting the flap with a strabismus hook. Any adhesions between conjunctiva and Tenon's capsule should be lysed to prevent traction on the flap when repositioned over the cornea. As its wide lateral attachments remain intact, the conjunctival flap maintains an adequate blood supply.

The flap is then placed over the cornea and sutures are placed. Two fine mattress sutures are placed in the exposed superficial sclera at the 5 and 7 clock hours 2 mm from the

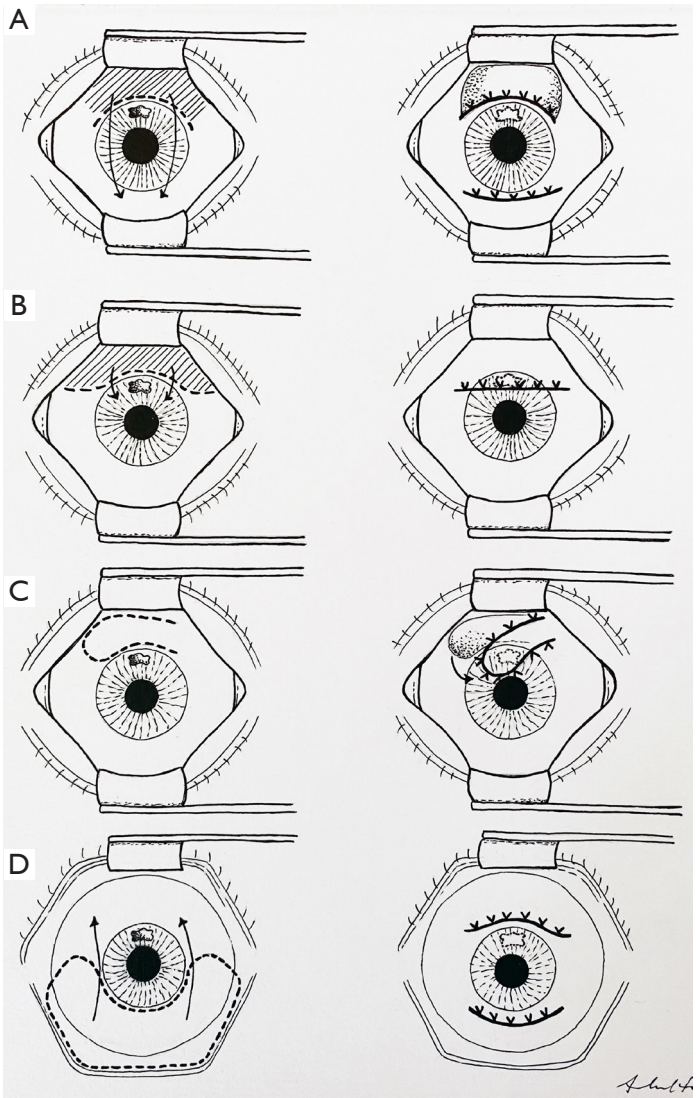

Figure 1 Conjunctival flap techniques. (A) Bipedicle flap; (B) partial/limbal advancement flap; (C) selective pedunculated conjunctival flap; (D) inferior palpebral-bulbar flap. Illustration by Adele Heib, MD.

limbus through the inferior flap margin. The lower border of the flap is then attached to the conjunctiva inferiorly using additional sutures on each side of the mattress sutures. Another mattress suture is similarly centrally placed in the superior limbal sclera through the upper border of the flap. The lower edge of the superior Tenon's capsule is then sutured to the superior flap border using additional interrupted sutures (1).

Partial/limbal advancement flap

Paton and Milauskas modified and reported the partial conjunctival flap technique, in which only the conjunctiva adjacent to the limbus and corneal pathology is used (*Figure 1B*). This flap is advanced over the lesion and secured with a running mattress 10-0 nylon suture (5).

Selective pedunculated conjunctival flap with or without Tenon's capsule

In 1976, Cies and Odeh-Nasrala introduced the racquet conjunctival flap surgery, which was a smaller, pedunculated, perilimbal conjunctival flap that is mobilized to cover a corneal lesion (5). Khodadoust and Quinter described a

similar selective pedunculated conjunctival flap in 2003 that could be performed with a microscope in a minor surgical procedure room. The loose epithelium of the affected cornea and about 1-mm boundary are first removed with a cotton-tipped applicator or Weck cell sponge. Additional sterilization is performed with a cotton-tipped applicator soaked in 5% povidone iodine applied and left on the area of the lesion without rinsing. The surgeon must then choose the most appropriate area of conjunctiva for the pedunculated flap based on the size and position of the denuded cornea, usually the area nearest the lesion and with the best blood supply (6). The area in the fornix closest to the lesion is optimal as the flap base, allowing for the least amount of rotation of the flap. However, superior forniceal conjunctiva is preferred, whereas the thickened interpalpebral conjunctiva should be avoided (5).

The surgeon next injects 0.5–1 mL of subconjunctival 1–2% lidocaine hydrochloride with epinephrine (1:100,000) under the bulbar conjunctiva chosen for the flap, with the needle puncture site avoiding the tissue for the flap. A cotton-tipped applicator can be rolled over the ballooned conjunctiva to spread the anesthetic and reduce conjunctival stretching. A peritomy is performed in the selected quadrant. A suitable size of pedunculated conjunctival flap is isolated by creating a crescent-shaped incision peripheral to the peritomy (*Figure 1C*). The flap is mobilized by carefully extending the incision while preserving the vasculature. The incision is extended until the mobilized flap can remain in place over the corneal defect without traction on the tissue. If a corneal ulcer has frank perforations, Tenon's capsule is mobilized along with the conjunctiva for the flap. The initial bite with 10-0 monofilament nylon suture is initiated through the conjunctival flap near the limbus. The needle then enters at the edge of the diseased cornea, is passed through the intact cornea, and is then pulled out of the margin of the intact corneal epithelium, avoiding imbricating the flap edges. The closure is run continuously around the edges of the flap. The final knot is tied and buried under the conjunctiva or buried within the corneal tissue. The flap over the corneal defect should be neither too tight nor too loose; sutures that are too tight may pull through the conjunctival flap, whereas a loose flap will not heal and may retract during the postoperative period. After completion of the running suture, the edges of the corneal epithelium can be rolled over the suture and denuded area (4).

Conversely, Cies' technique uses interrupted sutures to secure the flap and mobilizes the adjacent conjunctiva to cover the conjunctival donor site (5). Sandinha *et al.* reported a similar technique, the superior forniceal conjunctival advancement pedicle (SFCAP) in 2006. Their first suture is inserted at the 6 o'clock position of the corneal ulcer and the end of the conjunctival flap. Then, additional interrupted sutures are used to close the pedicle over the corneal perforation and prevent any leak age (7).

After the procedure, antibiotic ointment and a cycloplegic drug are administered and the eye is patched. After 24 hours, the dressing is changed, and the eye is treated with a topical antibiotic until it heals. The sutures may be removed 10 days to 2 weeks postoperatively if they become loose, otherwise, they can be left in place for weeks or months (6).

Modified inferior palpebral-bulbar conjunctival flap

Mekonnen introduced a technique that uses the inferior palpebral and bulbar conjunctiva for a flap (*Figure 1D*). Initially, to retract the lower eyelid, a 4-0 silk suture is passed through the lower eyelid margin. A 6-0 vicryl traction suture is inserted through the inferior peripheral cornea to supraduct the eye to expose the inferior fornix. The distance between the lower tarsal border and the lower limbus is marked and measured. Subconjunctival 2% lidocaine is injected adjacent to the inferior tarsal border, producing a bleb that extends across the inferior palpebral, forniceal, and bulbar conjunctivas. An incision along the inferior edge of the tarsus is incised with sharp Westcott scissors. Then, separation of the conjunctiva from the lower lid retractors to the level of the inferior fornix is performed using blunt Westcott scissors with the tips facing away from the conjunctiva. Tissue forceps are utilized to gently hold the conjunctiva, while toothed forceps provide countertraction on the retractors. Using blunt Westcott scissors, horizontal dissection is performed from the medial to the temporal fornix, while vertical dissection is extended from the inferior tarsal border, beyond the fornix and bulbar conjunctiva, to the limbus. The bulbar conjunctival dissection is then extended laterally to create medial and lateral pockets from the 2 to 10 clock hour positions, to ensure adequate flap size and to facilitate mobility (8).

A conjunctival peritomy from 3 to 9 o'clock is performed. A mucous membrane graft measuring 15 mm by 20 mm is harvested and adhered to the inferior palpebral defect with fibrin glue, and then trimmed to size. A blade is used to remove the corneal epithelium, and the flap is placed onto the cornea and secured with interrupted 8-0 vicryl

sutures along the inferior and superior limbus. The defect in the inferior bulbar conjunctiva is subsequently covered with an amniotic membrane transplant using fibrin glue. A symblepharon ring is inserted, followed by an eyelid closure using a Frost suture (8).

In the case of postoperative flap retraction and corneal thinning due to appositional pressure from the symblepharon ring, the ring can be removed, and a multilayered amniotic membrane graft attached across the area of corneal thinning using fibrin glue (8).

Indications

(I) Infectious keratitis-viral, bacterial, fungal;
(II) Neurotrophic;
(III) Noninfectious corneal ulcers;
(IV) Descemetocele;
(V) Nontraumatic corneal melts and perforations;
(VI) Chemical burns;
(VII) Herpes Zoster and herpes simplex keratouveitis associated with neurotrophic disease;
(VIII) Preservation of the globe;
(IX) Preservation and preparation of the glob for future sight restoring optical keratoplasty.

Indications for conjunctival flaps can be divided into therapeutic, aesthetic, tectonic, and analgesic purposes. Therapeutic indications include unresponsive ulcerative infectious keratitis, severe chemical injury, persistent corneal epithelial defect, and corneal limbal disease. Ocular surface preparation for a cosmetic scleral shell is the most common aesthetic indication. Corneal perforation, glaucoma surgery complications, and corneal and scleral melting are the most common tectonic indications. The most common analgesic indication is bullous keratopathy with a poor visual prognosis. Overall, thin conjunctival flaps are used to relieve discomfort, provide therapeutic benefit, and improve appearance (5).

The purpose of conjunctival flap surgery in ocular surface disease and ulceration (both infectious and non-infectious) is to prevent stromal melting and probable perforation. This stabilizes the eye to allow for subsequent surgery for vision restoration. In cases where subsequent corneal surgery cannot be performed later such as high-grade stem cell deficiency, vision 20/400 or worse may be preserved with a conjunctival flap as definitive treatment.

Conjunctival flaps may be used for corneal disorders that do not respond to medical treatment, tarsorrhaphy, or induced ptosis. Conjunctival flaps are suitable for chronic ocular surface disease and nonhealing corneal epithelial defects. In chronic and non-responsive viral, bacterial, and fungal corneal infections, it has been utilized to stabilize the eye. In the occurrence of a descemetocele or perforation, a corneal patch may be performed before a conjunctival flap is considered. These could be performed with amniotic membrane or umbilical cord tissue. Corneal patch grafts would require the availability of properly packaged, preserved, and stored corneal graft material. The conjunctival blood supply helps deliver immunoglobulins, anti-collagenases, and systemic antibiotics to the corneal lesion, in addition to providing corneal support and fibrovascular tissue to fill epithelial and stromal abnormalities. Non-living tissues, such as amniotic membrane, do not offer this benefit although they may provide growth factors which stimulate healing. Neurotrophic ulcers, marginal ulcers, exposure keratopathy, and bullous keratopathy (with low visual potential) are additional indications for the procedure.

Complications

(I) Flap retraction;
(II) Buttonholes in the flap;
(III) Epithelial cyst formation;
(IV) Ptosis.

The complications associated with conjunctival flaps typically are mild and clinically minor, and typically occur due to inadequate surgical technique (9-11). However, the flap historically had higher complication rates up to 24% (12). The complications include enlargement of flap buttonholes, flap retraction, epithelial cysts around the limbus, ptosis, erosion from underlying ulcer (rare), and persistence of pain (rare) when flap is contraindicated (e.g., absolute glaucoma or phthisis) but still used instead of enucleation (9).

Hemorrhage

Hemorrhage under the flap can occur within the first postoperative week, which can decrease the flap transparency (9).

Flap retraction

Poor surgical mobilization and adherence of the flap can lead to flap retraction. However, flap retractions occur infrequently and can be revised surgically (11).

Buttonhole formation

In addition, buttonholes in the flap can occur when separating Tenons capsule from the overlying conjunctiva. Buttonhole formation can be minimized by the help of an assistant to hold up the edges of the conjunctiva while performing the dissection with blunt tipped scissors. Buttonholes can lead to further ulceration in the area and should be closed using 10-0 nylon sutures incorporating the flap into the surrounding corneal tissue. Meticulous suturing technique is important. The buttonhole enlargement may be clinically insignificant in the absence of underlying inflammatory corneal disease or traction of the flap. A buttonhole will enlarge regardless of its size intraoperatively. Traction can lead to not only buttonholes but also retraction and tearing of the conjunctival flap from the sutures. A buttonhole with underlying inflammatory corneal disease may be mistaken for flap erosion. Buttonholes and flap erosions are difficult to treat; they frequently require a new conjunctival flap made from undisturbed conjunctiva (9). If a small hole is formed in the flap by accident, it can be sutured with satisfactory results with 10-0 or 11-0 nylon on an atraumatic needle like those used in microvascular surgery (13). An extra flap from the inferior bulbar conjunctiva may be used if the defect is significant.

Cyst formation

Incomplete removal of corneal epithelium may result in epithelial inclusion cysts, which are often occur at the limbus. Small epithelial inclusion cysts have been reported to occur at a rate of 2.5% (11). The cysts may be easily drained with a needle but often recur; excision of the cyst wall can prevent such recurrence (9,11).

Fluid accumulation under flap

Fluid collection may occur under the flap if perforation occurs either during or before the procedure is performed. Among 122 cases, none had fluid accumulation between the cornea and flap (9), in comparison to Gundersen's report in 1969 (14).

Ptosis

Postoperative ocular discomfort often results in ptosis, which usually resolves along with the discomfort. However, a complication of longstanding ptosis may develop from the excision of excessive conjunctival tissue from the superior fornix, thus exerting downward traction of the lid (9). The incidence of mild ptosis has been reported as high as 7% but can be avoided by leaving a symblepharon shell in place for 4 weeks to prevent superior fornix scarring and foreshortening (11).

Persistent pain

There have been very few cases with mild, persistent discomfort or photophobia postoperatively. Persistent pain is a rare complication that typically occurs only when a conjunctival flap is not the proper treatment, such as in phthisis bulbi or absolute glaucoma (9).

Flap melt

The most serious complications are flap melt and corneal perforation, which have been reported in 1.2% of the cases, typically 2 to 4 weeks after the procedure (13).

Reported series and success rates

Conjunctival flaps have been used for numerous and varied corneal conditions, with success characterized as globe preservation, prevention of endophthalmitis, in addition to decreased pain, fewer required follow up visits, and less frequent topical medications.

Gundersen and Pearlson's review of corneal cases over thirty-seven years showed the greatest utility of conjunctival flaps in treating chronic herpetic keratitis and impending perforations. They found value in treating neuroparalytic keratopathy, marginal ulceration, severe endocrine exophthalmos, filamentary keratopathy, and other obstinate corneal disease. The most common indication was bullous keratopathy (14), which no longer requires such treatment because of the development of advanced transplantation techniques, such as Descemet's stripping automated endothelial keratoplasty and Descemet's membrane endothelial keratoplasty.

Paton and Milauskas reported the benefits of relief of symptoms, therapeutic benefits, and cosmetic improvement in their reviewed of 122 consecutive cases. Contrary to Gunderson, they did not advocate keratectomy and only recommended removing necrotic tissue and surface epithelium. Many of their cases were corneal ulcers resistant to therapy, including viral, bacterial, and fungal infections.

They reported two failed cases associated with Mooren's ulcer, in which the flap did not halt the disease process (9). This failure in treating Mooren's ulcers was confirmed by Li *et al.* in 2017 (15).

For eyes with treatment-resistant corneal conditions, the Gundersen flap has successfully provided a stable ocular surface, with resolution of the symptoms and no flap retractions or dehiscence (12). In 33 cases of treatment-resistant corneal disease, half of which had bacterial or viral ulcers, 25 received a total hood flap and eight a partial conjunctival flap. One third of the cases had undergone prior penetrating keratoplasty (PKP) and received conjunctival flaps when the grafts completely failed. Overall, 9 of the thirty-three underwent PKP an average of 14.8 months following the flap procedure, with improvement of visual acuity in eight of these patients (16). A partial or total flap successfully stabilizes the patient's ocular surface in most cases despite the risk of postoperative flap recession and the need for surgical intervention. Conjunctival flap surgery is an important and useful surgical option in the treatment of ocular surface disease, especially for recalcitrant infectious keratitis and corneal ulcers (17). For refractory corneal defects, conjunctival flaps provide liberation from pain, intensive surface treatment, and frequent examinations. Conjunctival flaps, though rarely applied, present the best treatment for refractory neurotrophic keratitis and non-healing epithelial defects (13). Conjunctival flaps also provide prompt resolution of ulceration in neurotrophic corneal disease (18).

Conjunctival flaps in the treatment of herpes keratouveitis with persistent corneal epithelial defects resulted in intact, healthy ocular surface and a non-inflamed eye require few medications and infrequent office visits. No patients had recurrent live viral activity. The surgical techniques for these cases varied; Tenons capsule was not completely removed from the conjunctiva, but instead, about one-third thickness of Tenons was included with the flap (19).

Alino and Perry concluded that conjunctival flaps were underutilized and should be considered for persistent non-healing epithelial defects, based on their five-year review of 61 patients, with 48 total and 13 partial conjunctival flaps (20). The 7 complications included two flap retractions that required re-suturing in the total flap group, as well as three flap retractions in the partial flap group. One case that received a partial flap required a conversion to total flap with lamellar keratoplasty one week postoperatively, followed by flap retraction with subsequent corneal perforation four months postoperatively that required PKP and tarsorrhaphy. An additional patient with a partial conjunctival flap suffered perforation after flap retraction, requiring PKP.

The modified selective pedunculated superior forniceal conjunctival flap provides successful globe preservation for non-healing, non-traumatic corneal melts and perforations, including those secondary to bacterial keratitis, neurotrophic keratitis, and multiple retinal procedures with previous corneal grafts with compromised ocular surfaces. This surgical technique is appropriate in the managing impending and frank corneal perforations when donor material is not available and tissue transplantation in unsuitable (7).

In 2013, a novel approach using fibrin glue for Gundersen flap surgery reduced surgical procedure time, hastened ocular surface rehabilitation, and had similar outcomes to conventional conjunctival flap surgery. Seven of seven patients achieved a stable ocular surface with no flap retractions or exposure of the underlying corneal surface (21).

A 10-year 2017 review of 251 eyes in 253 patients showed success of flaps in maintaining globe integrity; reducing pain and the inflammatory process; arresting corneal ulceration; and preventing secondary infections. The flap acts as a biologic patch with trophic, protective, and analgesic effects, thus controlling local corneal infections, melts, and perforations to preserve the globe. Clinically, 224 patients (88.5%) had vision no worse than preoperatively, though a best-corrected visual acuity (BCVA) of 29 (11.5%) of the patients decreased postoperatively (13).

Disadvantages

Vision may be impaired in circumstances where the flap covers the visual axis. Visual acuity may be preserved in cases where the flap only covers the peripheral cornea. However, in most cases where a whole conjunctival flap is required, the globe's integrity, rather than vision, is the primary issue.

Conjunctiva covering the entire cornea inhibits monitoring of disease progression by preventing any view of the anterior chamber and prevents direct view of the corneal pathology. Unless the flap is very thin or very peripheral, the cosmetic aspect may be an issue for the patient, and this should be discussed with the patient before surgery.

Conjunctival flaps render the monitoring of glaucoma difficult, due to the inability to accurately measure intraocular pressure (6). The significant conjunctival

dissection and mobilization that occurs during the Gundersen flap technique jeopardizes the donor site if the patient has a trabeculectomy in the future (7).

While local retrobulbar injection and, in some cases, local infiltration anesthesia can be used to perform this procedure, it is still a surgical procedure that requires the patient to undergo significant surgical manipulation and should only be considered after non-surgical options have been exhausted.

Alternative treatments

The number of cases requiring conjunctival flap cover surgery has decreased over time. This could be attributed to the availability of alternate and more effective treatments for significant ocular surface problems, such as tissue adhesives, soft bandage contact lenses, more powerful antimicrobials, better ocular lubrication systems, immunosuppressive drugs, and other surgical procedures are used.

Conservative medical techniques in the care of non-healing corneal ulcerations and impending perforations vary in their success, depending on the extent and etiology of the disease process. Punctal plugs and punctal cautery can relieve dry eyes, and bandage contact lenses are sometimes helpful. In addition, tarsorrhaphy may be required if lagophthalmos is due to mechanical or neurologic causes, while botulinum toxin injections into the levator can provide ptotic protection. Autologous serum tears containing neurotrophic growth factors can help promote epithelial cell proliferation, migration, and differentiation. Oral tetracycline reduces inflammatory mediators and have been reported to improve healing of epithelial defect by inhibiting bacterial lipases and lipid peroxidases.

Amniotic membrane grafts can help promote healing in the slowly healing corneal ulcer. Acting as a basement membrane, these tissues are believed to guide and promote epithelial proliferation and migration while supporting cell adhesion. They are also believed to inhibit inflammation and corneal necrosis, as the amniotic membrane stroma contains proteinase inhibitors. Newer therapies, such as the nerve growth factor Oxervate [cenegermin, recombinant human nerve growth factor (rhNGF); Boston, MA: Dompé U.S. Inc.], provide a promising approach to the treatment of persistent corneal epithelial defects, but are often insufficient in maintaining ocular surface stability in extreme cases.

Corneal neurotization has proved successful in some cases of neurotrophic keratopathy. Various techniques using direct nerve transfer of the ipsilateral infraorbital, supraorbital, or supratrochlear nerves have been developed, in addition to processed nerve allografts. Confocal microscopy has shown re-innervation in as early as six months. Limitations of these alternative treatments also exist, however. Corneal donor tissue may not be available for patch grafting, lamellar, or full-thickness transplantation. Necrotic, inflamed tissue in the peripheral cornea may also impair the ability to perform a PKP. The amniotic membrane and umbilical cord grafting are limited in that they may not provide a robust enough substitute for healing compared to the properly prepared vascularized conjunctival flap. Using transplant materials always carries the risk of infectious or prion disease transmission. ProKera may fail to succeed in enhancing corneal epithelial cell proliferation and inhibiting stromal tissue loss and ulceration. Bandage contact lenses, such as Kontur (Hercules, CA: Kontur Kontact Lens, Co., Inc.), still require medications and frequent office visits and medical monitoring, while still presenting an increased risk of microbial keratitis.

Optical rehabilitation after conjunctival flap

Conjunctival flaps may be performed to preserve and stabilize the globe for a cosmetic scleral shell or for future sight-restoring surgery. Patients can also be fitted with an iris-print contact lens as early as 4–6 weeks postoperatively for cosmesis (11).

One advantage of the conjunctival flap is that it can be removed easily for additional vision restoring surgery. Removal requires only a minor surgical procedure; topical anesthesia is sufficient, but retrobulbar anesthesia is preferable. In cases where Bowman's membrane is intact, such as bullous keratopathy, the flap can be nicked and peeled off the cornea (to at least 1 mm peripheral to the limbus to avoid regrowth of the flap onto the cornea). Especially in cases of peripheral corneal disease, a trephine placed over the flap can be used to protect the peripheral cornea while the central button of flap tissue is excised with scissors and fine-tipped forceps. As ingrowth of the flap tends to reduce the size of the central window, a large trephine (e.g., 9 mm) should be implemented. Indications for flap excision were vision improvement in cases of peripheral corneal scarring, examination of the cornea for future PKP, and cosmesis after resolution of inflammatory processes (9).

If the goal of flap removal is to improve visual acuity, corneal surgery is usually required. PKP should never

be carried out simultaneously with the removal of the flap; it should only be considered after a few weeks until inflammation recedes, and the cornea heals. Furthermore, if additional corneal surgery is performed soon after flap excision, conjunctival tissue tends to regenerate onto the peripheral cornea. In cases of herpetic keratitis, a period of at least 8 months before flap removal is not always necessary but allows for maximum corneal healing and prevention of recurrence of chronic herpetic keratitis (9). Insler and Pechous performed nine PKPs in patients with flaps. Vision improved in eight cases. It was concluded that total and partial therapeutic conjunctival flaps improved the recipient bed and facilitated a successful result following PKP in severely inflamed eyes (12).

Removal of the conjunctival flap is not necessary before a corneal graft surgery; keratoplasty with the conjunctival flap remaining has resulted in similar benefits and few complications and also requires no change in keratoplasty technique (22).

The selection of cases for PKP after conjunctival flaps should be limited to those without other sight-threatening comorbidities, such as uveitis, glaucoma, cataracts, and diseases of the optic nerve and retina. Conjunctival flaps have shown to improve the condition of the recipient bed for transplant in severely inflamed eyes. The therapeutic conjunctival graft serves to mitigate the advanced inflammation, vascularization, corneal ulceration, and substantial risk for transplantation, thus increasing the possibility for a successful corneal graft. Histopathologic study of the buttons showed that the surface conjunctival epithelium thickened with increased goblet cells, with underlying conjunctival chorion and corneal stromal collagen lamellae. Reported complications include graft rejection and glaucoma that were all treated medically (20).

Advantages of various techniques

In comparison to the Gundersen and partial flaps, the selective pedunculated conjunctival flap and SFCAP neither require extensive conjunctival dissection nor obscure the whole cornea. This allows postoperative observation of the anterior chamber. The SFCAP and the pedunculated flap with Tenon's capsule also provide enough thickness to successfully treat impending or frank corneal perforations (6,7,22).

Summary

Conjunctival flaps have historically demonstrated success in preserving the globe in patients with severe ocular surface disease. There are multiple indications for their use, including infectious keratitis, neurotrophic keratitis, nontraumatic corneal melts, descemetoceles, perforations, and corneal burns. The flaps provide nutritional, metabolic, structural, and vascular support, while limiting inflammation and infection. The extraocular surgical techniques can be performed in various ways, including bipedicle (superior or inferior), partial or total, as well as pedunculated. Fewer flaps are performed today because of the development of other treatment modalities, including serum tears, bandage lenses, corneal grafting (both lamellar and full thickness), Oxervate, amniotic membrane, and umbilical cord grafting. Despite the availability of newer conservative medical modalities, conjunctival flaps have proven successful and beneficial in various ways that these alternatives have not.

Conjunctival flaps can prevent the emotional and psychological effects of enucleation or evisceration. while decreasing pain, discomfort, and inflammation. Moreover, patients need fewer medications and office visits, while retaining the future option for visual rehabilitation when appropriate. The future will likely present us with new technologies and techniques for globe preservation and sight restoration. The conjunctival flap may serve as an intermediate step towards the integration of these novel modalities. Currently, this procedure remains a viable and important instrument in our surgical toolbox.

Acknowledgments

We thank Adele Heib, MD for illustrating the diagrams specifically for this manuscript.
Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editors (Joann Kang and Roy S. Chuck) for the series "Ocular Surface Reconstruction/Transplantation" published in *Annals of Eye Science*. The article has undergone external peer review.

Conflicts of Interest: Both authors have completed the ICMJE

uniform disclosure form (available at https://aes.amegroups.com/article/view/10.21037/aes-22-36/coif). The series "Ocular Surface Reconstruction/Transplantation" was commissioned by the editorial office without any funding or sponsorship. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Byers WG. Conjunctival Flaps in Ophthalmic Surgery. Trans Am Ophthalmol Soc 1910;12:398-409.
2. Green J. Conjunctivo-plasty in Certain Corneal Affections. Trans Am Ophthalmol Soc 1927;25:39-47.
3. Haik GM. A fornix conjunctival flap as a substitute for the dissected conjunctival flap: a clinical and experimental study. Trans Am Ophthalmol Soc 1954-1955;52:497-524.
4. Gundersen T. Conjunctival flaps in the treatment of corneal disease with reference to a new technique of application. AMA Arch Ophthalmol 1958;60:880-8.
5. Cies WA, Odeh-Nasrala N. The racquet conjunctival flap. Ophthalmic Surg 1976;7:31-2.
6. Khodadoust A, Quinter AP. Microsurgical approach to the conjunctival flap. Arch Ophthalmol 2003;121:1189-93.
7. Sandinha T, Zaher SS, Roberts F, et al. Superior forniceal conjunctival advancement pedicles (SFCAP) in the management of acute and impending corneal perforations. Eye (Lond) 2006;20:84-9.
8. Mekonnen B, Kossler AL, Lin CC. Modified Gundersen Flap Using Inferior Palpebral-Bulbar Conjunctiva. Cornea 2022;41:260-3.
9. Paton D, Milauskas AT. Indications, surgical technique, and results of thin conjunctival flaps on the cornea: a review of 122 consecutive cases. Int Ophthalmol Clin 1970;10:329-45.
10. Sun YC, Kam JP, Shen TT. Modified conjunctival flap as a primary procedure for nontraumatic acute corneal perforation. Ci Ji Yi Xue Za Zhi 2018;30:24-8.
11. Kohlhaas M, Perdikakis G, Iraklis V, et al. Treatment of Chronic and Painful Corneal Defects with a Complete or Partial Conjunctival Flap. Klin Monbl Augenheilkd 2022;239:73-8.
12. Lim LS, How AC, Ang LP, et al. Gundersen flaps in the management of ocular surface disease in an Asian population. Cornea 2009;28:747-51.
13. Yao Y, Jhanji V. Conjunctival flap cover surgery: 10-year review. Ann Eye Sci 2017;2:25.
14. Gundersen T, Pearlson HR. Conjunctival flaps for corneal disease: their usefulness and complications. Trans Am Ophthalmol Soc 1969;67:78-95.
15. Li S, Deng Y, Du C, et al. Rapid deterioration of Mooren's ulcers after conjunctival flap: a review of 2 cases. BMC Ophthalmol 2017;17:93.
16. Insler MS, Pechous B. Conjunctival flaps revisited. Ophthalmic Surg 1987;18:455-8.
17. Oostra TD, Mauger TF. Conjunctival Flaps: A Case Series and Review of the Literature. Eye Contact Lens 2020;46:70-3.
18. Lugo M, Arentsen JJ. Treatment of neurotrophic ulcers with conjunctival flaps. Am J Ophthalmol 1987;103:711-2.
19. Brown DD, McCulley JP, Bowman RW, et al. The use of conjunctival flaps in the treatment of herpes keratouveitis. Cornea 1992;11:44-6.
20. Alino AM, Perry HD, Kanellopoulos AJ, et al. Conjunctival flaps. Ophthalmology 1998;105:1120-3.
21. Chung HW, Mehta JS. Fibrin glue for Gundersen flap surgery. Clin Ophthalmol 2013;7:479-84.
22. Geria RC, Zarate J, Geria MA. Penetrating keratoplasty in eyes treated with conjunctival flaps. Cornea 2001;20:345-9.

doi: 10.21037/aes-22-36
Cite this article as: Gibralter RP, Hawn VS. Conjunctival flaps for the treatment of advanced ocular surface disease—looking back and beyond. Ann Eye Sci 2022;7:36.