Grafts in Glaucoma Surgery: A Review of the Literature

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Abstract: Patients with bleb leakage, dehiscence, or infection after trabeculectomy need urgent bleb salvaging to prevent vision loss. Patients who have undergone a glaucoma drainage device surgery may have tube erosion, which is yet another devastating and outcome-compromising complication. The bleb or the tube in such cases needs to be patched by a biologic tissue, which is roofed by the conjunctiva and acts as a barrier against external infections. Sclera, pericardium, cornea, and dura mater are the commonly used patch graft materials. This review reports the outcomes of several new and old graft materials used to repair the post trabeculectomy compromised bleb and tube exposure in glaucoma drainage device surgeries.

Key Words: bleb, glaucoma drainage device, patch graft, tube, trabeculectomy


Affecting more than 70 million people worldwide and making approximately 10% of them bilaterally blind, glaucoma today is the leading cause of irreversible blindness in the world. The main treatment for glaucoma aims to reduce intraocular pressure (IOP) to slow or prevent further vision loss. Intraocular pressure can be lowered with medications and laser or incisional surgeries.

Surgical intervention in uncontrolled glaucoma is considered the most effective procedure for lowering IOP. Trabeculectomy has remained the gold standard for glaucoma surgery against which other modalities are compared. It has been historically preferred over tube-shunt implantation. However, a greater appreciation of the efficacy of tube shunts and a growing concern about long-term bleb-related complications have influenced the expanded use of tube shunts as an alternative to trabeculectomy. This assertion is backed by the results of the Tube Versus Trabeculectomy (TVT) study. After 5 years of follow-up, shunt surgery proved a higher success rate: 70.2% as compared with 53.1% in the trabeculectomy with mitomycin C (MMC) group. Both procedures were associated with similar reduction in IOP and use of supplemental medical therapy, although additional glaucoma surgery was needed more frequently after trabeculectomy with MMC than tube-shunt placement. However, both types of surgeries have their own set of complications that require active intervention by the ophthalmologist.

Tube-shunt procedures have been reported with complications like hypotony in the immediate postsurgery period with nonvalved devices, fibrous encapsulation with decreased permeability of the capsule around the plate, wound dehiscence with tube/plate erosion, infection, corneal decompensation, strabismus, and tube obstruction. Aqueous shunt exposure especially has been linked with postoperative endophthalmitis in tube-shunt procedures with tube erosion as the cause for corneal decompensation in 60% of cases in one review. A number of causes for tube/plate erosion have been postulated including immune-mediated inflammation causing patch graft melting, excessive tension or mechanical friction of tissue, poor perfusion, and ischemic damage to the conjunctiva. Studies have also noted smoking, pseudoexfoliation glaucoma, history of dry eye syndrome, diabetes, younger age, and inflammation as risk factors for tube exposure. Black race, diabetes mellitus, a high number of glaucoma medications before shunt implantation, a history of multiple glaucoma laser procedures, and combination of an initial aqueous shunt implantation with another surgery have been found to be associated with a worse outcome after exposure repair.

Trabeculectomy is also associated with wound leaks, especially the late-onset wound leak which can lead to hypotony, choroidal effusion, corneal decompensation, maculopathy, blebitis, and endophthalmitis.

SALVAGING WOUND LEAKS

Surgical intervention with grafts is mostly required to manage or prevent these complications of glaucoma surgery. Various authors have successfully demonstrated the use of autologous or human donor sclera, pericardium, dura mater, donor cornea, fascia lata, acellular dermal graft, buccal mucosa, autologous tragal perichondrium, autologous tenon, amniotic membrane, porcine small intestinal submucosa, expanded polytetrafluoroethylene, and biodegradable implants like ologen as material for patch graft purposes in glaucoma surgery. Novel techniques like the use of grafts for increasing plate surface area and corneal collagen cross-linking for anterior segment tectonic reconstruction are opening up new dimensions for use of grafts in glaucoma surgery.

This review elucidates several patch graft materials that are used to address various complications of trabeculectomy and glaucoma drainage devices (GDDs).
Sclera

First used as glycerin preserved donor sclera by Freedman for Molteno implants in 1987 with success,\textsuperscript{26} sclera is one of the most popular mediums used for grafting purpose in glaucoma surgery.

Autologous Sclera

Autologous sclera can be harvested as a partial thickness flap just anterior to the rectus muscle insertion and parallel to the limbus 180 degrees away from site of Ahmed glaucoma valve (AGV) placement. It can also be fashioned from the sclera adjacent to the tube and subsequent rotation of the flap over the tube. Easy availability, low cost, immunological safety, and sterility has prompted the use of autologous scleral flaps.\textsuperscript{8} Wolf et al,\textsuperscript{9} in a study of 51 patients who underwent primary AGV surgery with autologous scleral flaps, reported that scleral rotation flaps (24 patients) gave better results than scleral free-flap grafts (27 patients); 8.9\% of the free-flap group had tube exposure at 24 and 55 months post-operatively compared with none of the patients in the rotational flap group. Graft thinning without evidence of conjunctival erosion was observed in 55\% (15 patients) in the free-flap group and in 29.1\% (7 patients) in the rotational flap group.\textsuperscript{9} However, theoretical risk of globe rupture and decreased subsequent tectonic integrity of the globe have to be considered preoperatively before undertaking this procedure.

Heterologous Sclera

Tsoukanas et al\textsuperscript{10} studied the use of fresh heterologous donor sclera in 60 patients and found a 90.5\% and 81\% success at 1 and 2 years’ follow-up after AGV implantation in accordance with TVT criteria. The patch graft was soaked in a 5% povidone iodide solution for 4 minutes, then copiously rinsed with balanced salt solution, and uveal tissue was removed by sharp dissection under the microscope. Subsequently, it was used to cover the tube after it was trimmed in size to allow for a more smooth transition of conjunctiva into cornea. This study reported no dellen formation, immunological reaction, early/late blebitis, or endophthalmitis, and there was 1.6\% tube exposure occurring 30 days after surgery.\textsuperscript{10}

Dubey et al\textsuperscript{11} used heterologous sclera retrieved from enucleated globes, cleaned in an aseptic laminar flow hood and stored in glycerin or alcohol (used up to 1 year), and from corneoscleral rims that were stored primarily in McCarey-Kaufman medium or Optsol (used up to 5 or 14 days, respectively) for AGV implantation. In a 55 patient study, they reported a success rate of 89.1\% according to TVT parameters with cumulative probability of success as 85.45\% at 1 year and 79.63\% at 3 years. They reported a 2\% rate of tube extrusion with their technique and managed it by tube repositioning and reinforcement with alcohol preserved scleral patch. None of the patients developed motility disorder, wound leak, bleb-related infections, or encapsulation. This study is unique as it reports that in donors with septicemia there is a statistically significant biologic growth in 31.25\% of corneoscleral tissue.\textsuperscript{11}

Zeppa et al\textsuperscript{12} have also demonstrated a sutureless technique of scleral graft placement with fibrin glue in a 15 patient study with 1-year follow-up. They reported a 100\% success rate with no complications in the postoperative period.\textsuperscript{12}

With heterologous scleral grafts it is vital to conduct routine testing for all infections such as HIV 1 and 2, hepatitis B, hepatitis C, and syphilis. Virus and prion diseases are reported to transmit very rarely and simply excluding donors with neurological diseases/unknown cause of death can eliminate this risk as well.\textsuperscript{26}

Corneal Graft Sterilization by $\gamma$-Irradiation

In a 24-month follow-up study of 10 patients, corneal graft sterilization by $\gamma$-irradiation (VisionGraft) and tissue processing has shown to decrease risk of disease transmission and improve availability of corneal grafts. The inherent tensile strength of corneal tissue also facilitates easy manipulation and suturing during surgery. These grafts provide the added advantage of clear window for tube inspection, monitoring inflammation, and facilitating laser suture lysis in non-valved devices. Gamma $\gamma$-irradiation reduces malignant cells and other living cells in the graft tissue, including antigen-presenting cells, which reduces the possibility of allograft rejection by preventing direct sensitization. This sterile cornea allograft can be stored for at least 18 months at room temperature.\textsuperscript{14}

In a study done by Ekici et al,\textsuperscript{26} 169 patients were implanted with a 9-mm split-thickness half-moon $\gamma$-irradiation corneal allograft (VisionGraft). They reported an erosion rate of 2\% with a vast majority of the allografts being stable during the follow-up period, with no evidence of immunological reaction, infection, or exposure. In this study, 87.5\% were primary tube shunt surgeries with 63.9\% AGV placement.\textsuperscript{29}

Partial Thickness Corneal Grafts

Partial thickness corneal grafts (300 $\mu$m thick) have been used to protect the GDD tube from erosion. In a study of 45 eyes with a minimum follow-up of 1 year, Spierer et al showed a 6.7\% rate of graft melting and a 2.2\% rate of tube exposure. These grafts were those harvested from corneas unsuitable for penetrating keratoplasty or anterior lamella from a previous Descemet stripping endothelial keratoplasty procedure. There were no other complications and the grafts maintained clarity throughout the follow-up.\textsuperscript{30}

Corneal grafts have also been employed to repair leaking blebs in trabeculectomy. Rumelt and Rehany first described the use of donor corneal patch graft for incompetence of the scleral flap and prevention of hypotony.\textsuperscript{31} Mistlberger et al\textsuperscript{12} repaired an area of late scleral necrosis and bleb leak using an excimer laser (Excimer-Laser-Corneal-Shaping-System, ELCS-S) shaped stromal patch graft to cover the scleral defect. This step was followed by watertight closure of the conjunctiva. In a 1-year follow-up, the leak remained successfully repaired and the intraocular pressure stayed between 8 and 14 mm Hg without medication.\textsuperscript{32} Bochmann et al,\textsuperscript{13} in a series of 5 cases of severe hypotony, demonstrate the successful reconstruction of the outflow resistance of melted trabeculectomy scleral flaps after antiproliferative agents. During a 9-month follow-up, this procedure successfully reversed...
hypotony in all cases and no recurrences of bleb leak or hypotony were observed.13

Recent Advances—Corneal Collagen Cross-Linked Stromal Grafts

Corneal collagen cross-linking has been shown to increase the corneal rigidity more than 3 times after treatment. Kymionis et al10 demonstrated a novel use of the usually discarded anterior stromal part of a precut corneal graft for Descemet stripping automated endothelial keratoplasty (DSEAK). The approximately 350-μm grafts were cross-linked with riboflavin and ultraviolet-A irradiation in accordance with Dresden protocol.11 Subsequently, they were used in 2 patients with AGV tube extrusion. This avascular, reinforced corneal button was shown to be biocompatible, strong, cost effective, and had low immunogenetic properties. In a 1-year follow-up, the grafts remained in place, were completely epithelialized, and showed no signs of inflammation/rejection. The authors, however, accept that these transparent grafts require either a conjunctival or a scleral graft to provide sufficiently opaque aesthetically acceptable appearance.24

Amniotic Membrane

Amniotic membrane consists of a single layer of epithelial cells that are attached to a thick basement membrane and an avascular stromal matrix. Being a fetal tissue it is considered to be immunologically inert and has several physiologic properties, including antiscarring, anti-inflammatory, and antiangiogenic, and provides substrate for epithelial cell growth and attachment both in vivo and in vitro.24

In a 30-patient comparative study between the use of preserved amniotic membrane (Biotissue; Miami, Florida) and conjunctival advancement flap for repair in Seidel positive leaking blebs, Budenz et al25 showed cumulative survival rates for amniotic membrane transplant as 81%, 74%, and 46% at 6 months, 1 year, and 2 years, respectively. The cumulative survival rate was 100% for conjunctival advancement throughout follow-up. The mean IOP and mean number of glaucoma medications in use was the same in the 2 groups at all time intervals.35

However, in a 30-patient study Rausher et al26 showed a convergent trend of conjunctival advancement flaps and human preserved amniotic membrane results on the long-term Kaplan-Meier survival curves for leaking bleb repairs. They reported a cumulative success rate of 63% (19/30 eyes) with 73.3% (11/15 eyes) success with the conjunctiva group as compared with 53.3% (8/15 eyes) in the amniotic membrane group after an 80-month follow-up. The authors recommend the use of amniotic membrane as an alternative for bleb repair in cases of p.Timeout and in cases of thinned, scarred, or foreshortened conjunctiva that is unsuitable for standard advancement.36

Anand et al27 demonstrated the use of a 300-μm amniotic membrane patch graft in 44 patients requiring GDD surgery. They reported a success rate of 93% of eyes with a mean follow-up of 22 ± 3 months (17–28 months). Tube exposure occurred in 1 patient (2.27%), which was managed using a double pericardial and amniotic membrane patch graft. The authors specially highlight the ability of amniotic membrane to facilitate laser suture lysis due to translucency of the graft in this study.20

To assess the wound modulation properties of amniotic membrane, Yazdani et al28 compared it with an antifibrotic agent (MMC) in patients with AGV implantation. They showed that MMC and amniotic membrane are safe during AGV implantation but do not influence success rates or intraocular pressure outcomes.37

Pericardium

Preserved Cadaveric Human Pericardium

Raviv et al34 demonstrated the use of 450 μm thick, 8 × 8 mm, preserved human cadaveric pericardial graft (Tutoplast Pericardium; IOP Inc, Costa Mesa, California) as a patch graft material in GDD surgery. There was asymptomatic thinning in 11.3% (5 of 44) of patients but no infection, tube erosion, graft rejection, or inflammation was noted in a 6- to 14-month follow-up period. They recommended the use of ultrasound biomicroscopy as a modality to assess postoperative graft thinning.41

Lankaranian et al38 have shown double-thickness human cadaveric pericardium patch grafts (DTPP; Tutoplast) to be better than single-thickness pericardium patch (STPP; Tutoplast) grafts. They reported 16.0% conjunctival erosion in the STPP group (31 of 90 patients), which was subsequently corrected using DTPP and followed up for a mean of 8.6 months after repair with no additional conjunctival erosions. None of the eyes in the DTPP group developed conjunctival erosion (59 of 90 patients).38

Experimental Porcine Pericardium

Pinto et al39 demonstrated porcine pericardium as an alternative to glycerin preserved homologous scleral patch graft for GDD silicone tube in rabbit models. However, porcine pericardium was shown to be associated with significant inflammation at both histopathologic and clinical levels, although no cases of graft melting and tube exposure were found.39

Bovine Pericardium

Quaranta et al41 used a sutureless bovine pericardial patch graft as a safe and rapid procedure for AGV implantation in 20 patients. The pericardial membrane was cut using an ordinary corneal trephine and the anterior part of the tube was covered with the graft and kept in place with fibrin glue. During a 24-month follow-up, there was no conjunctival erosion, thinning of pericardial patch graft over the tube, or tube exposure and no signs of endophthalmitis were recorded.42

Other Uses of Pericardial Grafts

Papaconstantinou et al used sterile human pericardial graft to successfully treat hypotony in a case with leaking filtering bleb, which occurred years after the trabeculectomy done in a patient for pediatric glaucoma.41 Shazly et al43 used processed pericardial grafts in 3 patients with patulous sclerostomy with necrotic edges. The graft was used to seal sclerostomy tracks without the need to suture the friable sclerostomy edges. They placed a wedge-shaped graft into the old sclerostomy tract, which was subsequently trimmed and sutured to the sclera. The tube was then reinserted into a new sclerostomy site and sutured in place.41

Porcine Subintestinal Submucosa

Porcine subintestinal submucosa (KeraSys; IOP Inc, Costa Mesa, California) is a clear, cosmetically acceptable bioengineered lamellar porcine small intestinal submucosa, specially developed to prevent tube exposure in GDD surgery. Nagi et al evaluated the effectiveness of this graft in a 42 eye study with
an average follow-up of 15.24 ± 10.44 months. They reported an exposure rate of 10% (4 eyes) with observations pointing at diabetes, hypertension, and previous ocular surgery as risk factors for tube exposure.21

Dura Mater
Brandt et al22 first successfully used commercially available, dehydrated human dura mater in a case with gradual melting of a scleral patch graft.12

Zalta13 compared dura mater with scleral allografts in 1816 patients with AGV implantation. Patch graft failure occurred in 6.3% (44 eyes) of the initial 695 procedures using dura and in 5.8% (65 eyes) of the subsequent 1121 procedures using sclera. The time interval after AGV surgery until the occurrence of graft failure was significantly longer for dura (5.8 ± 3.8 years) than for sclera (2.7 ± 1.9 years).43

Fascia Lata

Heterologous Fascia Lata
Tanjel et al15 first demonstrated the use of human donor preserved fascia lata (Tutoplast fascia lata; Biodynamics International, Inc, Tampa, Florida) in 22 eyes followed for a mean of 19 months. No clinical signs of graft rejection, foreign body reaction, tube erosion, or graft melt were observed in the study group during the follow-up period.15

Gamma-irradiated fascia lata has also been successfully used to manage a case of severe discomfort due to an overfiltering bleb.44

Long-term survival of fascia lata patch graft (Tutoplast fascia lata; Biodynamics International, Inc, Tampa, Florida) has also been demonstrated by Gutierrez-Diaz et al45 in a patient with Cogan Reese syndrome requiring AGV implantation.45

Autologous Fascia Lata
Egrilmez et al46 reported the use of autologous fascia lata in a patient with scleromalacia perforans for glaucoma implant surgery with fascia lata forming the reinforced base for underlying sclera and a patch graft overlaying the tube to prevent tube erosion. There was no reported complication in the 24-month follow-up.46

Oral Mucosa

Autologous buccal membrane grafts have been used for correction of restricted socket syndrome, ocular adnexal reconstruction after tumor resection, cicatricial ocular surface diseases, therapy-refractory pterygia, conjunctival insufficiency after filtering glaucoma surgery, and the combination of mucosa and amniotic membrane grafting for fornix reconstruction. Buccal mucosa has also been shown to have more thickness, stability, and cosmetic appeal than amniotic membrane. It comprises an outer fibrous layer consisting of fibroblasts that form the perichondrium, a layer of dense irregular collagenous connective tissue that surrounds the cartilage of developing bone. It provides a source of collagen fibers, similar to those of the sclera.

Use of autologous tragal perichondrium has been demonstrated by Chun et al10 in a patient with total limbal stem cell deficiency who had recurrent AGV tube exposure even after scleral patch and double layered amniotic membrane graft. They reported a successful and complication-free postoperative period in a 20-month follow-up.18

Polytetrafluoroethylene

Preclude (Gore & Associates Inc, Flagstaff, Arizona) is a biodegradable ologen implant (Aeon Astron Corporation, Taipei, Taiwan) consisting of >90% lyophilized porcine atelocollagen (type plana clip erosion. They reported an overall success rate of 94% for tubes alone. For tubes, clips, and plates they reported a 70% success rate after primary buccal membrane repair and 85% after more than 1 repair attempt.48

Autologous Tenon Tissue
Tamcelık et al,16 in a retrospective case series that included 303 eyes with refractory glaucoma, described a new technique of combining a short scleral tunnel with Tenon advancement and duplication for AGV placement. They reported an exposure rate of 12.9% (11 eyes) in group 1 (without patch graft: 96 eyes) after a mean 9.2 ± 3.7 years of follow-up; in group 2 (with donor scleral patch: 78 eyes), a 2.2% (6 eyes) exposure rate after a mean 8.9 ± 3.3 years of follow-up; and in group 3 (combined short scleral tunnel with Tenon advancement and duplication technique: 129 eyes), there was no conjunctival exposure after a mean 7.8 ± 2.8 years of follow-up.19

Acellular Dermal Graft
Du et al10 reported the use of acellular dermal graft (ADG) in a patient with Ahmed valve extrusion having a complicated ocular history, multiple failed repair attempts, and wound dehiscence. An ADG was placed with glue and then sutured to the edge of the dehiscence. The conjunctiva grew over the graft, allowing the wound to close. The wound site was reported to be intact for more than 3 years.16

Tragal Perichondrium
The perichondrium is a layer of dense irregular collagenous connective tissue that surrounds the cartilage of developing bone. It can be easily cut, molded, and sutured and is resistant to infection. It was originally made as an outer fibrous layer consisting of fibroblasts that produces collagenous fibers, similar to those of the sclera.

Use of autologous tragal perichondrium has been demonstrated by Chun et al10 in a patient with total limbal stem cell deficiency who had recurrent AGV tube exposure even after a scleral patch and double layered amniotic membrane graft. They reported a successful and complication-free postoperative period in a 20-month follow-up.18

Ologen Implant
Rosentreter et al11 reported the use of a 5 × 5 mm slice of the biodegradable ologen implant (Aeon Astron Corporation, Taipei, Taiwan) consisting of >90% lyophilized porcine atelocollagen (type
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<tr>
<th>Author</th>
<th>Coverage Material</th>
<th>Type of Graft</th>
<th>Nature of Study</th>
<th>No. Eyes</th>
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<th>Success Rate (%)</th>
<th>Complications</th>
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<tr>
<td>Tanji et al (1996)</td>
<td>Fascia lata</td>
<td>Allograft</td>
<td>Primary patch graft</td>
<td>22</td>
<td>19</td>
<td>100</td>
<td>Suture track fistula in one eye (5%) managed with scleral patch graft.</td>
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<td>Raviv et al (1998)</td>
<td>Pericardium</td>
<td>Allograft (Tutoplast)</td>
<td>Primary patch graft</td>
<td>44</td>
<td>10.2</td>
<td>100</td>
<td>Thinning in 11.3% (5 eyes) but no other complications.</td>
</tr>
<tr>
<td>Aslanides et al (1999)</td>
<td>Sclera</td>
<td>Autograft</td>
<td>Primary patch graft</td>
<td>17</td>
<td>14.8</td>
<td>100</td>
<td>No complications reported; however, study excluded patients with compromised scleral rigidity.</td>
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<tr>
<td>Smith et al (2002)</td>
<td>Sclera</td>
<td>Allograft (Tutoplast)</td>
<td>Primary patch graft</td>
<td>64 (sclera: 23; dura: 18; pericardium: 23)</td>
<td>Sclera: 65.7</td>
<td>16 eyes showed thinning: sclera, 26.1% (6 eyes); dura, 22.2% (4 eyes); and pericardium, 26.1% (6 eyes).</td>
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<tr>
<td>Rauscher et al (2007)</td>
<td>Amniotic membrane</td>
<td>Allograft AMF vs autograft conjunctiva</td>
<td>RCT for leak repair</td>
<td>30</td>
<td>80</td>
<td>AMT: 53.3</td>
<td>Study halted due to higher failure in AMT.</td>
</tr>
<tr>
<td>Lankaranian et al (2008)</td>
<td>Conjunctiva</td>
<td>Allograft STPP vs DTTP (Tutoplast)</td>
<td>Primary patch graft</td>
<td>90 (STPP: 31; DTTP: 59)</td>
<td>STPP: 18.6</td>
<td>STPP group had erosions in 16% (5 eyes), treated with DTTP.</td>
<td></td>
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<tr>
<td>Zaheer (2012)</td>
<td>Dura mater</td>
<td>Allograft</td>
<td>Primary patch graft</td>
<td>1816 (dura: 695; sclera: 1121)</td>
<td>48</td>
<td>Total failure: 6% (109 eyes); Dura, 6.3% (44 eyes) and sclera, 5.8% (65 eyes).</td>
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<tr>
<td>Tamcelik et al (2013)</td>
<td>Sclera</td>
<td>Allograft vs tenon advancement autograft</td>
<td>Primary patch graft</td>
<td>303 (without graft: 96; sclera: 78; tenon: 129)</td>
<td>Without graft: 110.4</td>
<td>Exposure rates: without graft, 12.9% (11 eyes); sclera, 2.2% (6 eyes); tenon, 0%.</td>
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<tr>
<td>Zhou et al (2013)</td>
<td>Sclera</td>
<td>Allograft sclera vs autograft scleral flap vs artificial dura</td>
<td>Primary patch graft</td>
<td>35 (scleral graft: 10; scleral flap: 16; dura: 9)</td>
<td>15</td>
<td>Scleral graft: 80 Scleral flap: 87.5 Dura: 33.3 Authors demonstrate poor biocompatibility of artificial sclera in GDD procedures.</td>
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<td>Wigton et al (2014)</td>
<td>Cornea</td>
<td>Allograft glycerin preserved cornea vs Tutoplast</td>
<td>Primary patch graft</td>
<td>262</td>
<td>Cornea: 14.6; Pericardium: 11.03</td>
<td>–</td>
<td>Reported exposure rates for pericardium, 8.9% (9 eyes); cornea, 1.9% (3 eyes).</td>
</tr>
<tr>
<td>Ekici et al (2015)</td>
<td>Cornea</td>
<td>Allograft γ-irradiated (VisionGraft)</td>
<td>Primary patch graft</td>
<td>169</td>
<td>4.8</td>
<td>98.2</td>
<td>Exposure rate of 1.8% (3 eyes) reported. Bullous pemphigoid and chronic allergic conjunctivitis identified as risk factors for rejection.</td>
</tr>
<tr>
<td>Tsoukanas et al (2015)</td>
<td>Sclera</td>
<td>Allograft (fresh)</td>
<td>Primary patch graft</td>
<td>64</td>
<td>18.2</td>
<td>–</td>
<td>Study gave exposure rate of 1.6% (1 eye). Exclusive use of AGV FP 7.</td>
</tr>
<tr>
<td>Dubey et al (2016)</td>
<td>Sclera</td>
<td>Allograft (glycerin/MK/ Optisol)</td>
<td>Primary patch graft</td>
<td>55</td>
<td>20.6</td>
<td>–</td>
<td>Reported a 3.6% rate (2 eyes) of conjunctival thinning with 1 each of graft and tube exposure.</td>
</tr>
<tr>
<td>Spierer et al (2016)</td>
<td>Cornea</td>
<td>Allograft (300 µm partial thickness)</td>
<td>Primary patch graft</td>
<td>45</td>
<td>12</td>
<td>–</td>
<td>Corneal graft melting in 6.7% (3 eyes). Tube exposure and additional surgery to re-patch or suture the conjunctiva over the tube was needed in 2.2%.</td>
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<tr>
<td>Wolf et al (2016)</td>
<td>Sclera</td>
<td>Autograft (free vs rotational)</td>
<td>Primary patch graft</td>
<td>51 (free: 27; rotational: 2)</td>
<td>Free: 55.6; Rotational: 24.2</td>
<td>–</td>
<td>No exposure reported in rotational flap group with 8.9% (2 eyes) in free-flap group. Graft thinning of 35% (15 eyes) in free-flap group and in 29.1% (7 eyes) in rotational flap group.</td>
</tr>
<tr>
<td>Yazdani et al (2016)</td>
<td>Amniotic membrane</td>
<td>Allograft vs MMC</td>
<td>RCT to study wound modulation</td>
<td>75 (AGV: 25; with AMT: 25; with MMC: 25)</td>
<td>12</td>
<td>–</td>
<td>Hypertensive phase was slightly more common with standard AGV surgery (82%) as compared with AGV with MMC (60%) and AGV with AMT (70%). Equal efficacy reported with MMC and AMT.</td>
</tr>
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</table>

RCT indicates randomized controlled trial.
of antigen-free highly purified type I collagen) and <10% lyophilized porcine glycosaminoglycan as a wound-healing scaffold for management of a patient with tube exposure after scleral necrosis. No severe postoperative complications were detected on follow-up. Six months after revision surgery, the ologen implant was neither visible nor detectable by ultrasound biomicroscopy.

Table 1 summarizes salient studies describing various graft materials, nature of use, success rates, and complications.

**WHICH PATCH GRAFT IS BETTER?**

Smith et al\(^7\) demonstrated equal efficacy of EtoH preserved donor sclera (23 eyes), Tutoplast dura (18 eyes), and Tutoplast pericardium (23 eyes) patch grafts in 64 eyes with at least 24 months follow-up after glaucoma drainage implant surgery. They reported equivalent thinning in all the patch grafts: 26.1%, 22.2%, and 26.1% in sclera, dura, and pericardium, respectively. Exposure rates of 4.3%, 5.6%, and 0% were reported in sclera, dura, and pericardium, respectively. Follow-up was 65.7 ± 13.0 months for the scleral patch group, 47.2 ± 4.5 months for the dura patch group, and 32.6 ± 5.6 months for the pericardium patch group. The pericardium group had shorter follow-up but had comparable incidence of thinning to the scleral patch group. The authors thus concluded that affordability and availability of the graft drive surgeon preference for the same and make scleral grafts a preferred choice. However, the sterility offered by the pericardium and dura groups is also an important preoperative factor that should be considered before choosing the patch graft material.

Zhou et al\(^6\) evaluated the efficacy and complications of glaucoma drainage implant surgery with scleral graft, scleral flap, and artificial biological dural grafts in 35 eyes. They reported success rates of 80% (8/10 eyes), 87.5% (14/16 eyes), and 33.3% (3/9 eyes) in the scleral graft group, scleral flap group, and artificial biological dural graft group, respectively, at 12-month and 15-month follow-up. They concluded that the artificial biological dural graft has poor compatibility with conjunctiva and results in severe complications; thus, it is not recommended to be used in glaucoma drainage implant surgery.\(^49\)

Wigton et al\(^6\) demonstrated better results with glycerol preserved corneas as compared with Tutoplast pericardium in a retrospective study of 262 eyes. Nine out of 101 (8.9%) patients in the pericardium group experienced an erosion compared with 3 out of 161 (1.9%) in the cornea group. The cornea group had a longer follow-up (440 days) and median time to exposure (440 days) was also higher than the pericardium group (331 days vs 252 days).\(^28\)

**SURGEON’S CHOICE**

In our opinion, all patch graft materials have been shown to decrease the potentially devastating complications of tube exposure and bleb leaks with variable success rates. The difference in success rates, in addition to individual material properties, can be attributed to several other parameters like surgeon’s skill, ocular surface status, systemic disease, earlier interventions, graft quality, postoperative care, and patient demographic profile.

The choice of graft material, however, is vital and should be made while keeping in mind several factors like affordability of the material, with autologous grafts being the cheapest to harvest and use. The ease of availability also has to be considered because materials like PTFE, dura mater, and pericardium are not readily available in all countries. We also have to remember cosmetic appeal while considering the ease of postoperative maneuvers (like laser suture lysis) and monitoring of host site. Clear grafts like corneal patch graft and amniotic membrane have especially been used for these purposes.

There are a variety of ways in which patient care can be approached; the underlying therapeutic principle, however, remains the same. To conclude, this review suggests that surgeons should be open to embracing novel modalities enumerated above, especially when conventional methods fail. It is a known fact that the success rate of a graft falls considerably with an increased number of failed interventions with the same patch material.

**REFERENCES**


19. Tamcellici N, Ozbek A, Sarici AM, et al. Tenon advancement and


