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Stromal Lenticule Transplantation for Management of Corneal Perforations: One Year Results

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Abstract

Purpose: To study application of stromal lenticules extracted by femtolaser small incision lenticule extraction (SMILE) surgery as a surgical adjuvant for sealing corneal perforation.

Methods: Corneal stromal lenticules obtained through SMILE surgery with central thickness 100 µm or more were fixed over corneal perforation sites using 10-0 nylon interrupted stitches with overlying single layer of amniotic membrane. Seven patients were monitored for a minimum of 1 year and were assessed using slit-lamp biomicroscopy, fluorescein stain, tonometry, and best spectacle-corrected visual acuity (BSCVA) measurements. Postoperative complications were recorded throughout the follow up period.

Results: Corneal perforations had successfully been sealed in all 7 patients; 3 patients (42.9%) exhibited improved postoperative BSCVA. During the follow-up period of 12 months, no evidence of infection, relapse, or re-perforation was detected in any patient.

Conclusions: These preliminary findings suggest that the use of corneal lenticules may be a safe and effective surgical adjuvant for corneal perforation closure, with potential clinical application as relatively simple and inexpensive temporary measures to improve corneal condition for further definitive interventions.

Keywords: Corneal perforation; Femto-smile; Lenticule

Introduction

The most common cause of corneal perforation is infection; bacterial, fungal, or viral. Infection accounts for 24%-55% of all perforations [1-7], with bacterial infections being most common [3]. Inflammatory conditions such as collagen vascular diseases, acne rosacea, Wegener's granulomatosis, and Mooren's (idiopathic) ulcer can also cause peripheral, and occasionally central, ulcerative keratitis and subsequent perforation. The use of topical corticosteroids, topical antibiotics, and topical nonsteroidal antiinflammatory drugs (NSAIDs) may exacerbate or initiate a stromal melt in the presence of some of these disorders, but perforation can also occur spontaneously [8].

Corneal perforation is an emergent condition caused by various types of infectious and noninfectious corneal disorders. Surgical and/or nonsurgical intervention is sometimes required to close the perforation, to reform the collapsed anterior chamber, and to restore visual function. In the worst scenario, irreversible angle-closure glaucoma and microbial endophthalmitis can occur, which lead to blindness [9].

There are a variety of approaches for the management of corneal perforations, from nonsurgical treatments such as bandage soft contact lenses and tissue glues [10], to surgical modalities such as simple cornea suturing, conjunctival flaps, multilayered amniotic membrane transplantation (AMT), [11,12] and tectonic corneal grafts [13,14].

The choice of the treatment depends on the size and location of the perforation and status of underlying diseases.

In the current study, we report the clinical results of surgical management for corneal perforations using stromal lenticule from Small Incision Lenticule Extraction (SMILE) Surgery.

Patient and Methods

Study design

This prospective interventional study was carried out in 7 patients with corneal perforation treated by tectonic surgery using corneal lenticules from femtolaser SMILE surgery. The procedures were conducted from September 2014 to September 2015 at Tiba Ophthalmic Center, Shebin El Kom, Menoufia governorate, Egypt. The Ethics Committee of the College of Medicine, Menoufia University approved this study. The research followed the tenets of the Declaration of Helsinki.

Patients participated in this study provided written informed consent that included potential complications and need for further interventions. All donors provided written informed consent for lenticule donation, and donor tissues were collected in completely aseptic conditions.

Corneal perforation was confirmed clinically on slit lamp biomicroscope and confirmed by Seidel test using sterile fluorescein stripes. The size of the perforations ranged from 1.5 to 3.4 mm measured using slit lamp scale and confirmed intraoperatively.

The most common cause for corneal perforation was resistant fungal keratitis (4 patients), which is frequent in this agricultural area. Two patients had severe dry eye due to rheumatoid arthritis with peripheral corneal melting. In one case corneal perforation resulted from bacterial infection with a history of contact lens wear.

Preoperative assessment

Confirmation of corneal perforation carried out by Seidel test using sterile fluorescein staining. Best spectacle-corrected visual acuity (BSCVA) was assessed preoperatively. Corneal perforation size was recorded preoperatively by slitlamp scale.

After administering anesthesia, the tips of the caliper were placed at the edge of the corneal perforation vertically and horizontally, and the measurement was confirmed from the scale.

Surgical technique

Corneal stromal lenticules were extracted during SMILE procedures performed by a single ophthalmologist (A S) using a 500 kHz VisuMax Femtosecond Laser System (Carl Zeiss Meditec AG, Jena, Germany). SMILE procedures were performed using a 110 μm cap thickness, 7.9 mm cap diameter, 6.5 mm optical zone of the lenticule, and 120 degree side-cut angle. All lenticules were immediately preserved at 4°C in Optisol (Chiron Ophthalmics, Irvine, CA, USA) containing chondroitin sulfate, dextran 40, optisol base powder, Sodium Bicarbonate, gentamycin, amino acids, sodium pyruvate, mercaptoethanol and purified water. The average duration of preservation before surgical use was approximately 7 days.

Donors were selected from SMILE patients with refractive correction spherical equivalents of greater than 6 diopters, thus ensuring donor lenticule central thickness of ≥ 100 mm. All donors were negative for infections, corneal disease, human immunodeficiency virus, syphilis, hepatitis, and cancer. No donor had eye surgery before.

All lenticule graft surgeries were performed under peribulbar anesthesia (2% lignocaine hydrochloride and 0.75% bupivacaine) except one patient who preferred general anesthesia. Epithelial tissues were debrided with a sponge 1.0 to 2.0 mm from the perforation site. Single corneal lenticule was centered over the perforation. A 10-0 nylon interrupted suture was used to sew the lenticule to the healthy cornea around the perforation. The 12-o'clock and 6-o'clock sutures were taken first followed by the 3-o'clock and 9-o'clock sutures. All the 7 patients had an extra amniotic membrane patch overlaid on the lenticule grafts. The amniotic membrane patch was placed flat across the area of perforation with the epithelial side up. A 10-0 nylon interrupted suture was used to sew the amniotic membrane to the limbus. Bandage contact lens applied at end of the procedure.

Postoperative treatment

For all patients with corneal perforation, antibiotic eye drops (Moxifloxacin) were administered 5 times a day after surgery for 14 days. Additionally systemic antibiotics (oral ciproflioxacin 750 mg twice per day for 3 days). Mycotic keratitis received topical natamycin 5% five times per day.

Cycloplegic drops were administered as needed. Suture removal was initiated 3 weeks postoperatively. Early suture removal was performed in cases of loose or infiltrated sutures.

Follow-up and assessments

Corneal sealing, digital intraocular pressure and inflammation were examined postoperatively at 1 day, 7 days, 14 days, and at 3, 6, 9, and 12-month follow-up time points.

Additional examinations were conducted in between these intervals as needed, for complications or other patient concerns. Corneal perforation and BSCVA were assessed at 3, 6, and 12 months postoperatively.

Results

Demographic and clinical condition of patients

Patients included were 4 men (aged 63, 58, 58 and 30 years) and 3 women (70, 54 and 71 years). Corneal perforation sizes ranged from 1.5 to 3.4 mm (mean 2.69 ± 1.0 mm).

In all patients, corneal perforations were partially blocked by intraocular tissues, particularly the iris. Central perforation was noted in 5 patients. No patient demonstrated signs of exagerated infection during or immediately after surgery. Table 1 summarizes patient demographics and surgical outcomes.

Patient No.	Sex	Age (years)	Aetiology of perforation	Size of perforation	Associated Findings	Initial BSCVA	Lenticels Thickness, μm	AC formation	Postop. BSCVA	Anesthesia
1	M	63	Fungal keratitis	3.1 × 3.4 mm	Iris prolapse	HM	115	Failed	CF at 50 cm	LA
2	F	70	Rheumatoid arthritis	1.5 × 1.8 mm	Severe dry eye	CF at 30 cm	105	AC formed	HM	LA
3	F	54	Fungal keratitis	2.6 × 2.6 mm	Iris prolapse	HM	121	AC formed	HM	LA
4	F	71	Fungal keratitis	3.1 × 2.8 mm	Iris prolapse	HM	140	AC formed	HM	LA
5	M	58	Rheumatoid arthritis	2 × 2.5 mm	Severe dry eye	HM	120	AC formed	HM	LA
6	M	58	Fungal keratitis	3.2 × 3.2 mm	Iris prolapse	PL	112	Failed	HM	LA
7	M	30	Bacterial keratitis	2.9 × 3 mm	Iris prolapse	HM	125	AC formed	Cf at 50 cm	GA

Table 1: Summarizes patient demographics and surgical outcomes.

Corneal lenticule was successfully sutured over the corneal perforation and the corneal perforation was sealed in all patients. Four weeks after the operation, stabilization of lenticules took place and some sutures began to get loose, which was removed using 27 gauge needle tip and forceps. At approximately 8 weeks after the operation, part of the lenticule as well as overlying amniotic membrane became successfully incorporated into the corneal stroma and reepithelialization was achieved.

In all patients, corneal perforation was successfully sealed, with no evidence of leakage even when moderate pressure was applied to the globe (Figure 1). Anterior chamber formation occurred in all patients, except patients 1 and 6 which AC formation failed to occur due to extensive anterior synechiae (Figure 2). Five eyeballs exhibited good ocular tension by finger measurement but 2 eyes showed increased intraocular pressure that controlled medically. All eyes had no signs of recurrent inflammation during the acute period after surgery.

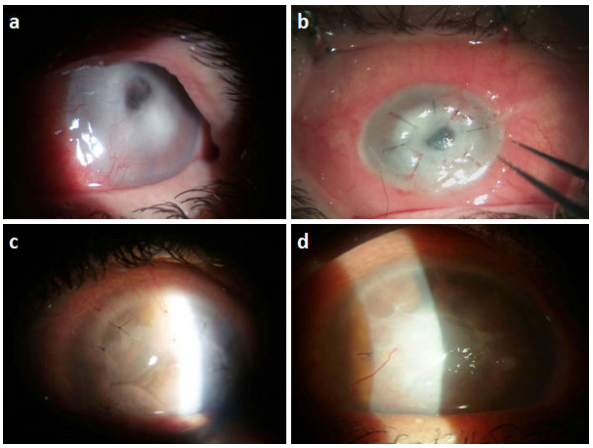

Figure 1: Preoperative and postoperative aspects of the cornea in patient 3. a) Presurgical iris prolapse through the central corneal perforation. b) Grafted lenticule sutured over the corneal perforation intraoperatively. c) Postoperative aspect of the same eye one week after surgery. d) Sealed perforation with anterior chamber formation and corneal scarring at 6 months postoperatively.

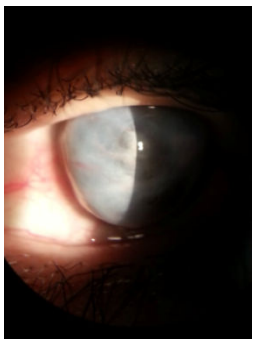

Figure 2: Failure of anterior chamber formation in patient 6.

Dense corneal vascularization noted in all cases postoperatively with no evidence of rejection. BSCVA had improved in 3 patients (1, 6 and 7); remained stable in 3 patients (3, 4 and 5); deteriorated in one patient (case 2).

Discussion

Many ocular conditions can subject the cornea to progressive thinning and possible perforation. These conditions range from chronic circumstances associated with long-standing ocular or systemic diseases such as corneal melt in rheumatoid arthritis, to a more acute and rapidly progressing problem such as aggressive herpes simplex keratitis. The common denominators in all of these conditions are persistent corneal epithelial erosions, stromal thinning, Descemet's membrane rupture, and possible global collapse.

For some of these conditions, complete penetrating keratoplasty may not be the most optimal solution at the time of presentation. The urgent and emergent nature of the condition may also require immediate repair of the problem in the office. Classically tissue adhesive application, placement of patch grafts or use of therapeutic contact lens are often be used to provide prompt closure of perforation or to prevent complete perforation, either permanently or temporarily in preparation for a more definite treatment.

Many studies have demonstrated that conventional tissue adhesive, conjunctival flaps and amniotic membrane techniques for corneal perforation closure are not suitable when corneal perforation sizes exceed 2.0 mm in diameter or demonstrate anterior bulging characteristics [15,16].

Following the introduction of the VisuMax femtosecond laser (Carl Zeiss Meditec, Jena, Germany) in 2007 [17], the intrastromal lenticule method was reintroduced in a procedure called Femtosecond Lenticule Extraction (FLEx). After the successful implementation of FLEx, a new procedure called Small Incision Lenticule Extraction (SMILE) was developed. This procedure involves passing a dissector through a small 2-3 mm incision to separate the lenticular interfaces and allow the lenticule to be removed thus eliminating the need to create a flap. The SMILE procedure is now gaining popularity following the results of the first prospective trials [18,19].

Pradhan et al. [20] reported that an allogeneic lenticule obtained by SMILE from a myopic donor was implanted into a recipient eye through a small incision to correct hyperopia. Lim et al. [21] conducted the same procedure and used it on allogeneic corneal lenticule implantation for the treatment of presbyopia.

In the present study, we sutured corneal lenticule grafts onto the corneal perforation with overlying amniotic membrane patch to regain ocular integrity. The maximum perforation size amenable to SMILE-generated lenticule is not known, but we successfully managed a 3.1 × 3.4 mm perforation with this approach.

Wu et al. [22] sutured 2 overlapped corneal lenticule grafts onto the corneal perforation corneal perforations were successfully sealed in all 6 patients; in our technique using single layer of stromal lenticule with overlying single layer of amniotic membrane achieved similar results.

In conclusion, Preliminary results of this technique achieved its primary goal in sealing corneal perforation in all samples of the study with no complications or immunologic rejection episodes were noted throughout the study period. No relapses of the ulcerative corneal condition or perforation occurred in any of the cases during the follow-up period.

Various modalities was described to deal with corneal perforations in the literature, thanks to the emerging technology of femtolaser and femto-SMILE we introduce a new modality for management of corneal perforations using plain stromal lenticule combined with amniotic membrane patch.

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