

Long-term Outcomes of Keratolimbal Allograft for the Treatment of Severe Ocular Surface Disorders

Luca Ilari, MD, Sheraz M. Daya, FRCS(Ed), FACS

Purpose: To investigate the long-term outcome of keratolimbal allograft (KLAL) for the treatment of severe ocular surface disorders.

Design: Retrospective, noncomparative case series.

Participants: Twenty patients (23 eyes) with severe ocular surface disorders.

Intervention: Thirty-three KLAL procedures were performed. Ten patients (10 eyes) underwent KLAL in combination with other surgical procedures. Oral or topical cyclosporine or both were used after surgery in 15 patients to prevent allograft rejection.

Main Outcome Measures: Reconstruction of the ocular surface with restoration of phenotypic corneal epithelium, reduction of corneal vascularization and conjunctivalization, decreased pain, and visual improvement.

Results: The mean follow-up was 60 months (range, 15–96 months). Eight eyes (24.2%) never reepithelialized and were considered primary failures. The remaining 25 grafts initially restored a phenotypic corneal epithelium, but at last follow-up only 7 (21.2%) were stable. Graft survival rate was 54.4% at 1 year, 33.3% at 2 years, and 27.3% at 3 years. Visual acuity improved or was unchanged in 19 eyes (82.6%) and decreased in 4 eyes (17.4%). Seventeen corneal transplantations (3 lamellar keratoplasties and 14 penetrating keratoplasties) were performed either in combination with or after a KLAL. All three lamellar keratoplasties were successful, whereas 13 of the 14 penetrating keratoplasties failed. Cyclosporine was used initially in high-risk recipients and later in all recipients. Allograft rejection episodes occurred in 13 KLAL procedures of 11 eyes (39.4%) and were more common in patients treated with cyclosporine compared with the untreated group (87.5% vs. 22.2%). Graft survival was longer in the cyclosporine-treated group compared with the untreated group.

Conclusions: Keratolimbal allograft is useful in ocular surface reconstruction and restores phenotypic corneal epithelium. Graft survival rate, however, decreases dramatically over a 2-year period. Long-term use of cyclosporine appears to prolong graft survival but does not prevent acute allograft rejections. *Ophthalmology* 2002;109:1278–1284 © 2002 by the American Academy of Ophthalmology.

The clinical spectrum of limbal stem cell deficiency includes pain and photophobia, punctate epithelial keratopathy, irregular corneal epithelium, persistent epithelial defects, chronic inflammation, corneal neovascularization, conjunctivalization, scarring, and decreased visual acuity (VA). If untreated, this condition may lead to chronic pain, epithelial defects, higher risk of bacterial keratitis, and corneal perforation. Several studies have shown the efficacy and limits of different surgical procedures to treat stem cell deficiency by transplanting healthy limbal tissue.^{1–12} In cases of bilateral disease, an allograft transplantation of limbal tissue is necessary. This is achieved by either a keratolimbal allograft (KLAL) obtained from a donor eye or by a living related conjunctival limbal

allograft (lrCLAL). A further option is to transplant ex vivo cultured stem cells.^{13–15}

Problems related to the use of KLAL and lrCLAL are that the limbal tissue is vascularized, is highly antigenic, and is rich in Langerhans cells. Langerhans cells have an important role in the afferent arm of an immune response by processing and presenting antigens to the T cells. Thus, these procedures theoretically carry a high risk of immune rejection. Selection of an HLA-matched donor, although advisable to decrease the risk of allograft rejection, is not always practical when performing a KLAL.

In this study, we reviewed our series of KLAL procedures performed over an 8-year period, and we describe how the surgical procedure evolved to include changes in techniques and the use of adjunct treatments. Long-term outcomes, the role of cyclosporine A (CSA), and possible prognostic indicators are discussed.

Materials and Methods

Thirty-three KLAL procedures were performed in 23 eyes (20 patients) for severe ocular surface disease from 1992 through

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From the Corneo Plastic Unit & Eye Bank, Queen Victoria Hospital, East Grinstead, West Sussex, England.

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Reprint requests to Sheraz M. Daya, FRCS(Ed), FACS, Corneo Plastic Unit & Eye Bank, Queen Victoria Hospital, East Grinstead, West Sussex RH19 3DZ, England. E-mail: sdaya@compuserve.com.

1999. The mean age was 45 years (range, 22–77 years), 12 patients were male and 8 were female. Common preoperative diagnoses were Stevens-Johnson syndrome (seven eyes) and severe chemical injuries (seven eyes; Table 1). The mean interval between the onset of the disease and the first KLAL procedure was 17.6 years (range, 1 month–40 years). Thirteen patients (14 eyes) had prior ocular surgery, of which 12 patients (12 eyes) had two or more procedures (Table 1). Main indications for KLAL were severe disruption of the ocular surface with variable degrees of keratinization, symblepharon, inflammation, ocular pain, and signs of stem cell deficiency, such as corneal epitheliopathy, persistent epithelial defects, corneal conjunctivalization, and reduced VA.

Visual acuity was measured on a standard Early Treatment Diabetic Retinopathy Study (ETDRS) chart. The VA of patients who could not read the chart at 1 meter was assessed by the ability either to count the number of fingers or to perceive movements of the examiner's hand. In 18 eyes (78.3%), VA was counting fingers or worse.

The extent of the disease was assessed retrospectively from medical records, clinical drawings, and anterior segment photographs. All patients had been treated extensively with conservative therapy before surgical options were considered. This included the use of lubricant agents, punctal occlusion, bandage contact lenses, and tarsorrhaphy.

The aim of the treatment was to rehabilitate the ocular surface. Ocular surface rehabilitation can be divided in two components: (1) restoration of phenotypic corneal epithelium (in all cases) and (2) reconstruction of the ocular surface by elimination of symblepharon, ankyloblepharon, and keratinization, where present.

Success in this study observed the outcomes of the two parameters: first, restoration of phenotypic corneal epithelium, and second, reconstruction of the ocular surface.

Outcome measures included reduction in ocular pain, photophobia, extent of symblephara, keratinization, surface inflammation, corneal conjunctivalization, superficial vascularization, corneal epitheliopathy, and change in VA.

Surgical Technique

Donor Tissue. Healthy limbal epithelium for transplant was obtained from either two fresh, whole donor globes stored at 4°C or eye bank corneoscleral rims stored in organ culture medium at 36°C.

Preparation of the Host Eye. The recipient eye was prepared by performing a 360° conjunctival peritomy. Bulbar conjunctiva was undermined and allowed to fall back posteriorly to the fornices. Abnormal corneal epithelium and vascularized pannus were removed.

Preparation of Allograft Lenticules. Over the 8 years of this study, surgical techniques changed, and these are described in chronologic order. One of three different techniques was used: (1) the donor globe was hand held in a gauze swab, and a thin layer of corneoscleral limbus was excised with a disposable von Graefe knife using a technique similar to peeling an orange; (2) between six and eight separate epithelial lenticules were excised from the corneoscleral limbus using a whole donor globe²; (3) in the last 10 cases, the whole corneoscleral rim was dissected, as described by Tsubota.³ The allograft tissue was then placed around the recipient corneoscleral limbus and sutured to the underlying sclera with 10-0 nylon or 10-0 Vicryl (Ethicon, Livingstone, Scotland).

In selected cases, KLAL was combined with penetrating keratoplasty, cataract extraction, amniotic membrane transplantation, or a combination thereof. Amniotic membrane transplantation was introduced in this institution in 1996, and in this study, it was used as a basement membrane substrate for epithelial growth in five

eyes. After it was rinsed in antibiotic solution, the amniotic membrane was placed over the eye with the epithelial side facing outward and secured with 8-0 and 10-0 Vicryl sutures. The allograft lenticules were then sutured over the amniotic membrane after slits were created in the amniotic membrane to permit contact of the lenticules to the scleral surface.

At the end of the procedure, subconjunctival injections of cefuroxime and dexamethasone were administered. A bandage contact lens was placed over the eye to protect the lenticules and regenerating epithelium from any disturbance from the eyelids.

Postoperative Care

After surgery, all patients were treated with topical preservative-free antibiotics and dexamethasone 0.1% four times daily. All patients initially received intravenous methylprednisolone 2 mg/kg on the day of surgery followed by 1 mg/kg per day for 2 further days. Oral prednisolone was then started at 1 mg/kg per day and tapered over a period of 2 to 3 weeks. In 15 patients (23 KLALs), cyclosporine (CSA) was used to prevent rejection of the allograft. Nine patients (16 KLALs) received oral CSA, and 6 patients (7 KLALs) received topical CSA. Cyclosporine was initially used topically in high-risk cases, whereas oral CSA was administered in very high-risk cases or after an episode of acute allograft rejection. Later in the study, all patients received long-term oral CSA after surgery. Oral CSA was started at 3 mg/kg after surgery and later tapered to maintain serum CSA levels to between 70 and 180 µg/l. Six patients (six KLALs) were receiving low-dose CSA (1–2 mg/kg) at last follow-up. Serum creatinine and blood pressure measurements were obtained regularly. Oral CSA dosages were decreased whenever the serum CSA level exceeded the normal range, creatinine levels increased more than 30% from baseline, or there was a significant increase in blood pressure. Four patients (four KLALs) received topical autologous plasma twice hourly for the first 2 weeks, both as a tear replacement and to accelerate epithelial healing by providing growth factors.¹⁶

Preparation of Autologous Plasma. The patient's blood was collected in a sterile 250-ml bag containing citrate-phosphate-dextrose-adenine. The bag was then centrifuged at 4°C for 30 minutes at 3000 rpm. The resultant plasma was then collected and stored in a drug refrigerator for clinical use.

Results

Donor Tissue

The mean age of the donor was 43.5 years (standard deviation [SD], 20.9 years). Mean moist chamber storage time was 30.6 hours (SD, 16.2; range, 6–75 hours). Where organ culture-preserved material was used, mean organ culture storage time was 17.8 days (SD, 3.8 days; range, 13–22 days).

Clinical Outcomes

The mean follow-up was 60 months (range, 15–96 months). Of 33 KLAL procedures, 8 (24.2%) never reepithelialized and were considered primary failures (Table 1). Where ocular surface reconstruction was one of the surgical goals, KLAL managed to accomplish this in 7 of 10 eyes (70%). In 25 of 33 cases (75.8%), KLAL initially managed to restore corneal epithelium, and mean time of reepithelialization was 19.3 days (range, 3–45 days; SD, 18 days). In the long-term, 18 failed and only 7 (21.2%) were stable at last follow-up. Excluding primary failures, the mean time to failure was 17.5 months (range, 1–47 months; Fig 1). Clinical

Table 1. Patient

Patient No.	Age (yrs)*	Gender	Eye	Underlying Diagnosis	Principal Indication	From onset of Disease Time to Surgery (yrs)	Concurrent Surgery	No. Keratolimb Allograft
1	39	M	Left	AIE	PED	40		2
2	60	M	Left	Trachoma	Keratinization	10	LK	1
3	51	M	Left	Chemical injury	Keratinization	9		1
4	22	F	Right	Chemical injury	PED	0.17		1
5	54	M	Left	Chemical injury	Keratinization	2		1
6	72	M	Right	HSV	PED	30		1
7	39	M	Right	Chemical injury	Visual impairment	11		1
8	77	F	Right	OCP	Keratinization	15	AMT	1
9	31	M	Right	SJS	Visual impairment	11	PK + vitrectomy	1
10A	39	F	Right	SJS	Pain	34	PK	1
10B	41	F	Left	SJS	Pain	35		1
11	35	F	Right	SJS	Visual impairment	32	AMT	1
12	29	F	Left	SJS	PED	10		2
13	23	M	Left	Thermal injury	PED	0.25	AMT, PK	1
14A	43	F	Right	SJS	Pain	29		1
14B	44	F	Left	SJS	Visual impairment	30		1
15	62	F	Left	OCP	Cicatrization	20	PK, ECCE+IOL, AMT	4
16	25	F	Left	EEC	Visual impairment	25	LK	1
17	45	M	Left	Chemical injury	Visual impairment	20	PK, Ahmed valve	2
18A	49	M	Left	AKC	Visual impairment	24		2
18B	48	M	Right	AKC	Visual impairment	23		2
19	40	M	Right	Chemical injury	PED	0.1	AMT+PK	3
20	71	M	Right	Chemical injury	Visual impairment	4		1

AIE = atypical ichthyosiform erythroderma; AKC = atopic keratoconjunctivitis; AMT = amniotic membrane transplant; CAU = conjunctival autograft; syndrome; F = female; HSV = herpes simplex keratitis; IOL = intraocular lens implant; KLAL = keratolimb allograft; Kpro = keratoprosthesis; LK = defect; PK = penetrating keratoplasty; SJS = Stevens-Johnson syndrome; TSSpCIOL = transsclerally sutured posterior chamber implant.

*Age at time of initial keratolimb allograft.

features of KLAL failure are summarized in Table 2. Nine eyes that failed had further surgery to restore the ocular surface, and two eyes regained satisfactory VA after implantation of a Dohlman-Doane keratoprosthesis (Table 3).¹⁷

At last follow-up, VA improved in 10 eyes (43.5%), was unchanged in 9 (39.1%), and decreased in 4 (17.4%; Fig 2).

Acute allograft rejection was characterized by pain, photophobia, sectorial conjunctival injection, and edema with local epitheliopathy leading to an epithelial defect (Fig 3).¹⁸ Sixteen episodes of acute rejection occurred in 13 KLAL procedures of 11 eyes

(39.4%). Three patients had two rejection episodes, the second of which led to graft failure in all cases (patients 10A, 13, and the first KLAL of patient 18B). The mean time to rejection was 16.9 months (range, 2–37 months). Failure of KLAL occurred in 10 of 13 KLAL procedures (76.9%), of which 7 failed secondary to acute rejection.

In 11 eyes (11 patients, 15 KLALs), the KLAL was combined with or was followed by keratoplasty. The mean interval between KLAL and keratoplasty was 14.8 months (range, 2–40 months). Seventeen keratoplasties were performed, of which 14 were penetrating keratoplasties (PK) and 3 were lamellar keratoplasties. All three lamellar keratoplasties (100%) remained clear (Fig 4), whereas 13 of 14 PKs (92.9%) failed. Mean failure time was 9.5 months. In 10 PKs (76.9%), failure was associated with failure of KLAL (Table 4). In the remaining 3 PKs (23.1%), failure was secondary to endothelial decompensation (n = 2) and microbial keratitis (n = 1). There was no difference in KLAL survival

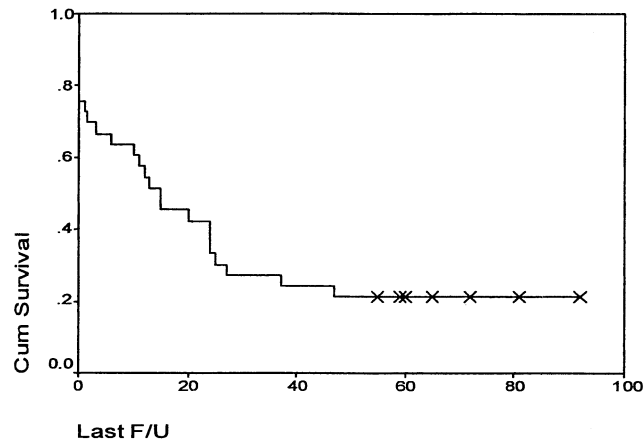


Figure 1. Survival curve of keratolimb allograft (months).

Table 2. Failed Keratolimb Allograft: Clinical Features

	No. Keratolimb Allograft	(%)
PED/recurrent ED	19	(73.1)
Corneal conjunctivalization	16	(61.5)
Corneal opacification	12	(46.2)
Keratinization	5	(19.2)
Diffuse corneal vascularization	4	(15.4)

ED = epithelial defect; PED = persistent epithelial defect.

Data and Outcomes

Prior Surgery	Surgery after Keratolimbic allograft	Outcomes		
		No. Primary Failures	Surface Reconstruction	Restoration of Corneal Epithelium
Pterygium excision × 2	ECCE	0	Not applicable	Yes
PK + ECCE, LK, PK	CSCALT	0	Yes	Yes
	Conjunctival flap, Molteno	0	Not applicable	No
PK + ECCE + IOL	CAU, PK, AMT × 2	1	No	No
PK + ECCE + IOL	PK + IOL exchange	0	Not applicable	No
PK	PK	0	Not applicable	No
Multiple PK	Kpro	0	No	No
PK (3)/Cyclocryotherapy (4)/Molteno		0	Yes	Yes
PK	lrCLAL, ECCE + IOL	0	Not applicable	No
LK, ECCE + IOL		0	Not applicable	Yes
	lrCLAL, ECCE + IOL	0	Yes	No
PK+ECCE+IOL, Cyclocryotherapy × 2, PK	PK × 2 conjunctival flap	1	Not applicable	No
	CSCALT	0	Yes	No
	lrCLAL	0	Yes	No
	lrCLAL	0	Yes	No
	PK, lrCLAL, AMT × 2, KPro	3	No	No
	PK, AMT × 2	0	Not applicable	No
PK × 2, trabeculectomy × 2, ECCE + IOL	PK × 2	0	Not applicable	Yes
ECCE + IOL, trabeculectomy	lrCLAL	0	Not applicable	No
	ECCE + IOL, LK	0	Not applicable	Yes
AMT, tenoplasty	lrCLAL	3	Yes	No
PK + ECCE + IOL, Cyclocryotherapy, PK × 5, TSSpcIOL		0	Not applicable	Yes

CSCALT = in vitro cultured stem cell transplantation; ECCE = extracapsular cataract extraction; EEC = ectodermal dysplasia, ectrodactyly, cleft palate lamellar keratoplasty; lrCLAL = living related conjunctival limbal allograft; M = male; OCP = ocular cicatricial pemphigoid; PED = persistent epithelial

between procedures combined with a keratoplasty and those followed by keratoplasty. There was, however, a tendency for the KLAL combined with a keratoplasty to fail earlier than the KLAL followed by keratoplasty (12.5 months vs. 20.5 months).

Of all initially successful procedures (n = 25), 16 (10 patients) required either oral or topical CSA (Table 5). There was a lower incidence of rejection episodes in the group not receiving CSA. Acute allograft rejection accounted for 50% of failures in the group receiving CSA compared with 16.7% in the non-CSA group.

Table 3. Final Outcome of 23 Eyes Undergoing Keratolimbic Allograft (Including Procedures after Keratolimbic Allograft Failure)

Procedure	No. Eyes	Survival*	Failure*
Stem cell transplantation			
KLAL	23	7	16
lrCLAL	6	6	-
CSCALT	2	2	-
CLAU	1	—	1
Keratoprosthesis	2		
Conjunctival flap	2		
No surgery	3		

CLAU = conjunctival limbal autograft; CSCALT = in vitro cultured stem cell transplantation; lrCLAL = living related conjunctival limbal allograft.

*Only relevant to outcomes of stem cell transplantation.

The cyclosporine group, however, demonstrated longer KLAL survival (the mean time to failure was 22 months as opposed to 13.5 months in the non-CSA group).

In five eyes (seven KLALs), amniotic membrane transplantation was used in combination with KLAL. Four KLAL procedures were primary failures, whereas three failed between 1 and 13 months (mean, 6.25 months).

Complications

Raised intraocular pressure developed in six eyes (26.1%). In four eyes, the intraocular pressure was controlled with topical antiglau-

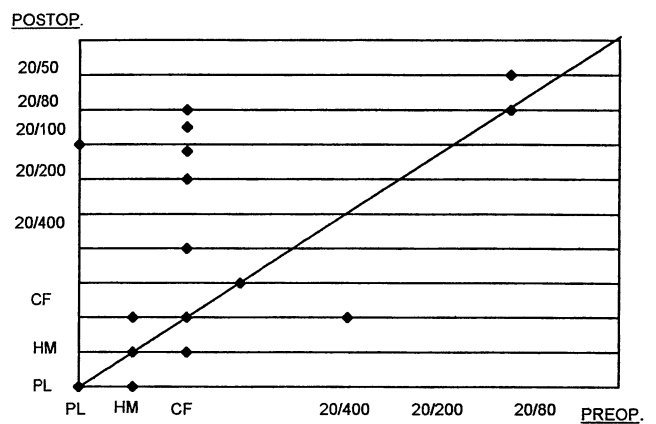


Figure 2. Visual acuity.

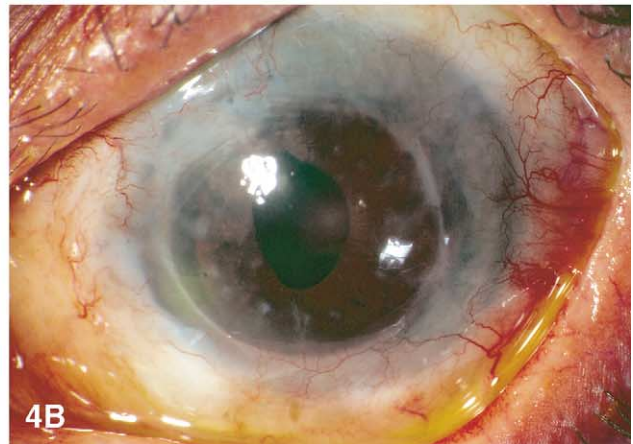
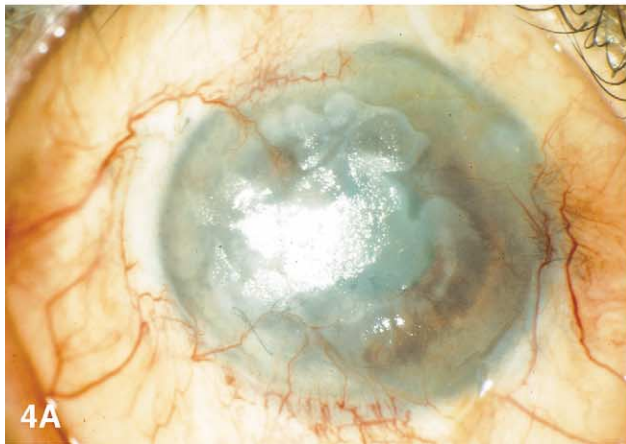
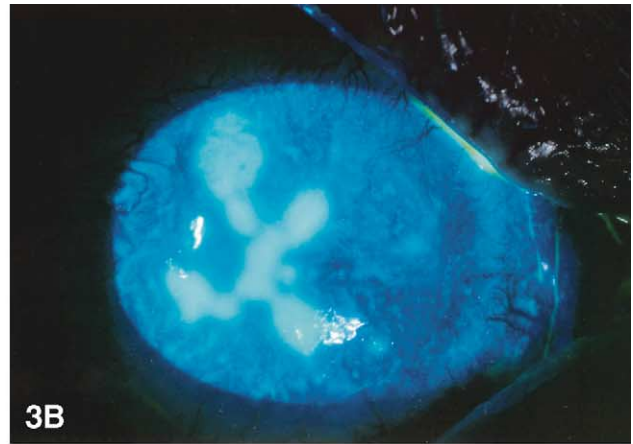
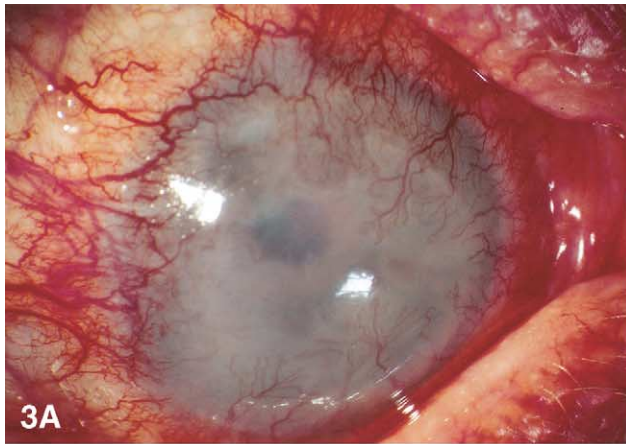


Figure 3. Patient 18B. **A**, Clinical appearance of acute allograft rejection 27 months after keratolimbal allograft. **B**, Same eye showing a large epithelial defect.

Figure 4. Patient 2. **A**, Preoperative appearance of the left eye with evidence of extensive corneal keratinization and conjunctivalization. **B**, Same eye 60 months after keratolimbal allograft and lamellar keratoplasty. The corneal surface is clear with no evidence of corneal vascularization or keratinization. Visual acuity was 20/30.

coma treatment, whereas in two eyes, both with no visual potential, it was higher than 21 mmHg at last follow-up. Corneal necrosis after a persistent epithelial defect occurred in three eyes (13%). Microbial keratitis developed in three eyes. One of three eyes had three separate episodes of keratitis (one resulting from *Hemophilus influenzae* and two resulting from coagulase-negative *Staphylococci*) presenting several months after the KLAL.

Table 4. Clinical Features of Penetrating Keratoplasty Failure

	No. Eyes
Associated with KLAL failure	
PED	7
Keratinization	2
Acute rejection	1
Vascularization	2
Not associated with KLAL failure	
Endothelial decompensation	2
Microbial keratitis	1

KLAL = keratolimbal allograft; PED = persistent epithelial defect.

Discussion

Keratolimbal allograft is one of few surgical options available to treat bilateral stem cell deficiency and severe disruption of the ocular surface.²⁻⁹ Other procedures include conjunctival limbal autografts in case of unilateral disease,^{1,5} living related conjunctival limbal allografts (lrCLAL),^{5,10-12} and, more recently, ex vivo cultured stem cell transplantation.¹³⁻¹⁵ Advantages of KLAL over lrCLAL are availability of tissue, larger amount of limbal stem cells that can be transplanted, and the possibility of repeating the procedure in case of failure. Conversely, advantages of using tissue obtained from relatives include better histocompatibility with theoretically decreased chances of immunologic rejection as well as availability of fresh tissue for immediate transplantation.

In most cases analyzed in this study, not only was there evidence of stem cell deficiency, but the primary pathologic characteristics had affected the whole ocular surface with secondary dryness, symblepharon, trichiasis, and entropion. These cases required surgical procedures either before the

Table 5. Outcomes of Keratolimbic Allograft in Patients with and without Postoperative Cyclosporine excluding Primary Failures

	Oral Cyclosporine (8 Eyes)		Topical Cyclosporine (6 Eyes)		Not Treated (8 eyes)	
	No.	(%)	No.	(%)	No.	(%)
KLAL	10		6		9	
Success	3	(30)	1	(16.7)	3	(33.3)
Failure	7	(70)	5	(83.3)	6	(66.7)
Allograft rejection*	6	(60)	5	(83.3)	2	(22.2)
Failure from rejection	4	(40)	2	(33.3)	1	(11.1)

KLAL = keratolimbic allograft.

*Number of KLAL with one or more rejection episodes.

KLAL or in combination with KLAL such as lid repair, release of symblepharon, and reformation of the forniceal anatomy to reconstruct the ocular surface.

Eight grafts (24.2%) never reepithelialized the surface and were considered primary failures. All these eyes had severe ocular surface damage and were highly inflamed and keratinized. In the remaining 25 KLALs, no significant correlations between outcomes and preoperative diagnosis were found (Table 6). Both patients with ocular-cicatricial pemphigoid eventually required a keratoprosthesis for visual rehabilitation. In both cases, the ocular surface was severely compromised with recurrent keratinization, inflammation, and symblepharon.

Over an 8-year period, three different techniques were used in the preparation of the allograft lenticules. This surgical evolution reflected the need for an easier, more reproducible, and atraumatic way to perform KLAL. The amniotic membrane was also used in five eyes as a basement membrane substrate. However, these changes did not appear to influence clinical outcome.

Preoperative ocular status was found to influence surgical outcomes. Keratinization, classified as moderate to severe, was found in 50% of KLAL failures (n = 13) and in only 14.3% of successful KLAL procedures (n = 1). Moderate to severe degrees of symblepharon were found in

68.7% of failed allografts and in 42.9% of successful allografts. Severe ocular surface inflammation was also found to be a poor prognostic factor for allograft survival and was associated with an increased risk of allograft rejection. These findings are similar to those reported by other authors.⁷

At last follow-up, KLAL managed to maintain a healthy and stable corneal epithelial surface in 7 eyes of 23 (30.4%). These results are poor compared with other studies, which may be related to more severe ocular surface disease found in our series, with most having highly inflamed and keratinized eyes. Additionally, follow-up (60 months) in this study was longer than in the others (Table 7). Most KLAL procedures failed within 24 months (n = 22; 66.7%), whereas only 4 (12.1%) failed later.

The usefulness of CSA as an immunosuppressant agent has shown conflicting results. The rationale for the use of immunosuppressants is to increase graft survival rate by decreasing progressive destruction of limbal stem cells from acute or chronic allograft rejection. Acute allograft rejection rate as reported by others varies from none⁴ to 30%¹⁹, and in this study it was 39.4%. There is no consensus regarding specific immunosuppressive regimens after KLAL. Systemic CSA was used in more severe cases and in higher doses where there was recurrent inflammation. In this study, if cases of primary failure are excluded, no difference in KLAL survival was found between patients treated or not treated with long-term CSA. However, there was a higher rate of acute allograft rejections in patients treated with oral CSA as compared with the patients not receiving CSA. This probably reflects patient selection for using oral CSA. This was administered in the first 3 years of this study only to very high-risk patients and after an acute allograft rejection. Later in the study, all patients received long-term oral CSA after surgery. Although there were fewer episodes of acute rejection in the group not receiving CSA, KLAL survival was shorter (13.5 months compared with 22 months). This possibly reflects a process of chronic low-grade rejection as suggested by Daya¹⁸ and Holland and Schwartz,²⁰ which may be prevented or delayed by the use of CSA.

There was no difference in KLAL survival whether it was performed simultaneously with a keratoplasty or as a later procedure. However, KLAL combined with keratoplasty appeared to have a shorter survival time than KLAL followed by keratoplasty. Holland and Schwartz²⁰ suggested waiting at least 3 months after an epithelial trans-

Table 6. Final Outcomes of Keratolimbic Allograft and Preoperative Diagnosis

Diagnosis	No. of Eyes	Success (%)	Failure (%)
Chemical	7	2 (28.6)	5 (71.4)
SJS	7	2 (28.6)	5 (71.4)
OCP	2	0 (0)	2 (100)
AKC	2	1 (50)	1 (50)
Thermal	1	0 (0)	1 (100)
Trachoma	1	1 (100)	0 (0)
EEC	1	0 (0)	1 (100)
AIE	1	1 (100)	0 (0)
HSV	1	0 (0)	1 (100)
Total	23	7 (30.4)	16 (69.6)

AIE: atypical ichthyosiform erythroderma; AKC = atopic keratoconjunctivitis; EEC = ectodermal dysplasia, ectrodactyly, cleft palate syndrome; HSV: herpes simplex keratitis; OCP = Ocular Cicatricial Pemphigoid; SJS = Stevens-Johnson syndrome.

Table 7. Comparison of Survival of Stem Cell Procedures (%)

Author	Procedure	No. Eyes	Mean (approximated) Follow-up				
			6 mos	12 mos	18 mos	24 mos	36 mos
Current series	KLAL	23	63.6	54.4	45.5	3.3	27.3
Tsubota ⁶	KLAL	14	85.7				
Tan ^{5*}	KLAL/lrCLAL	6		77.7			
Tsubota ³	KLAL	9		100			
Holland ⁷	KLAL	25			72		
Rao ¹¹	lrCLAL	9			77.8		
Daya and Ilari ¹²	lrCLAL	10				80	
Tsubota ⁹	KLAL	43					51

KLAL = keratolimbal allograft; lrCLAL = living related conjunctival limbal allograft.

*Group including 6 KLAL and 3 lrCLAL procedures.

plantation before considering a corneal graft to allow stabilization of the transplanted epithelial tissue. Conversely, Rao et al¹¹ advocated a combined approach with the rationale of avoiding the need for a second procedure and preserving donor transient amplifying cells. Because successful epithelial transplantation often obviates the need for keratoplasty,¹² we believe it is best to wait at least 1 year if not longer before performing a keratoplasty, and in cases where there is a normal endothelium, a deep lamellar keratoplasty is preferable.

This study includes an 8-year period during which KLAL was performed for a variety of diseases. Most of these patients had a severe degree of ocular surface compromise at presentation. During this time, surgical techniques have evolved and adjunct treatments like amniotic membrane transplantation and autologous plasma have been added in selected cases. Therefore, it is difficult to analyze our results; however, it is clear that survival of KLAL in these challenging cases is poor in the long term.

In summary, the main conclusions of this study are as follows. First, KLAL does reconstruct the ocular surface. Phenotypic corneal epithelium is restored only in the short-term in most cases. Second, early reconstruction of a viable ocular surface permits the use of other procedures such as lrCLAL and ex vivo cultured stem cell transplantation. Third, several combined or consecutive surgical procedures often are necessary. Fourth, long-term administration of low-dose CSA appears to prolong the survival of KLAL possibly by decreasing chronic rejection.

References

1. Kenyon KR, Tseng SCG. Limbal autograft transplantation for ocular surface disorders. *Ophthalmology* 1989;96:709–22; discussion 722–3.
2. Thoft RA. Keratoepithelioplasty. *Am J Ophthalmol* 1984;97:1–6.
3. Tsubota K, Toda I, Saito H, et al. Reconstruction of the corneal epithelium by limbal allograft transplantation for severe ocular surface disorders. *Ophthalmology* 1995;102:1486–96.
4. Tsai RJF, Tseng SCG. Human allograft limbal transplantation for corneal surface reconstruction. *Cornea* 1994;13:389–400.
5. Tan DTH, Ficker LA, Buckley RJ. Limbal transplantation. *Ophthalmology* 1996;103:29–36.
6. Tsubota K, Satake Y, Ohyama M, et al. Surgical reconstruction of the ocular surface in advanced ocular cicatricial pemphigoid and Stevens-Johnson syndrome. *Am J Ophthalmol* 1996;122:38–52.
7. Holland EJ. Epithelial transplantation for the management of severe ocular surface disease. *Trans Am Ophthalmol Soc* 1996;94:677–743.
8. Tseng SCG, Prabhasawat P, Barton K, et al. Amniotic membrane transplantation with or without limbal allografts for corneal surface reconstruction in patients with limbal stem cell deficiency. *Arch Ophthalmol* 1998;116:431–41.
9. Tsubota K, Satake Y, Kaido M, et al. Treatment of severe ocular-surface disorders with corneal epithelium stem-cell transplantation. *N Engl J Med* 1999;340:1697–703.
10. Kwitko S, Marinho D, Barcaro S, et al. Allograft conjunctival transplantation for bilateral ocular surface disorders. *Ophthalmology* 1995;102:1020–5.
11. Rao SK, Rajagopal R, Sitlakshmi G, Padmanabhan P. Limbal allografting from related live donors for corneal surface reconstruction. *Ophthalmology* 1999;106:822–8.
12. Daya SM, Ilari L. Living related conjunctival limbal allograft (lrCLAL) for the treatment of stem cell deficiency. *Ophthalmology* 2001;108:126–33; discussion 133–4.
13. Pellegrini G, Traverso CE, Franzi AT, et al. Long-term restoration of damaged corneal surfaces with autologous cultivated corneal epithelium. *Lancet* 1997;349:990–3.
14. Tsai RJF, Li LM, Chen JK. Reconstruction of damaged corneas by transplantation of autologous limbal epithelial cells. *N Engl J Med* 2000;343:86–93.
15. Schwab IR, Reyes M, Isseroff RR. Successful transplantation of bioengineered tissue replacements in patients with ocular surface disease. *Cornea* 2000;19:421–6.
16. Tsubota K, Goto E, Shimmura S, Shimazaki J. Treatment of persistent epithelial defect by autologous serum application. *Ophthalmology* 1999;106:1984–9.
17. Dohlman CH. Keratoprosthesis. In: Krachmer JH, Mannis MJ, Holland EJ, eds. *Cornea*. St Louis: Mosby, 1997; v. 3, chap. 151, 1855–63.
18. Daya SM, Bell D, Habib NE, et al. Clinical and pathologic findings in human keratolimbal allograft rejection. *Cornea* 2000;19:443–50.
19. Tseng SCG, Chen JJY, Huang AJW, et al. Classification of conjunctival surgeries for corneal disease based on stem cell concept. *Ophthalmol Clin North Am* 1990;3:595–610.
20. Holland EJ, Schwartz GS. Epithelial stem-cell transplantation for severe ocular-surface disease [editorial]. *N Engl J Med* 1999;340:1752–3.