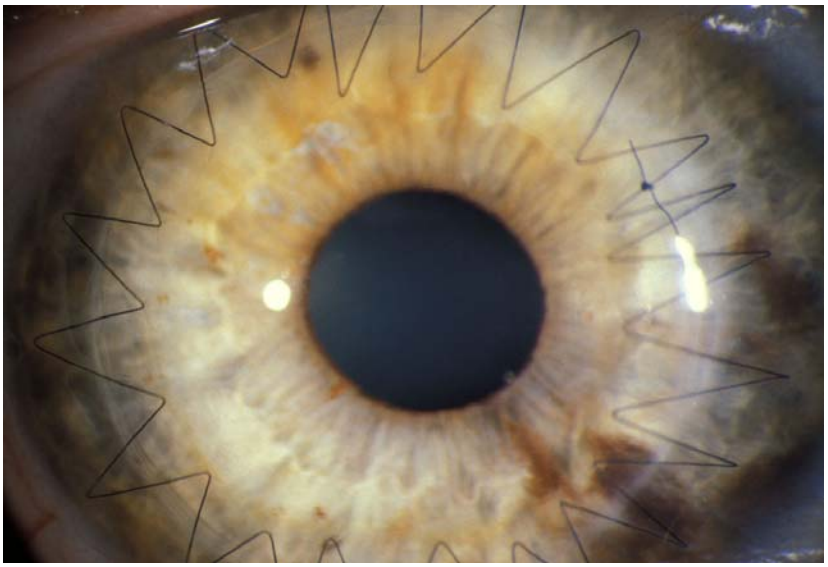
THE AUSTRALIAN CORNEAL GRAFT REGISTRY



2007 REPORT

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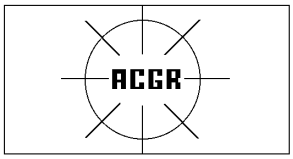

THE AUSTRALIAN CORNEAL GRAFT REGISTRY

2007 REPORT

Edited by: KA Williams, MT Lowe, CM Bartlett, L Kelly and DJ Coster

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TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF CONTRIBUTORS

Aboud, JD
Achnad, J
Adler, P
Agnello, R
Allan, B
Ambler, J
Anderson, IL
Anderson, PF
Andersons, V
Apel, AJG
Apel, J
Armstrong, RJ
Arnold, JJ
Asimakis, P
Athanasiou, C
Atkins, T
Atkinson, GA
Austin, CW
Bailey, C
Baker, CH
Bambery, SJ
Barila, A
Barker, NH
Barnes, C
Barnett, WJ
Barrett, G
Bassili, S
Beaumont, P
Beckingsale, P
Benecke, P
Benjamin, FA
Bennett, C
Benson, CJ
Billson, F
Binetter, R
Bolliger, PA
Booth, F
Booth-Mason, S
Boreham, C
Borger, JP
Bors, FH
Both, R
Bougher, GJ
Brennan, MH
Brian, G
Briner, AM
Brooks, AMV
Brown, C
Brunckhorst, A
Buckley, CA
Burgess, F
Burt, P
Burvill, MJ
Byrne, JB
Cains, SE
Calthorpe, M
Campbell, DV
Campbell, W
Candy, D
Carey, TM
Carroll, LA
Chan, DGW
Chadha, VB
Challinor, CJ
Chan, DGW
Chandra, J
Chapman, PJ
Charawanamuttu, A
Chau, P
Chehade, M
Chelvanayagam, D
Cher, I
Cherny, M
Chester, GH
Chin, D
Ch'ng, AC
Chua, SK
Clark, B
Cohen, PRA
Cohn, GS
Collie, DM
Conrad, D
Constable, IJ
Conway, RM
Cooper, PS
Cooper, RL
Coote, BD
Coote, MA
Cornwell, R
Coroneo, M
Cosgrove, JM
Coster, DJ
Cottee, LB
Cranstoun, PD
Crawford, BA
Crawford, GJ
Crayford, BB
Crock, GW
Crompton, JL
Cunningham, F
Czigler, B
Dalton, JA
Dang, V
Daniell, M
Da Rin, D
Davey, JC
Davies, GA
Davies, IC
Davies, RP
Davis, H
Davis, JL
Delaney, MR
Della, N
Den, BD
Denman, DP
Dethlefs, R
Diamond, J
Dickson, D
Dinihan, I
D'Mellow, G
Dobinson, J
Donovan, B
Douglas, I
Downie, NA
Doyle, S
Duggan, JM
Duke, PS
Duncan, M
Dunlop, A
Dunlop, C
Dunlop, I
Durkin, DT
du Temple, DJ
Dyer, JA
Dyson, C
Economos, AS
Elder, JR
Ellis, MF
English, FP
English, KP
English, M
Evans, L
Farinelli, AC
Farpour, B
Favilla, I
Favilla, ML
Ferguson, M
Field, A
Finkelstein, E
Fitzsimons, SR
Fleming, R
Fong, LP
Foo, K
Forster, TDC
Fraenkel, G
Francis, IC
Franks, SS
Frauenfelder, G
Frumar, KD
Fullarton, F
Galbraith, JEK
Galbraith, JK
Gaston, G
Genge, J
Gibbons, N
Giblin, ME
Gibson, AG
Gibson, AJG
Gibson, BHL
Giles, M
Gillies, M
Gillies, WE
Glasson, WJ
Glastonbury, J
Gnanaharan, P
Goddard, SJ
Godfrey, S
Goggin, M
Golchin, B
Goldberg, I
Gole, G
Gormley, P
Greer, DV
Gregor, DJ
Gregory, EM
Grice, MJ
Griffits, RKS
Groeneveld, E
Grover, VK
Gullifer, KP
Hall, AJH
Hall, DR
Hall, P
Halley, RM
Ham, B
Hammerton, M
Handley, DE
Hardy Smith, P
Harkness, MM
Harris, A
Harrisberg, BP
Harrison, MR
Hart, DRL
Hatfield, E
Hauptman, O
Haybittel, M
Hayes, P
Haymet, BT
Heery, SE
Hefferan, W
Heine, DI
Heiner, PC
Heinze, JB
Henderson, RG
Henderson, T
Hennessy, M
Henry, JG
Heron, H
Heyworth, P
Hill, GO
Hipwell, GC
Hirst, L
Ho, R
Hobbs, I
Hodson, T
Hollows, FC
Hoole, GA
Hornbrook, JW
House, PH
Howes, F
Howsam, GN
Hughes, PH
Hunter, GT
Hunyor, A
Hurley, I
Hutchinson, B
Ingham, P
Irvine, S
Isbell, G
Jacobi, L
Jamieson, IW
Jaross, N
Johnson, GW
Jones, S
Jordan, AS
Kappagoda, MB
Karagiannis, A
Karunaratne, D
Kaufman, DV
Kearney, RJ
Keldoulis, T
Kelly, AJ
Kennedy, IH
Kent, DG
Kent, R
Kevin, JBR
Khannah, G
King, AC
Kingston, RA
Kirkwood, RA
Kitchen, D
Knight, J
Kokak, G
Kokkinakis, J
Koniuszko, GA
Kosmin, A
Kwong, RNK
La Nauze, JH
Lai Kwon, N
Lam, CM
Lam, GC
Lamb, AM
Landers, JAG
Lane, MJ
Lansdell, BJ
Larkin, P
Latimer, P
Law, W
Lawless, M
Lawson, DJ
Leber, GL
Leckie, TD
Lee, GA
Lee, JH
Lee, V
Leikin, S
Le May, M
Lenton, LM
Leppard, S
Leunig, GA
Liew, S
Lillicrap, GR
Lim, ASM
Lindsay, R
Lister, J
Littlewood, KR
Liu, HA
Livingstone, E
Lloyd, D
Loane, M

LIST OF CONTRIBUTORS

Lockerbie, SE
Lockie, P
Lones, RI
Loughnan, MS
Lowe, DR
Macken, P
Mackey, DA
Maclean, H
MacRobert, I
Madhok, P
Mahmood, M
Majzoub, U
Maloof, A
Mantzioros, N
Maragoudakis, G
Markwick, KC
Martin, FJ
Martin, PA
Marton, S
Materne, M
McAuliffe, DJ
McCartney, PJ
McClellan, KA
McCluskey, PJ
McCombe, MF
McDermott, ND
McDonald, RA
McGeorge, PA
McGovern, RA
McGovern, ST
McGree, MD
McGuinness, EF
McGuinness, R
McKay, AL
McKay, DL
McKinnies, C
McLennan, M
McKnight, D
McNeil, G
Meades, K
Meagher, PJ
Medownick, M
Mele, EM
Mills, R
Milverton, EJ
Minogue, MJ
Moon, ME
Moore, CE
Moore, DC
Moore, GGD
Moore, MC
Moran, DJ
Morgan, MW
Morgan, WH
Morlet, GC
Morlet, N
Morton, MR
Moshegov, C
Mountford, J
Mulligan, NB

Munchenberg, P
Munt, PC
Murrell, I
Nagle, F
Nallari, L
Nanda, U
Nardi, W
Nathan, F
Newland, H
Newman, J
Newman, M
Nicholls, SG
Nicoll, AM
Nixon, GK
Noble, JA
Noble, M
North, IM
Novakovic, P
O'Brien, DP
O'Callaghan, GJ
O'Connor, C
O'Connor, DM
O'Connor, PA
O'Day, J
O'Donnell, BA
O'Hagan, S
Ohlrich, JG
Ohlrich, S
O'Leary, BJP
O'Neill, JC
Ong, K
Painter, GT
Parker, RW
Pater, JB
Patrick, RK
Paul, R
Pavy, IG
Peachey, G
Pearce, B
Pellew, JH
Perks, KC
Perriam, DJ
Perrin, R
Peters, J
Petsoglou, C
Phillips, AJ
Pigott, LJ
Pittar, MR
Pittar, YA
Playfair, TJ
Pluschke, ME
Pluschke, WEW
Poon, A
Porter, GT
Porter, WT
Pradhan, JS
Pyle, JD
Pyne, RJ
Quatermass, ME
Qureshi, S
Rait, J

Ramani, V
Ramsay, RJ
Rathod, CB
Rawson, LR
Readshaw, GG
Reich, JA
Reich, P
Renton, R
Retsas, CW
Rice, N
Richards, J
Richardson, P
Riddington, L
Rigg, RW
Roberts, TV
Robertson, IF
Robinson, D
Robinson, LP
Robson, M
Rodan, BA
Roden, D
Rogers, CM
Rogers, JA
Rose, MJA
Rose, P
Rosen, B
Rosen, PA
Rosenberg, AM
Ross, C
Ross, SM
Ruddell, TJ
Runciman, JC
Russell, LJ
Saareste, AG
Sack, M
Samuel, MV
Saunders, BG
Saunders, S
Scales, WTH
Scargill, SW
Schiller, GM
Scobie, MA
Seawright, A
Sebban, A
Serdiuk, A
Shanahan, LF
Sharota, DT
Sheppard, CL
Siebert, S
Silva, M
Simon, A
Simpson, MB
Sindhu, K
Singh, H
Singh, I
Slack, A
Slade, JH
Slade, MP
Smiles, JJ
Smith, G

Smith, JEH
Smith, RL
Snibson, GR
Somerville, G
Southgate, D
Spiro, HP
Spring, TF
Starling, D B
Stasiuk, RM
Steiner, M
Steiner, MD
Stern, H
Stevens, P
Stewart, ADH
Stewart, PA
Stubbs, GM
Stuckey, GC
Sullivan, FP
Sullivan, L
Sumich, PM
Sutton, G
Sutton, JE
Tamblyn, DM
Tang, KC
Tangas, C
Taylor, C
Taylor, GAM
Taylor, H
Taylor, RF
Tester, MP
Thomas, CS
Thompson, C
Thomson, CW
Thomson, GGB
Thyer, HW
Tibbs, GJ
Tole, D
Tolmie, N
Toohey, MG
Townsend, CL
Tregenza, P
Treloar, D
Treplin, MCW
Tridgell, DE
Tye, AA
Unger, H
Vajpayee, R
Vandeleur (Jnr), KW
Vandeleur (Snr), KW
Velez, S
Verma, N
Vernon, AC
Versace, P
Violi, C
Vojlay, R
Waite, S
Waldie, MS
Walker, A
Walker, FA
Walker, TD

Walland, MJ
Walsh, EM
Walsh, MA
Warburton, C
Ward, WJ
Watson, S
Watt, B
Watts, WH
Waugh, ML
Weber, A
Wechsler, AW
Weir, P
Welch, R
Wenas, H
Westlake, W
Westmore, RN
Whaites, MA
Whitehouse, CA
Whitehouse, GM
Whitford, JD
Whitford, RF
Whiting, M
Whitney, JR
Wicks, NS
Wiffen, SJ
Williams, NB
Williams, RD
Williams, W
Willoughby, JG
Wilson, BG
Wilson, RG
Wilson, T
Win Law, W
Windle, PL
Wingate, RJB
Wise, GM
Wolfe, RJB
Wong-See, J
Woo, HY
Wood, RFJ
Woods, S
Workman, D
Worner, CM
Worsnop, DP
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& Medical Superintendents of various hospitals.

(n=591)

HOW TO READ OUR KAPLAN-MEIER GRAFT SURVIVAL PLOTS

1. The vertical axis shows the probability of graft survival. "Perfect" survival (no failures) equates to a probability of 1.0. It may help to think of this as 100% survival.

2. The horizontal axis shows time elapsed since the event being considered - in this context, the date of graft.

3. The numbers of recipients "at risk" (ie, being followed) at given times after graft are shown below the curves. At time zero, all patients in the given cohort are at risk. At the furthermost point on the right hand side of any curve, one patient in the cohort (the one who has been followed for the longest time) is at risk.

   We suggest that you interpret the curves with this in mind. A sudden dramatic "dip" in survival at the far right of a given curve may merely mean, for example, that one of only two grafts that have been followed for this length of time has failed.

   When the survival curve drops to zero, the probability of graft survival beyond that time is zero. This means that all grafts that have reached this time elapsed from graft have failed. It does not mean that all grafts in this stratum have failed.

4. The p values shown have been calculated by log-rank analysis and reflect a comparison of the behaviour of the curves as a whole (taking all available data into consideration), rather than at any one time-point.

INTRODUCTION

The Australian Corneal Graft Registry (ACGR) opened in May 1985 and thus has now been in operation for over 22 years. However, the census date for this report was 01/09/2006. Over the years, we have collected data on more than 18,500 corneal grafts. The majority of corneal grafts registered have been penetrating, but increasing numbers of lamellar and limbal grafts have also been registered over recent years, as patterns of surgical practice change.

At registration, we seek information on the recipient, the donor, the eye bank practices and the operative procedure. Follow-up then occurs at approximately yearly intervals for an indefinite period, and ceases upon loss of the graft, or the death or loss-to-follow-up of the patient. At each round of follow-up, we request information on the graft and visual outcome, and upon relevant post-operative events and treatments.

The data are entered into an Access database and checked for consistency. Descriptive, univariate and multivariate analyses are subsequently performed using SPPS and Stata software, and the report is eventually collated.

We thank all our many contributors for their tireless efforts on our behalf. We hope you enjoy reading this report and that it may be useful in your clinical practice.

1. OVERVIEW AND CONTRIBUTOR INFORMATION

1.1 CURRENT DATABASE

1.1.1 Synopsis of the current database

A synopsis of the current state of the database is shown in Table 1.1. For the purposes of this table, graft recipients who died or who were lost to follow-up with a surviving graft have been counted amongst those with surviving grafts.

Table 1.1 Synopsis of the current database (CENSUS DATE 1/9/2006)

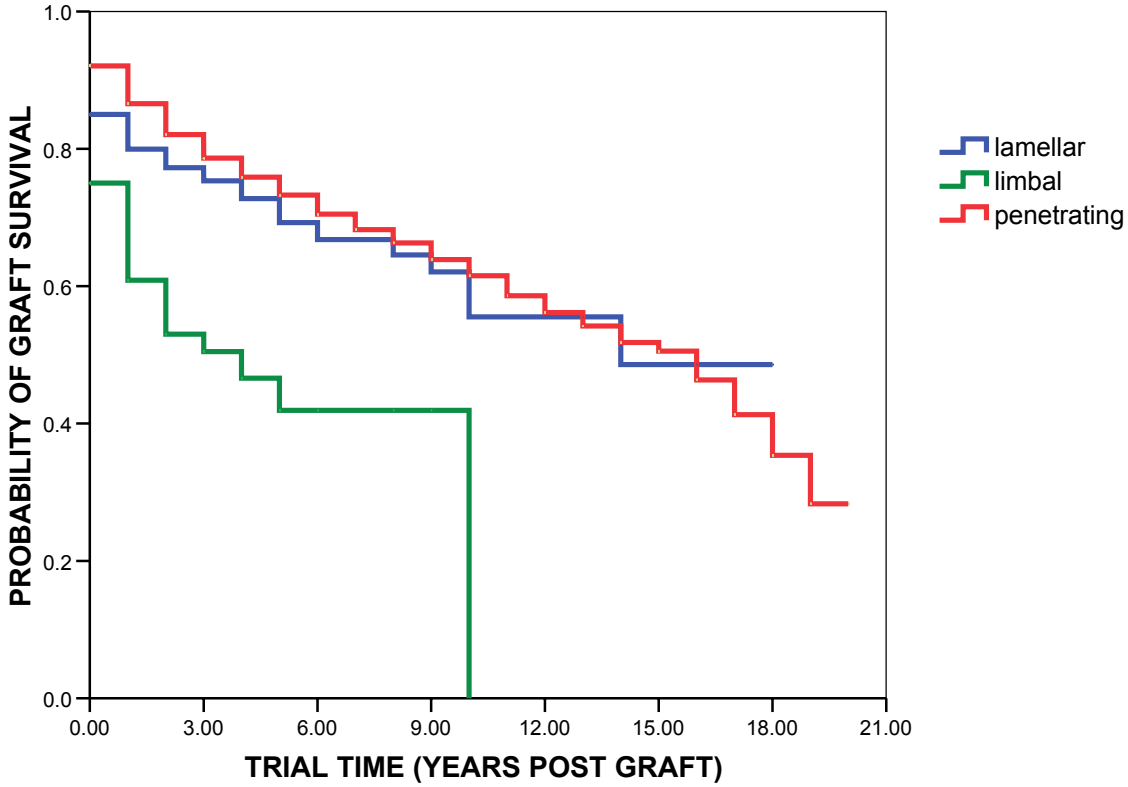
Graft status	Whole database		Penetrating		Lamellar		Limbal	
	No.	%	No.	%	No.	%	No.	%
Number registered	**18205**	**100%**	**17090**	**100%**	**1013**	**100%**	**102**	**100%**
Number followed	**14158**	**78%**	**13350**	**78%**	**720**	**71%**	**88**	**86%**
Followed for <1 year	2525	18%	2217	17%	280	24%	28	32%
Followed ≥1 & <2 years	3481	25%	3278	25%	180	27%	23	26%
Followed ≥2 & <4 years	3725	26%	3566	27%	136	29%	23	26%
Followed ≥4 & <6 years	1796	13%	1724	13%	65	10%	7	8%
Followed ≥6 & <8 years	1029	7%	996	7%	29	5%	4	7%
Followed ≥8 & <10 years	635	5%	623	5%	10	1%	2	4%
Followed ≥10 & <12 years	384	3%	375	3%	8	1%	1	1%
Followed ≥12 & <14 years	304	2%	300	3%	4	<1%	-	-
Followed ≥14 & <16 years	172	1%	167	1%	5	<1%	-	-
Followed ≥16 & <18 years	75	<1%	73	<1%	2	<1%	-	-
Followed ≥18 & <20 years	30	<1%	29	<1%	1	<1%	-	-
Followed ≥20 years	2	<1%	2	<1%	-	-	-	-
Recipient deaths	871	5%	835	5%	31	3%	5	5%
Total recipients lost	6174	34%	5779	34%	371	37%	24	24%
Recipient loss to follow up within first year after graft	1660	9%	1469	9%	178	18%	13	13%
Lost in Register	1470	8%	1339	8%	121	12%	10	10%
Grafts not yet followed	1037	6%	888	5%	146	14%	3	3%
Surviving when last seen	**11070**	**78%**	**10456**	**78%**	**561**	**78%**	**48**	**55%**
Failed when last seen	**3088**	**22%**	**2894**	**22%**	**159**	**22%**	**40**	**45%**

Penetrating grafts	**94.0% of total database**
Lamellar grafts	**5.5% of total database**
Limbal grafts	**0.5% of total database**

1.1.2 Survival of penetrating, lamellar and limbal grafts

Kaplan-Meier plots of the survival of penetrating, lamellar and limbal corneal grafts are presented in Figure 1.1 (Log Rank Statistic=65.41; df=2; p<0.00001). In these and all subsequent survival curves, the number of grafts at risk in each stratum is shown in the table immediately below the curves and graft survival at various intervals post graft is presented in the following table. Thus, 13,350 penetrating grafts have been followed for periods of between approximately one to about twenty years, 720 lamellar grafts have been followed for between one and about eighteen years and 88 limbal grafts for between one and about ten years. At ten years post-graft all limbal grafts have failed, although there are some limbal grafts surviving at periods less than ten years.

Figure 1.1 Survival of penetrating, lamellar and limbal corneal grafts



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Penetrating	13350	5183	2372	1124	529	167	28	0
Lamellar	720	162	56	26	11	4	1	n/a
Limbal	88	21	4	2	n/a	n/a	n/a	n/a

Identity	No. initially at risk	Probability of graft survival (at years post-graft)				
		1	5	10	15	20
Penetrating	13350	.865	.733	.615	.505	n/a
Lamellar	720	.799	.692	.555	n/a	n/a
Limbal	88	.608	.419	.000	n/a	n/a

n/a = not applicable

OVERALL CORNEAL GRAFT SURVIVAL
TYPE OF GRAFT

Penetrating corneal graft survival:	**87% at 1 year**
Mean Survival 12.41 years	**73% at 5 years**
(SE=0.15; 95% CI: 12.11, 12.72)	**62% at 10 years**
Median Survival approx. 16 years	**50% at 15 years**
Lamellar corneal graft survival:	**80% at 1 year**
Mean Survival 11.36 years	**69% at 5 years**
(SE=0.64; 95% CI: 10.12, 12.61)	**56% at 10 years**
Median Survival approx. 14 years	
Limbal corneal graft survival:	**61% at 1 year**
Mean Survival 4.96 years	**42% at 5 years**
(SE=0.60, 95% CI: 3.79, 6.12)	**0% at 10 years**
Median Survival 4 years	

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

1.2 GRAFTS REGISTERED BY STATE, TERRITORY AND INDIVIDUAL

1.2.1 Grafts entered by Australian state and territory

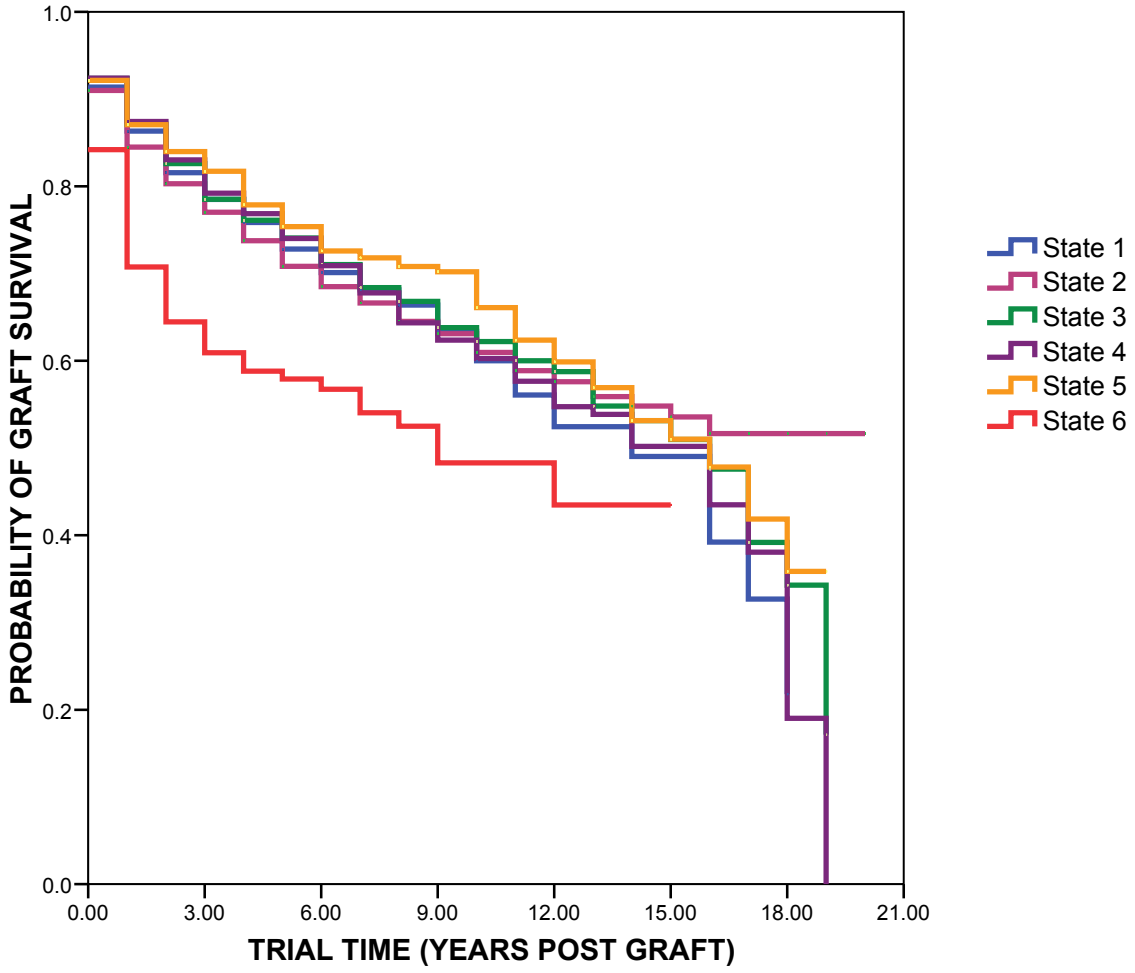
The number of grafts entered from each state is shown in Table 1.2. Percentages are calculated as proportions of the total number of grafts registered, n=18,205. For the Kaplan-Meier plot, grafts performed in the NT have been included with the grafts for SA, and those performed in the ACT have been included in the NSW numbers.

Table 1.2 Grafts entered and followed from each Australian state

	TOTAL GRAFTS ENTERED						TOTAL GRAFTS FOLLOWED					
State	Penetrating		Lamellar		Limbal		Penetrating		Lamellar		Limbal	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
NSW	6302	35%	550	3%	30	<1%	4611	25%	360	2%	21	<1%
VIC	3890	22%	118	<1%	15	<1%	3169	17%	81	<1%	13	<1%
QLD	2570	14%	79	<1%	2	<1%	2091	11%	63	<1%	1	<1%
WA	2052	11%	110	<1%	12	<1%	1385	8%	80	<1%	11	<1%
SA	1877	10%	109	<1%	39	<1%	1740	10%	92	<1%	38	<1%
TAS	383	2%	46	<1%	4	<1%	339	2%	43	<1%	4	<1%
ACT	14	<1%	-	-	-	-	14	<1%	-	-	-	-
NT	2	<1%	1	<1%	-	-	1	<1%	1	<1%	-	-
Sub-total	**17090**	94%	**1013**	6%	**102**	<1%	**13350**	73%	**720**	4%	**88**	<1%
TOTAL	**18205**						**14158**					

Figure 1.2 compares the graft survival for each state (Log Rank Statistic=63.86; df=5; p<0.00001). Individual states have been de-identified.

Figure 1.2 Graft survival from each Australian state



Number At Risk

Identity	Graft survival (at years post-graft)				
	1	5	10	15	20
State 1	.863	.728	.600	.490	.218
State 2	.845	.708	.610	.536	n/a
State 3	.871	.741	.622	.510	.343
State 4	.874	.740	.602	.502	.190
State 5	.870	.754	.661	.510	.359
State 6	.707	.579	.483	n/a	n/a

OVERALL CORNEAL GRAFT SURVIVAL
BY STATE

State 1:	**86% at 1 year**
Mean Survival 11.45 years	**73% at 5 years**
(SE= 0.23, 95% CI: 11.01, 11.90)	**60% at 10 years**
Median Survival approx. 14 years	**49% at 15 years**
State 2:	**85% at 1 year**
Mean Survival 12.88 years	**71% at 5 years**
(SE = 0.32, 95% CI: 12.26, 13.51)	**61% at 10 years**
Median Survival approx. 17 years	**54% at 15 years**
State 3:	**87% at 1 year**
Mean Survival 12.22 years	**74% at 5 years**
(SE= 0.25, 95% CI: 11.73, 12.70)	**62% at 10 years**
Median Survival approx. 16 years	**51% at 15 years**
State 4:	**87% at 1 year**
Mean Survival 11.86 years	**74% at 5 years**
(SE = 0.34, 95% CI: 11.19, 12.53)	**60% at 10 years**
Median Survival approx. 16 years	**50% at 15 years**
State 5:	**87% at 1 year**
Mean Survival 12.58 years	**75% at 5 years**
(SE = 0.37, 95% CI: 11.87, 13.30)	**66% at 10 years**
Median Survival approx. 16 years	**51% at 15 years**
State 6:	**71% at 1 year**
Mean Survival 8.36years	**58% at 5 years**
(SE =0.46, 95% CI: 7.45, 9.26)	**48% at 10 years**
Median Survival approx. 9 years	

KEY: n/a = not applicable
SE = standard error
CI = confidence interval
df = degrees of freedom
p = probability

1.2.2 Contributors in each state

The numbers of contributing ophthalmologists and additional practitioners involved in recipient follow-up are shown in Table 1.3. The follow-up practitioners listed in Table 1.3 are exclusive of contributing surgeons. Follow-up practitioners are mostly other ophthalmologists, but include general practitioners, optometrists and hospital registrars. Overall, 55% of contributors perform grafts.

Table 1.3 Contributors in each state

	Contributing Surgeons		Follow-up Practitioners		Number of contributors with ≥50 records per state		
State	**No.**	**%**	**No.**	**%**	**No.**	**Graft total** Surgeons Total / State Total	**%**
NSW	126	20%	79	13%	27	5707/6882	83%
VIC	90	14%	49	8%	14	3066/4023	76%
WA	48	8%	15	2%	10	1662/2174	76%
SA	43	7%	31	5%	7	1679/2025	83%
QLD	26	4%	75	12%	3	2536/2651	96%
TAS	8	<1%	5	<1%	1	328/433	76%
ACT	3	<1%	11	2%	0	0/14	0%
NT	1	<1%	4	<1%	0	1/3	33%
OVERSEAS	-	-	9	1%	0	-	-
Sub total	**345**	**55%**	**278**	**45%**	**62**	**14979/18205**	**82%**
Total Contributors	**623 (100%)**				**62 surgeons performed 82% of the grafts**		

It can be seen that 62 ophthalmologists, 18% of all contributing surgeons, contributed 82% of all registered graft records.

1.2.3 The 'centre effect'

69 surgeons have contributed 25 or more records with follow up for penetrating grafts. Of these, 27 surgeons also performed ≥25 penetrating grafts for keratoconus. Penetrating graft survival stratified by individual surgeons is shown in figures 1.3 & 1.4.

Figure 1.3 shows graft survival for those grafts performed by surgeons that performed ≥25 penetrating grafts with follow up for keratoconus (Log Rank Statistic=58.88; df=26; p<0.00001).

Figure 1.4 shows graft survival for penetrating grafts performed by surgeons that performed ≥25 penetrating grafts with follow up *excluding* those performed for keratoconus (Log rank Statistic=337.15; df=68; p<0.00001).

Figure 1.3 The centre effect: penetrating grafts (keratoconus only)

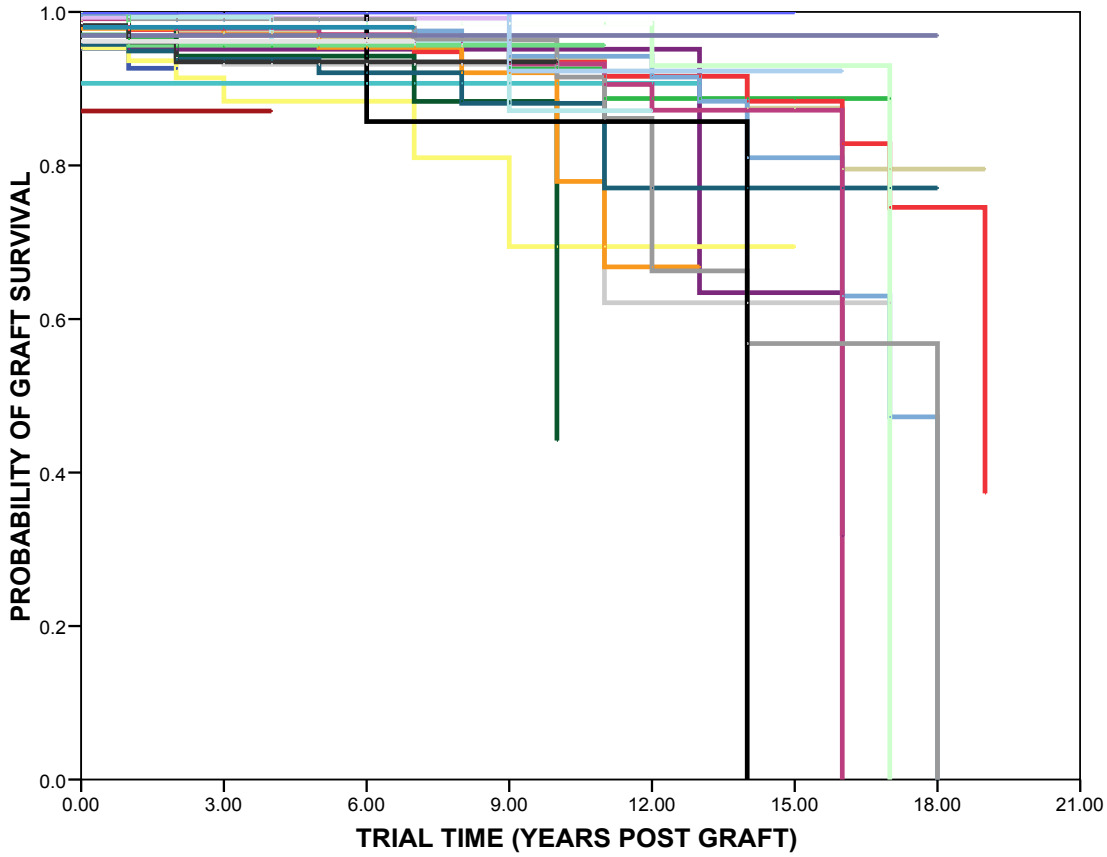
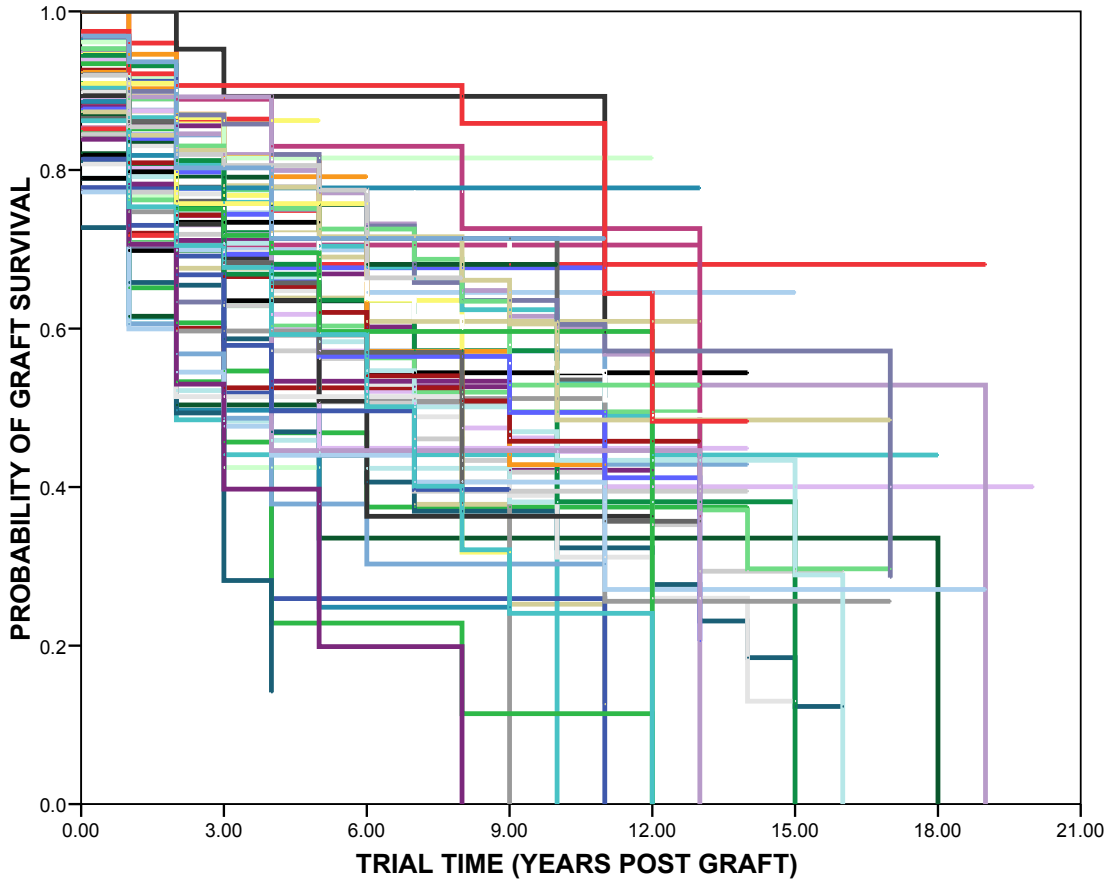


Figure 1.4 The centre effect: penetrating grafts (keratoconus excluded)



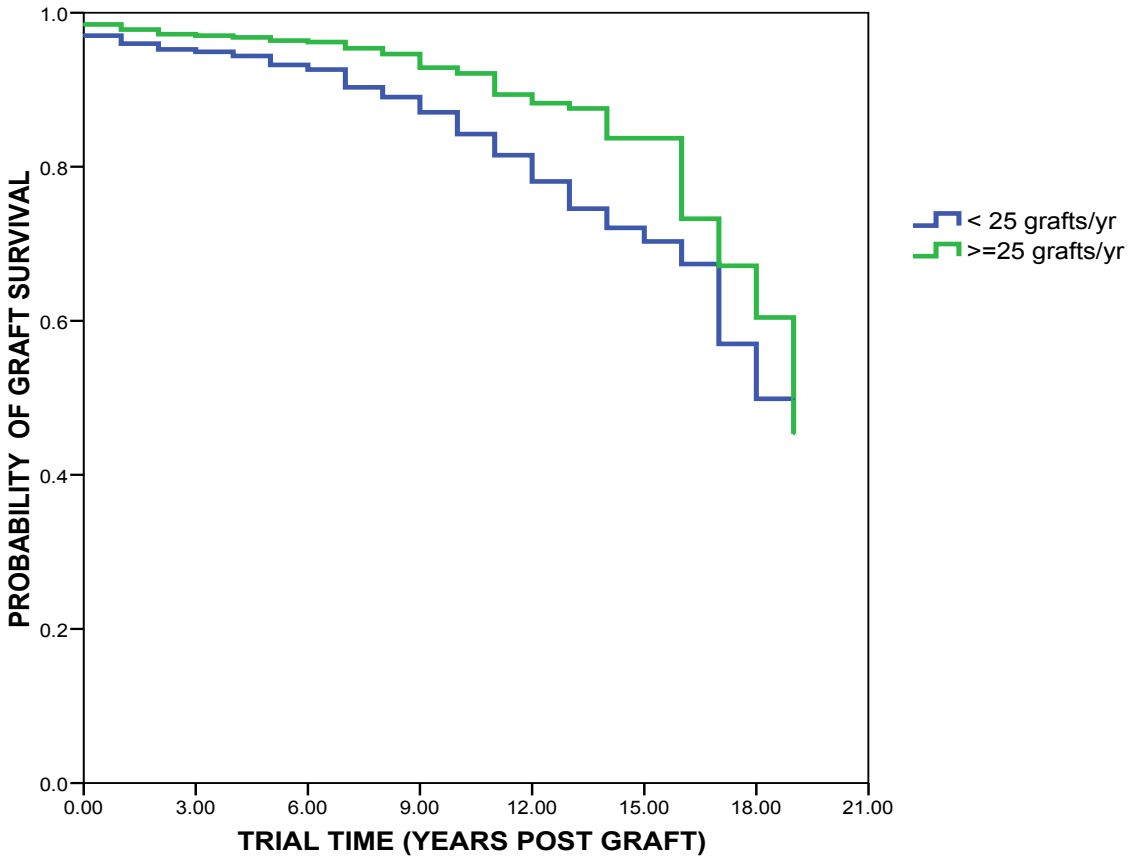
The centre effect exerts a strong influence on corneal graft survival. Plainly, some of the observed variation in outcome can be attributed to marked variations in indications for graft within different practices.

However the centre effect is also of significance when only grafts for keratoconus are considered, suggesting that intra-operative factors or post-operative management may influence graft outcome.

1.2.4 Outcome: influence of surgeon workload per year

Figure 1.5 shows the survival of all penetrating grafts for keratoconus performed by the 12 surgeons with a workload of 25 or more penetrating grafts per year on average, compared with those whose workload is less than 25 grafts per year (Log Rank Statistic=22.08; df=1; p<0.00001).

Figure 1.5 Number of grafts performed/year (penetrating grafts for keratoconus only)



Number At Risk

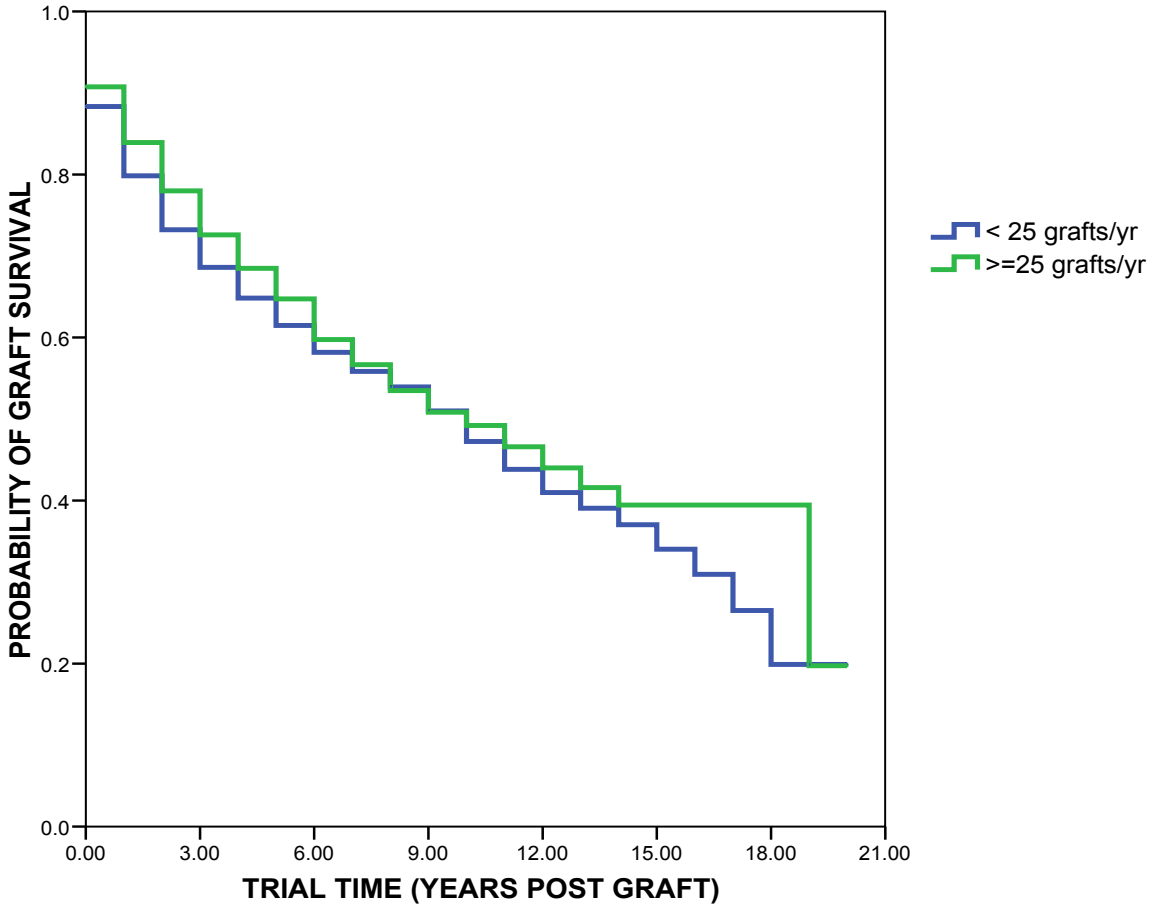
Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
≥ 25 grafts/year	2310	1072	561	322	161	64	10	n/a
< 25 grafts/year	1856	886	462	227	120	41	8	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
≥ 25 grafts/year	2310	.978	.964	.921	.732	n/a
< 25 grafts/year	1856	.960	.932	.843	.703	n/a

Figure 1.6 compares graft survival for grafts excluding those first grafts for keratoconus (Log Rank Statistic=14.22; df=1; p=0.0002).

In both keratoconus and non keratoconus cases, graft survival is slightly but significantly better for those surgeons with a high workload.

Figure 1.6 Number of grafts performed/year (penetrating grafts only, keratoconus excluded)



Number At Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
≥ 25 grafts/year	4124	1460	585	262	109	25	2	n/a
< 25 grafts/year	5060	1765	764	313	139	37	8	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
≥ 25 grafts/year	4124	.839	.647	.493	.396	n/a
< 25 grafts/year	5060	.798	.615	.472	.340	n/a

For the first time, there is a statistically significant difference in surgeon workload for both keratoconus and non-keratoconus cases. Graft survival is higher for surgeons with a high workload.

PENETRATING CORNEAL GRAFT SURVIVAL
KERATOCONUS ONLY: EFFECT OF CASE-LOAD

≥ 25 grafts/year:	**98% at 1 year**
Mean Survival 16.88 years	**96% at 5 years**
(SE=0.24; 95% CI: 16.41, 17.35)	**92% at 10 years**
Median Survival approx. 19 years	**73% at 15 years**
< 25 grafts/year:	**96% at 1 year**
Mean Survival 15.65 years	**93% at 5 years**
(SE=0. 30; 95% CI: 15.05, 16.25)	**84% at 10 years**
Median Survival approx. 18 years	**70% at 15 years**

PENETRATING CORNEAL GRAFT SURVIVAL
KERATOCONUS EXCLUDED: EFFECT OF CASE-LOAD

≥ 25 grafts/year:	**84% at 1 year**
Mean Survival 10.79 years	**65% at 5 years**
(SE=0.28; 95% CI: 10.24, 11.34)	**49% at 10 years**
Median Survival approx. 10 years	**40% at 15 years**
< 25 grafts/year:	**80% at 1 year**
Mean Survival 9.95 years	**62% at 5 years**
(SE=0.24; 95% CI: 9.48, 10.42)	**47% at 10 years**
Median Survival approx. 10 years	**34% at 15 years**

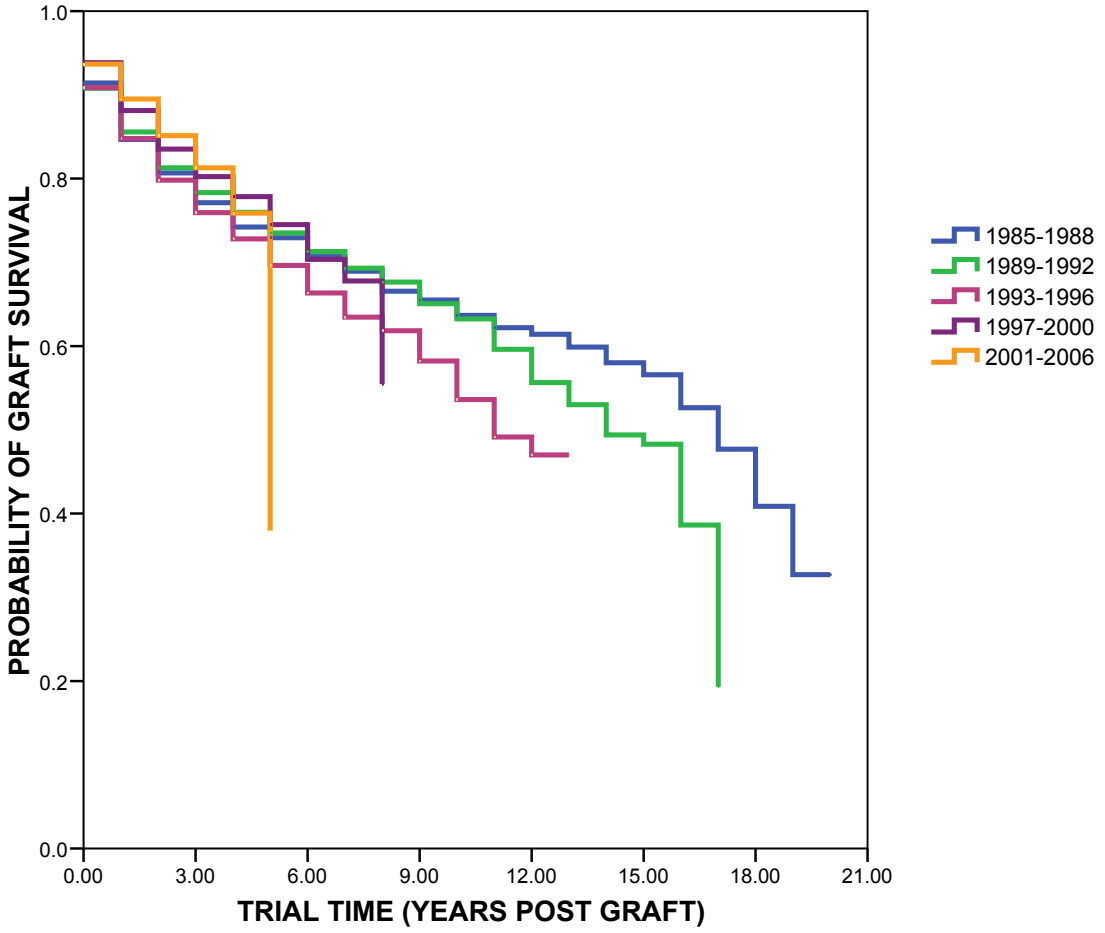
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

1.2.5 Outcome: according to era

A comparison of graft survival since the Australian Corneal Graft Registry began is shown in Figure 1.7. Grafts performed in 4 year blocks, 1985-1988, 1989-1992, 1993-1996, 1997-2000 and 2001-2006 were compared (Log Rank Statistic=39.15; df=4; p<0.00001). Graft survival appears significantly worse for those grafted in the 1993-1996 period.

Figure 1.7 Graft outcome measured in groups of years (penetrating grafts only)



Number At Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
1985 - 1988	1689	813	518	319	236	122	28	0
1989 - 1992	3551	1640	931	549	270	45	0	n/a
1993 - 1996	2880	1275	654	256	23	n/a	n/a	n/a
1997 - 2000	2730	1189	269	0	n/a	n/a	n/a	n/a
2001 - 2006	2500	266	0	n/a	n/a	n/a	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
1985 - 1988	1689	.847	.729	.637	.566	n/a
1989 - 1992	3551	.856	.735	.632	.483	n/a
1993 - 1996	2880	.848	.696	.536	n/a	n/a
1997 - 2000	2730	.881	.745	.554	n/a	n/a
2001 - 2006	2500	.895	.379	n/a	n/a	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
STRATIFIED BY ERA

1985-1988:	**85% at 1 year**
Mean Survival 12.88 years	**73% at 5 years**
(SE=0.27; 95% CI: 12.36, 13.41)	**64% at 10 years**
Median Survival 17 years	**57% at 15 years**
1989-1992:	**86% at 1 year**
Mean Survival 11.27 years	**74% at 5 years**
(SE=0.17; 95% CI: 10.93, 11.60)	**63% at 10 years**
Median Survival 14 years	**48% at 15 years**
1993-1996:	**85% at 1 year**
Mean Survival 8.73 years	**70% at 5 years**
(SE=0.13; 95% CI: 8.48, 8.99)	**54% at 10 years**
Median Survival 11 years	
1997-2000:	**88% at 1 year**
Mean Survival 6.36 years	**75% at 5 years**
(SE=0.07; 95% CI: 6.23, 6.49)	**55% at 10 years**
Median Survival approx. 8 years	
2001-2006:	**90% at 1 year**
Mean Survival 4.25 years	**38% at 5 years**
(SE =0.04; 95% CI: 4.17, 4.34)	
Median Survival 5 years	

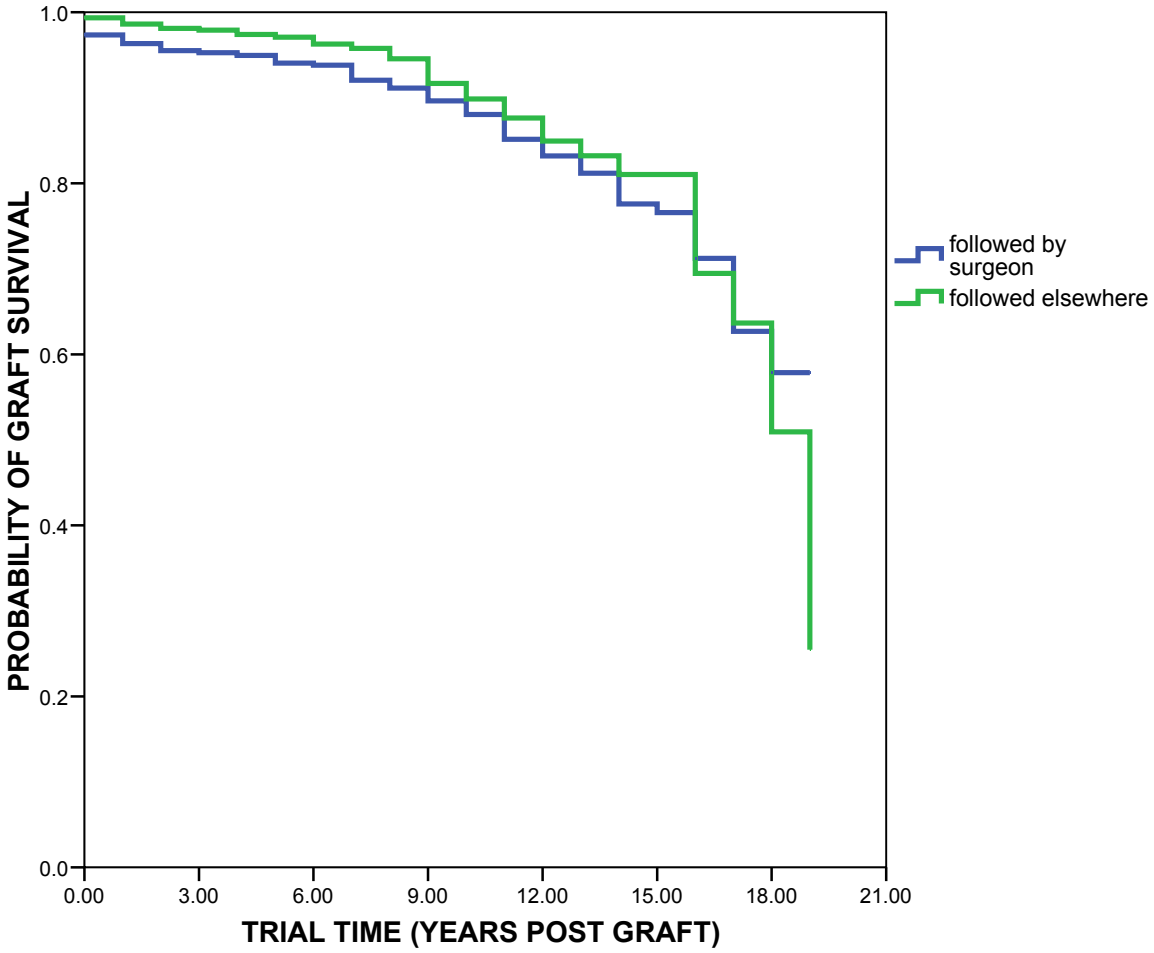
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

1.2.6 Outcome: whether followed by contributing surgeon or another practitioner

Figure 1.8 compares graft outcome for first grafts for keratoconus, stratified by whether the graft has been followed by the contributing surgeon or by another practitioner (Log Rank Statistic=6.63; df=1; p=0.0100).

Figure 1.8 Follow-up surgeon/other practitioner - 1st graft for keratoconus only



Number At Risk

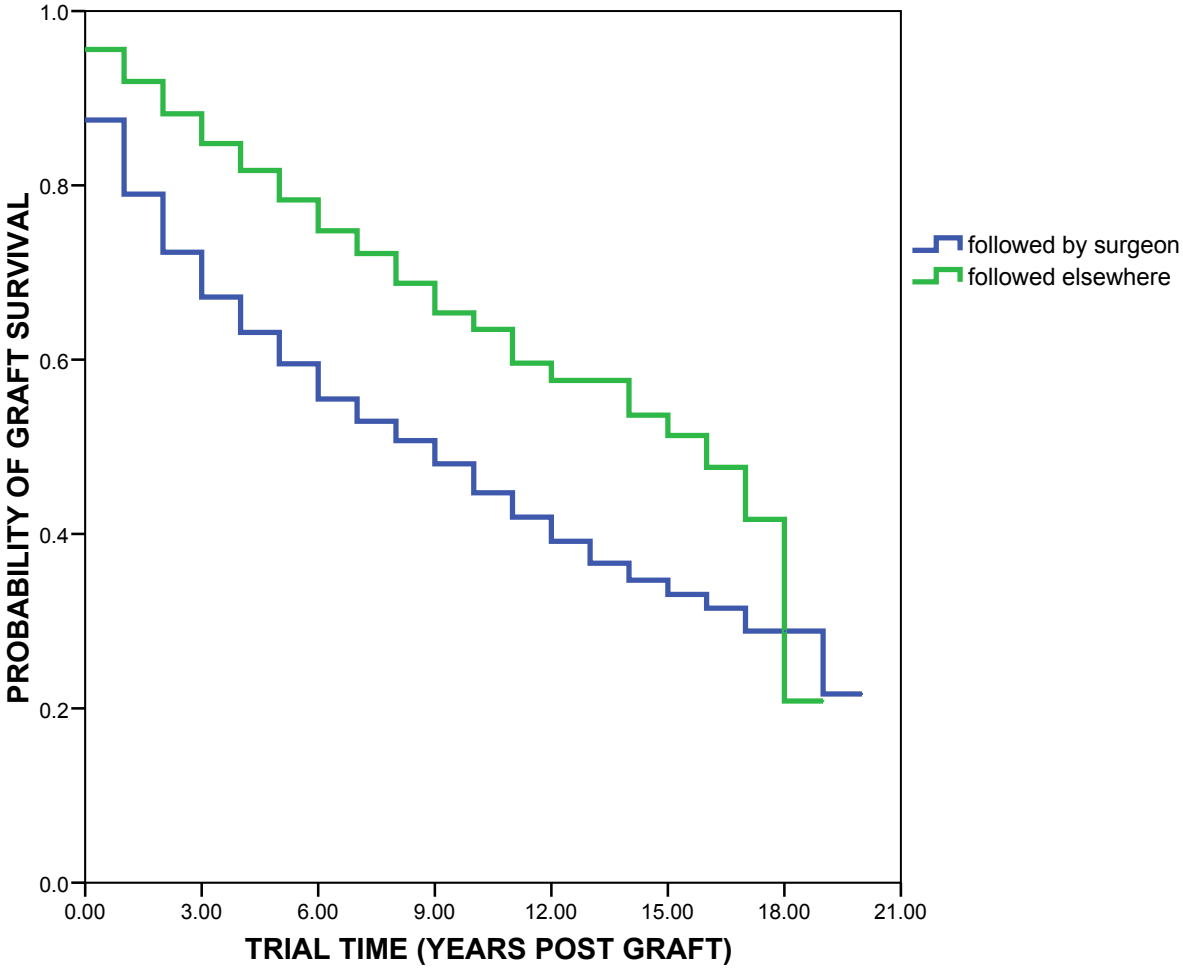
Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Followed by surgeon	3313	1497	785	421	218	77	13	n/a
Followed elsewhere	912	470	241	131	65	29	5	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Followed by surgeon	3313	.963	.941	.880	.766	n/a
Followed elsewhere	912	.986	.971	.899	.694	n/a

Figure 1.9 compares the outcome for all grafts excluding those performed for keratoconus, followed by the contributing surgeon or by another practitioner (Log Rank Statistic=174.57; df=1; p<0.00001).

Graft survival is better when the patient is followed up elsewhere in both keratoconus and non keratoconus cases.

Figure 1.9 Follow-up surgeon/other practitioner - keratoconus excluded



Number At Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Followed by surgeon	8127	2646	1074	458	197	42	7	n/a
Followed elsewhere	1806	753	332	143	60	23	4	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Followed by surgeon	8127	.790	.595	.447	.331	n/a
Followed elsewhere	1806	.919	.783	.635	.476	n/a

OVERALL CORNEAL GRAFT SURVIVAL
FOLLOWUP SURGEON; KERATOCUS ONLY

Followed by surgeon:	**96% at 1 year**
Mean Survival 16.23 years	**94% at 5 years**
(SE=0.22; 95% CI: 15.81, 16.66)	**88% at 10 years**
Median Survival approx. 19 years	**77% at 15 years**
Followed elsewhere:	**99% at 1 year**
Mean Survival 16.58 years	**97% at 5 years**
(SE=0.38; 95% CI: 15.85, 17.32)	**90% at 10 years**
Median Survival approx. 19 years	**69% at 15 years**

OVERALL CORNEAL GRAFT SURVIVAL
FOLLOWUP SURGEON; KERATOCONUS EXCLUDED

Followed by surgeon:	**79% at 1 year**
Mean Survival 9.77 years	**60% at 5 years**
(SE=0.20; 95% CI: 9.37, 10.17)	**45% at 10 years**
Median Survival approx. 9 years	**33% at 15 years**
Followed elsewhere:	**92% at 1 year**
Mean Survival 12.55 years	**78% at 5 years**
(SE=0.36; 95% CI: 11.85, 13.25)	**64% at 10 years**
Median Survival approx. 16 years	**48% at 15 years**

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

1.3 SUMMARY OF OVERVIEW AND CONTRIBUTOR INFORMATION

- As of 1st September 2006, 18205 grafts had been registered of which 94% were penetrating, 5.5% were lamellar, and 0.5% were limbal.
- Overall, 78% of grafts have been followed on at least one occasion, 34% of grafts are known to be lost to follow-up, 5% of grafts can no longer be followed because of recipient death, and 22% of grafts have failed.
- Penetrating corneal graft survival is 73% at 5 years.
  Lamellar corneal graft survival is 69% at 5 years.
  Limbal allograft survival is 42% at 5 years.
- Corneal grafts have been entered into the Registry from all states and territories: NSW 38%, VIC 22%, QLD 14%, SA 12%, WA 11%, TAS 2%, ACT and NT <1%.
- 82% of grafts have been contributed by 18% of all contributing surgeons.
- A centre effect operates within the database for grafts for keratoconus, and for all grafts excluding those performed for keratoconus.
- Surgeons who perform 25 or more grafts per year on average appear to achieve better results in terms of graft survival than do those who perform fewer grafts.
- Patients who were followed up by another practitioner have a better outcome compared with patients who were followed up by the surgeon. This is probably due to case selection.

2. DONORS AND EYE-BANKING

2.1 CAUSE OF DONOR DEATH

The major cause of donor death is listed in Table 2.1. Diseases of the cardiac/circulatory system remain by far the most common cause of death in corneal donors, followed by strokes and other haemorrhages, and malignancies.

Table 2.1 Causes of donor death

Cause of death related to	Number of eyes	%
Cardiac/circulatory system	5719	31%
Cerebrovascular system	3122	17%
Malignancy	2894	16%
Trauma/accident/poisoning/medical misadventure	1900	11%
Respiratory system	1861	6%
Other specified cause Includes: digestive system 391 nervous system 355 genitourinary system 281 cardiogenic shock 250	1547	13%
Unknown to ACGR	1138	6%
Total	**18181**	**100%**

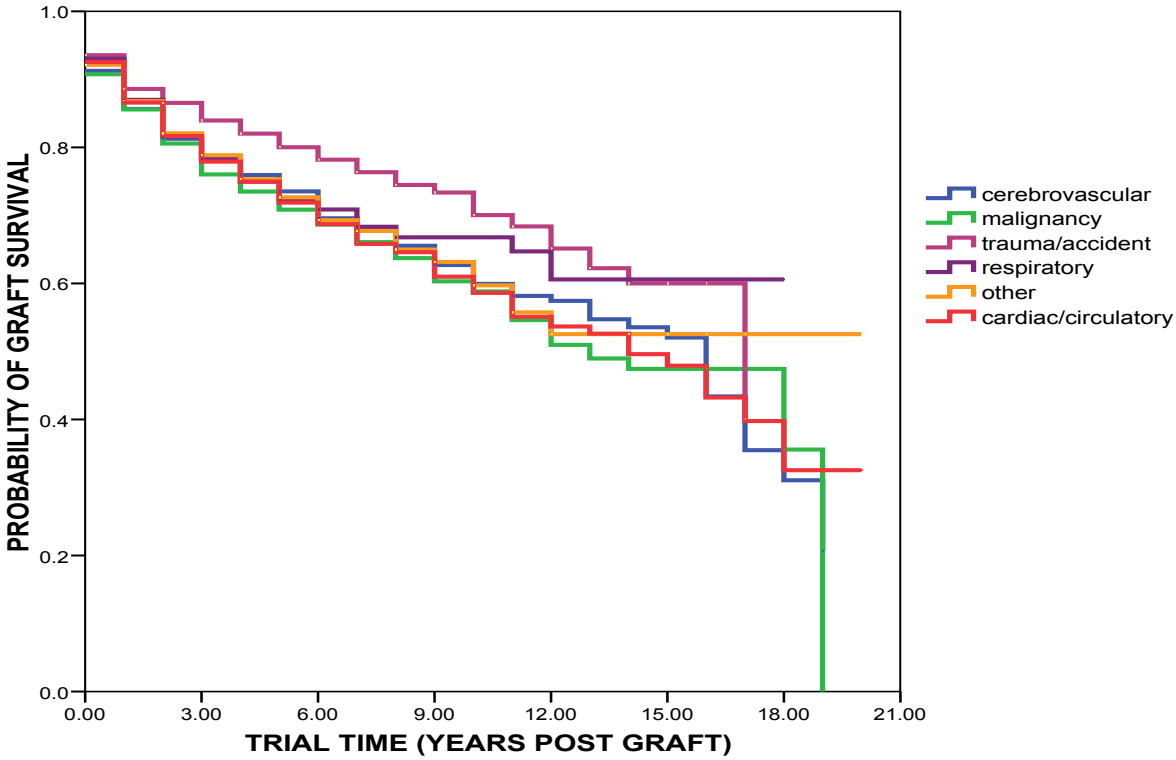
24 grafts were performed using live donors and/or the cornea used was from the recipient's contralateral eye.

All Kaplan-Meier plots and associated tables in this chapter have been calculated using penetrating grafts only.

Kaplan-Meier survival curves for penetrating grafts for the most common causes of donor death are shown in Figure 2.1 (Log Rank Statistic=27.15; df=5; p<0.00001).

Closer inspection revealed that 48% of corneas in the trauma/accidental death group were used for patients with keratoconus, compared with 27% in the cardiac group, 31% in the cerebrovascular group, 29% in the malignancy group 29% in other causes of death group and 26% in the respiratory group. Further, 53% of the recipients in the trauma group were 40 years of age or younger at the time of graft compared with 26% in the cardiac group, 31% in the cerebrovascular group, 30% in the other cause of death group, 29% in the malignancy group and 26% in the respiratory group. When donors dying from trauma are removed from the analysis, there is no longer a significant difference amongst groups (Log Rank Statistic=4.02; df=4; p=0.403).

Figure 2.1 Cause of donor death (penetrating grafts only)



Number At Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Cerebrovascular	2548	998	428	185	79	36	8	n/a
Malignancy	2086	764	356	168	75	22	4	n/a
Trauma/accident	1321	570	262	132	63	16	0	n/a
Respiratory	1350	510	205	102	47	9	1	n/a
Other	1169	457	194	72	35	7	1	n/a
Cardiac/circulatory	3919	1536	724	339	157	58	11	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Cerebrovascular	2548	.857	.735	.599	.521	n/a
Malignancy	2086	.856	.709	.588	.474	n/a
Trauma/accident	1321	.886	.800	.700	.600	n/a
Respiratory	1350	.870	.723	.668	n/a	n/a
Other	1169	.868	.727	.597	n/a	n/a
Cardiac/circulatory	3919	.866	.719	.586	.479	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
CAUSE OF DONOR DEATH

Cerebrovascular:	**86% at 1 year**
Mean Survival 11.98 years	**73% at 5 years**
(SE=0.30; 95% CI: 11.38, 12.57)	**60% at 10 years**
Median Survival 16 years	**52% at 15 years**
Malignancy:	**86% at 1 year**
Mean Survival 11.75 years	**71% at 5 years**
(SE=0.32; 95% CI: 11.12, 12.38)	**59% at 10 years**
Median Survival 13 years	**47% at 15 years**
Trauma/accident:	**89% at 1 year**
Mean Survival 12.63 years	**80% at 5 years**
(SE=0.29; 95% CI: 12.06, 13.19)	**70% at 10 years**
Median Survival 17 years	**60% at 15 years**
Respiratory:	**87% at 1 year**
Mean Survival 12.55 years	**72% at 5 years**
(SE=0.33; 95% CI: 11.91, 13.19)	**67% at 10 years**
Median Survival approx. 15 years	
Other:	**87% at 1 year**
Mean Survival 12.89 years	**73% at 5 years**
(SE=0.47; 95% CI: 11.97, 13.81)	**60% at 10 years**
Median Survival approx. 15 years	
Cardiac/circulatory:	**87% at 1 year**
Mean Survival 12.11 years	**72% at 5 years**
(SE=0.26; 95% CI: 11.60, 12.62)	**59% at 10 years**
Median Survival 14 years	**48% at 15 years**

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

2.2 DONOR GENDER

The gender of corneal donors continues to show the expected preponderance of males (Table 2.2), given the causes of donor death (see table 2.1).

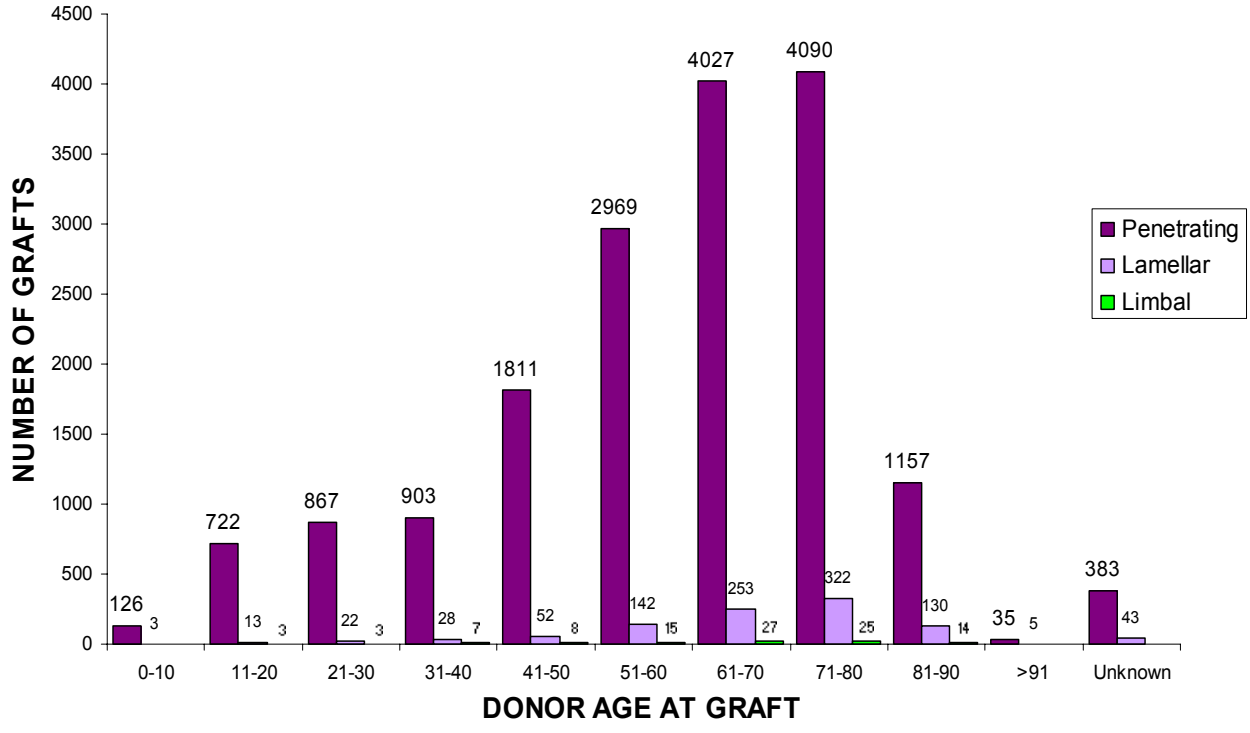
Table 2.2 Donor gender

Gender	Penetrating grafts		Lamellar grafts		Limbal grafts		Total	
	No.	%	No.	%	No.	%	No.	%
Male	10435	57%	544	3%	66	<1%	**11045**	**61%**
Female	5826	32%	412	2%	32	<1%	**6270**	**34%**
Unknown	829	5%	57	<1%	4	<1%	**890**	**5%**
TOTAL	**17090**	**94%**	**1013**	**6%**	**102**	**<1%**	**18205**	**100%**

2.3 DONOR AGE

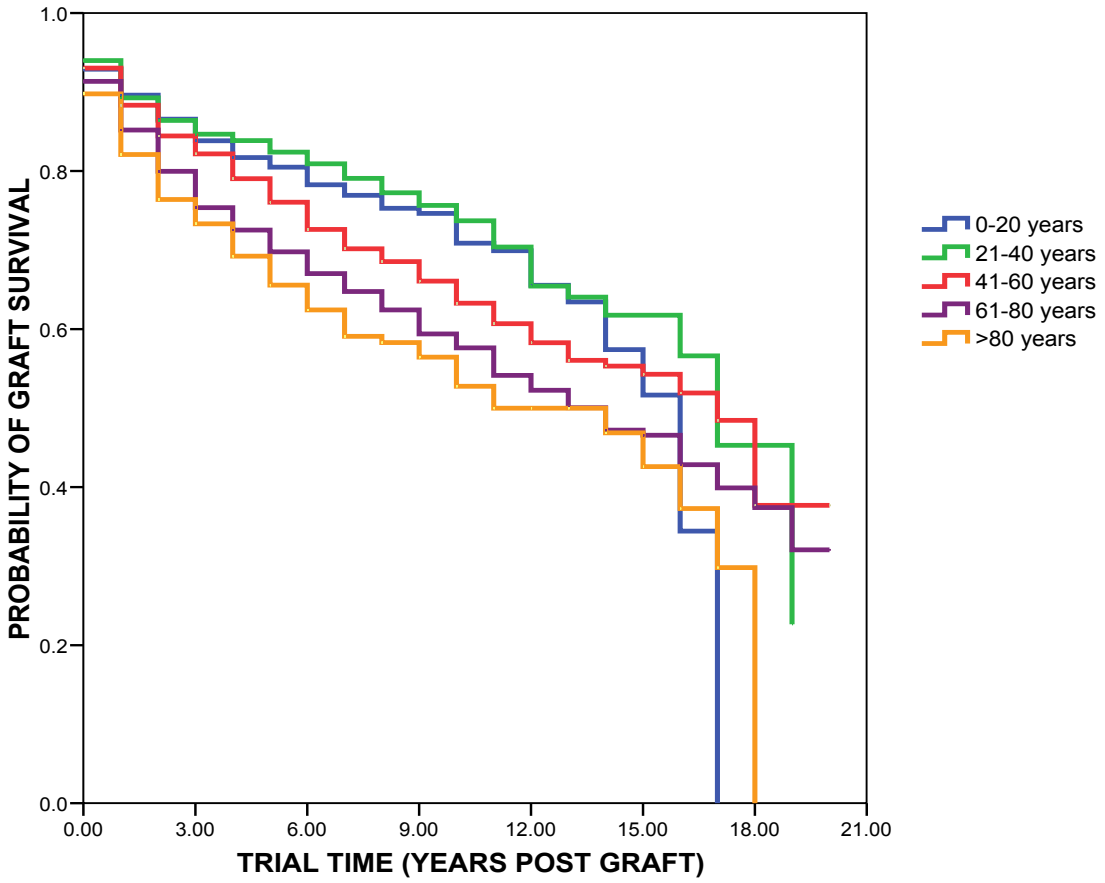
Donor age at death ranged from 11 days to 99 years. The age distribution is plotted in histogram form in Figure 2.2.

Figure 2.2 Donor age in decades



Figures 2.3, 2.4 and 2.5 show the influence of donor age on corneal graft survival. Figure 2.3 shows the influence of donor age in 20 year blocks on the cohort of penetrating grafts (Log Rank Statistic=100.66; df=4; p<0.00001). Corneal graft survival appears to be influenced by donor age *when the total cohort is examined*.

Figure 2.3 Donor age in 20 year blocks (penetrating grafts only)



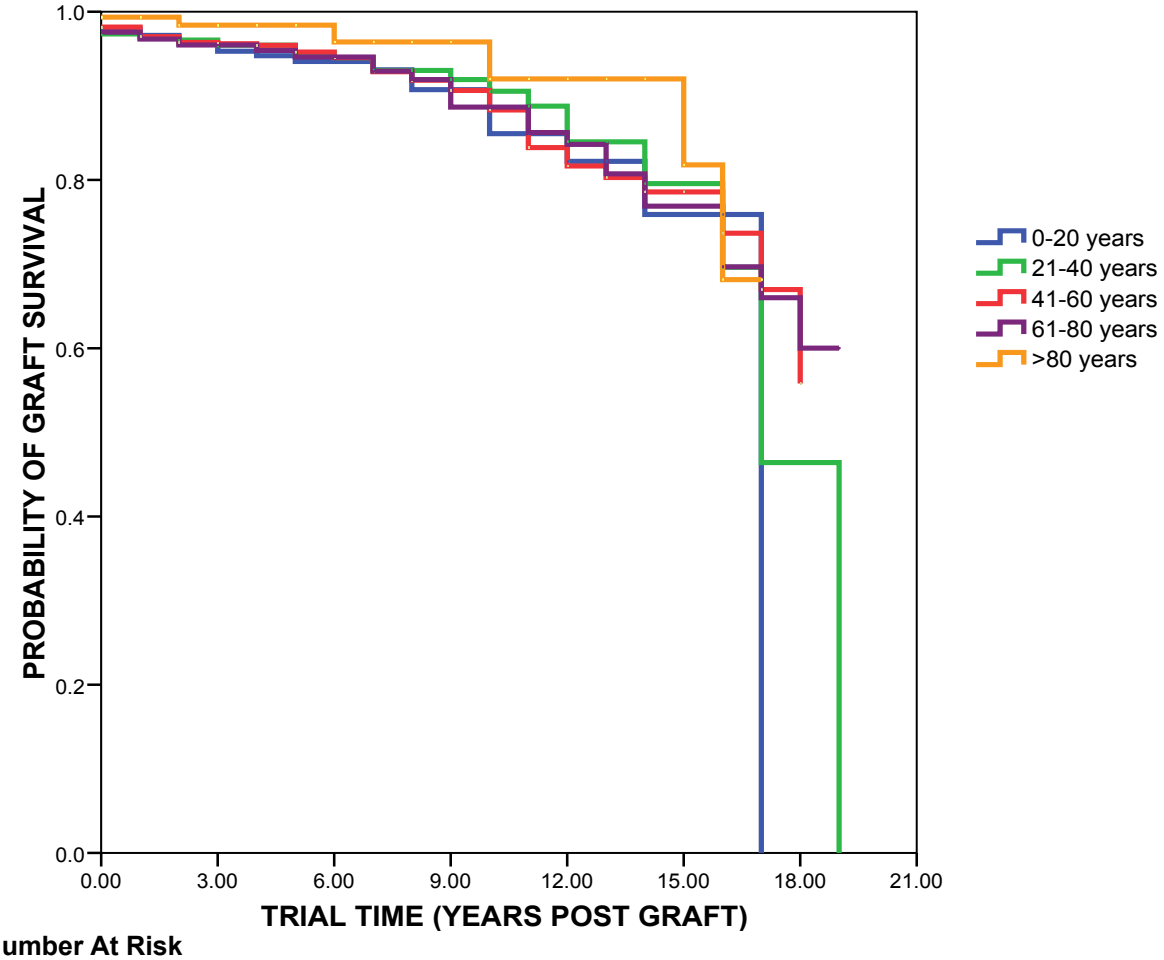
Number At Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
0-20 years	982	443	216	118	48	10	0	n/a
21-40 years	1313	547	281	145	71	20	2	n/a
41-60 years	3583	1424	639	305	150	53	9	n/a
61-80 years	6488	2445	1090	493	230	73	16	n/a
>80 years	975	322	146	63	30	11	1	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
0-20 years	982	.896	.805	.709	.516	n/a
21-40 years	1313	.893	.824	.737	.566	n/a
41-60 years	3583	.883	.761	.633	.543	n/a
61-80 years	6488	.852	.698	.576	.468	n/a
>80 years	975	.821	.656	.528	.426	n/a

Figure 2.4 shows the influence of donor age on grafts for keratoconus only (Log Rank Statistic=2.60; df=4; p=0.6268). Donor age does *not* appear to affect graft survival in the subset of patients with keratoconus. For further explanation of curves that drop to zero please refer to page 8.

Figure 2.4 Donor age (penetrating grafts for keratoconus only)



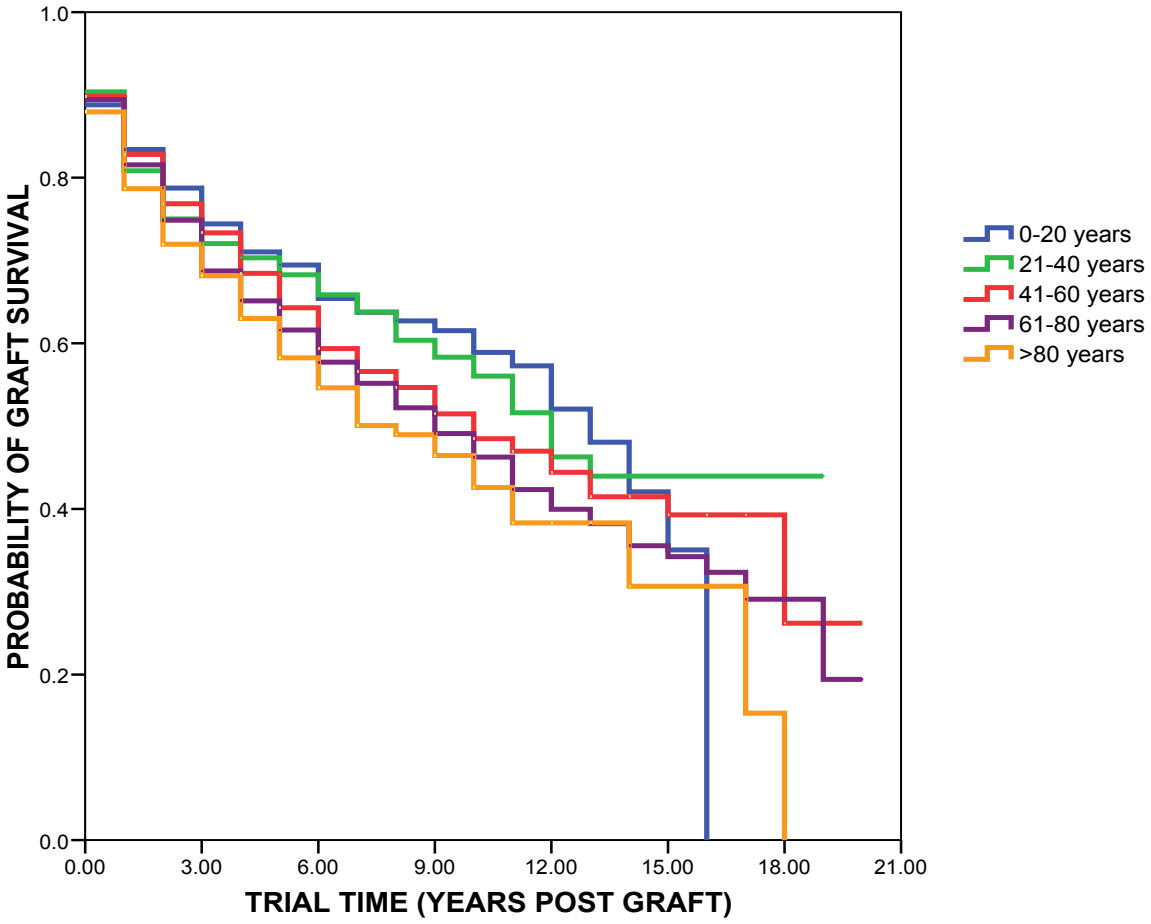
Number At Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
0-20 years	438	224	113	65	26	4	0	n/a
21-40 years	680	319	167	86	42	13	1	n/a
41-60 years	1368	614	287	150	76	34	6	n/a
61-80 years	1521	726	408	225	123	46	11	n/a
>80 years	154	77	49	24	15	9	0	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
0-20 years	438	.972	.941	.855	.759	n/a
21-40 years	680	.969	.951	.905	.696	n/a
41-60 years	1368	.970	.952	.883	.737	n/a
61-80 years	1521	.967	.946	.856	.697	n/a
>80 years	154	.984	.964	.920	.818	n/a

Figure 2.5 shows the influence of donor age on the survival of grafts performed for all indications excluding keratoconus (Log Rank Statistic=15.99; df=4; p=0.0030). Some effect of donor age on graft survival *is* apparent in this cohort, with donors under 20 years achieving better than expected survival and those over 80 years appearing to have worse than expected survival rates.

Figure 2.5 Donor age (penetrating grafts, keratoconus excluded)



Number At Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
0-20 years	543	219	103	53	22	6	n/a	n/a
21-40 years	632	228	114	59	29	7	1	n/a
41-60 years	2214	810	352	155	75	19	3	n/a
61-80 years	4966	1719	682	268	107	27	5	n/a
>80 years	820	245	97	39	15	2	1	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
0-20 years	543	.834	.694	.589	.350	n/a
21-40 years	632	.808	.683	.560	.440	n/a
41-60 years	2214	.828	.643	.485	.393	n/a
61-80 years	4966	.815	.616	.463	.342	n/a
>80 years	820	.787	.582	.426	.307	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
DONOR AGE IN 20 YEAR BLOCKS

0-20 years:	**90% at 1 year**
Mean Survival 12.33 years	**80% at 5 years**
(SE=0.35; 95% CI: 11.65, 13.02)	**71% at 10 years**
Median Survival 16 years	**52% at 15 years**
21-40 years:	**89% at 1 year**
Mean Survival 13.78 years	**82% at 5 years**
(SE=0.41; 95% CI: 12.98, 14.58)	**74% at 10 years**
Median Survival 17 years	**57% at 15 years**
41-60 years:	**88% at 1 year**
Mean Survival 13.04 years	**76% at 5 years**
(SE=0.29; 95% CI: 12.46, 13.62)	**63% at 10 years**
Median Survival 17 years	**54% at 15 years**
61-80 years:	**85% at 1 year**
Mean Survival 11.88 years	**70% at 5 years**
(SE=0.21; 95% CI: 11.46, 12.29)	**58% at 10 years**
Median Survival 14 years	**47% at 15 years**
>80 years:	**82% at 1 year**
Mean Survival 10.52 years	**66% at 5 years**
(SE=0.42; 95% CI: 9.69, 11.35)	**53% at 10 years**
Median Survival 11 years	**43% at 15 years**

PENETRATING CORNEAL GRAFT SURVIVAL
DONOR AGE; KERATOCONUS ONLY

0-20 years:	**97% at 1 year**
Mean Survival 15.07 years	**94% at 5 years**
(SE=0.40; 95% CI: 14.28, 15.86)	**86% at 10 years**
Median Survival 17 years	**76% at 15 years**
21-40 years:	**97% at 1 year**
Mean Survival 16.20 years	**95% at 5 years**
(SE=0.58; 95% CI: 15.07, 17.34)	**90% at 10 years**
Median Survival 17 years	**70% at 15 years**
41-60 years:	**97% at 1 year**
Mean Survival 15.81 years	**95% at 5 years**
(SE=0.29; 95% CI: 15.24, 16.37)	**88% at 10 years**
Median Survival approx.18 years	**74% at 15 years**
61-80 years:	**97% at 1 year**
Mean Survival 16.33 years	**95% at 5 years**
(SE=0.28; 95% CI: 15.78, 16.89)	**86% at 10 years**
Median Survival approx. 18 years	**70% at 15 years**
>80 years:	**98% at 1 year**
Mean Survival 15.88 years	**96% at 5 years**
(SE=0.44; 95% CI: 15.01, 16.75)	**92% at 10 years**
Median Survival approx. 17 years	**82% at 15 years**

PENETRATING CORNEAL GRAFT SURVIVAL
DONOR AGE; KERATOCONUS EXCLUDED

0-20 years:	**83% at 1 year**
Mean Survival 10.13 years	**69% at 5 years**
(SE=0.42; 95% CI: 9.31, 10.94)	**59% at 10 years**
Median Survival 13 years	**35% at 15 years**
21-40 years:	**81% at 1 year**
Mean Survival 11.23 years	**68% at 5 years**
(SE=0.52; 95% CI: 10.22, 12.24)	**56% at 10 years**
Median Survival 12 years	**44% at 15 years**
41-60 years:	**83% at 1 year**
Mean Survival 10.71 years	**64% at 5 years**
(SE=0.38; 95% CI: 9.97, 11.45)	**48% at 10 years**
Median Survival 10 years	**39% at 15 years**
61-80 years:	**81% at 1 year**
Mean Survival 10.02 years	**62% at 5 years**
(SE=0.26; 95% CI: 9.51, 10.53)	**46% at 10 years**
Median Survival 9 years	**34% at 15 years**
>80 years:	**79% at 1 year**
Mean Survival 8.93 years	**58% at 5 years**
(SE=0.51; 95% CI: 7.93, 9.93)	**43% at 10 years**
Median Survival 8 years	**31% at 15 years**

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

We return to the issue of donor age in chapter 8.

2.4 DEATH-TO-ENUCLEATION AND DEATH-TO-GRAFT TIMES

Death-to-enucleation and death-to-graft times are shown in Table 2.4. Death-to-enucleation times were available for 97% of penetrating grafts, 95% of lamellar grafts and 99% of limbal grafts. Death-to-graft times were available for 84% penetrating, 77% lamellar and 85% limbal grafts respectively.

Table 2.4 Corneal collection times for penetrating, lamellar and limbal grafts

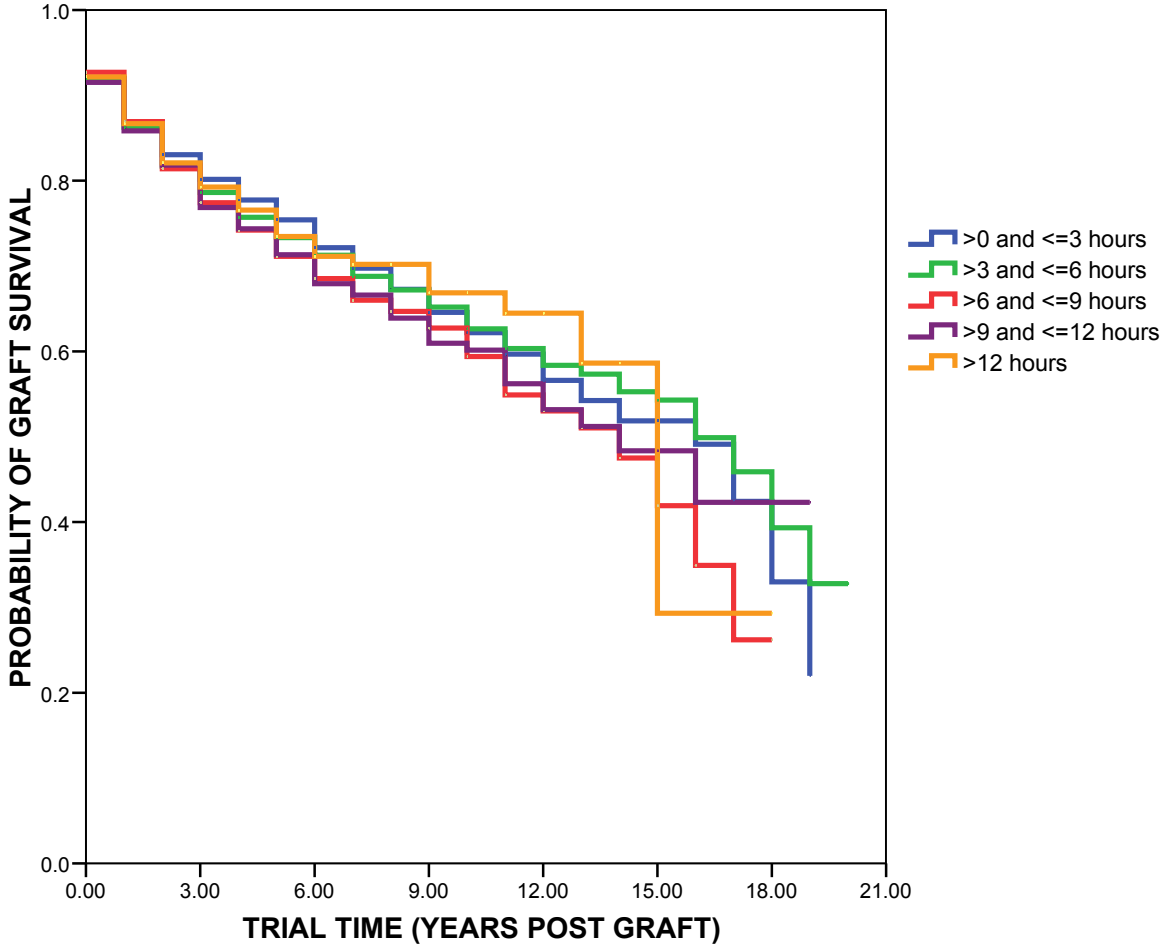
Time	Penetrating Grafts		
	Total	Median time in hours	Range: hours (days)
Death-to-enucleation times	16650	6	1-37 (0-3)
Death-to-graft times	14440	62	2-999 (0-42)
Death-to-graft times for storage in:			
MK medium	4106	46	3-410 (0-17)
Optisol	5927	98	3-999 (0-42)
CSM	3178	82	12-832 (0-33)
K-Sol	645	118	8-783 (0-35)
Moist Pot	280	21	2-384 (0-16)

Time	Lamellar Grafts		
	Total	Median time in hours	Range: hours (days)
Death-to-enucleation times	965	8	1-59 (0-2)
Death-to-graft times	768	145	7-1104 (0-46)
Death-to-graft times for storage in:			
Moist Pot	398	178	7-1104 (0-46)
Optisol	225	120	15-1000 (0-42)
CSM	68	244	46-1067 (2-44)
MK medium	54	81	13–464 (0-19)

Time	Limbal Grafts		
	Total	Median time in hours	Range: hours (days)
Death-to-enucleation times	101	6	1-17 (0-1)
Death-to-graft times	87	37	6-999 (0-42)
Death-to-graft times for storage in:			
Moist Pot	65	32	6-999 (0-42)
Optisol	14	116	27-349 (1-15)
MK medium	4	54	26-173 (1-7)
CSM	4	327	100-665 (4-28)

The influence of increasing death-to-enucleation time on penetrating graft survival is illustrated in Figure 2.6. Death-to-enucleation times of 3 hours or less were compared with times of: over 3 hours and up to 6 hours; over 6 hours and up to 9 hours; over 9 hours and up to 12 hours; and over 12 hours.

Figure 2.6 Death-to-enucleation times (penetrating grafts only)



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
>0 and ≤3 hours	3869	1730	900	475	232	79	9	n/a
>3 and ≤6 hours	3673	1418	640	301	153	57	14	n/a
>6 and ≤9 hours	2946	1079	464	198	88	17	3	n/a
>9 and ≤12 hours	2043	692	273	108	37	12	1	n/a
>12 hours	803	262	95	42	20	2	0	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
>0 and ≤3 hours	3869	.869	.754	.622	.491	n/a
>3 and ≤6 hours	3673	.863	.734	.627	.543	n/a
>6 and ≤9 hours	2946	.869	.711	.594	.419	n/a
>9 and ≤12 hours	2043	.858	.713	.601	.423	n/a
>12 hours	803	.867	.732	.643	.292	n/a

Of the 803 penetrating corneal grafts that were enucleated >12 hours after donor death, only 7 were >24 hours. The vast majority (603) were enucleated between 13-16 hours (inclusive) after donor death. These curves are not significantly different from each other (Log Rank Statistic=5.54; df=4; p=0.2365).

PENETRATING CORNEAL GRAFT SURVIVAL
DEATH TO ENUCLEATION TIME

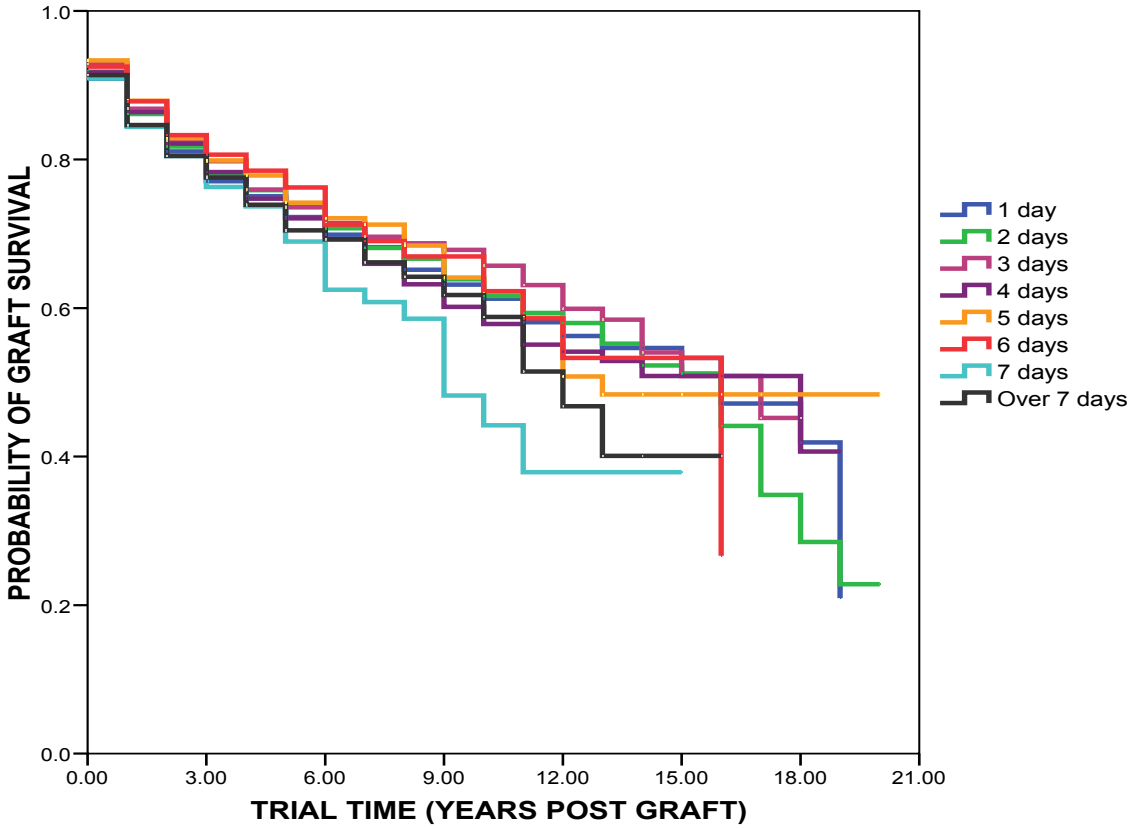
>0 and ≤3 hours:	**87% at 1 year**
Mean Survival 12.30 **years**	**75% at 5 years**
(SE=0.21; 95% CI: 11.89, 12.71)	**62% at 10 years**
Median Survival 16 **years**	**49% at 15 years**
>3 and ≤6 hours:	**86% at 1 year**
Mean Survival 12.77 **years**	**73% at 5 years**
(SE=0.27; 95% CI: 12.24, 13.29)	**63% at 10 years**
Median Survival 16 **years**	**54% at 15 years**
>6 and ≤9 hours:	**87% at 1 year**
Mean Survival 11.15 **years**	**71% at 5 years**
(SE=0.27; 95% CI: 10.61, 11.68)	**59% at 10 years**
Median Survival 14 **years**	**42% at 15 years**
>9 and ≤12 hours:	**86% at 1 year**
Mean Survival 11.85 **years**	**71% at 5 years**
(SE=0.40; 95% CI: 11.06, 12.64)	**60% at 10 years**
Median Survival approx. 14 **years**	**42% at 15 years**
>12 hours:	**87% at 1 year**
Mean Survival 11.67 **years**	**73% at 5 years**
(SE=0.75; 95% CI: 10.19, 13.15)	**64% at 10 years**
Median Survival approx. 15 **years**	**29% at 15 years**

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

Figure 2.7 shows death-to-graft times stratified in number of days for penetrating grafts (Log Rank Statistic=11.08; df=7; p=0.1350). Death-to-graft time exerts no significant influence on graft survival.

Figure 2.7 Death-to-graft times (penetrating grafts only)



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
1 day	1088	504	303	162	93	41	9	n/a
2 days	2339	1044	529	263	132	49	11	n/a
3 days	2421	1026	487	238	119	34	2	n/a
4 days	2021	790	330	146	59	19	5	n/a
5 days	1515	527	213	95	37	9	1	n/a
6 days	1148	380	137	50	22	4	n/a	n/a
7 days	572	174	53	17	4	1	n/a	n/a
Over 7 days	394	138	57	26	11	2	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
1 day	1088	.846	.723	.613	.533	n/a
2 days	2339	.861	.736	.616	.512	n/a
3 days	2421	.868	.736	.657	.508	n/a
4 days	2021	.864	.721	.578	.508	n/a
5 days	1515	.879	.742	.622	n/a	n/a
6 days	1148	.878	.762	.623	.266	n/a
7 days	572	.844	.690	.442	n/a	n/a
Over 7 days	394	.846	.705	.588	n/a	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
DEATH TO GRAFT TIME

1 day:	**85% at 1 year**
Mean Survival 12.22 years	**72% at 5 years**
(SE=0.34; 95% CI: 11.55, 12.88)	**61% at 10 years**
Median Survival 16 years	**53% at 15 years**
2 days:	**86% at 1 year**
Mean Survival 12.24 years	**74% at 5 years**
(SE=0.30; 95% CI: 11.66, 12.82)	**62% at 10 years**
Median Survival 16 years	**51% at 15 years**
3 days:	**87% at 1 year**
Mean Survival 12.17 years	**74% at 5 years**
(SE=0.25; 95% CI: 11.69, 12.65)	**66% at 10 years**
Median Survival 17 years	**51% at 15 years**
4 days:	**86% at 1 year**
Mean Survival 12.08 years	**72% at 5 years**
(SE=0.33; 95% CI: 11.43, 12.73)	**58% at 10 years**
Median Survival 18 years	**51% at 15 years**
5 days:	**88% at 1 year**
Mean Survival 12.82 years	**74% at 5 years**
(SE=0.47; 95% CI: 11.89, 13.75)	**62% at 10 years**
Median Survival 13 years	
6 days:	**88% at 1 year**
Mean Survival 11.07 years	**76% at 5 years**
(SE=0.37; 95% CI: 10.35, 11.79)	**62% at 10 years**
Median Survival 16 years	**27% at 15 years**
7 days:	**84% at 1 year**
Mean Survival 9.01 years	**69% at 5 years**
(SE=0.54; 95% CI: 7.94, 10.07)	**44% at 10 years**
Median Survival 9 years	
Over 7 days:	**85% at 1 year**
Mean Survival 10.17 years	**70% at 5 years**
(SE=0.55; 95% CI: 9.08, 11.26)	**59% at 10 years**
Median Survival 12 years	

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

2.5 CORNEAL STORAGE MEDIA

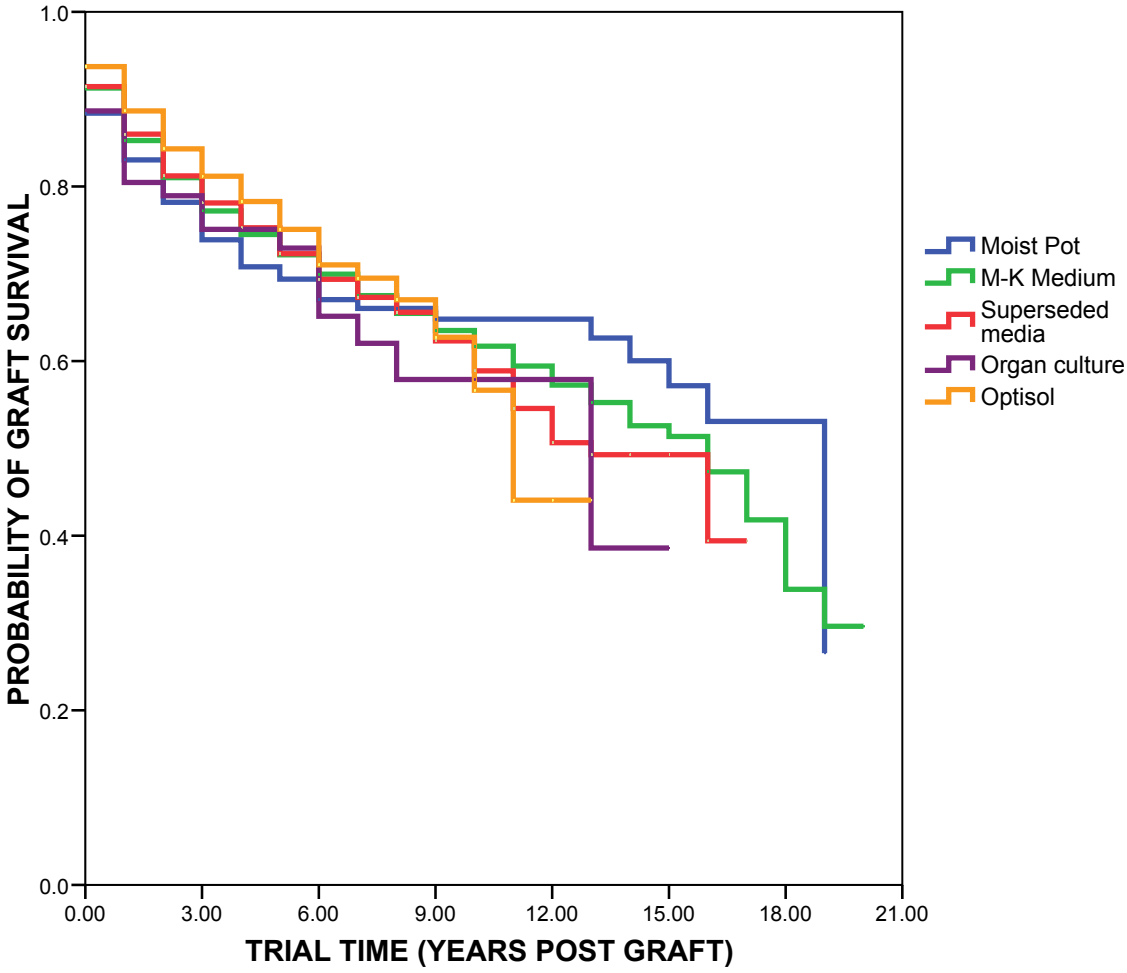
The corneal storage media in which donor corneas were preserved are shown in Table 2.5.

Table 2.5 Corneal storage media

Storage medium	Penetrating		Lamellar		Limbal	
Optisol	7542	44%	289	29%	18	18%
M-K medium	4549	27%	71	7%	7	7%
CSM	3552	21%	78	7%	4	4%
Moist pot	327	2%	509	50%	72	71%
K-Sol	682	4%	22	2%	-	
DexSol	187	1%	-		-	
Organ Culture	92	<1%	2	<1%	-	
Frozen	1	<1%	20	2%	-	
Unknown to ACGR	158	<1%	22	2%	1	<1%
Total	**17090**	**(100%)**	**1013**	**(100%)**	**102**	**(100%)**

Figure 2.8 shows the influence of storage medium on survival of grafts (Log Rank Statistic=18.45; df=4; p=0.001). Type of storage medium significantly influences corneal graft survival, with Optisol performing better than other media.

Figure 2.8 Storage media (penetrating grafts only)



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Moist Pot	310	146	89	54	35	21	7	n/a
M-K Medium	4363	2065	1197	666	352	129	21	n/a
Superseded media*	3864	1627	763	320	125	13	0	n/a
Organ culture	88	41	28	13	5	2	n/a	n/a
Optisol	4583	1242	259	47	6	n/a	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Moist Pot	310	.830	.694	.648	.572	n/a
M-K Medium	4363	.853	.722	.617	.514	n/a
Superseded media*	3864	.860	.723	.589	.394	n/a
Organ culture	88	.805	.729	.579	n/a	n/a
Optisol	4583	.886	.751	.567	n/a	n/a

* Superseded media: CSM, K-Sol and DexSol

PENETRATING CORNEAL GRAFT SURVIVAL
STORAGE MEDIUM

Moist Pot:	**83% at 1 year**
Mean Survival 12.61 years	**69% at 5 years**
(SE=0.58; 95% CI: 11.47, 13.75)	**65% at 10 years**
Median Survival 19 years	**57% at 15 years**
M-K Medium:	**85% at 1 year**
Mean Survival 12.38 years	**72% at 5 years**
(SE=0.20; 95% CI: 11.99, 12.77)	**62% at 10 years**
Median Survival 16 years	**51% at 15 years**
Superseded media:	**86% at 1 year**
Mean Survival 11.00 years	**72% at 5 years**
(SE=0.20; 95% CI: 10.61, 11.40)	**59% at 10 years**
Median Survival 13 years	**39% at 15 years**
Organ culture:	**80% at 1 year**
Mean Survival 9.65 years	**73% at 5 years**
(SE=0.83; 95% CI: 8.03, 11.27)	**58% at 10 years**
Median Survival 13 years	
Optisol:	**89% at 1 year**
Mean Survival 9.16 years	**75% at 5 years**
(SE=0.21; 95% CI: 8.75, 9.57)	**57% at 10 years**
Median Survival 11 years	

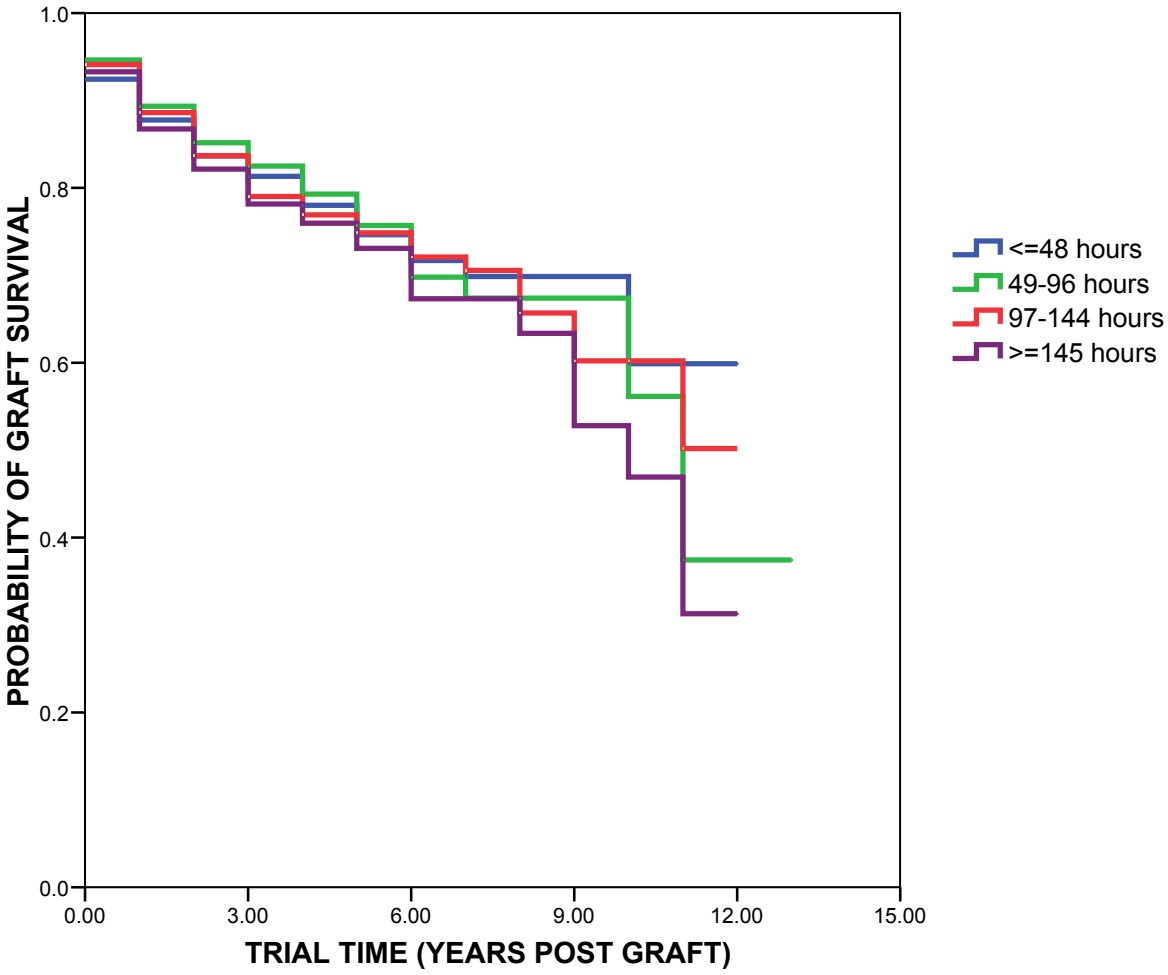
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

2.5.1 Optisol storage time

Figure 2.9 compares graft outcome for Optisol-preserved corneas stored for periods of 0-48 hours, 49-96 hours, 97-144 hours and more than 144 hours (Log Rank Statistic=2.66; df=3; p=0.4475). Corneal storage time in Optisol does not influence graft survival. It should be noted that 441 grafts preserved in Optisol had no storage time listed.

Figure 2.9 Optisol storage time (penetrating grafts only)



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years
<=48 hours	1374	397	76	9	0	n/a
49 - 96 hours	1306	380	64	14	1	n/a
97-144 hours	1135	324	81	12	0	n/a
>=145 hours	327	103	38	12	0	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
<=48 hours	1374	.878	.746	.599	n/a	n/a
49 - 96 hours	1306	.893	.757	.562	n/a	n/a
97-144 hours	1135	.886	.749	.602	n/a	n/a
>=145 hours	327	.867	.731	.469	n/a	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
OPTISOL STORAGE TIME

0 - 48 hours:	**88% at 1 year**
Mean Survival 8.99 years	**75% at 5 years**
(SE=0.28; 95% CI: 8.44, 9.53)	**60% at 10 years**
Median Survival approx. 12 years	
49 - 96 hours:	**89% at 1 year**
Mean Survival 9.10 years	**76% at 5 years**
(SE=0.46; 95% CI: 8.19, 10.01)	**56% at 10 years**
Median Survival 11 years	
97 - 144 hours:	**89% at 1 year**
Mean Survival 8.76 years	**75% at 5 years**
(SE=0.29; 95% CI: 8.19, 9.33)	**60% at 10 years**
Median Survival approx. 12 years	
≥145 hours:	**87% at 1 year**
Mean Survival 8.18 years	**73% at 5 years**
(SE=0.40; 95% CI: 7.39, 8.97)	**47% at 10 years**
Median Survival 10 years	

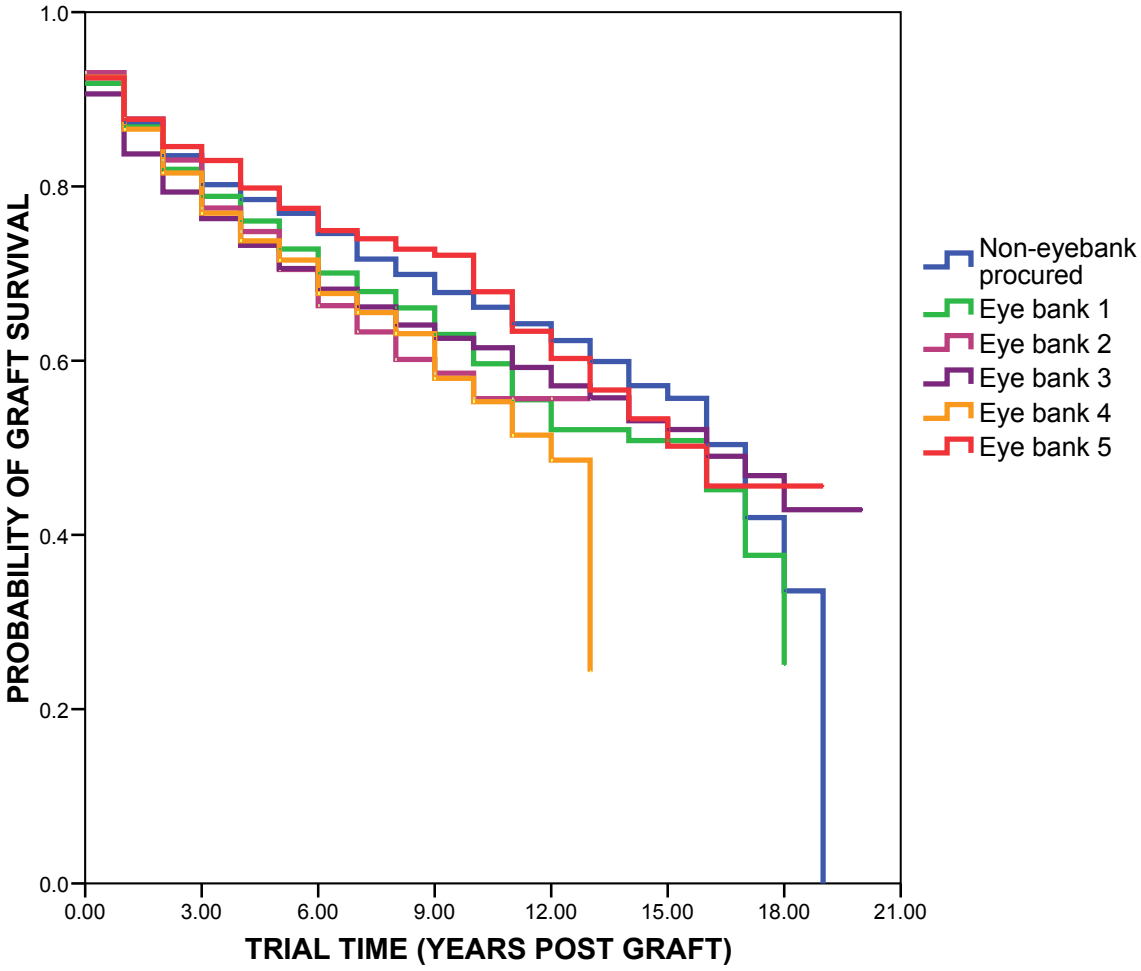
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

2.6 DONOR PROCUREMENT SOURCE

Figure 2.10 shows the influence of donor procurement source on corneal graft survival (Log Rank Statistic=19.24; df=5; p<0.002). For the Kaplan-Meier curve below, the Eye Banks have been de-identified. Procurement sources included the Eye Banks in SA (n=2004), QLD (n=1471), NSW (n=4439), WA (n=1233) and VIC (n=2500, including 60 corneas procured from Victorian Forensic Pathology) and corneas that were privately procured, years ago, by the operating surgeon (n= 1703). Where a surgeon did not appear to have recorded an eye bank number, the graft was included with the eye bank of the State where it was sourced.

Figure 2.10 Corneal procurement source (penetrating grafts only)



Number at Risk

Identity	Graft survival (at years post-graft)				
	1	5	10	15	20
Non eye bank	.873	.769	.661	.557	n/a
Eye bank 1	.868	.728	.596	.452	n/a
Eye bank 2	.877	.705	.556	n/a	n/a
Eye bank 3	.837	.706	.615	.521	n/a
Eye bank 4	.866	.716	.553	n/a	n/a
Eye bank 5	.876	.775	.679	.502	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
DONOR CORNEA PROCUREMENT SOURCE

Private procurement:	**87% at 1 year**
Mean Survival 12.74 years	**77% at 5 years**
(SE=0.26; 95% CI: 12.24, 13.24)	**66% at 10 years**
Median Survival 17 years	**56% at 15 years**
Eye bank 1:	**87% at 1 year**
Mean Survival 11.59 years	**73% at 5 years**
(SE=0.23; 95% CI: 11.15, 12.04)	**60% at 10 years**
Median Survival 16 years	**45% at 15 years**
Eye bank 2:	**88% at 1 year**
Mean Survival 9.02 years	**70% at 5 years**
(SE=0.26; 95% CI: 8.52, 9.52)	**56% at 10 years**
Median Survival approx. 13 years	
Eye bank 3:	**84% at 1 year**
Mean Survival 12.55 years	**70% at 5 years**
(SE=0.31; 95% CI: 11.94, 13.16)	**61% at 10 years**
Median Survival 16 years	**52% at 15 years**
Eye bank 4:	**87% at 1 year**
Mean Survival 8.92 years	**72% at 5 years**
(SE=0.17; 95% CI: 8.60, 9.25)	**55% at 10 years**
Median Survival 12 years	
Eye bank 5:	**88% at 1 year**
Mean Survival 12.87 years	**77% at 5 years**
(SE=0.41; 95% CI: 12.07, 13.67)	**68% at 10 years**
Median Survival 16 years	**50% at 15 years**

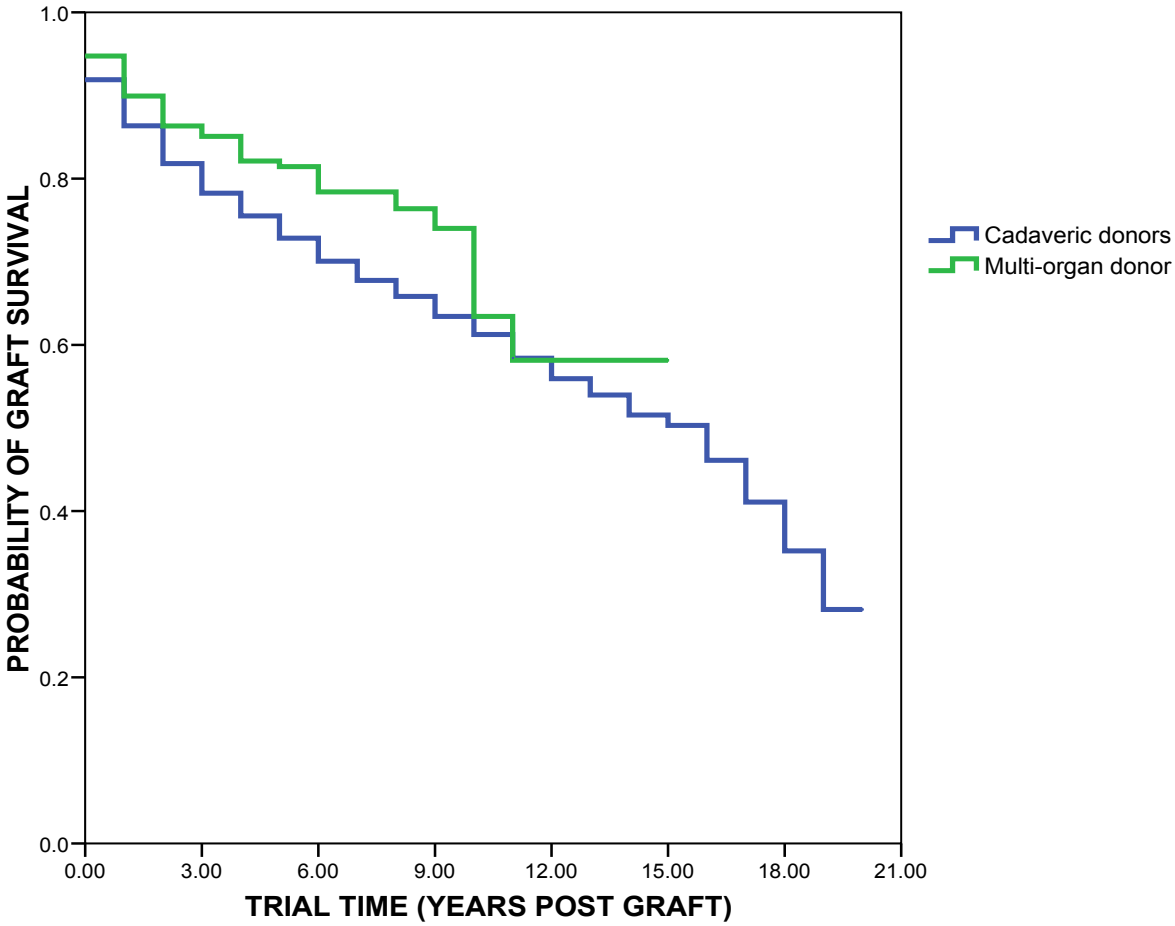
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

2.7 MULTI-ORGAN DONORS

One thousand, one hundred and forty seven corneas, representing 6% of those registered, were collected from multi-organ donors and used for 1108 penetrating, 32 lamellar and 7 limbal grafts. Follow-up after graft has been recorded for 760 penetrating grafts, 18 lamellar grafts and 6 limbal grafts. Figure 2.11 shows the survival curve for the 760 penetrating grafts for which follow-up is available (Log Rank Statistic=12.84; df=1; p=0.0003). Graft survival is significantly better for corneas retrieved from multi-organ donors than from cadaveric donors.

Figure 2.11 Multi-organ donors (penetrating grafts only)



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Cadaveric donors	12590	4908	2292	1092	524	165	28	n/a
Multi-organ donors	760	275	80	32	5	0	**n/a**	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Cadaveric donors	12590	.863	.728	.612	.503	n/a
Multi-organ donors	760	.899	.814	.634	n/a	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
MULTI-ORGAN DONORS

Cadaveric donors:	**86% at 1 year**
Mean Survival 12.36 years	**73% at 5 years**
(SE=0.15; 95% CI: 12.05, 12.66)	**62% at 10 years**
Median Survival 16 years	**50% at 15 years**
Multi-organ donors:	**90% at 1 year**
Mean Survival 11.23 years	**81% at 5 years**
(SE=0.45; 95% CI: 10.35, 12.10)	**63% at 10 years**
Median Survival approx. 15 years	

KEY: n/a = not applicable
SE = standard error
CI = confidence interval
df = degrees of freedom
p = probability

2.7.1 Multi-Organ Donors vs Cadaveric donors

Tables 2.6, 2.7, 2.8, and 2.9 compare gender, age, cause of death, death-to-enucleation times and death-to-graft times of multi-organ donors and cadaveric donors. Multi-organ donors tend to be relatively younger than cadaveric donors, and are more likely to have died from cerebrovascular disease or trauma/accident/poisoning.

Table 2.6 Gender of multi-organ donors

	Multi-organ donors		Cadaveric donors	
Gender	**No. of eyes**	**%**	**No. of eyes**	**%**
Male	635	55%	10410	61%
Female	492	43%	5778	34%
Unknown to ACGR	20	2%	870	5%
Total	**1147**	**100%**	**17058**	**100%**

Figure 2.12 Age of multi-organ donors

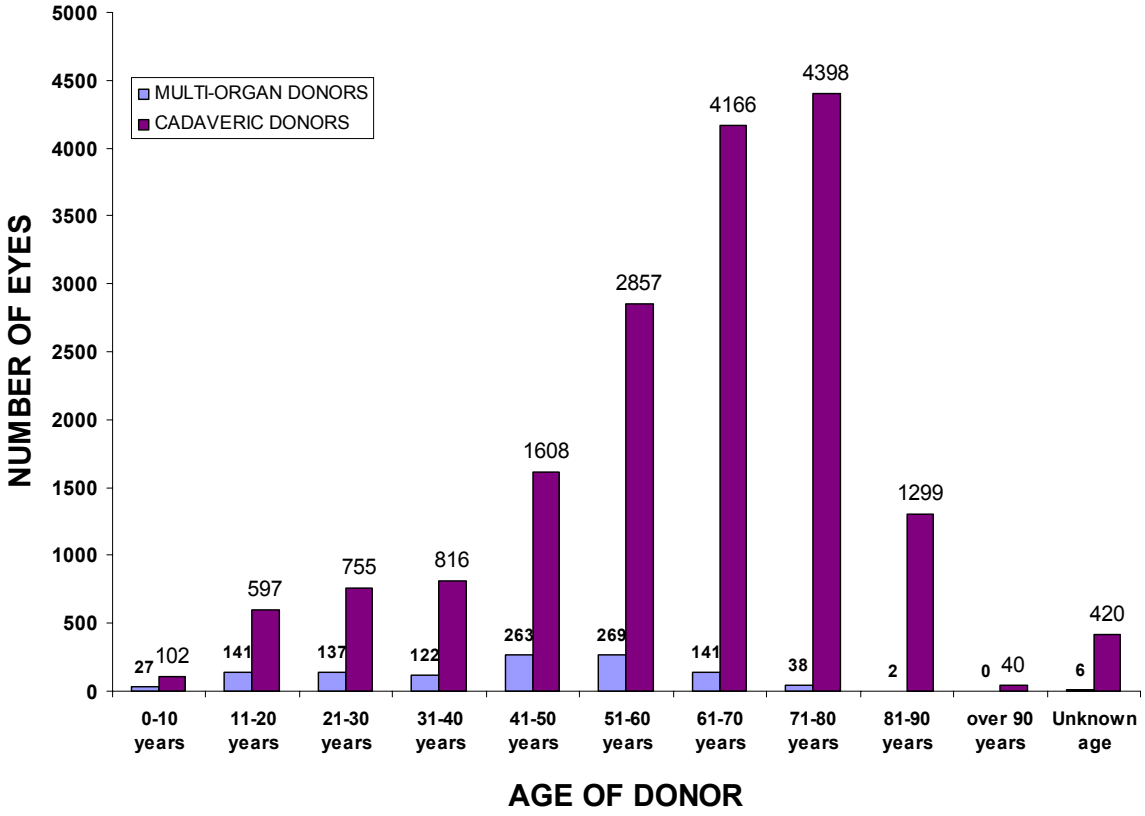


Figure 2.13 Cause of death of multi-organ donors

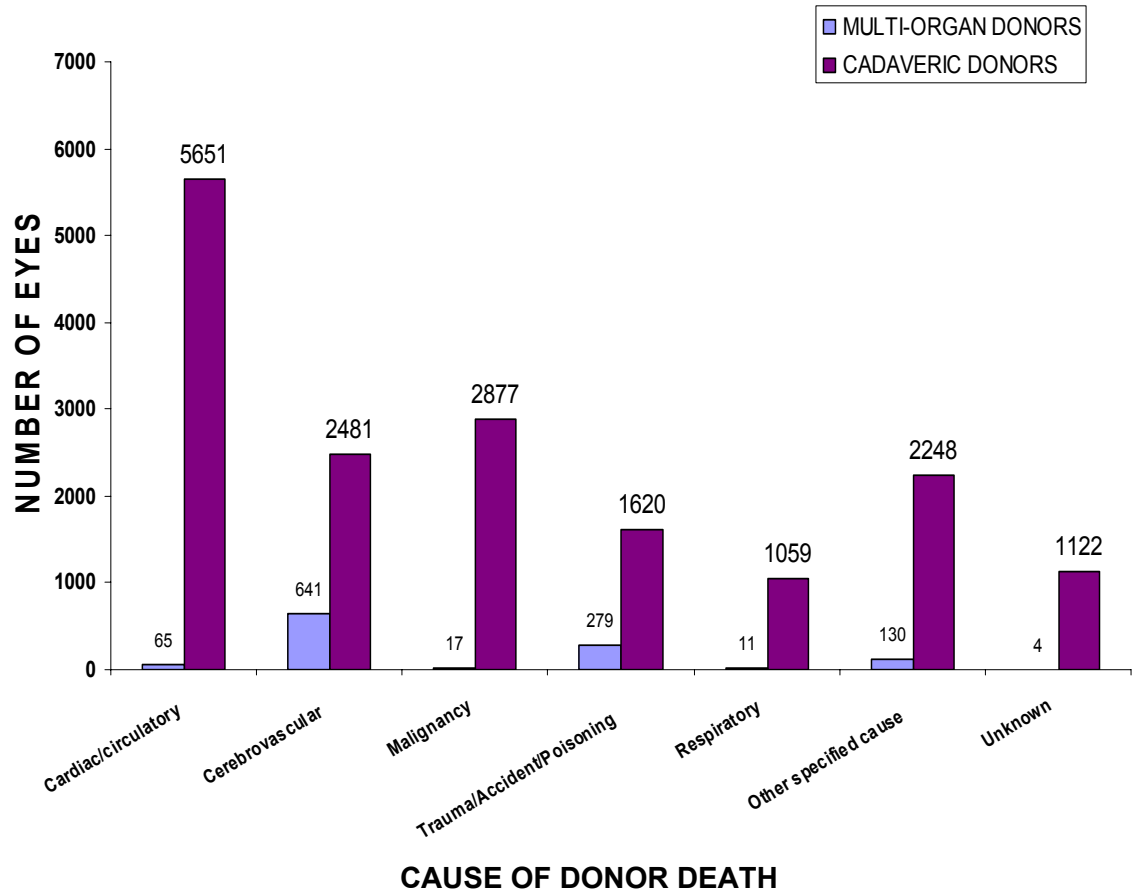


Table 2.9 Death-to-enucleation and death-to-graft times for multi-organ donors

	Multi-organ donors		Cadaveric donors	
	Death-to-enucleation time	**Death-to-graft time**	**Death-to - enucleation time**	**Death-to-graft time**
Median time (hours)	2	66	6	69
Range (hours)	1-23	3-802	1-59	2-1104
Total number of grafts for which data are available	**1127/1147**	**904/1147**	**16589/17058**	**14402/17058**

2.8 PRIMARY NON-FUNCTIONING GRAFTS

Grafts that fail to clear in the early post-operative period are considered to be primary non-functioning grafts (PNFs).

Thus far, 137 PNFs have been recorded by 60 surgeons, out of 14158 grafts that have been followed. This number represents penetrating, lamellar and limbal grafts. Of these, only 3 ‘pairs’ of cornea (from the same donor), representing 6 primary non-functioning grafts, have been recorded by the Australian Corneal Graft Registry. The remaining 131 primary non-functioning grafts were from separate donors.

Table 2.10 shows features of corneas used in primary non-functioning grafts.

Table 2.10 Features of primary non-functioning grafts

Feature	No.	%
Procurement source:		
Private:	**9**	**7%**
Eyebank:	**128**	**93%**
1	75	55%
4	23	17%
3	17	12%
5	6	4%
2	7	5%
Death to enucleation times		
≤6 hours	65	47%
>6 hours	67	49%
Not known to ACGR	5	4%
Storage medium		
CSM	51	37%
Optisol	47	34%
MK medium	27	20%
Moistpot	6	5%
K-Sol	3	2%
Unknown to ACGR	3	2%
Donor age		
≤7 years	1	<1%
>80 years	11	8%
Main indication for graft		
Keratoconus (inc hydrops)	37	27%
Pseudophakic bullous keratopathy	36	26%
Previous failed graft	21	15%
Aphakic bullous keratopathy	9	7%
Fuchs' dystrophy	7	5%
Scars	7	5%
Interstitial keratitis/abscess	3	2%
Peters' anomaly	2	1%
Perforation	5	4%
Miscellaneous	10	7%
Total corneas	**137**	**100%**

2.9 SUMMARY OF DONOR AND EYE-BANKING INFORMATION

- The most common cause of donor death related to diseases of the cardiac/circulatory system, followed by strokes and other haemorrhages, and malignancy. No influence of cause of donor death on graft survival was observed, other than that corneas collected from victims of traumatic or accidental death appeared to show improved survival. However, such corneas were preferentially used for recipients with keratoconus.

- Corneas used for transplantation were collected from men and women in the ratio of approximately 1.8:1.

- Approximately 65% of corneas were retrieved from donors aged 51-80 years at the time of death. Donor age exerted no influence on survival of grafts performed for keratoconus, but for all other indications for penetrating keratoplasty, better survival was achieved with corneas from younger donors, at least in univariate analysis.

- Median death-to-enucleation time for penetrating grafts was 6 hours. Median death-to-graft time was 62 hours. Neither death-to-enucleation nor death-to-graft time affected corneal graft survival significantly.

- Most corneas are currently stored in Optisol in Eye Banks. Corneal storage time in Optisol does not affect graft survival.

- Over 93% of all corneas used for transplantation were retrieved from non-beating heart donors and 6% from multi-organ donors. The multi-organ donor pool has quite different characteristics from the pool from which the majority of corneas are drawn. In particular, multi-organ donors tended to be younger and were more likely to have died from strokes/haemorrhage or from traumatic or accidental death than cadaveric donors. Corneas from multi-organ donors exhibited better survival after transplantation than did those from cadaveric donors.

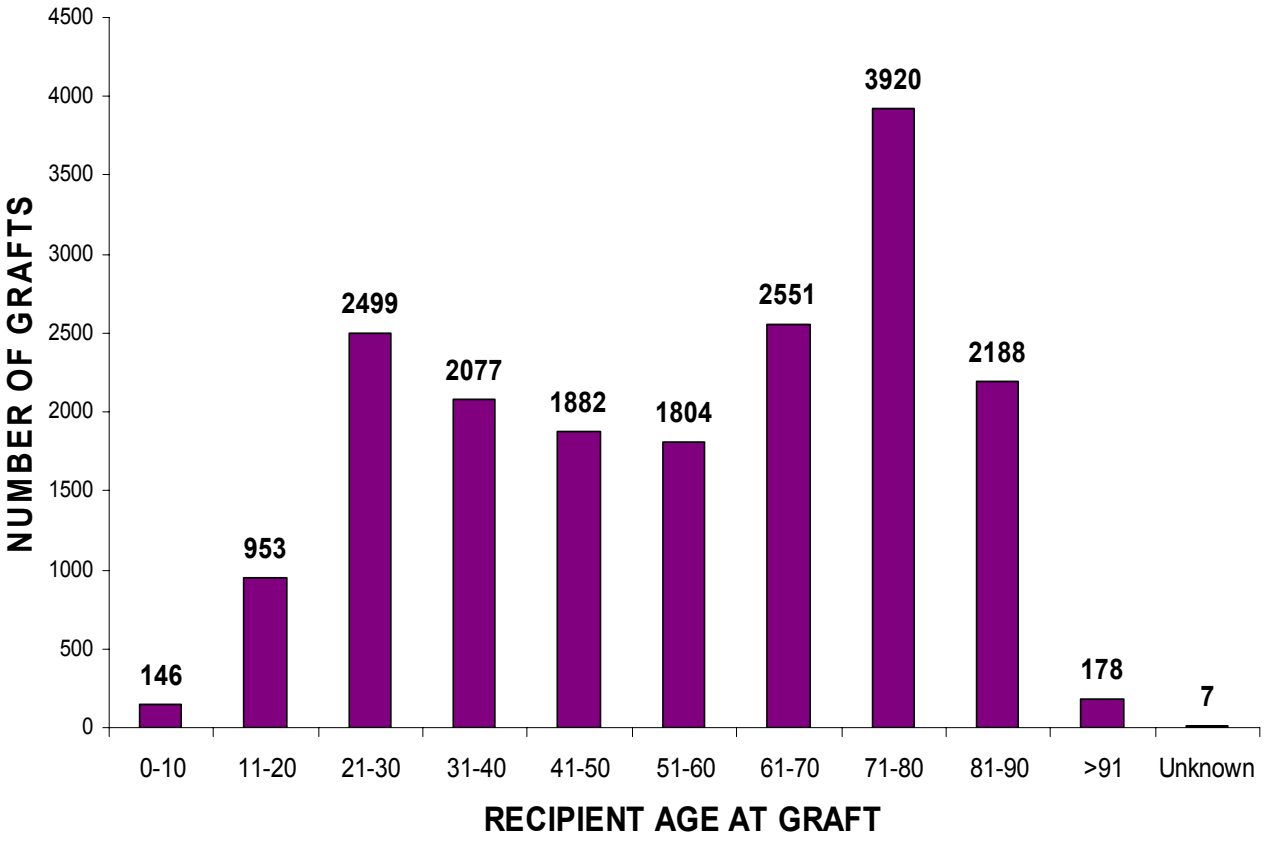
- Less than 1% of all corneas failed to function in the immediate post-operative period.

3. RECIPIENTS

3.1 RECIPIENT AGE AT GRAFT

Recipient age at graft varied from 14 days to 97 years and 5 months with a median age of 59 years. Figure 3.1 shows the spread of recipient ages, with peaks in the 20-40 and 60-80 age ranges.

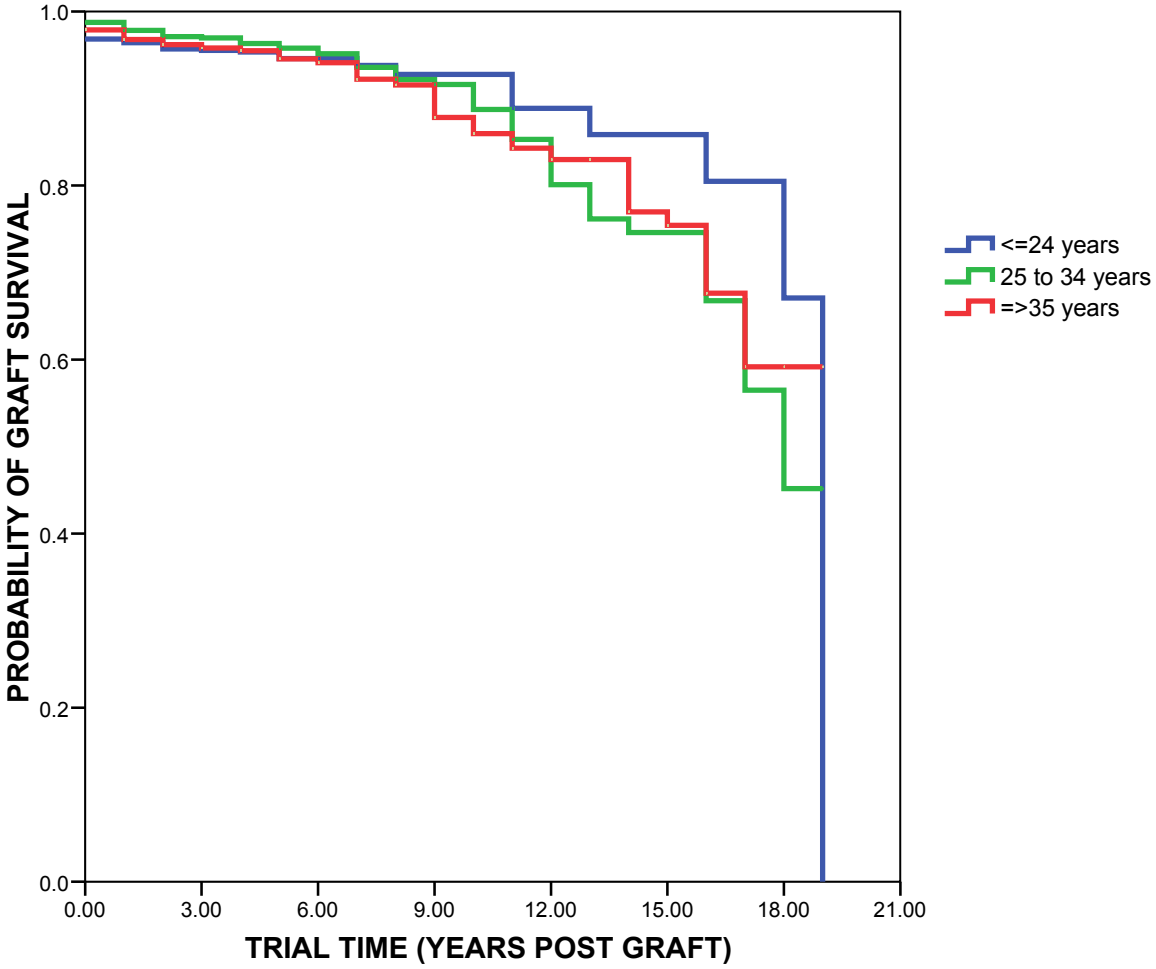
Figure 3.1 Age at graft



Except where indicated, all Kaplan-Meier plots and associated tables in this chapter have been calculated using penetrating grafts only.

Figure 3.2 shows graft survival for all penetrating grafts for keratoconus. Age at graft appears to have no significant effect on survival in this cohort (Log Rank Statistic=0.93; df=2; p= 0.6279).

Figure 3.2 Recipient age (keratoconus only)



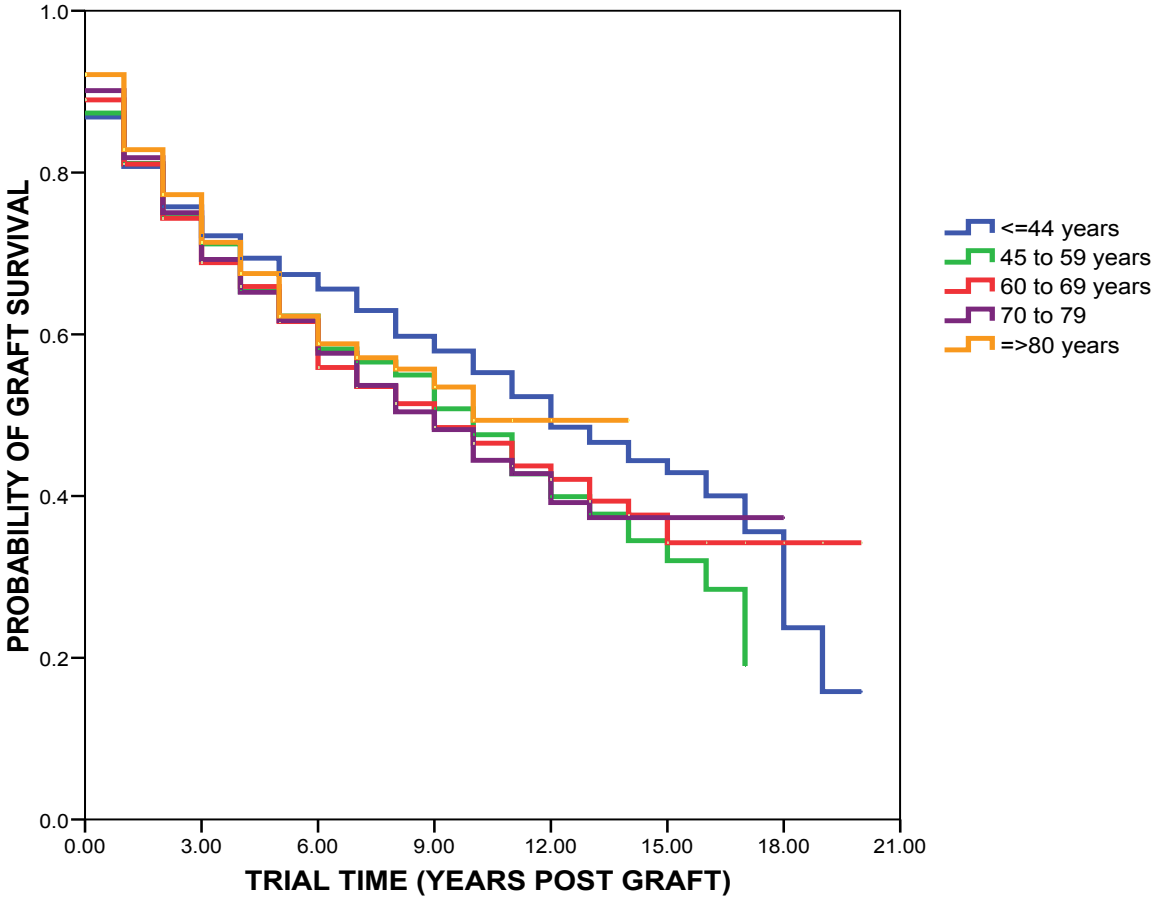
Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
≤24 years	1298	615	296	146	72	25	6	n/a
25 - 34 years	1358	597	300	160	82	31	5	n/a
≥35 years	1510	748	428	244	128	50	7	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
≤24 years	1298	.964	.946	.889	.805	n/a
25 - 34 years	1358	.978	.958	.887	.805	n/a
≥35 years	1510	.968	.946	.860	.754	n/a

Figure 3.3 shows graft survival for all penetrating grafts excluding keratoconus. The majority of recipients grafted for reasons other than keratoconus are aged over 70 years at the time of transplantation. Age at graft appears to have no significant effect on graft survival when keratoconus is excluded (Log Rank Statistic=8.09; df=4; p=0.0885).

Figure 3.3 Recipient age (keratoconus excluded)



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
≤44 years	1324	509	261	131	69	30	6	n/a
45 - 59 years	1400	549	260	146	61	14	0	n/a
60 - 69 years	1687	693	336	158	79	11	3	n/a
70 - 79 years	2916	1039	382	115	36	6	1	n/a
≥80 years	1852	432	109	25	2	n/a	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
≤44 years	1324	.807	.674	.553	.429	n/a
45 - 59 years	1400	.811	.623	.476	.320	n/a
60 - 69 years	1687	.810	.616	.465	.342	n/a
70 - 79 years	2916	.818	.617	.444	n/a	n/a
≥80 years	1852	.828	.622	.494	n/a	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
RECIPIENT AGE; KERATOCONUS ONLY

Aged ≤24 years:	**96% at 1 year**
Mean Survival 17.05 years	**95% at 5 years**
(SE=0.31; 95% CI: 16.44, 17.65)	**89% at 10 years**
Median Survival 19 years	**80% at 15 years**
Aged 25 to 34 years:	**98% at 1 year**
Mean Survival 16.03 years	**96% at 5 years**
(SE=0.36; 95% CI: 15.34, 16.73)	**89% at 18 years**
Median Survival 18 years	**80% at 15 years**
Aged ≥35 years:	**97% at 1 year**
Mean Survival 16.17 years	**95% at 5 years**
(SE=0.29; 95% CI: 15.60, 16.74)	**86% at 10 years**
Median Survival approx. 17 years	**75% at 15 years**

PENETRATING CORNEAL GRAFT SURVIVAL
RECIPIENT AGE; EXCLUDING KERATOCONUS

Aged ≤44 years:	**81% at 1 year**
Mean Survival 11.04 years	**67% at 5 years**
(SE=0.38; 95% CI: 10.30, 11.77)	**55% at 10 years**
Median Survival 12 years	**43% at 15 years**
Aged 45 - 59 years:	**81% at 1 year**
Mean Survival 9.25 years	**62% at 5 years**
(SE=0.28; 95% CI: 8.71, 9.79)	**48% at 10 years**
Median Survival 10 years	**32% at 15 years**
Aged 60 - 69 years:	**81% at 1 year**
Mean Survival 10.30 years	**62% at 5 years**
(SE=0.36; 95% CI: 9.61, 11.00)	**46% at 10 years**
Median Survival 9 years	**34% at 15 years**
Aged 70 - 79 years:	**82% at 1 year**
Mean Survival 9.66 years	**62% at 5 years**
(SE=0.29; 95% CI: 9.10, 10.22)	**44% at 10 years**
Median Survival 9 years	
Aged ≥80 years:	**83% at 1 year**
Mean Survival 8.76 years	**62% at 5 years**
(SE=0.31; 95% CI: 8.15, 9.37)	**49% at 10 years**
Median Survival 10 years	

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

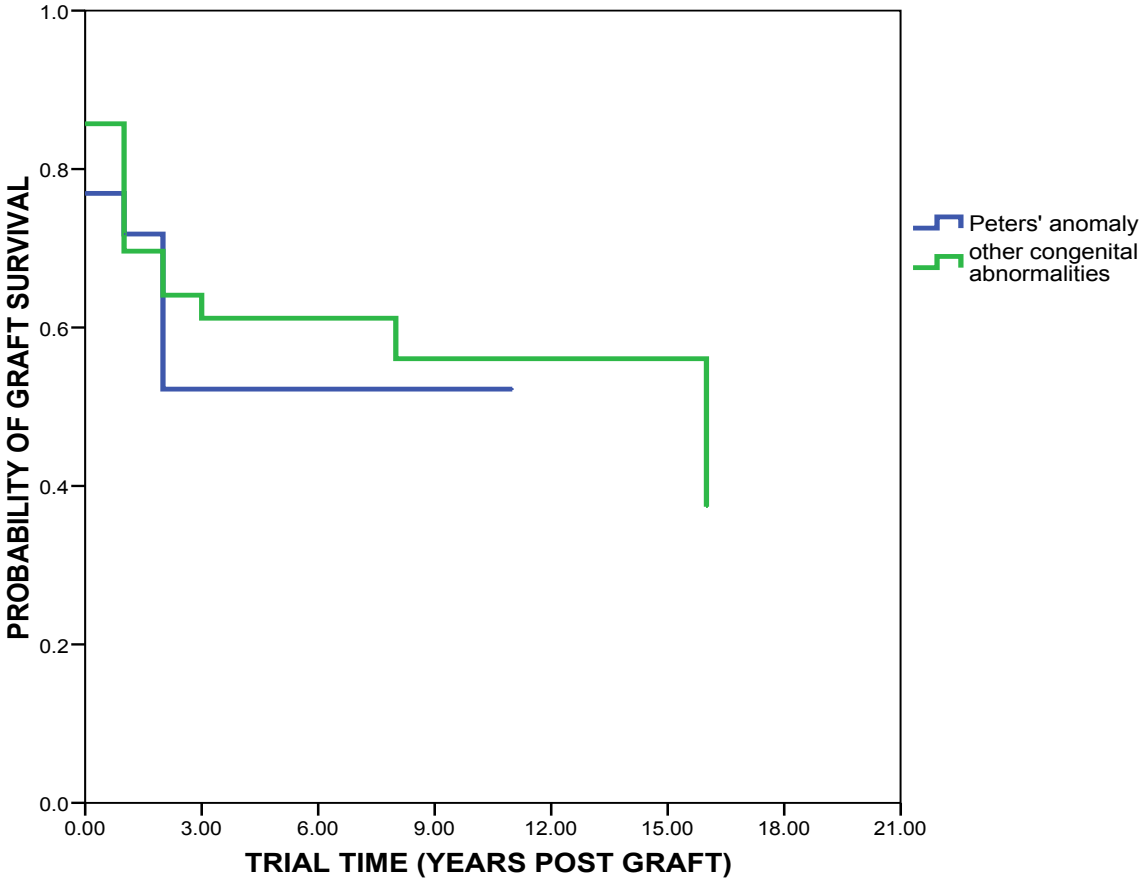
3.1.1 Infant, child and adolescent recipients

3.1.1.1 Congenital abnormalities

Eighty nine *first* ipsilateral grafts were performed for congenital abnormalities, including Peters' anomaly (26), congenital glaucoma (19), aniridia (16), congenital cataract (13), congenital opacities (5), anterior segment anomalies (3), limbal dysplasia (1), congenital endothelial dystrophy (2), anophthalmos (1) and unspecified anomaly (3).

Figure 3.4 shows the effect of Peters' anomaly or other congenital abnormality as the indication for graft (Log Rank Statistic=0.38; df=1; p=0.5394). Corneal grafts for these conditions were performed at any age, not just during childhood.

Figure 3.4 Peters' anomaly or other congenital abnormalities (overall first grafts only)



Number at Risk

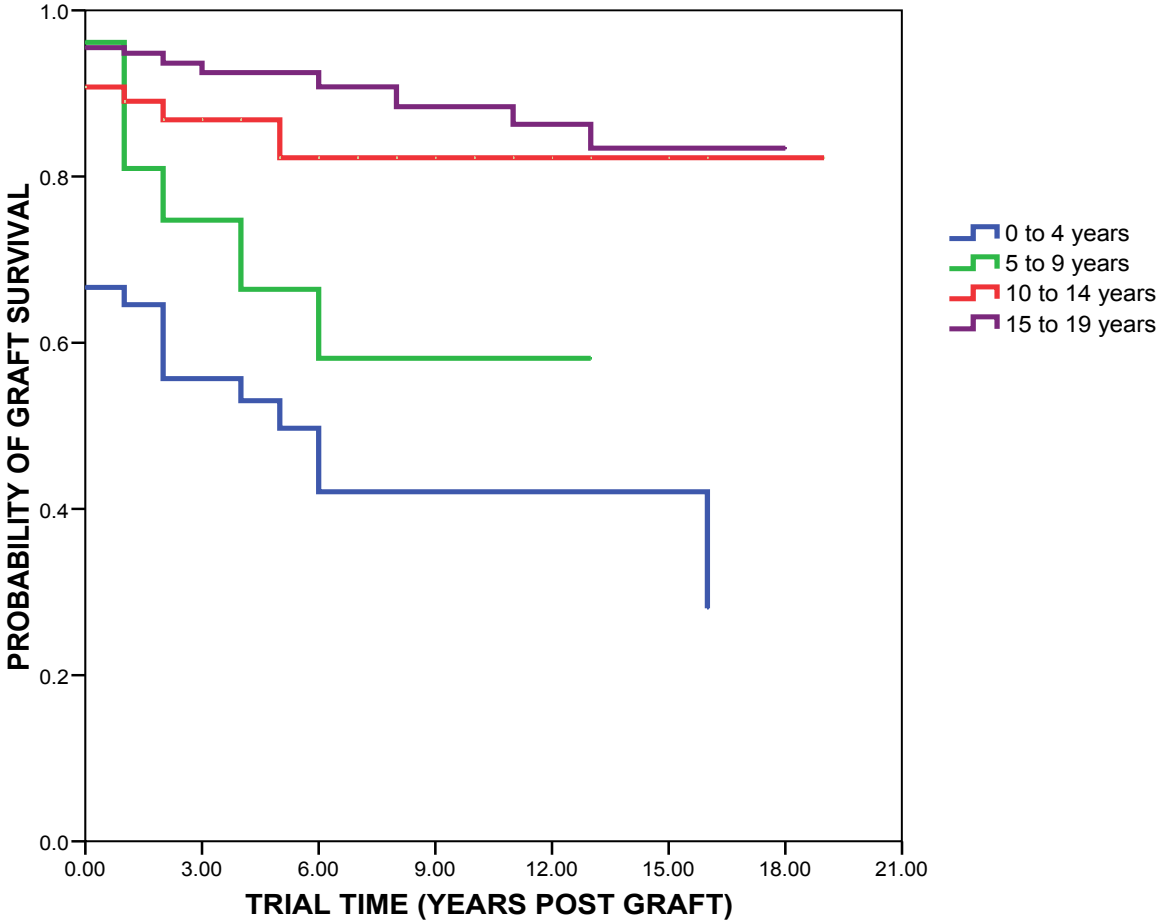
Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Peters' anomaly	26	6	1	n/a	n/a	n/a	n/a	n/a
Other congenital abnormalities	63	22	14	9	7	4	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	2	8	15	20
Peters' anomaly	26	.709	.516	n/a	n/a	n/a
Other congenital abnormalities	63	.698	.642	.562	.375	n/a

3.1.1.2 Paediatric recipients

The Registry database has records of 710 penetrating graft recipients who were under the age of 20 years at the time of graft and who have been followed since graft. Figure 3.5 shows graft survival of recipients under the age of 20 years at the time of graft in 5 year blocks (Log Rank Statistic=87.86; df=3; p<0.0001). Recipients under 4 years old appear to have a significantly poorer graft survival rate than older recipients whilst those over 14 years appear to have a significantly better graft survival rate.

Figure 3.5 Paediatric recipients



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
0 – 4 years	63	23	13	8	7	4	n/a	n/a
5 – 9 years	26	10	8	5	3	n/a	n/a	n/a
10 – 14 years	130	67	28	14	5	3	n/a	n/a
15 – 19 years	491	246	108	61	34	8	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
0 – 4 years	63	.646	.497	.421	.280	n/a
5 – 9 years	26	.810	.664	n/a	n/a	n/a
10 – 14 years	130	.891	.823	n/a	n/a	n/a
15 – 19 years	491	.948	.908	.863	n/a	n/a

FIRST OVERALL CORNEAL GRAFT SURVIVAL
CONGENITAL ABNORMALITIES

Peters' anomaly:	**71% at 1 year**
Mean Survival 6.11 years	**52% at 2 years**
(SE=1.16; 95% CI: 3.84, 8.38)	
Median Survival approx. 5 years	
Congenital abnormality:	**70% at 1 year**
Mean Survival 9.76 years	**64% at 2 years**
(SE=1.09; 95% CI: 7.63, 11.90)	**56% at 8 years**
Median Survival 16 years	**37% at 15 years**

PENETRATING CORNEAL GRAFT SURVIVAL
PAEDIATRIC RECIPIENTS

Aged 0 - 4 years:	**65% at 1 year**
Mean Survival 7.66 years	**50% at 5 years**
(SE=1.09; 95% CI: 5.53, 9.79)	**42% at 10 years**
Median Survival 5 years	**28% at 15 years**
Aged 5 - 9 years:	**81% at 1 year**
Mean Survival 8.66 years	**66% at 5 years**
(SE=1.31; 95% CI: 6.10, 11.22)	
Median Survival approx. 7 years	
Aged 10 - 14 years:	**89% at 1 year**
Mean Survival 15.92 years	**82% at 5 years**
(SE=0.70; 95% CI: 14.54, 17.30)	
Median Survival approx. 16 years	
Aged 15 - 19 years:	**95% at 1 year**
Mean Survival 15.98 years	**91% at 5 years**
(SE=0.36; 95% CI: 15.27, 16.69)	**86% at 10 years**
Median Survival approx. 18 years	

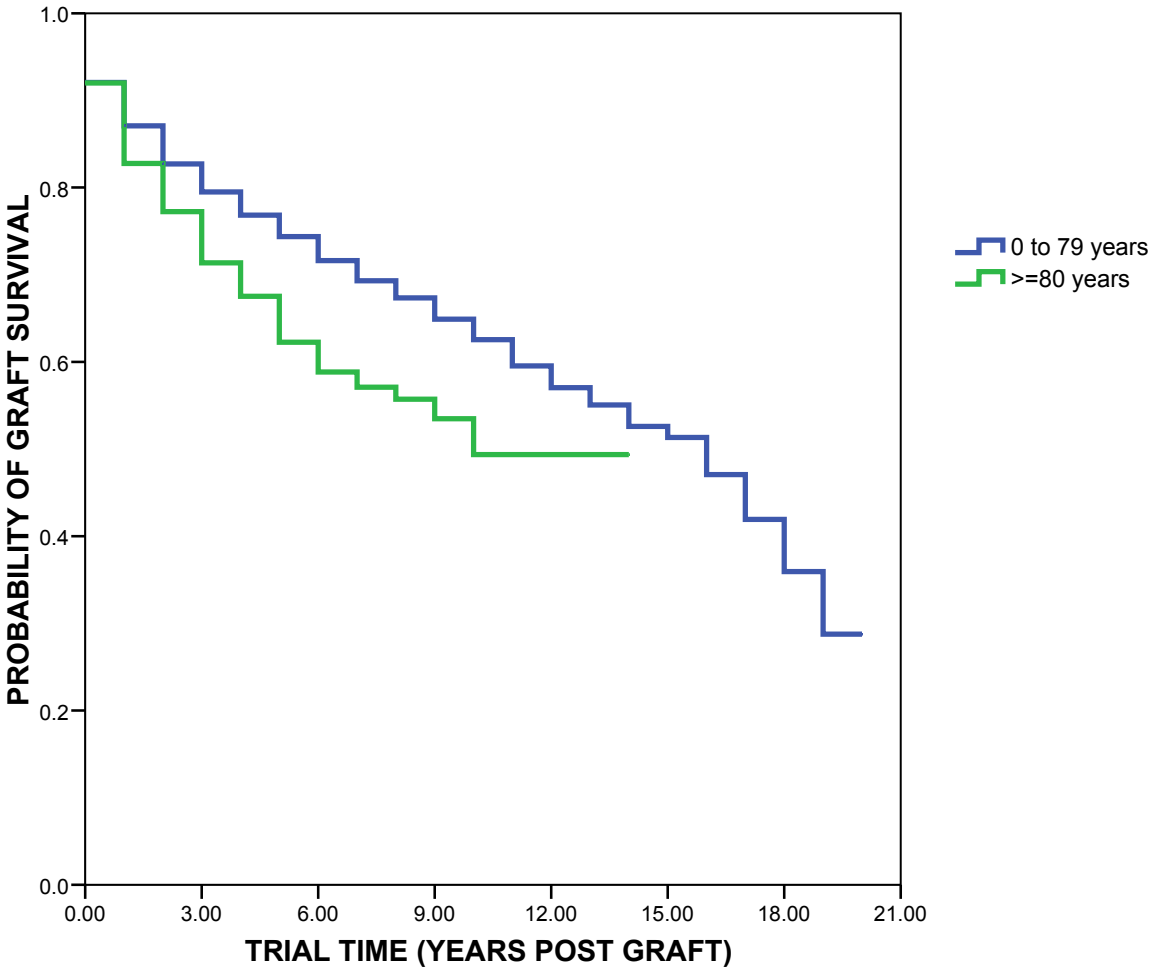
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

3.1.2 Elderly recipients

The Registry database has records of 1,863 penetrating graft recipients who were over the age of 80 years at the time of graft and who have been followed since graft. Figure 3.6 compares graft survival of those recipients under 80 years of age at the time of graft with recipients over 80 years of age at time of graft (Log Rank Statistic=34.27; df=1; p<0.0001). Recipients over 80 years old appear to have a significantly poorer survival rate than younger recipients. However, as shown in figure 3.7, when stratified in groups of 80-84 years, 85-89 years and 90 years of age and over at time of graft (Log Rank Statistic=0.39; df=2; p=0.8228) the survival rate is not significantly different over this age.

Figure 3.6 Elderly recipients compared to younger recipients

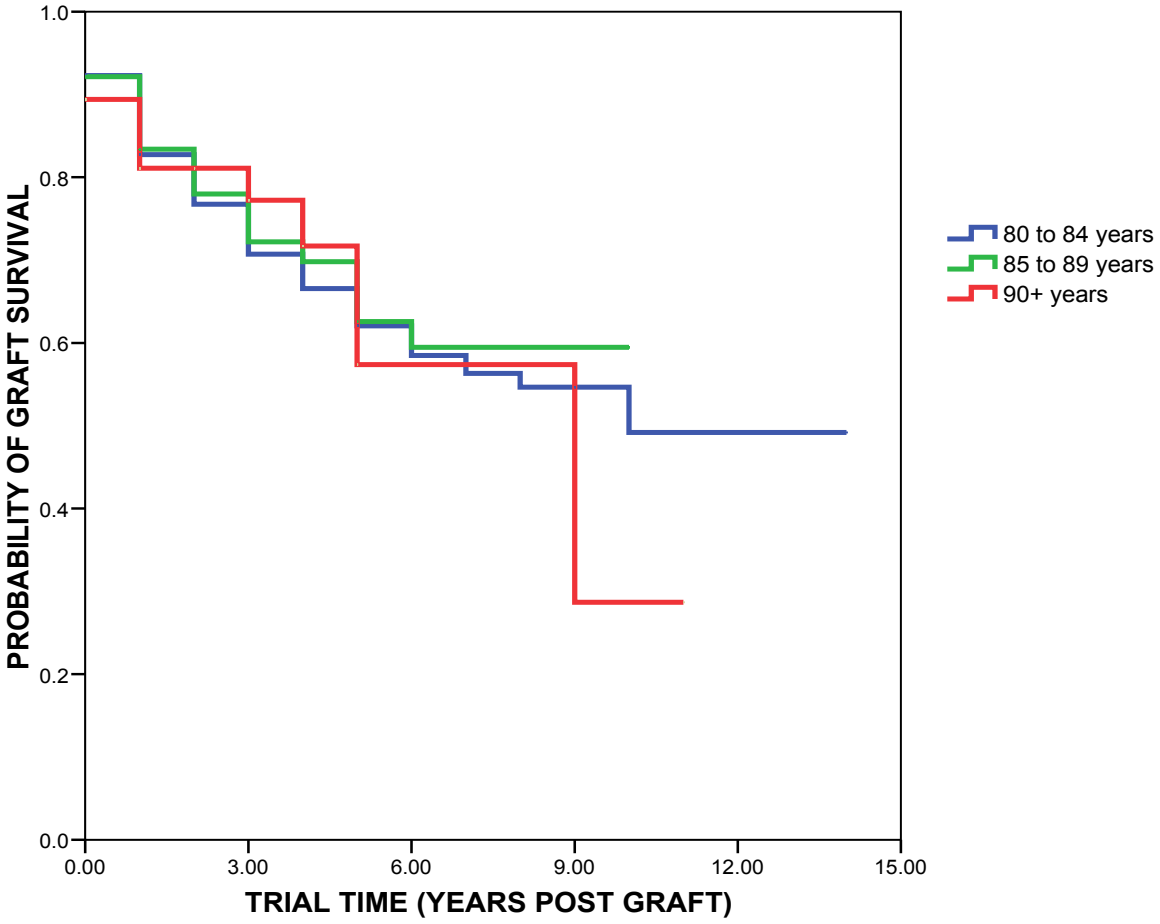


Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
0 to 79 years	11482	4748	2263	1099	527	167	28	n/a
≥80 years	1863	434	109	25	2	n/a	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
0 to 79 years	11482	.871	.744	.625	.513	n/a
≥80 years	1863	.828	.623	.494	n/a	n/a

Figure 3.7 Elderly recipients (over 80 years of age at graft)



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years
≥80 & <85 years	1177	305	87	10	2	n/a
≥85 & <90 years	535	108	20	4	n/a	n/a
≥90 years	151	21	2	1	0	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)			
		1	5	10	15
≥80 & <85 years	1177	.827	.620	.492	n/a
≥85 & <90 years	535	.834	.626	n/a	n/a
≥90 years	151	.811	.574	n/a	n/a

Of the 151 recipients over 90 years of age, 125 received a first graft and 26 were being regrafted. A total of 28 grafts (19%) in the over 90 age group have failed. Of the 26 regrafts, 11 have failed.

The most common indication for graft in the over 90 age group was pseudophakic bullous keratopathy (52%). The most common cause of graft failure was rejection (33%). Of the 151 recipients over 90 years of age at time of graft, the longest recorded survival time is 11 years, with the patient still alive at the last follow-up. Of the 123 surviving grafts in this group, 71 patients were still alive at the last follow-up. Of the 54 graft recipients recorded as having died, all except 2 died with functioning grafts.

PENETRATING CORNEAL GRAFT SURVIVAL
YOUNGER VERSUS ELDERLY RECIPIENTS

<80 years of age:	**87% at 1 year**
Mean Survival 12.57 years	**74% at 5 years**
(SE=0.16; 95% CI: 12.27, 12.88)	**62% at 10 years**
Median Survival 16 years	**51% at 15 years**
≥80 years of age:	**83% at 1 year**
Mean Survival 8.76 years	**62% at 5 years**
(SE=0.31; 95% CI: 8.15, 9.36)	**49% at 10 years**
Median Survival 10 years	

PENETRATING CORNEAL GRAFT SURVIVAL
VERY ELDERLY RECIPIENTS

≥80 & <85 years of age:	**83% at 1 year**
Mean Survival 8.72 years	**62% at 5 years**
(SE=0.36; 95% CI: 8.02, 9.42)	**49% at 10 years**
Median Survival 10 years	
≥85 & <90 years of age:	**83% at 1 year**
Mean Survival 6.96 years	**63% at 5 years**
(SE=0.32; 95% CI: 6.33, 7.58)	
Median Survival approx. 8 years	
≥90 years of age:	**81% at 1 year**
Mean Survival 6.87 years	**57% at 5 years**
(SE=0.88; 95% CI: 5.15, 8.60)	
Median Survival 9 years	

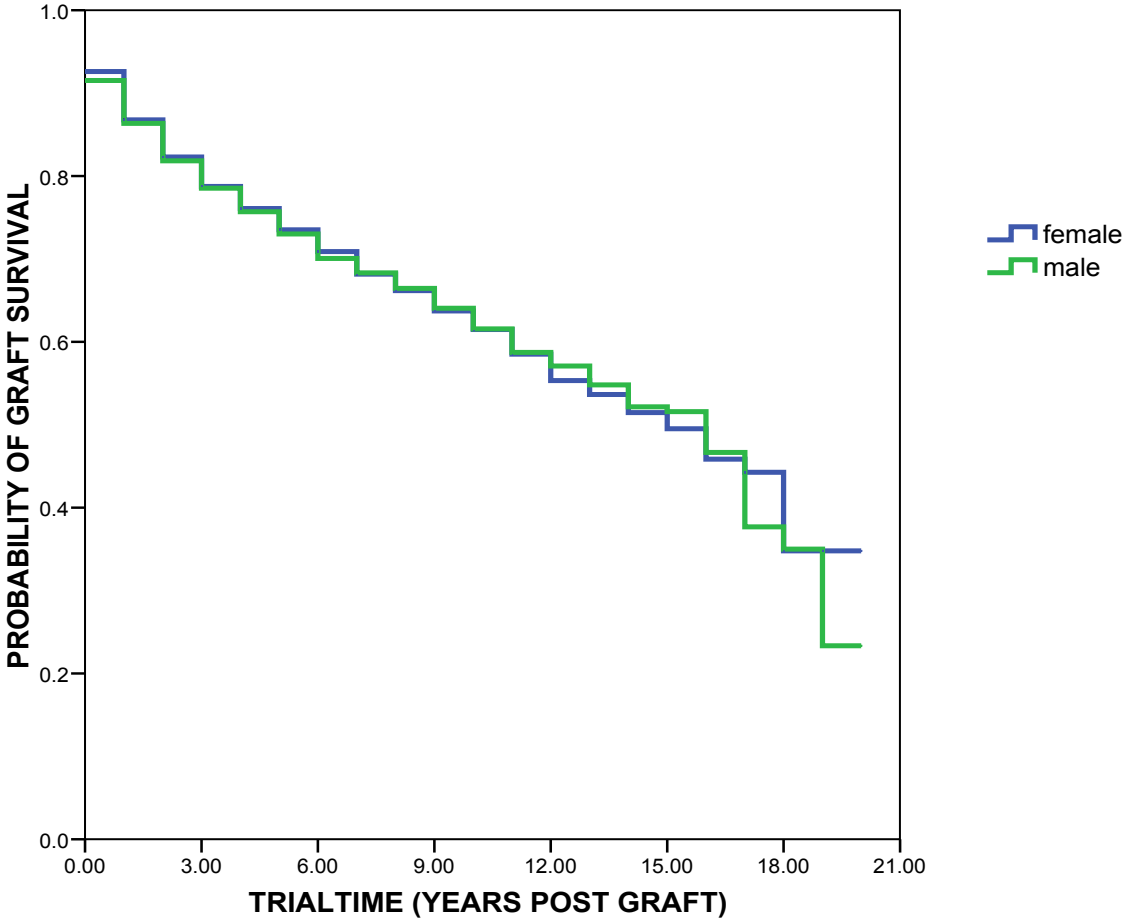
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

3.2 RECIPIENT GENDER

Thus far, 8728 males and 8362 females have received penetrating grafts, 619 males and 394 females have received lamellar grafts, and 67 males and 35 females have received limbal grafts. Figure 3.7 shows the influence of recipient gender on penetrating corneal graft survival (Log Rank Statistic=0.35; df=1; p=0.5561). Gender plays no significant role in graft survival overall.

Figure 3.8 Recipient gender



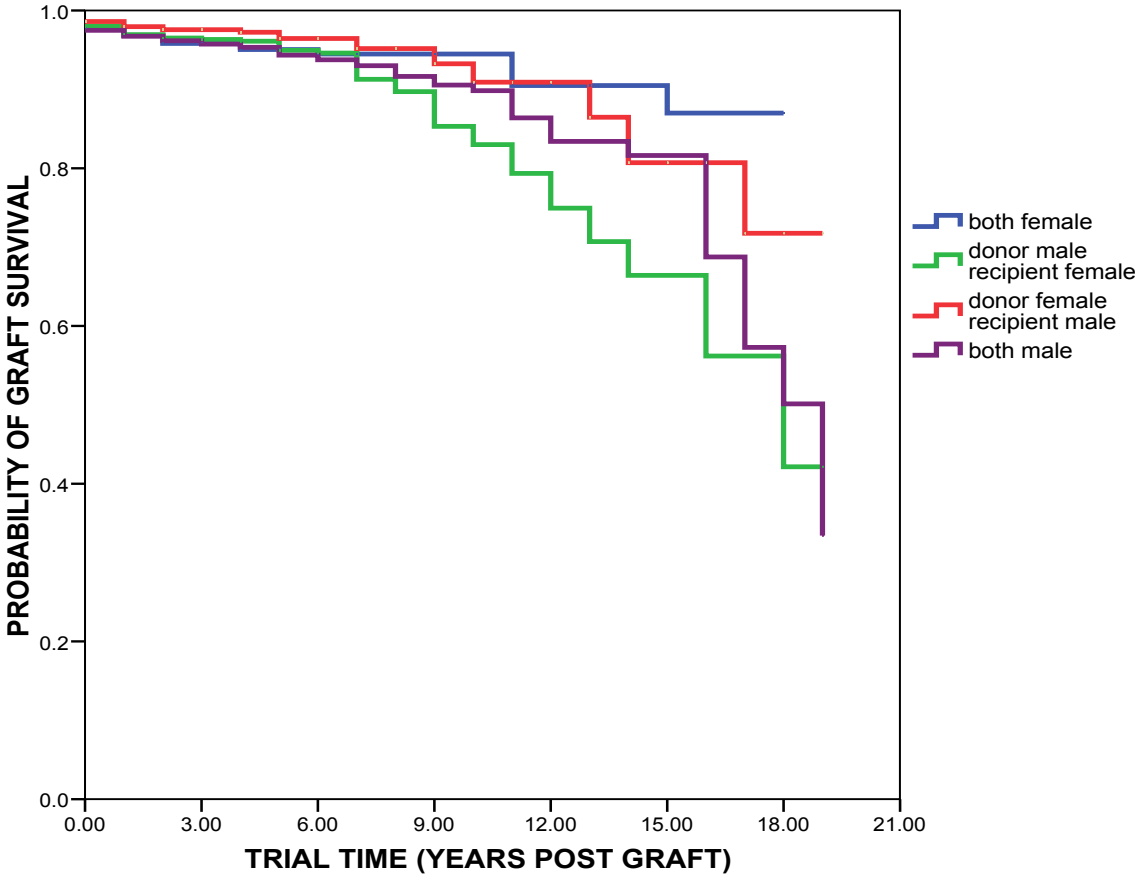
Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Female	6605	2663	1235	594	276	79	14	n/a
Male	6745	2516	1137	530	253	88	14	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Female	6605	.868	.735	.615	.495	n/a
Male	6745	.864	.730	.616	.516	n/a

Figures 3.9 and 3.10 examine the influence of donor-recipient gender match. Figure 3.9 compares survival of penetrating grafts performed for keratoconus, stratified according to the gender of donor and recipient. A significant effect becomes apparent when genders were mismatched (Log Rank Statistic=12.72; df=3; p=0.0053). The significant difference in p value appears to be due to a poorer survival rate when corneas from male donors are used for female recipients. There may be a biological explanation for this.

Figure 3.9 Gender match (keratoconus only)



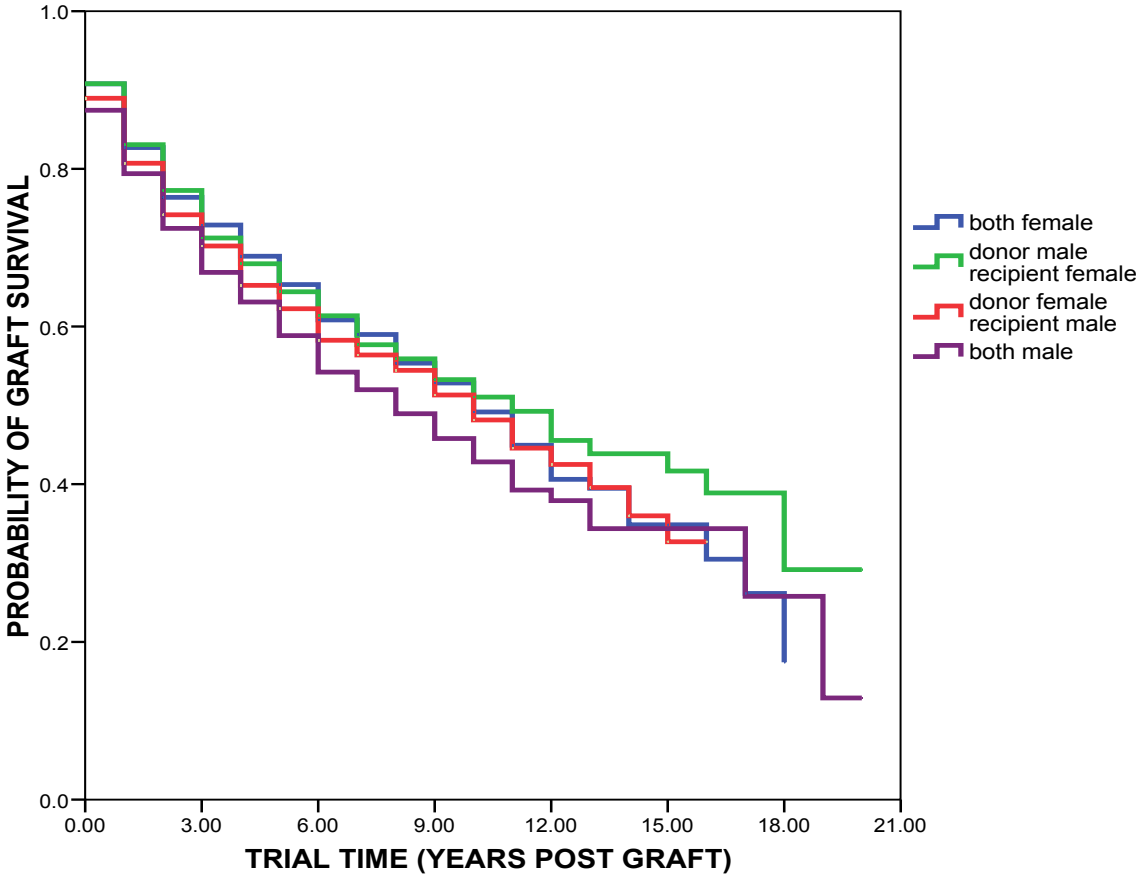
Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Donor & recipient female	591	292	164	100	57	26	2	n/a
Donor male; recipient female	865	382	202	98	53	19	3	n/a
Donor female; recipient male	1013	518	274	143	72	19	4	n/a
Donor & recipient male	1476	645	314	167	87	37	8	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Donor & recipient female	591	.969	.945	.905	.870	n/a
Donor male; recipient female	1013	.969	.949	.830	.562	n/a
Donor female; recipient male	865	.979	.965	.909	.807	n/a
Donor & recipient male	1476	.967	.943	.898	.687	n/a

Figure 3.10 shows survival curves stratified according to donor and recipient gender for all grafts performed for indications *other* than keratoconus (Log Rank Statistic=22.41; df=3; p<0.0001). When indicators other than keratoconus are analysed, poorer survival rates become apparent when both donor and recipient were male.

Figure 3.10 Gender match (keratoconus excluded)



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Donor & recipient female	1692	610	262	110	52	11	3	n/a
Donor male; recipient female	2953	1077	443	192	80	20	4	n/a
Donor female; recipient male	1428	469	203	87	43	11	n/a	n/a
Donor & recipient male	2599	857	343	141	43	17	3	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Donor & recipient both female	1692	.827	.653	.491	.305	n/a
Donor male; recipient female	2953	.831	.644	.511	.417	n/a
Donor female; recipient male	1428	.807	.622	.481	.327	n/a
Donor & recipient both male	2599	.794	.588	.428	.258	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
RECIPIENT GENDER

Female:	**87% at 1 year**
Mean Survival 12.49 years	**73% at 5 years**
(SE=0.21; 95% CI: 12.07, 12.90)	**61% at 10 years**
Median Survival 15 years	**49% at 15 years**
Male:	**86% at 1 year**
Mean Survival 12.34 years	**73% at 5 years**
(SE=0.22; 95% CI: 11.91, 12.78)	**62% at 10 years**
Median Survival 16 years	**52% at 15 years**

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

PENETRATING CORNEAL GRAFT SURVIVAL
GENDER MISMATCH; KERATOCONUS ONLY

Donor & recipient both female:	**97% at 1 year**
Mean Survival 16.72 years	**94% at 5 years**
(SE=0.26; 95% CI: 16.21, 17.22)	**90% at 10 years**
Median Survival approx. 18 years	**87% at 15 years**
Donor male & recipient female:	**97% at 1 year**
Mean Survival 15.35 years	**95% at 5 years**
(SE=0.41; 95% CI: 14.55, 16.15)	**83% at 10 years**
Median Survival 18 years	**56% at 15 years**
Donor female & recipient male:	**98% at 1 year**
Mean Survival 17.10 years	**96% at 5 years**
(SE=0.39; 95% CI: 16.35, 17.86)	**91% at 10 years**
Median Survival approx. 19 years	**81% at 15 years**
Donor & recipient both male:	**97% at 1 year**
Mean Survival 16.27 years	**94% at 5 years**
(SE=0.34; 95% CI: 15.60, 16.94)	**90% at 10 years**
Median Survival 19 years	**69% at 15 years**

PENETRATING CORNEAL GRAFT SURVIVAL
GENDER MISMATCH; KERATOCONUS EXCLUDED

Donor & recipient both female:	**83% at 1 year**
Mean Survival 9.85 years	**65% at 5 years**
(SE=0.32; 95% CI: 9.22, 10.49)	**49% at 10 years**
Median Survival 10 years	**30% at 15 years**
Donor male & recipient female:	**83% at 1 year**
Mean Survival 10.94 years	**64% at 5 years**
(SE=0.34; 95% CI: 10.28, 11.61)	**51% at 10 years**
Median Survival 11 years	**42% at 15 years**
Donor female & recipient male:	**81% at 1 year**
Mean Survival 9.05 years	**62% at 5 years**
(SE=0.28; 95% CI: 8.50, 9.61)	**48% at 10 years**
Median Survival 10 years	**33% at 15 years**
Donor & recipient both male:	**79% at 1 year**
Mean Survival 9.51 years	**59% at 5 years**
(SE=0.35; 95% CI: 8.82, 10.20)	**43% at 10 years**
Median Survival 8 years	**26% at 15 years**

KEY:

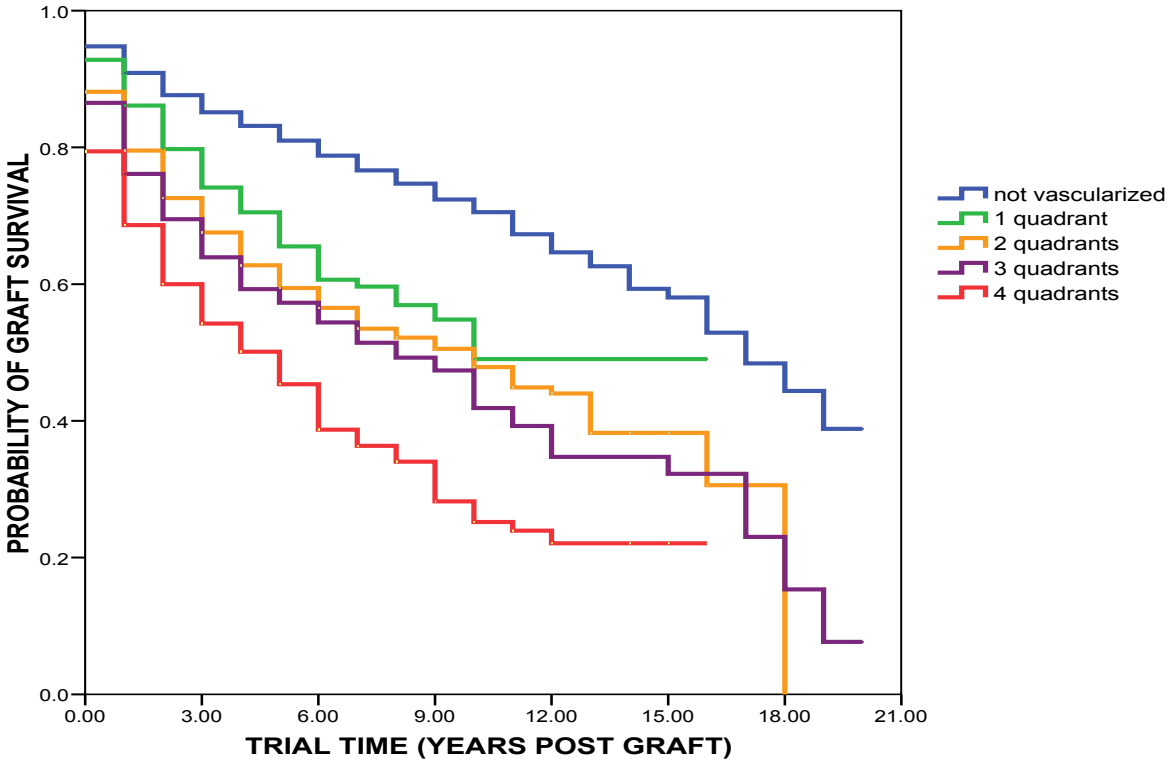
n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

3.3 PRE-GRAFT MORBIDITIES

3.3.1 Vascularisation

The effect of pre-graft vascularisation on graft outcome is shown in Figure 3.11. Graft survival decreases according to the number of quadrants of the cornea that contain vessels at the time of graft (Log Rank Statistic =894.02; df=4; p<0.00001).

Figure 3.11 Pre-graft vascularisation, penetrating grafts



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Not vascularised	9062	3794	1837	908	432	141	24	n/a
1 quadrant	861	285	94	27	8	1	n/a	n/a
2 quadrants	1449	520	205	95	50	7	1	n/a
3 quadrants	749	262	120	53	26	14	3	n/a
4 quadrants	1229	322	116	41	13	4	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Not vascularised	9062	.909	.810	.705	.580	n/a
1 quadrant	861	.861	.655	.490	n/a	n/a
2 quadrants	1449	.795	.594	.479	.306	n/a
3 quadrants	749	.761	.573	.419	.322	n/a
4 quadrants	1229	.686	.453	.252	n/a	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
PREGRAFT CORNEAL NEOVASCULARIZATION

Not vascularised:	**91% at 1 year**
Mean Survival 13.92 years	**81% at 5 years**
(SE=0.18; 95% CI: 13.56, 14.28)	**70% at 10 years**
Median Survival 17 years	**58% at 15 years**
1 quadrant vascularised:	**86% at 1 year**
Mean Survival 9.95 years	**65% at 5 years**
(SE=0.44; 95% CI: 9.09, 10.81)	**49% at 10 years**
Median Survival 10 years	
2 quadrants vascularised:	**79% at 1 year**
Mean Survival 9.55 **years**	**59% at 5 years**
(SE=0.35; 95% CI: 8.86, 10.25)	**48% at 10 years**
Median Survival 10 years	**31% at 15 years**
3 quadrants vascularised:	**76% at 1 year**
Mean Survival 9.11 years	**57% at 5 years**
(SE=0.47; 95% CI: 8.19, 10.03)	**42% at** 8 **years**
Median Survival 8 years	**32% at 15 years**
4 quadrants vascularised:	**69% at 1 year**
Mean Survival 6.33 years	**45% at 5 years**
(SE=0.30; 95% CI: 5.74, 6.91)	**25% at 10 years**
Median Survival 5 years	

KEY:

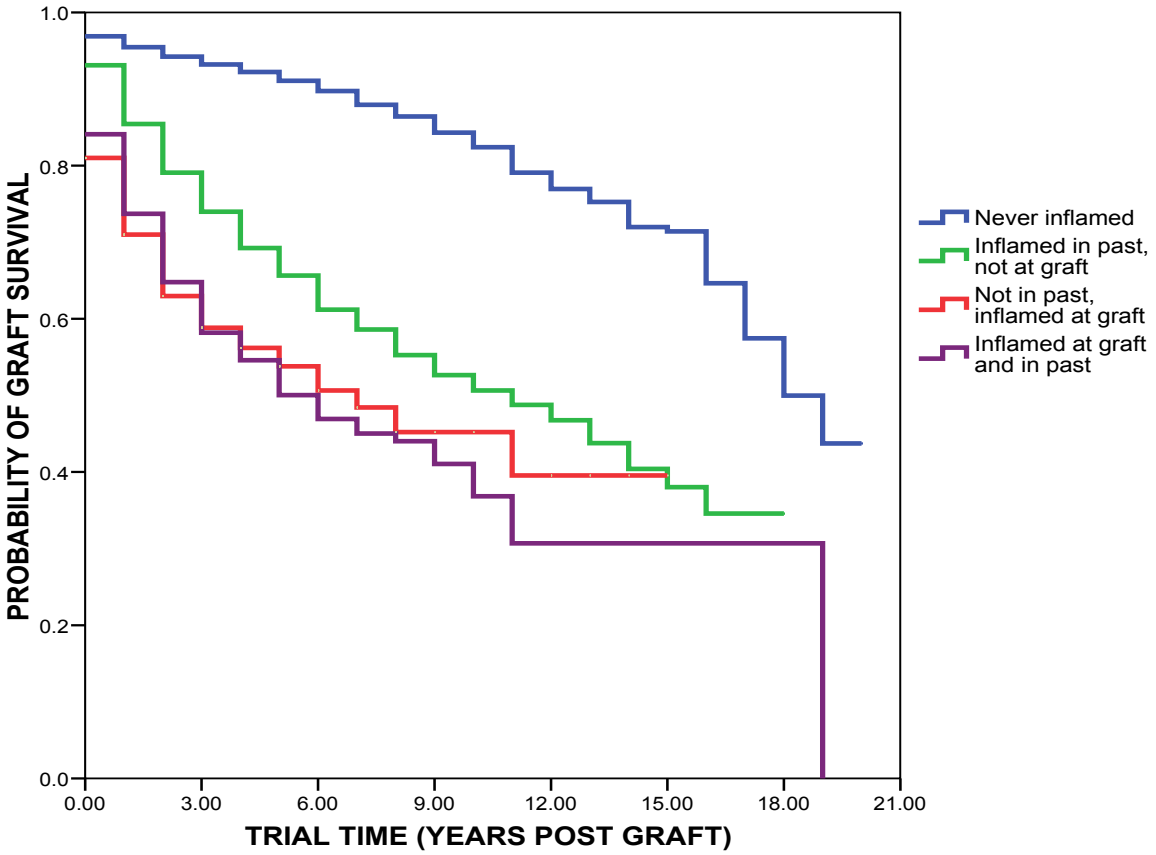
n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

3.3.2 Inflammation

Figure 3.12 shows the effect on graft outcome of first ipsilateral grafts where the eye had never been inflamed, compared with eyes that were inflamed at graft, or that had a history of inflammation in the past. A history of inflammation was judged to have occurred in any graft where there had been a record of steroids being administered during the 2 week period prior to graft, or where the grafted eye had undergone previous surgery.

Anterior segment inflammation at any time represents a significant factor for subsequent graft failure (Log Rank Statistic=1149.63; df=3; p<0.00001).

Figure 3.12 Pre-graft inflammation



Number at Risk

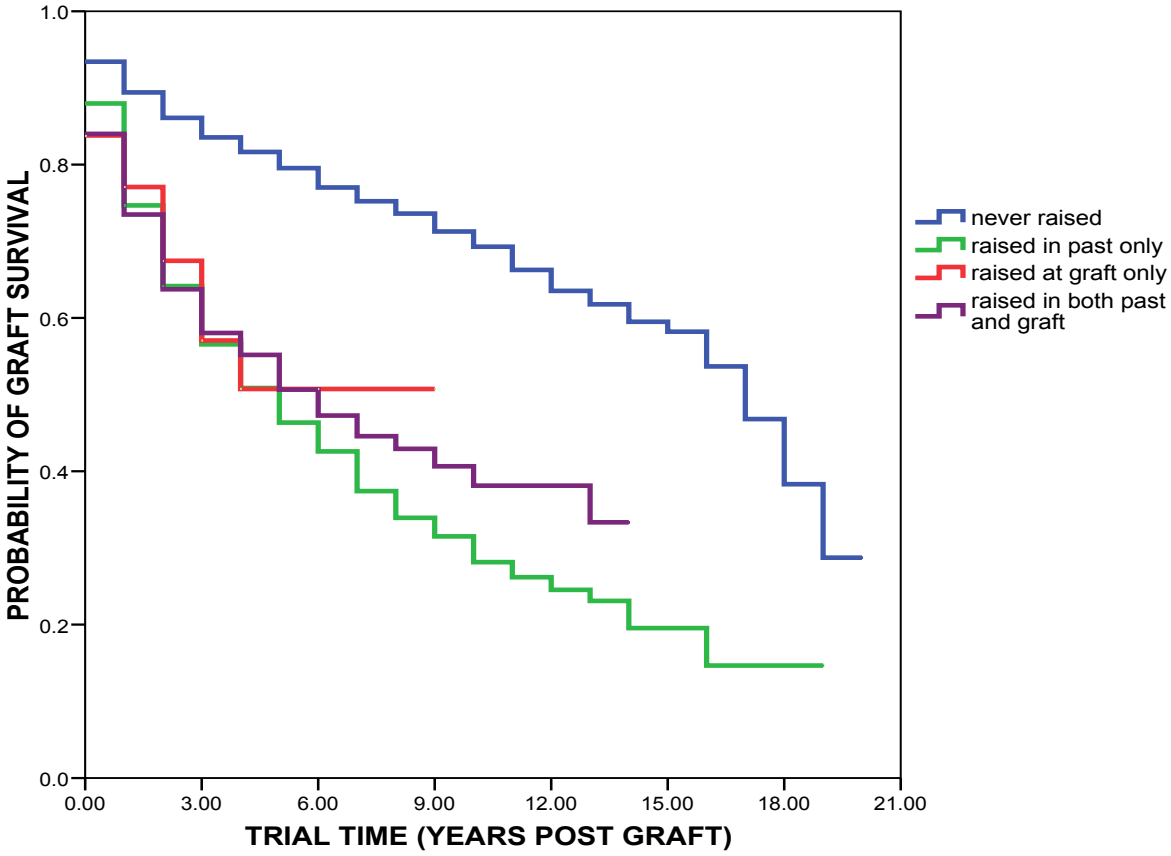
Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Never inflamed	5934	2764	1428	739	371	126	23	n/a
Inflamed in past, not at graft,	3247	1082	413	169	73	17	1	n/a
Not in past, inflamed at graft	300	91	34	10	7	1	n/a	n/a
Inflamed at graft and in past	1301	393	161	59	16	7	1	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Never inflamed	5934	.954	.911	.824	.646	n/a
Inflamed in past, not at graft,	3247	.854	.656	.506	.380	n/a
Not in past, inflamed at graft	300	.710	.538	.395	n/a	n/a
Inflamed at graft and in past	1301	.737	.500	.368	n/a	n/a

3.3.3 Intraocular pressure (pre-graft or at graft)

The effect of raised intraocular pressure (IOP) on graft survival is shown in Figure 3.13. Recipients with raised pressure at time of graft and in the past are compared with recipients in whom there had been a history of raised pressure but who had a normal pressure at the time of graft, with those with raised pressure at graft but not in the past, and with those in whom raised intraocular pressure had never been recorded. Raised intraocular pressure at any time prior to, or at graft, is a significant risk factor for corneal graft failure (Log Rank Statistic=676.72; df=3; p<0.00001).

Figure 3.13 Intraocular pressure (pre-graft/at time of graft)



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Never raised	9825	4007	1859	883	413	137	22	n/a
Raised in past only	1639	515	197	70	32	7	n/a	n/a
Raised at graft only	37	13	2	n/a	n/a	n/a	n/a	n/a
Raised in both past and graft	331	112	45	19	12	n/a	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Never raised	9825	.894	.795	.693	.582	n/a
Raised in past only	1639	.747	.464	.281	.195	n/a
Raised at graft only	37	.771	.507	n/a	n/a	n/a
Raised in both past and graft	331	.735	.506	.381	n/a	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
EFFECT OF INFLAMMATION

Never inflamed:	**95% at 1 year**
Mean Survival 15.84 years	**91% at 5 years**
(SE=0.21; 95% CI: 15.43, 16.26)	**82% at 10 years**
Median Survival 18 years	**65% at 15 years**
Inflamed in past, not at graft:	**85% at 1 year**
Mean Survival 10.32 years	**66% at 5 years**
(SE=0.27; 95% CI: 9.79, 10.84)	**51% at 10 years**
Median Survival 11 years	**38% at 15 years**
Not in past, inflamed at graft,:	**71% at 1 year**
Mean Survival 7.77 years	**54% at 5 years**
(SE=0.56; 95% CI: 6.66, 8.87)	**39% at 10 years**
Median Survival 7 years	
Inflamed at graft and in past:	**74% at 1 year**
Mean Survival 8.45 years	**50% at 5 years**
(SE=0.41; 95% CI: 7.65, 9.24)	**37% at 10 years**
Median Survival 6 years	

PENETRATING CORNEAL GRAFT SURVIVAL
HISTORY OF RAISED IOP

IOP never raised:	**89% at 1 year**
Mean Survival 13.57 years	**79% at 5 years**
(SE=0.18; 95% CI: 13.21, 13.93)	**69% at 10 years**
Median Survival 17 years	**58% at 15 years**
IOP raised in past only:	**75% at 1 year**
Mean Survival 7.11 years	**46% at 5 years**
(SE=0.32; 95% CI: 6.49, 7.73)	**28% at 10 years**
Median Survival 5 years	**19% at 15 years**
IOP raised at graft only:	**77% at 1 year**
Mean Survival 5.39 years	**51% at 5 years**
(SE=0.76; 95% CI: 3.90, 6.88)	
Median Survival approx. 4 years	
IOP raised in both past and graft:	**73% at 1 year**
Mean Survival 7.08 years	**51% at 5 years**
(SE=0.44; 95% CI: 6.22, 7.95)	**38% at 10 years**
Median Survival 6 years	

KEY: n/a = not applicable; df = degrees of freedom; SE = standard error; p = probability; CI = confidence interval

3.4 MAIN INDICATION FOR GRAFT

Table 3.1 Main indications for penetrating keratoplasty

Indication for graft	Sub-total	Total	%
Keratoconus		**5395**	**32%**
Uncomplicated	5183		
With hydrops	193		
Keratoglobus	19		
Bullous keratopathy		**4460**	**26%**
Pseudophakic	3493		
Aphakic	613		
Phakic pre-graft	217		
Unspecified	137		
Failed previous graft		**3307**	**19%**
Endothelial decompensation	707		
Unspecified	594		
Keratoconus	493		
HSV/HZO	145		
Graft rejection	318		
Corneal dystrophies	165		
Perforation	138		
Non-herpetic infections	141		
Abscess	83		
Mycotic ulcer	24		
Endophthalmitis	11		
Pseudomonas	11		
Miscellaneous [1]	12		
Astigmatism	140		
Scars/opacities	122		
Primary non-functioning grafts	90		
Trauma	74		
Glaucoma	36		
Ulcer - unspecified	35		
Burns	28		
Descemetocoele	20		
Cataract	32		
Wound dehiscence	15		
ICE syndrome	14		
Corneal Dystrophy		**1249**	**7%**
Fuchs' dystrophy	1047		
Granular dystrophy	50		
Lattice dystrophy	33		
Polymorphous dystrophy	26		
Macular dystrophy	24		
Crystalline dystrophy	11		
Anterior dystrophy	5		
Juvenile dystrophy	7		
Unspecified dystrophy	46		
Herpetic Eye Disease		**737**	**4%**
Scar resulting from herpetic eye disease	435		
Active HSV	100		
Herpetic perforation	145		
HZO	13		
Scarring - result of HZO infection	44		
Corneal scars and opacities (no history of herpetic disease)		**448**	**3%**
Unspecified scars and opacities	397		
Trachomatous scar	43		
Possible current trachoma	8		
Corneal ulcers (non HSV)		**344**	**2%**
Perforated	266		
Marginal, central or unspecified	53		
Recurrent erosions	11		
Scarring - result of marginal, central or unspecified ulcer	14		

Indication for graft	Sub-total	Total	%
Accidental injury		**289**	**1.7%**
Unspecified trauma	52		
Trauma (perforated)	8		
Scarring - result of trauma	172		
Burns	13		
Burns (perforated)	6		
Scarring - result of burns	38		
Non-herpetic infections		**211**	**1.2%**
Corneal abscess	80		
Scarring - result of corneal abscess	30		
Mycotic ulcer	37		
Scarring - result of mycotic ulcer	2		
Acanthamoeba keratitis	18		
Scarring - result of Acanthamoeba keratitis	5		
Endophthalmitis	10		
Scarring - result of endophthalmitis	4		
Pseudomonas	8		
Scarring - result of Pseudomonas infection	8		
Syphilitic interstitial keratitis	5		
Scarring - result of syphilitic interstitial keratitis	1		
Streptococcus viridans	1		
Scleral abscess	2		
Interstitial keratitis		**165**	**<1%**
Unspecified interstitial keratitis	131		
Scarring - result of interstitial keratitis	34		
Descemetocoele		**62**	**<1%**
Unspecified descemetocoele	60		
Scarring – result of descemetocoele	2		
Congenital abnormalities		**64**	**<1%**
Peters' anomaly	27		
Other [2]	28		
Scarring - result of congenital abnormalities	9		
Corneal degenerations [3]		**109**	**<1%**
Metabolic deposits [4]		**37**	**<1%**
ICE syndrome		**54**	**<1%**
Miscellaneous [5]		**119**	**<1%**
Unknown to ACGR		**40**	**<1%**
TOTAL		**17090**	**100%**

1 including Acanthamoeba (3); Streptococcus (2); Pneumococcus (1); candidiasis (1); aspergillosis (1); Fusarium (1); syphilitic interstitial keratitis (1); epidemic keratoconjunctivitis (1); unspecified mycoses (1).

2 including corneal opacities (8); congenital cataracts (4); anomalies of anterior segment (3); congenital glaucoma (3); aniridia (3); microcornea (2); congenital syphilis (2); congenital endothelial dystrophy (2); congenital rubella (1).

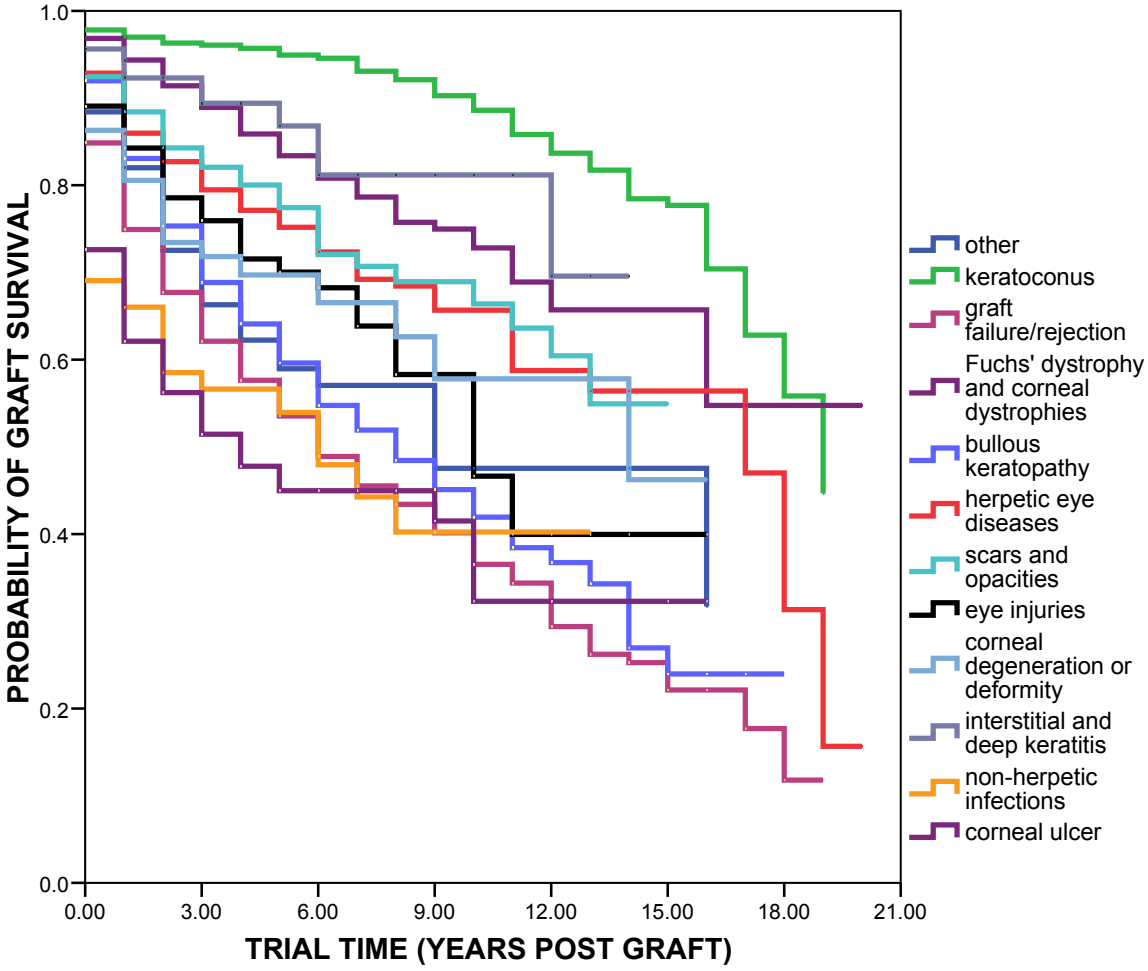
3 including corneal ectasia (63); unspecified corneal degeneration (14); rupture in Descemet's membrane (8); Salzmann's nodular dystrophy (7); unspecified corneal membrane change (6); macular degeneration (4); myopic degeneration (2); Terrien's marginal degeneration (2); keratomalacia (1); discrete colliquative keratopathy (1); neurotrophic ulcer (1).

4 including band shaped keratopathy (16); deposits associated with metabolic disorders (11); stromal pigmentations (4); unspecified corneal deposits (3); calcareous degeneration (3).

5 including astigmatism (22); cataract (20); neovascularisation (12); glaucoma (10); unspecified keratitis (9); patient's other cornea used for autologous graft (6); corneal staphyloma (4); retinal detachment, defect or haemorrhage (4); squamous cell carcinoma (4); aphakia (4); benign neoplasm (3); epithelial defect (2); synechiae (2); corneal pannus (2); scleral disorders (2); corneal tuberculosis (1); gonococcal ophthalmia (1); Fusarium infection (1); cystinosis (1); BMH (benign monoclonal hypergammaglobulinemia) (1); porphyria (1); hypopyon (1); Fuchs' heterochromic cyclitis (1); atopic keratoconjunctivitis (1); ocular cicatricial pemphigoid (1); Stevens-Johnson syndrome (1); rosacea keratitis (1); acquired keratoderma (1).

Figure 3.14 shows the survival curves for the main indications for graft as shown in Table 3.1. (Log Rank Statistic= 1578.24; df=11; p<0.00001).

Figure 3.14 Main indications for penetrating graft



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Other	164	58	31	18	9	5	n/a	n/a
Keratoconus	4183	1964	1024	549	282	105	18	n/a
Failed previous graft	2540	848	335	146	62	n/a	n/a	n/a
Fuchs' dystrophy and corneal dystrophies	946	444	227	99	43	9	3	n/a
Bullous keratopathy	3535	1152	406	145	45	9	1	n/a
Herpetic eye disease	587	256	133	74	39	13	3	n/a
Scars (non-herpetic)	397	152	72	30	20	3	n/a	n/a
Accidental injury	247	90	39	14	5	1	n/a	n/a
Corneal degeneration or deformity	146	45	22	13	8	3	n/a	n/a
Interstitial keratitis	137	64	31	13	7	0	n/a	n/a
Specified, non-herpetic infections	139	31	18	6	3	n/a	n/a	n/a
Ulcers	292	59	22	13	6	2	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Other	164	.820	.589	.475	.317	n/a
Keratoconus	4183	.970	.949	.886	.777	n/a
Failed previous graft	2540	.749	.535	.365	n/a	n/a
Fuchs' dystrophy and corneal dystrophies	946	.943	.834	.728	.547	n/a
Bullous keratopathy	3535	.831	.596	.419	.239	n/a
Herpetic eye disease	587	.860	.752	.588	.470	n/a
Scars (non-herpetic)	397	.884	.774	.664	n/a	n/a
Accidental injury	247	.842	.700	.466	n/a	n/a
Corneal degeneration or deformity	146	.805	.665	.578	n/a	n/a
Interstitial keratitis	137	.923	.868	.696	n/a	n/a
Specified, non-herpetic infections	139	.660	.539	n/a	n/a	n/a
Ulcers	292	.621	.450	.323	n/a	n/a

It should be noted that:

- the curve for bullous keratopathy includes pseudophakic, aphakic and unspecified bullous keratopathy.
- the curve for corneal dystrophy includes Fuchs' dystrophy, granular, lattice, polymorphous, macular, anterior, juvenile, crystalline and unspecified dystrophies. Fuchs' dystrophy has been separated from other corneal dystrophies in section 3.5.4.
- the curve for herpetic eye disease includes active and non-active HSV and HZO.
- the curve for scars and opacities (non-herpetic) does not include scars where ulcers, burns or trauma were the reason for graft.
- non-herpetic infections include abscess, mycotic ulcer, endophthalmitis, Acanthamoeba keratitis and Pseudomonas infection.

PENETRATING CORNEAL GRAFT SURVIVAL
INDICATION FOR GRAFT

Other:	**82% at 1 year**
Mean Survival 9.34 years	**59% at 5 years**
(SE=0.74; 95% CI: 7.89, 10.80)	**47% at 10 years**
Median Survival 9 years	**32% at 15 years**
Keratoconus:	**97% at 1 year**
Mean Survival 16.33 years	**95% at 5 years**
(SE=0.19; 95% CI: 15.96, 16.70)	**89% at 10 years**
Median Survival 19 years	**78% at 15 years**
Failed previous graft:	**75% at 1 year**
Mean Survival 8.04 years	**53% at 5 years**
(SE=0.26; 95% CI: 7.53, 8.55)	**36% at 10 years**
Median Survival 6 years	
Fuchs' dystrophy and corneal dystrophies:	**94% at 1 year**
Mean Survival 14.74 years	**83% at 5 years**
(SE=0.58; 95% CI: 13.61, 15.88)	**73% at 10 years**
Median Survival approx.17 years	**55% at 15 years**
Bullous keratopathy:	**83% at 1 year**
Mean Survival 8.93 years	**60% at 5 years**
(SE=0.28; 95% CI: 8.39, 9.48)	**42% at 10 years**
Median Survival 8 years	**24% at 15 years**
Herpetic eye disease:	**86% at 1 year**
Mean Survival 12.72 years	**75% at 5 years**
(SE=0.54; 95% CI: 11.65, 13.78)	**59% at 10 years**
Median Survival 17 years	**47% at 15 years**
Scars (non-herpetic):	**88% at 1 year**
Mean Survival 10.86 years	**77% at 5 years**
(SE=0.44; 95% CI: 9.99, 11.72)	**66% at 10 years**
Median Survival approx. 14 years	
Accidental injury:	**84% at 1 year**
Mean Survival 9.65 years	**70% at 5 years**
(SE=0.73; 95% CI: 8.22, 11.08)	**47% at 10 years**
Median Survival 10 years	
Corneal degeneration or deformity:	**80% at 1 year**
Mean Survival 10.29 years	**66% at 5 years**
(SE=0.80; 95% CI: 8.72, 11.85)	**58% at 10 years**
Median Survival 14 years	
Interstitial keratitis:	**92% at 1 year**
Mean Survival 11.72 years	**87% at 5 years**
(SE=0.55; 95% CI: 10.65, 12.80)	**70% at 10 years**
Median Survival approx. 14 years	
Infections (non-herpetic):	**66% at 1 year**
Mean Survival 6.54 **years**	**54% at 5 years**
(SE=0.65; 95% CI: 5.26, 7.82)	
Median Survival 6 years	
Ulcers:	**62% at 1 year**
Mean Survival 7.05 years	**45% at 5 years**
(SE=0.64; 95% CI: 5.80, 8.31)	**32% at 10 years**
Median Survival 4 years	

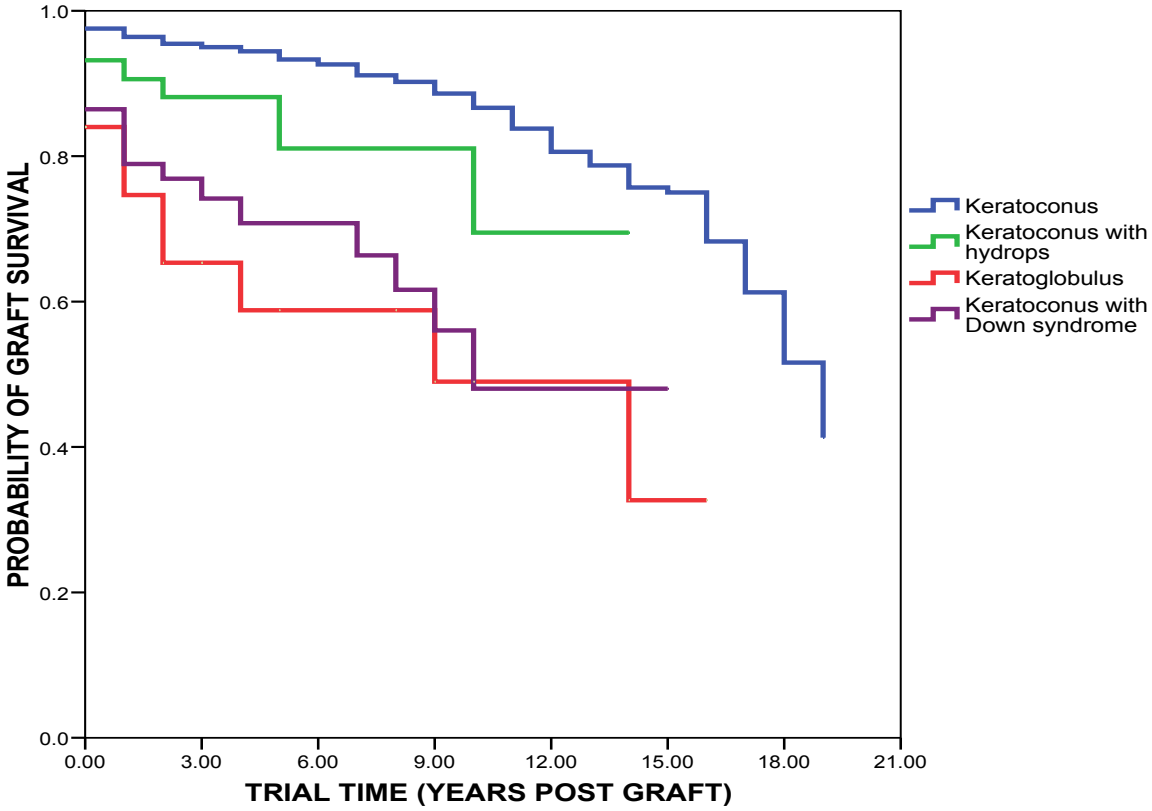
KEY: SE = standard error CI = confidence interval
df = degrees of freedom p = probability

3.5 EFFECT OF SPECIFIC INDICATION FOR GRAFT ON GRAFT SURVIVAL

3.5.1 Keratoconus, keratoconus with hydrops, keratoconus with Down syndrome, or keratoglobus

The effects of uncomplicated keratoconus, keratoconus with acute hydrops, keratoconus with Down syndrome/intellectual disability, or keratoglobus as reasons for graft are shown in Figure 3.15. (Log Rank Statistic=90.16; df=3; p<0.00001).

Figure 3.15 Keratoconus, keratoconus with hydrops, keratoconus with Down syndrome/intellectual disability, or keratoglobus



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Keratoconus	4543	2103	1083	566	288	111	19	n/a
Keratoconus with hydrops	132	53	18	10	4	n/a	n/a	n/a
Keratoglobus	25	13	8	6	3	1	n/a	n/a
Keratoconus with Down syndrome	59	28	18	11	4	1	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Keratoconus	4543	.964	.933	.866	.750	n/a
Keratoconus with hydrops	132	.906	.811	.695	n/a	n/a
Keratoglobus	25	.747	.588	.490	n/a	n/a
Keratoconus with Down syndrome	59	.789	.708	.480	n/a	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
KERATOCONUS

Keratoconus:	**96% at 1 year**
Mean Survival 15.96 years	**93% at 5 years**
(SE=0.19; 95% CI: 15.60, 16.33)	**87% at 10 years**
Median Survival 19 years	**75% at 15 years**
Keratoconus with hydrops:	**91% at 1 year**
Mean Survival 11.31 years	**81% at 5 years**
(SE=0.69; 95% CI: 9.96, 12.67)	**69% at 10 years**
Median Survival approx. 14 years	
Keratoglobus:	**75% at 1 year**
Mean Survival 8.94 years	**59% at 5 years**
(SE=1.53; 95% CI: 5.94, 11.94)	**49% at 10 years**
Median Survival 9 years	
Keratoconus with Down syndrome or intellectual disability:	**79% at 1 year**
Mean Survival 9.53 years	**71% at 5 years**
(SE=0.98; 95% CI: 7.61, 11.44)	**48% at 10 years**
Median Survival 10 years	

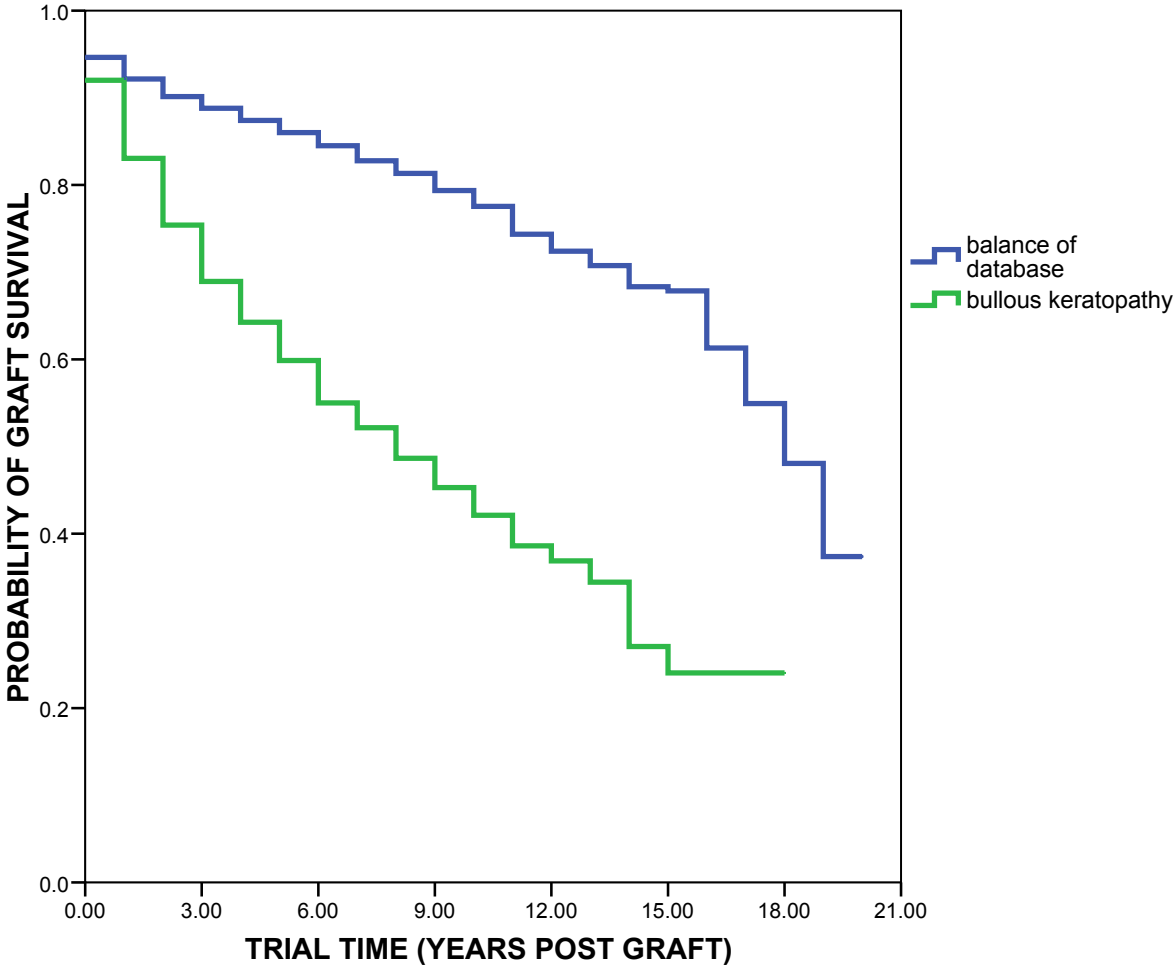
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

3.5.2 Bullous keratopathy

Figure 3.16 shows the effect of transplantation for bullous keratopathy on the survival of a first ipsilateral graft. Long term survival is plainly poor compared with survival in the remainder of the database (Log Rank Statistic=555.34; df=1; p<0.00001).

Figure 3.16 Bullous keratopathy



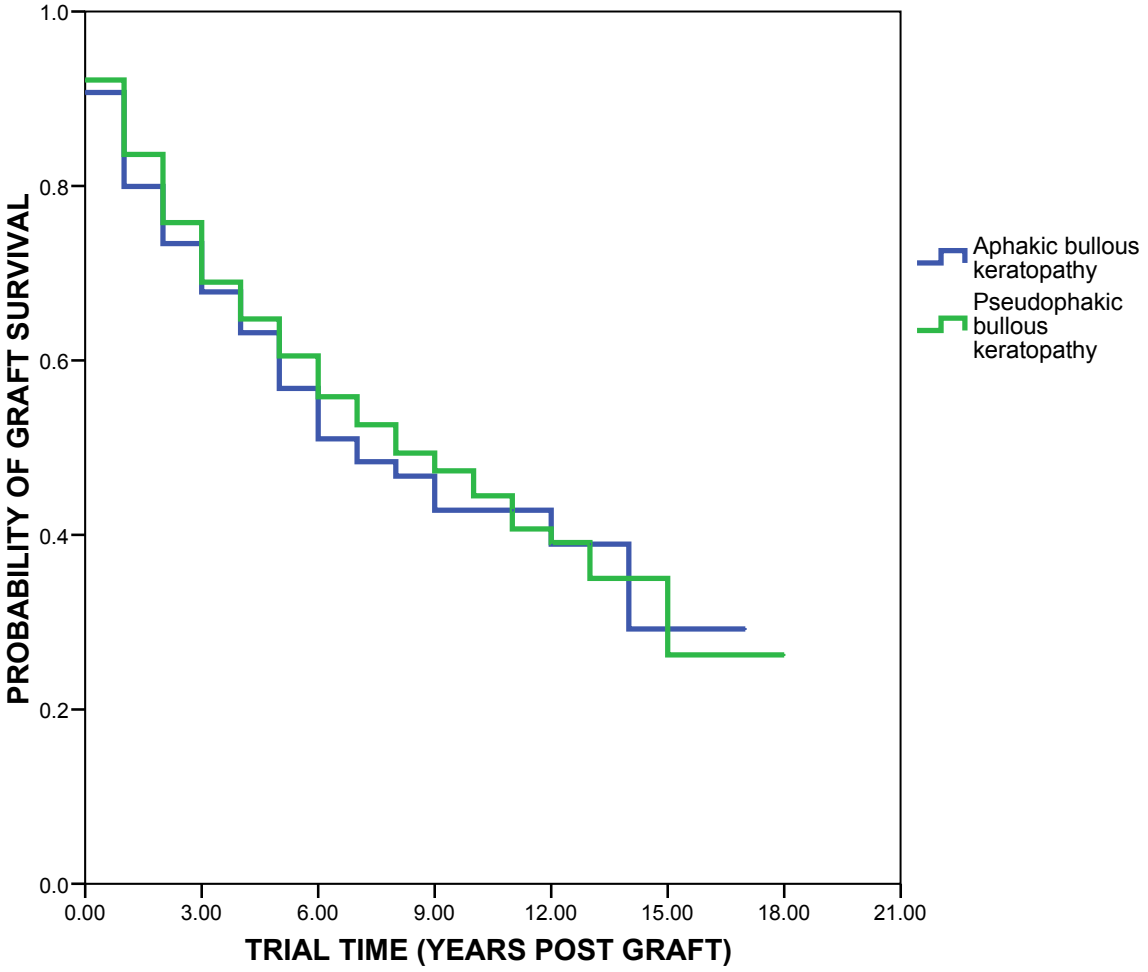
Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Balance of database for first grafts	7210	3157	1618	828	421	141	24	n/a
Bullous keratopathy	3535	1153	406	145	45	9	1	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Balance of database for first grafts	7210	.921	.860	.775	.678	n/a
Bullous keratopathy	3535	.830	.599	.421	.240	n/a

Figure 3.17 compares graft survival for bullous keratopathy in aphakes and pseudophakes. There is no significant difference between the curves (Log Rank Statistic=1.47; df=1; p=0.226).

Figure 3.17 Types of bullous keratopathy



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Aphakic bullous keratopathy	463	159	59	24	11	3	0	n/a
Pseudophakic bullous keratopathy	2751	878	297	97	26	4	1	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Aphakic bullous keratopathy	463	.799	.568	.428	.292	n/a
Pseudophakic bullous keratopathy	2751	.836	.605	.445	.262	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
BULLOUS KERATOPATHY

Balance of database for first grafts:	**92% at 1 year**
Mean Survival 15.00 years	**86% at 5 years**
(SE=0.20; 95% CI: 14.61, 15.38)	**77% at 10 years**
Median Survival 18 years	**68% at 15 years**
Bullous keratopathy:	**83% at 1 year**
Mean Survival 8.96 years	**60% at 5 years**
(SE=0.28; 95% CI: 8.41, 9.50)	**42% at 10 years**
Median Survival 8 years	**24% at 15 years**

PENETRATING CORNEAL GRAFT SURVIVAL
APHAKIC AND PSEUDOPHAKIC BULLOUS KERATOPATHY

Aphakic bullous keratopathy:	**80% at 1 year**
Mean Survival 8.72 years	**57% at 5 years**
(SE=0.57; 95% CI: 7.60, 9.84)	**43% at 10 years**
Median Survival 7 years	**29% at 15 years**
Pseudophakic bullous keratopathy:	**84% at 1 year**
Mean Survival 9.24 years	**60% at 5 years**
(SE=0.37; 95% CI: 8.52, 9.96)	**44% at 10 years**
Median Survival 8 years	**26% at 15 years**

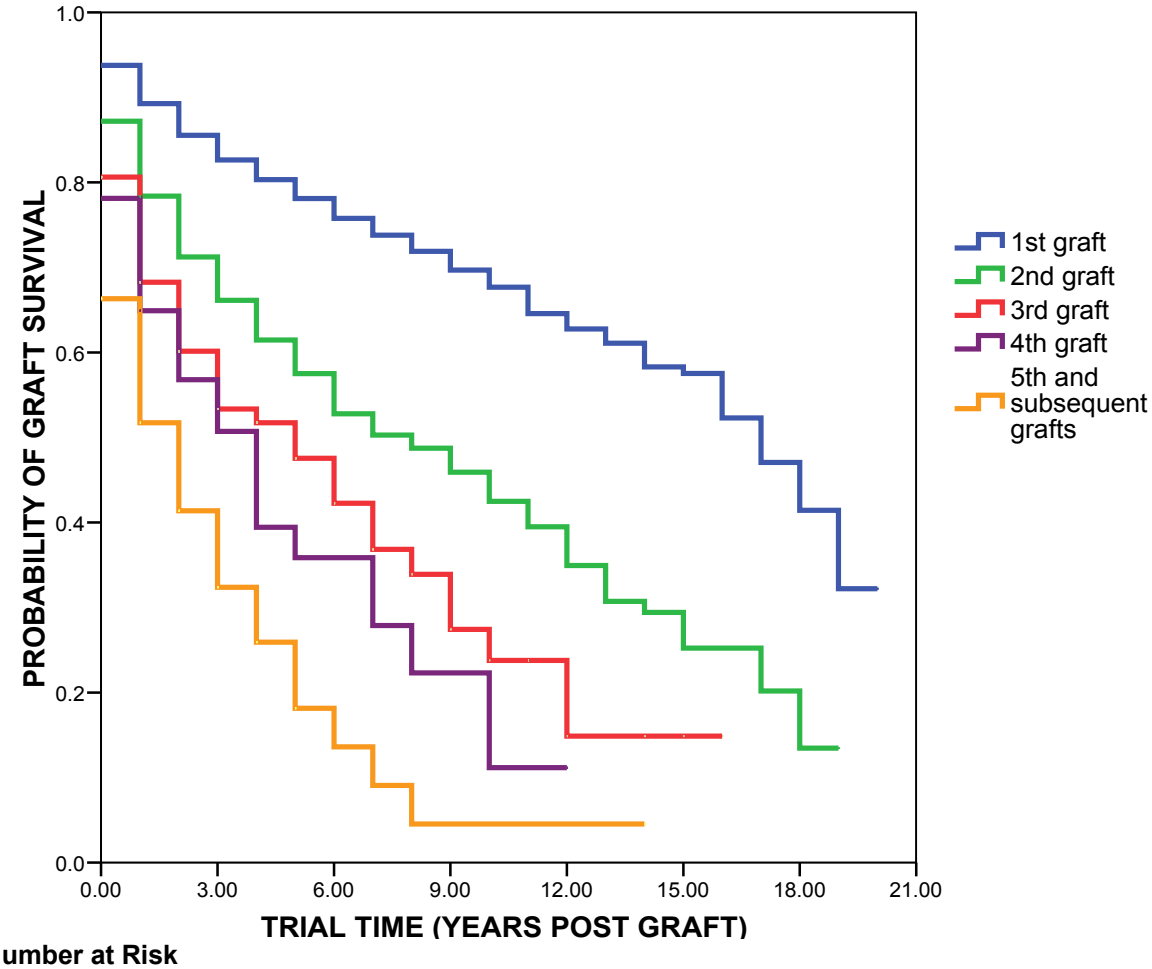
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

3.5.3 Previous failed ipsilateral graft

The influence of ipsilateral graft number is shown in Figure 3.18. Graft survival falls with increasing graft number (Log Rank Statistic=738.20; df=4; p<0.00001).

Figure 3.18 The effect of previous grafts in the grafted eye



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
1st graft	10782	4330	2036	977	467	151	25	n/a
2nd graft	1928	669	268	121	52	14	3	n/a
3rd graft	449	133	54	21	8	2	n/a	n/a
4th graft	96	28	10	4	1	n/a	n/a	n/a
5th & subsequent graft	95	23	4	1	n/a	n/a	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
1st graft	10782	.893	.781	.677	.575	n/a
2nd graft	1928	.784	.575	.425	.252	n/a
3rd graft	449	.683	.475	.238	n/a	n/a
4th graft	96	.649	.358	.111	n/a	n/a
5th & subsequent graft	95	.517	.181	n/a	n/a	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
GRAFT NUMBER

1st graft:	**89% at 1 year**
Mean Survival 13.46 years	**78% at 5 years**
(SE=0.17; 95% CI: 13.12, 13.80)	**68% at 10 years**
Median Survival 17 years	**57% at 15 years**
2nd graft:	**78% at 1 year**
Mean Survival 8.81 years	**57% at 5 years**
(SE=0.31; 95% CI: 8.20, 9.42)	**42% at 10 years**
Median Survival 8 years	**25% at 15 years**
3rd graft:	**68% at 1 year**
Mean Survival 6.09 years	**47% at 5 years**
(SE=0.42; 95% CI: 5.26, 6.92)	**24% at 10 years**
Median Survival 5 years	
4th graft:	**65% at 1 year**
Mean Survival 4.56 years	**36% at 5 years**
(SE=0.58; 95% CI: 3.43, 5.70)	**11% at 10 years**
Median Survival 4 years	
5th and subsequent grafts:	**52% at 1 year**
Mean Survival 2.86 years	**18% at 5 years**
(SE=0.47; 95% CI: 1.93, 3.79)	
Median Survival 2 years	

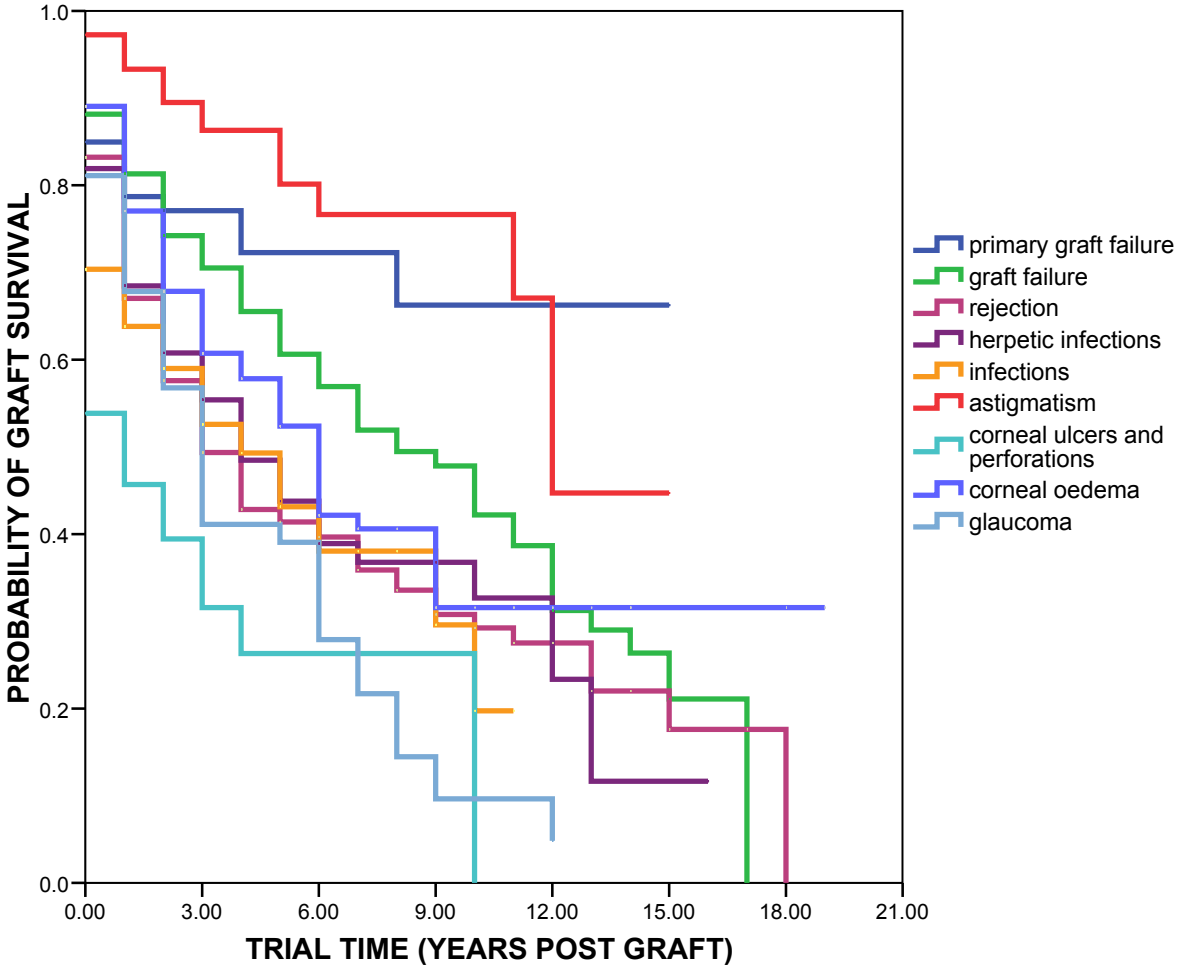
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

3.5.3.1 The effect of reason for failure of a previous graft

Figure 3.19 investigates the effect of different reasons for failure of a previous ipsilateral graft on the survival of the current graft. The data in this figure have been analysed taking into account cases where the main indication is failed graft. The secondary indication and primary and secondary presenting indications have been predicated as causation (Log Rank Statistic=145.86; df=8; p<0.00001).

Figure 3.19 The effect of reason for failure of a previous graft



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Primary graft failure	93	37	16	8	3	2	n/a	n/a
Unspecified graft failure	996	361	148	60	26	5	0	n/a
Rejection	411	119	48	24	13	5	1	n/a
Herpetic infection	199	68	27	12	7	1	n/a	n/a
Non viral infection	162	46	17	9	0	n/a	n/a	n/a
Astigmatism	109	56	23	11	3	1	n/a	n/a
Corneal ulcer/perforation	78	10	1	n/a	n/a	n/a	n/a	n/a
Corneal oedema	420	124	41	18	8	2	n/a	n/a
Glaucoma	90	29	14	3	2	n/a	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Primary graft failure	93	.787	.723	.662	n/a	n/a
Unspecified graft failure	996	.813	.606	.422	.211	n/a
Rejection	411	.670	.414	.292	.176	n/a
Herpetic infection	199	.684	.438	.327	n/a	n/a
Non viral infection	162	.638	.431	.197	n/a	n/a
Astigmatism	109	.933	.801	.671	n/a	n/a
Corneal ulcer/perforation	78	.457	.263	.000	n/a	n/a
Corneal oedema	420	.770	.524	.316	n/a	n/a
Glaucoma	90	.678	.391	.096	n/a	n/a

Regrafts for astigmatism and primary graft failures appear to have better graft survival than those for other reasons, whilst those regrafted for infections, glaucoma and ulcers have a poorer graft survival.

PENETRATING CORNEAL GRAFT SURVIVAL
REASON FOR FAILURE OF PREVIOUS GRAFT

Primary graft failure:	
Mean Survival 10.71 years	**79% at 1 year**
(SE=0.80; 95% CI: 9.13, 12.29)	**72% at 5 years**
Median Survival approx. 15 years	**66% at 10 years**
Unspecified graft failure:	**81% at 1 year**
Mean Survival 8.56 years	**61% at 5 years**
(SE=0.36; 95% CI: 7.86, 9.26)	**42% at 10 years**
Median Survival 8 years	**21% at 15 years**
Rejection:	
Mean Survival 6.63 years	**67% at 1 year**
(SE=0.50; 95% CI: 5.64, 7.61)	**41% at 5 years**
Median Survival 3 years	**29% at 10 years**
	18% at 15 years
Herpetic infection:	
Mean Survival 6.32 years	**68% at 1 year**
(SE=0.61; 95% CI: 5.12, 7.52)	**44% at 5 years**
Median Survival approx 4 years	**33% at 10 years**
Non-Viral Infection:	
Mean Survival 5.02 years	**64% at 1 year**
(SE=0.45; 95% CI: 4.14, 5.90)	**43% at 5 years**
Median Survival 4 years	**20% at 10 years**
Astigmatism:	
Mean Survival 11.17 years	**93% at 1 year**
(SE=0.86; 95% CI: 9.49, 12.85)	**80% at 5 years**
Median Survival 12 years	**67% at 10 years**
Corneal ulcer/perforation:	
Mean Survival 3.29 years	**46% at 1 year**
(SE=0.61; 95% CI: 2.08, 4.49)	**26% at 5 years**
Median Survival 1 year	**0% at 10 years**
Corneal oedema:	
Mean Survival 8.44 years	**77% at 1 year**
(SE=0.69; 95% CI: 7.09, 9.79)	**52% at 5 years**
Median Survival 6 years	**32% at 10 years**
Glaucoma:	
Mean Survival 4.20 years	**68% at 1 year**
(SE=0.50; 95% CI: 3.22, 5.19)	**39% at 5 years**
Median Survival 3 years	**10% at 10 years**

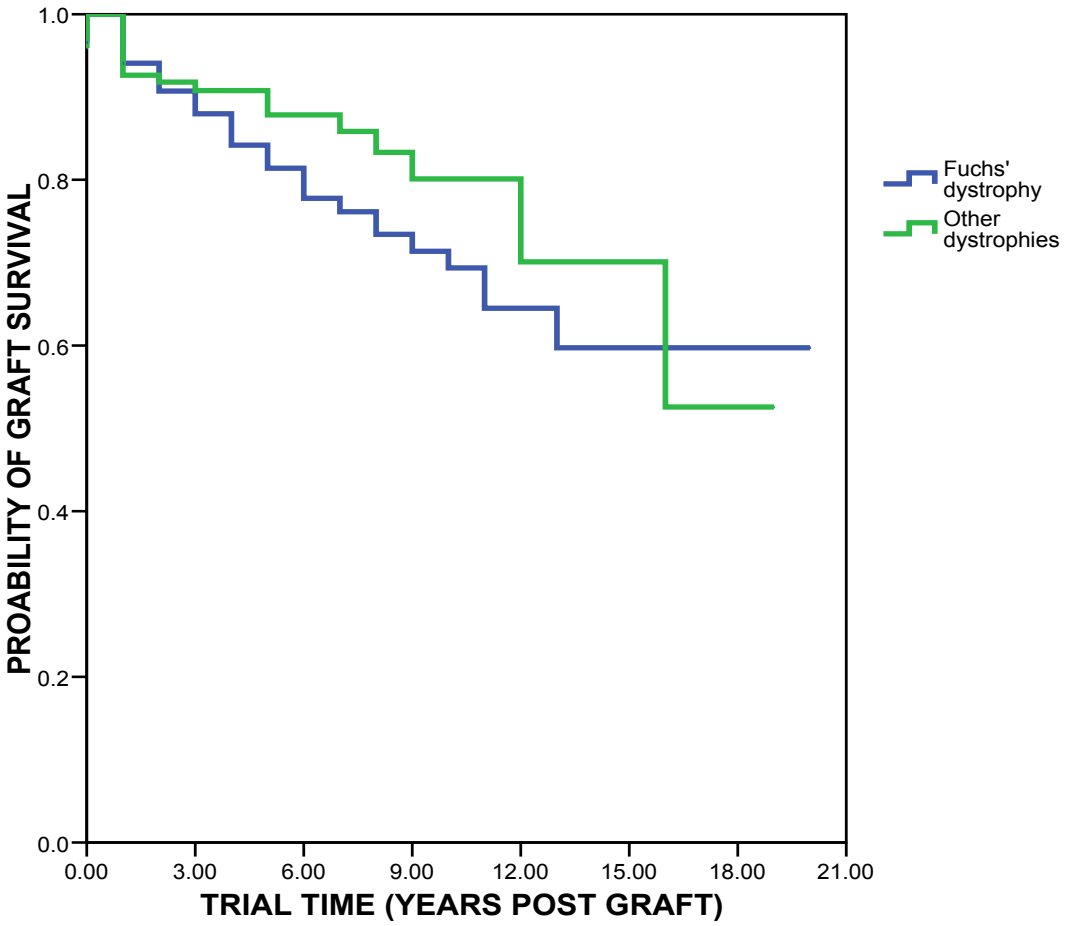
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom M
p	=	probability

3.5.4 Corneal dystrophy

Figure 3.20 shows the survival of first grafts for Fuchs' dystrophy compared with other corneal dystrophies (Log rank Statistic=2.00; df=1; p=0.1577).

Figure 3.20 Fuchs' and other corneal dystrophies



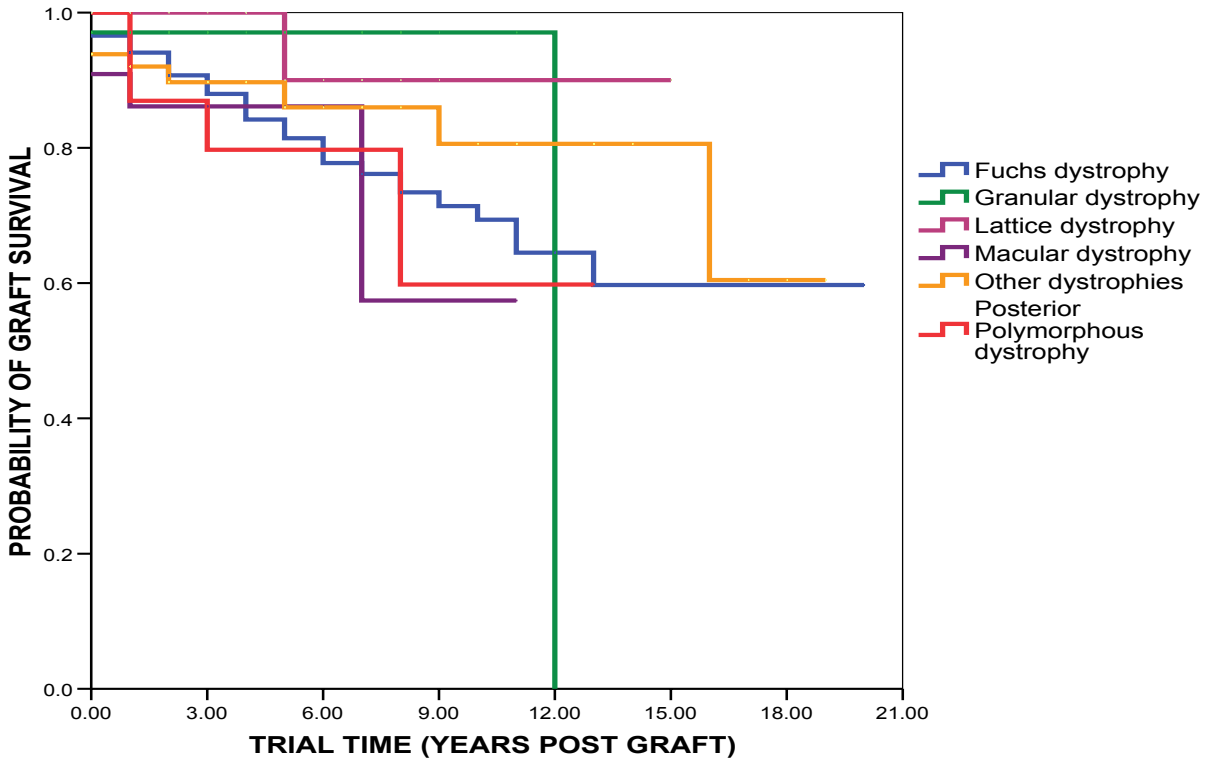
Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Fuchs' dystrophy	1201	528	245	108	42	5	1	n/a
Other dystrophies	171	89	47	26	16	5	2	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Fuchs' dystrophy	1201	.941	.814	.694	n/a	n/a
Other dystrophies	171	.926	.878	.801	.526	n/a

Figure 3.21 separates out the graft survival for different types of corneal dystrophy. Dystrophies include macular dystrophy (22), lattice dystrophy (27), granular dystrophy (34), posterior polymorphous dystrophy (23), and a miscellaneous group which includes unspecified (46), Reis-Buckler's syndrome (4), crystalline (11), and Meesman's dystrophy (4). The type of dystrophy does not appear to influence graft survival significantly (Log rank Statistic=6.10; df=5; p=0.296).

Figure 3.21 Corneal Dystrophies



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Fuchs' dystrophy	1201	528	245	108	42	5	1	n/a
Granular dystrophy	34	19	11	4	2	n/a	n/a	n/a
Lattice dystrophy	27	n/a	8	2	1	1	0	n/a
Macular dystrophy	22	10	4	1	n/a	n/a	n/a	n/a
Other dystrophies	65	33	20	16	11	4	2	n/a
Posterior polymorphous dystrophy	23	12	4	2	1	n/a	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Fuchs' dystrophy	1201	.941	.814	.694	n/a	n/a
Granular dystrophy	34	.971	n/a	n/a	.000	n/a
Lattice dystrophy	27	n/a	.900	n/a	n/a	n/a
Macular dystrophy	22	.861	.574	n/a	n/a	n/a
Other dystrophies	65	.920	.860	.806	.604	n/a
Posterior polymorphous dystrophy	23	.870	.598	n/a	n/a	n/a

OVERALL CORNEAL GRAFT SURVIVAL
FUCHS' DYSTROPHY

Fuchs' dystrophy:	**94% at 1 year**
Mean Survival 14.50 years	**81% at 5 years**
(SE=0.46; 95% CI: 13.60, 15.40)	**69% at 10 years**
Median Survival approx. 20 years	
Other dystrophies:	**93% at 1 year**
Mean Survival 14.85 years	**88% at 5 years**
(SE=0.85; 95% CI: 13.18, 16.53)	**80% at 10 years**
Median Survival approx. 19 years	**53% at 15 years**

PENETRATING CORNEAL GRAFT SURVIVAL
CORNEAL DYSTROPHIES

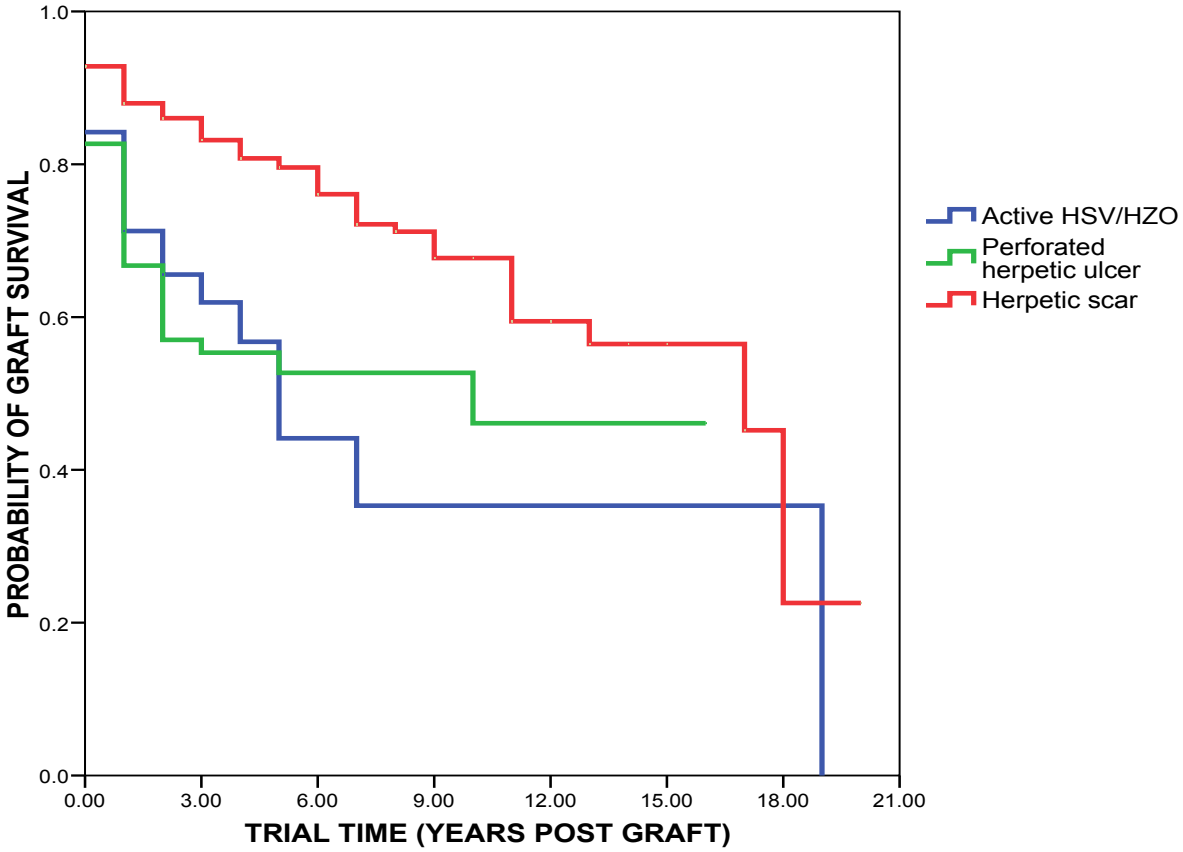
Fuchs' dystrophy:	**94% at 1 year**
Mean Survival 14.50 years	**81% at 5 years**
(SE=0.46; 95% CI: 13.60, 15.40)	**69% at 10 years**
Median Survival approx. 14 years	
Granular dystrophy:	**97% at 1 year**
Mean Survival 11.65 years	**0% at 15 years**
(SE=0.43; 95% CI: 10.81, 12.48)	
Median Survival 12 years	
Lattice dystrophy:	**90% at 5 years**
Mean Survival 14.00 years	
(SE=0.95; 95% CI: 12.14, 15.86)	
Median Survival approx. 15 years	
Macular dystrophy:	**86% at 1 year**
Mean Survival 8.37 years	**57% at 5 years**
(SE=1.17; 95% CI: 6.09, 10.66)	
Median Survival approx. 11 years	
Other dystrophies:	**92% at 1 year**
Mean Survival 15.44 years	**86% at 5 years**
(SE=1.08; 95% CI: 13.33, 17.56)	**81% at 10 years**
Median Survival approx. 19 years	**60% at 15 years**
Posterior polymorphous dystrophy:	**87% at 1 year**
Mean Survival 9.71 years	**60% at 5 years**
(SE=1.27; 95% CI: 7.23, 12.20)	
Median Survival approx. 9 years	

KEY: n/a = not applicable; df = degrees of freedom; SE = standard error; p = probability; CI = confidence interval

3.5.5 Herpes simplex virus infection

The effect of herpetic eye disease on a first graft is shown in more detail in Figure 3.22. Outcomes of grafts for inactive herpetic disease, active herpetic disease and for perforated herpetic ulcers are compared (Log rank Statistic=30.18; df=2; p<0.00001).

Figure 3.22 The effect of herpetic eye disease on graft survival



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Active HSV/HZO at graft	69	28	8	4	3	2	n/a	n/a
Perforated herpetic ulcer	113	32	17	9	5	2	n/a	n/a
Inactive HSV scar	404	199	111	60	31	8	2	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Active HSV/HZO at graft	69	.763	.502	.329	n/a	n/a
Perforated herpetic ulcer	113	.687	.534	.468	n/a	n/a
Inactive HSV scar	404	.889	.810	.613	.464	n/a

Not surprisingly, graft survival is significantly poorer for recipients with active herpetic infection at the time of graft than for those with inactive disease.

The major reason given for the failure of grafts performed for active herpetic infection is rejection (24%). However, in 20% of the grafts that have failed, there has been a recurrence of herpetic infection at some time during the post-graft period.

PENETRATING CORNEAL GRAFT SURVIVAL
HSV INFECTION

Active HSV/HZO at graft:	**76% at 1 year**
Mean Survival 9.05 years	**50% at 5 years**
(SE=1.50; 95% CI: 6.10, 12.00)	**33% at 10 years**
Median Survival 7 years	
Perforated herpetic ulcer:	**69% at 1 year**
Mean Survival 8.73 years	**53% at 5 years**
(SE=0.88; 95% CI: 7.00, 10.46)	**47% at 10 years**
Median Survival 10 years	
Inactive HSV scar:	**89% at 1 year**
Mean Survival 13.24 years	**81% at 5 years**
(SE=0.66; 95% CI: 11.95, 14.54)	**61% at 10 years**
Median Survival 17 years	**46% at 15 years**

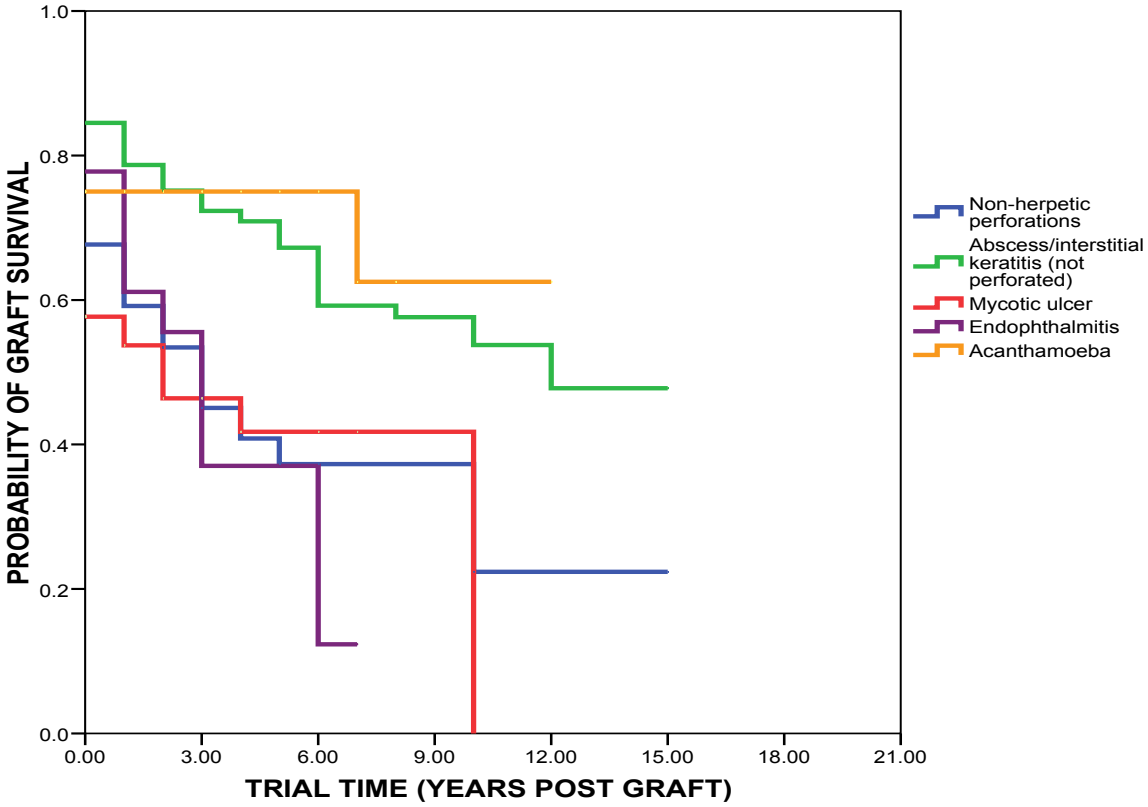
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

3.5.6 Non-herpetic infections

Graft survival for various infective indications for transplantation is shown in Figure 3.23. (Log Rank Statistic=31.64, df=4; p<0.00001). Corneal grafts performed for an abscess or interstitial keratitis appear to have better graft survival than those for other non-herpetic infections.

Figure 3.23 Non-herpetic infections



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Non-herpetic perforation	294	51	11	5	2	n/a	n/a	n/a
Abscess/interstitial keratitis	368	133	67	22	9	2	n/a	n/a
Mycotic ulcer	78	15	4	1	n/a	n/a	n/a	n/a
Endophthalmitis	27	9	3	n/a	n/a	n/a	n/a	n/a
Acanthamoeba	24	11	7	1	n/a	n/a	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Non-herpetic perforation	294	.592	.373	.224	n/a	n/a
Abscess/interstitial keratitis (not perforated)	368	.787	.672	.538	n/a	n/a
Mycotic ulcer	78	.537	.417	.000	n/a	n/a
Endophthalmitis	27	.611	.123	n/a	n/a	n/a
Acanthamoeba	24	.750	.625	n/a	n/a	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
INFECTIONS

Non-herpetic perforation:	**59% at 1 year**
Mean Survival 5.64 years	**37% at 5 years**
(SE=0.63; 95% CI: 4.42, 6.87)	**22% at 10 years**
Median Survival 3 years	
Abscess/interstitial keratitis (not perforated):	**79% at 1 year**
Mean Survival 9.33 years	**67% at 5 years**
(SE=0.49; 95% CI: 8.38, 10.29)	**54% at 10 years**
Median Survival 12 years	
Mycotic ulcer:	
Mean Survival 4.55 years	**54% at 1 year**
(SE=0.63; 95% CI: 3.31, 5.78)	**42% at 5years**
Median Survival 2 years	**0% at 10 years**
Endophthalmitis:	
Mean Survival 3.18 years	**61% at 1 year**
(SE=0.59; 95% CI: 2.03, 4.33)	**12% at 5 years**
Median Survival 3 year	
Acanthamoeba:	
Mean Survival 8.38 years	**75% at 1 year**
(SE=1.14; 95% CI: 4.84, 7.64)	**62% at 5 years**
Median Survival approx. 12 years	

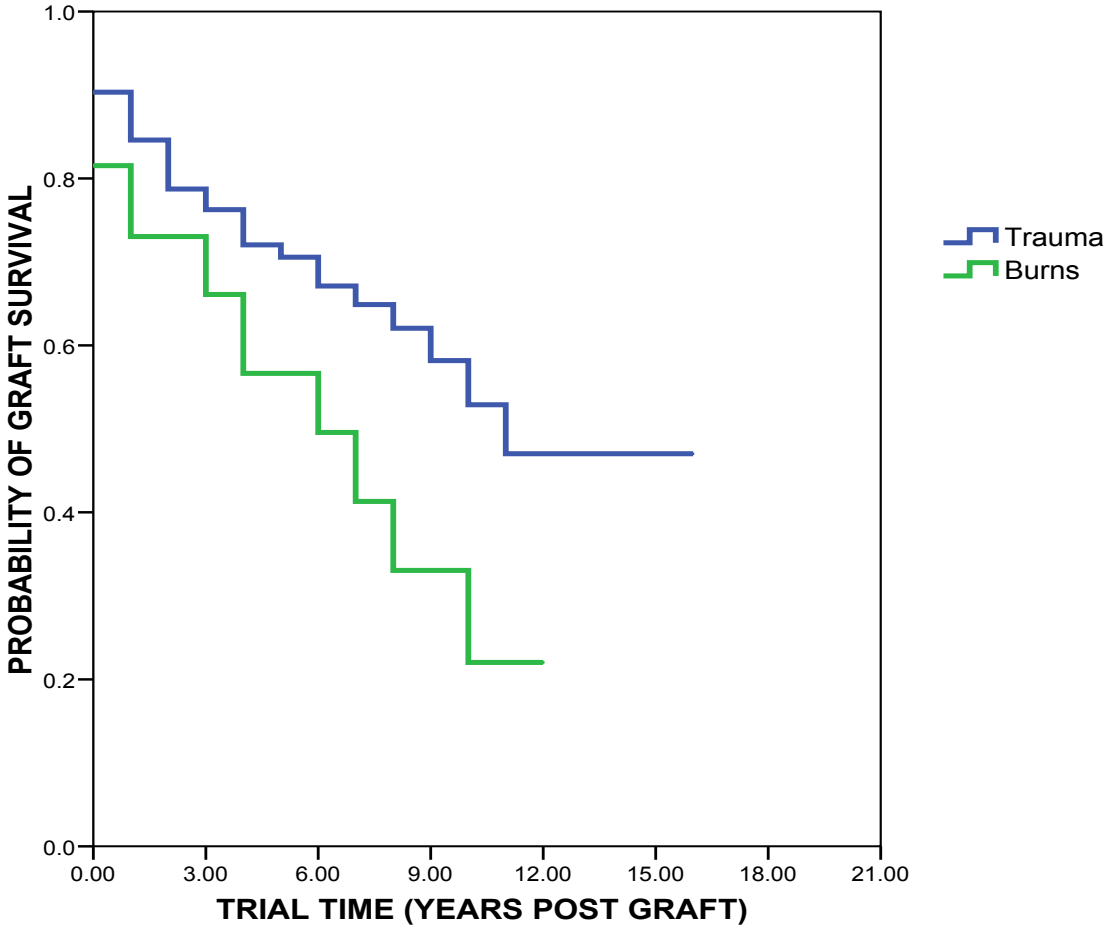
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

3.5.7 Burns and trauma

Outcome of first grafts performed for burns (chemical or thermal) or trauma is shown in Figure 3.24 (Log Rank Statistic=6.04, df=1; p=0.0140). As might be expected, outcome of corneal transplantation following burns is rather poor.

Figure 3.24 The effect of burns and trauma



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Trauma	269	96	41	16	5	1	n/a	n/a
Burns	65	21	8	3	2	n/a	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Trauma	269	.846	.706	.529	n/a	n/a
Burns	65	.730	.566	.220	n/a	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
BURNS AND TRAUMA

Trauma:	**85% at 1 year**
Mean Survival 10.13 years	**71% at 5 years**
(SE=0.69; 95% CI: 8.78, 11.48)	**53% at 10 years**
Median Survival 11 years	
Burns:	**73% at 1 year**
Mean Survival 6.08 years	**57% at 5 years**
(SE=0.79; 95% CI: 4.53, 7.63)	**22% at 10 years**
Median Survival 6 years	

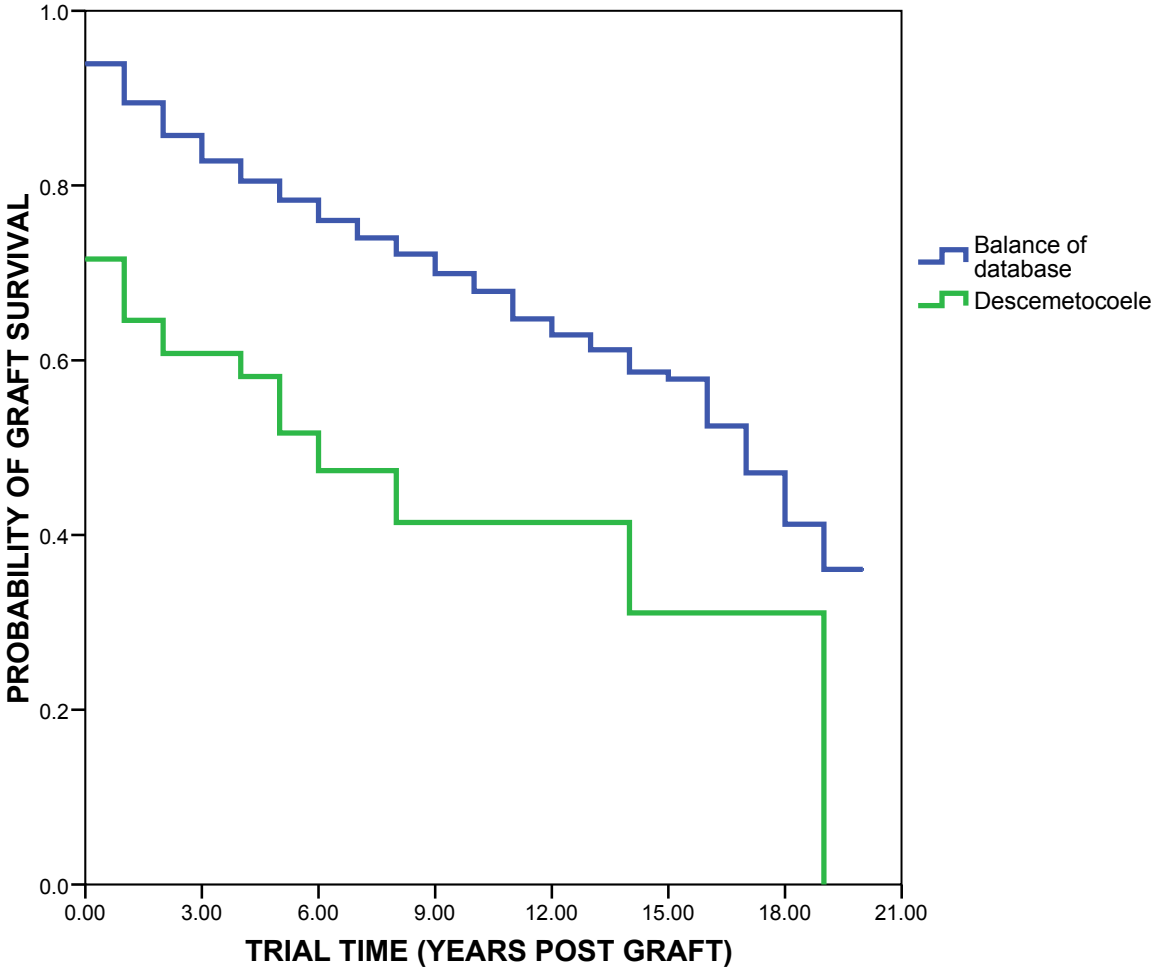
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

3.5.9 Descemetocoele

The influence of a descemetocoele as the indication for transplantation on the survival of a first graft is shown in Figure 3.25. The presence of descemetocoele is a risk factor for graft failure (Log Rank Statistic=46.80; df=1; p<0.00001).

Figure 3.25 The effect of descemetocoele on graft survival



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Balance of database	10694	4302	2024	970	461	148	24	n/a
Descemetocoele	88	28	12	7	6	3	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Balance of database	10694	.895	.783	.679	.578	n/a
Descemetocoele	88	.646	.517	.414	.311	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
DESCEMETOCOELE

Balance of database:	**89% at 1 year**
Mean Survival 13.53 years	**78% at 5 years**
(SE=0.18; 95% CI: 13.19, 13.87)	**68% at 10 years**
Median Survival 17 years	**58% at 15 years**
Descemetocoele:	**65% at 1 year**
Mean Survival 8.66 years	**52% at 5 years**
(SE=1.26; 95% CI: 6.20, 11.12)	**41% at 10 years**
Median Survival 6 years	**31% at 15 years**

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

3.6 SUMMARY OF RECIPIENT-RELATED FACTORS

- The distribution of recipient age at graft is bimodal, with peaks at around 20-40 years and around 60-80 years.
- A weak influence of recipient age on graft survival is apparent.
- Recipient gender does not influence graft survival, but there may be a weak effect of gender mismatch between donor and recipient.
- The sequelae of corneal vascularisation, inflammation and raised IOP prior to, or at the time of graft, all exert significant negative influences on graft survival.
- The main indications for penetrating keratoplasty are keratoconus (32%), bullous keratopathy (26%), failed previous graft (19%), corneal dystrophy (7%), and herpetic eye disease (4%). These broad indications account for 88% of penetrating grafts.
- Graft survival for uncomplicated keratoconus and for the corneal dystrophies is very good. Graft survival for bullous keratopathy, previous failed graft, burns, corneal ulcers, active HSV, infection, corneal perforations, endophthalmitis and mycotic ulcers is relatively poor.

4. PROCEDURES AT TIME OF GRAFT AND INFLUENCE OF INTRAOCULAR LENSES

4.1 OPERATIVE PROCEDURES AT GRAFT

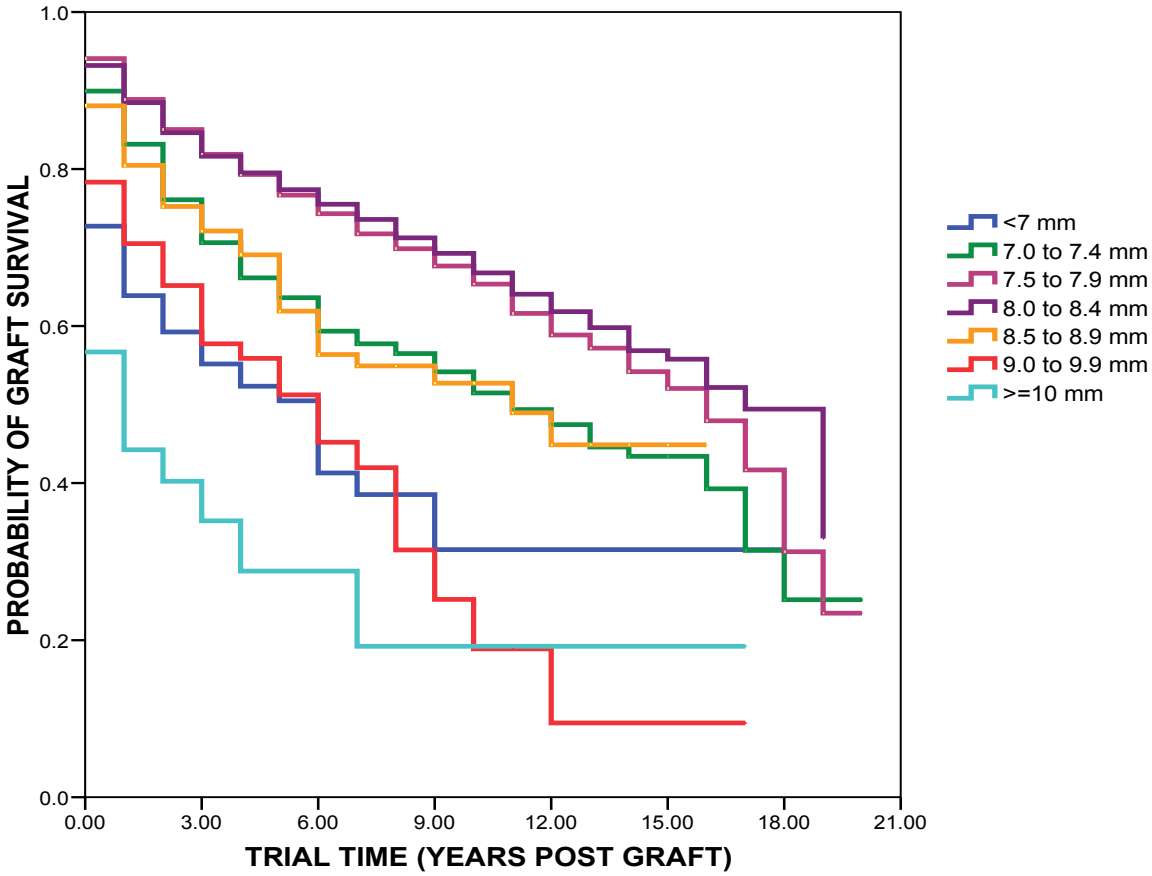
4.1.1 Hostbed size of graft

The hostbed size of the graft was recorded for 16,198 penetrating grafts, and ranged from 2.0 mm to 16.0 mm. Figure 4.1 shows the effect of graft size on the outcome of the 12,691 followed grafts with recorded graft size (Log Rank Statistic=422.36; df=6; p<0.00001). Grafts sized between 7.5 mm and 8.5 mm fare better than grafts that are larger or smaller.

Table 4.1 shows the reasons for failure of grafts of different sizes. Rejection is the major cause of failure, except for very large grafts, where infection becomes a problem. No difference is apparent in the reason for failure amongst different graft sizes.

All Kaplan-Meier plots and associated tables in this chapter have been calculated using penetrating grafts only.

Figure 4.1 Graft size



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Less than 7 mm	198	58	22	11	5	2	n/a	n/a
7.0 - 7.4 mm	1539	627	283	146	77	29	5	n/a
7.5 – 7.9 mm	5526	2288	1101	536	246	76	12	n/a
8.0 - 8.4 mm	4641	1753	789	361	172	53	10	n/a
8.5 – 8.9 mm	510	169	56	25	12	3	n/a	n/a
9.0 – 9.9 mm	180	44	17	2	n/a	n/a	n/a	n/a
10.0 mm thru highest	97	16	5	2	n/a	n/a	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Less than 7 mm	198	.639	.505	.315	n/a	n/a
7.0 - 7.4 mm	1539	.832	.636	.515	.434	n/a
7.5 – 7.9 mm	5526	.888	.767	.653	.520	n/a
8.0 - 8.4 mm	4641	.885	.774	.668	.558	n/a
8.5 – 8.9 mm	510	.805	.619	.490	n/a	n/a
9.0 – 9.9 mm	180	.705	.512	.189	n/a	n/a
10.0 mm thru highest	97	.442	.288	n/a	n/a	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
GRAFT SIZE

<7.0 mm:	**64% at 1 year**
Mean Survival 7.56 years	**50% at 5 years**
(SE=0.83; 95% CI: 5.93, 9.19)	**31% at 10 years**
Median Survival 6 years	
≥7.0 – 7.4 mm:	**83% at 1 year**
Mean Survival 10.78 years	**64% at 5 years**
(SE=0.37; 95% CI: 10.06, 11.50)	**51% at 10 years**
Median Survival 11 years	**43% at 15 years**
≥7.5 – 7.9 mm:	**89% at 1 year**
Mean Survival 12.83 years	**77% at 5 years**
(SE=0.24; 95% CI: 12.36, 13.29)	**65% at 10 years**
Median Survival 16 years	**52% at 15 years**
≥8.0 – 8.4 mm:	**88% at 1 year**
Mean Survival 13.11 years	**77% at 5 years**
(SE=0.23; 95% CI: 12.66, 13.55)	**67% at 10 years**
Median Survival 17 years	**56% at 15 years**
≥8.5 – 8.9 mm:	**80% at 1 year**
Mean Survival 9.47 years	**62% at 5 years**
(SE=0.51; 95% CI: 8.47, 10.47)	**49% at 10 years**
Median Survival 11 years	
≥9.0 – 9.9 mm:	**70% at 1 year**
Mean Survival 6.08 years	**51% at 5 years**
(SE=0.76; 95% CI: 4.59, 7.56)	**19% at 10 years**
Median Survival 6 years	
≥10.0 mm:	**44% at 1 year**
Mean Survival 4.55 years	**29% at 5 years**
(SE=1.09; 95% CI: 2.41, 6.68)	
Median Survival 1 year	

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

Table 4.1 Main reasons for graft failure according to hostbed size

Graft size mm	Total followed	Total failed	%	Main reasons for failure	No. failed	%
<7.0	198	88	44%	Rejection	24	27
				Infection[1]	18	20
				Endothelial cell failure	13	15
				Unspecified failure	7	8
				Glaucoma	6	7
				Retinal detachment	3	3
				Neovascularisation	3	3
				Primary non-function	2	2
7.0 - <8.5	11706	2361	20%	Rejection	747	32
				Endothelial cell failure	406	17
				Infection[2]	314	13
				Unspecified failure	258	11
				Glaucoma	190	8
				Primary non-function	112	5
				Trauma	56	2
				Neovascularisation	48	2
				Epithelial defect	42	2
				Scars and opacities	30	1
8.5 - <9.0	510	141	28%	Infection[3]	45	32
				Rejection	39	28
				Endothelial cell failure	14	10
				Unspecified failure	12	8
				Glaucoma	9	6
				Trauma	4	3
				Primary non-function	4	3
≥9.0	277	128	46%	Infection[4]	47	37
				Rejection	34	27
				Unspecified failure	9	7
				Corneal melt	8	6
				Endothelial cell failure	6	5
				Glaucoma	5	4
				Neovascularisation	4	3

1 includes perforated ulcer (6); endophthalmitis (5); abscess (4); HSV (1); mycotic ulcer (1); phthisical eye (1).

2 includes abscess (96); HSV (76); corneal ulcer (38); perforated ulcer (35); endophthalmitis (33); blind hypotensive eye (14); mycotic ulcer (9); pseudomonas (3); unspecified viral infection (3); streptococcus infection (2); Acanthamoeba (1); Fusarium (1); gonococcal infection (1); HZO (1); trachoma (1).

3 abscess (8); HSV (7); mycotic ulcers (7); perforated ulcers (7); ulcers (7); Acanthamoeba (3); endophthalmitis (2); hypotony of eye (2); Pseudomonas infection (1); Streptococcus infection (1).

4 mycotic ulcers (10); endophthalmitis (9); HSV (6); perforated ulcers (6); abscess (5); ulcers (3); Acanthamoeba (2); hypotony of eye (2); Pseudomonas infection (2); Streptococcus infection (1).

4.1.2 Accompanying procedures at graft

Table 4.2 lists the operative procedures that took place at the time of graft for all penetrating grafts in the database; 7,543 procedures were carried out during 6,899 graft operations (ie in 40% of the cohort).

It should be noted that data are no longer collected on ECCE/ICCE or the type of intraocular lens. Cataract extraction with an IOL inserted at the time of graft is categorised as a triple procedure.

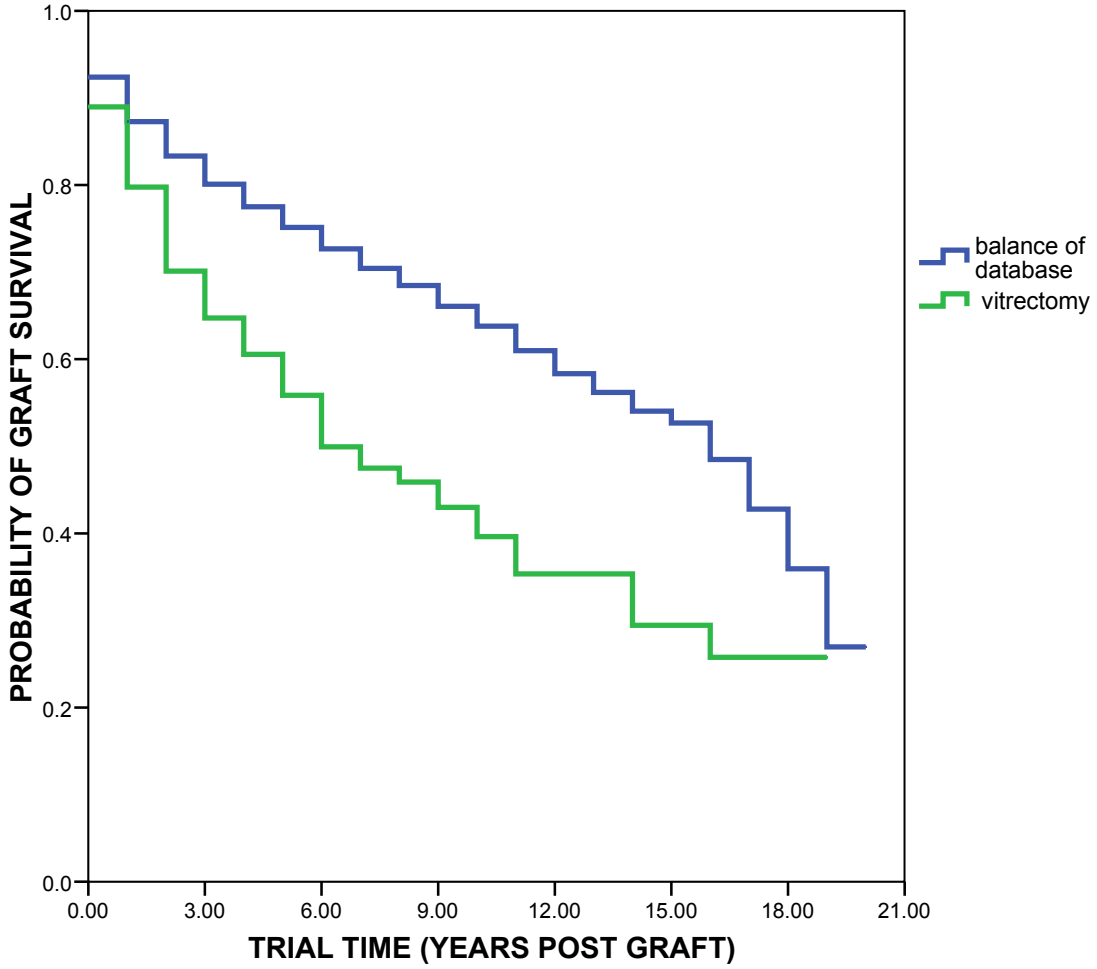
Table 4.2 Overview of operative procedures at graft

Procedure	Sub-total	No.	% of total grafts
Procedures dealing with IOLs		2437	14%
IOL removed and exchanged at graft	1373		
IOL inserted into aphakic eye	500		
Removal of IOL - patient left aphakic	270		
Cataract removed and patient left aphakic	195		
Reposition existing IOL	99		
Triple procedure		1743	10%
Vitrectomy		1675	10%
Iris procedures:		1229	7%
Peripheral iridectomy	981		
Pupilloplasty	84		
Iris repair/reconstruction	59		
Synechiolysis	55		
Division of anterior synechiae	50		
Glaucoma procedures:		113	<1%
Trabeculectomy	61		
Valve (implant/trimming etc)	46		
Cyclodialysis	6		
Tarsorrhaphy		58	<1%
Sphincterotomy		36	<1%
Gunderson flap/conjunctival flap		21	<1%
Anterior segment clearance/wash		19	<1%
Temporary keratoprosthesis (9 inserted/1 removed)		10	<1%
Retinal repair		8	<1%
Miscellaneous other procedures		194	1%
TOTAL PROCEDURES	7543 during 6899 graft operations (40%)		
TOTAL GRAFTS		17090	100%

4.1.3 Influence of vitrectomy

The influence of vitrectomy, performed at the time of graft, on subsequent corneal graft survival is shown in Figure 4.2 (Log Rank Statistic=148.62; df=1; p<0.00001).

Figure 4.2 Vitrectomy



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Balance of database	12007	4754	2202	1061	504	158	25	n/a
Vitrectomy	1343	429	170	63	25	9	3	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Balance of database	12007	.873	.751	.638	.527	n/a
Vitrectomy	1343	.798	.559	.396	.258	n/a

The main reasons for failure of grafts where a vitrectomy was performed at the time of graft were rejection (21%), bullous keratopathy and aphakia (10%), glaucoma (8%) and infection (3%). Of the 685 penetrating grafts that failed, 15 cases were reported to be primary non-functions.

PENETRATING CORNEAL GRAFT SURVIVAL
VITRECTOMY

Balance of database:	**87% at 1 year**
Mean Survival 12.74 years	**75% at 5 years**
(SE=0.16, 95% CI: 12.41, 13.06)	**64% at 10 years**
Median Survival 16 years	**53% at 15 years**
Vitrectomy:	**80% at 1 year**
Mean Survival 8.88 years	**56% at 5 years**
(SE=0.41, 95% CI: 8.09, 9.68)	**40% at 10 years**
Median Survival 6 years	**26% at 15 years**

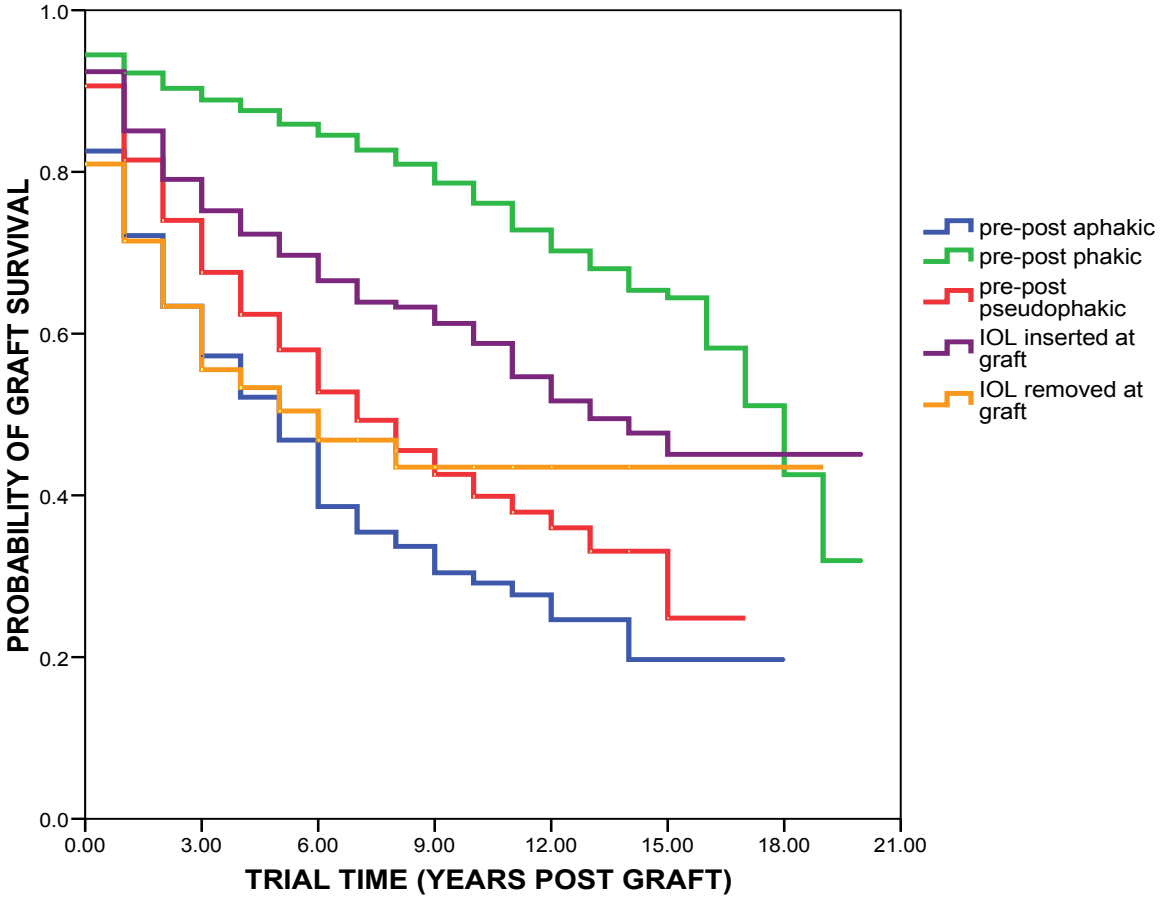
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

4.1.4 Lens insertion

Figure 4.3 compares graft survival for those recipients who were phakic, aphakic or pseudophakic at graft (and have remained so), with those recipients who had an IOL inserted or removed at the time of graft. Recipients undergoing an IOL insertion at the time of graft fare better than those retaining an existing intraocular lens, or those that remain aphakic (Log Rank Statistic=875.66; df=4; p<0.00001).

Figure 4.3 Lens status before and after graft



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Aphakic pre & post graft	683	196	74	31	18	n/a	n/a	n/a
Phakic pre & post graft	6513	2958	1522	798	394	140	24	n/a
Pseudophakic pre & post graft	2575	3746	1153	380	123	39	4	n/a
IOL inserted at time of graft	1972	756	354	157	73	18	2	n/a
IOL removed at time of graft	242	81	28	9	3	1	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Aphakic pre & post graft	683	.721	.468	.292	n/a	n/a
Phakic pre & post graft	6513	.922	.859	.761	.644	n/a
Pseudophakic pre & post graft	3746	.815	.580	.399	.248	n/a
IOL inserted at time of graft	1972	.851	.697	.588	.451	n/a
IOL removed at time of graft	242	.715	.504	.435	n/a	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
LENS STATUS

Aphakic pre & post graft:	**72% at 1 year**
Mean Survival 6.97 years	**47% at 5 years**
(SE=0.45; 95% CI: 6.09, 7.86)	**29% at 10 years**
Median Survival 5 years	
Phakic pre & post graft:	**92% at 1 year**
Mean Survival 14.67 years	**86% at 5 years**
(SE=0.20; 95% CI: 14.28, 15.06)	**76% at 10 years**
Median Survival 18 years	**64% at 15 years**
Pseudophakic pre & post graft:	**81% at 1 year**
Mean Survival 8.54 years	**58% at 5 years**
(SE=0.26; 95% CI: 8.02, 9.06)	**40% at 10 years**
Median Survival 7 years	**25% at 15 years**
IOL inserted at time of graft:	**85% at 1 year**
Mean Survival 12.16 years	**70% at 5 years**
(SE=0.36; 95% CI: 11.46, 12.87)	**59% at 10 years**
Median Survival 13 years	**45% at 15 years**
IOL removed at time of graft:	**71% at 1 year**
Mean Survival 9.47 years	**50% at 5 years**
(SE=0.80; 95% CI: 7.91, 11.03)	**43% at 10 years**
Median Survival 6 years	

KEY:

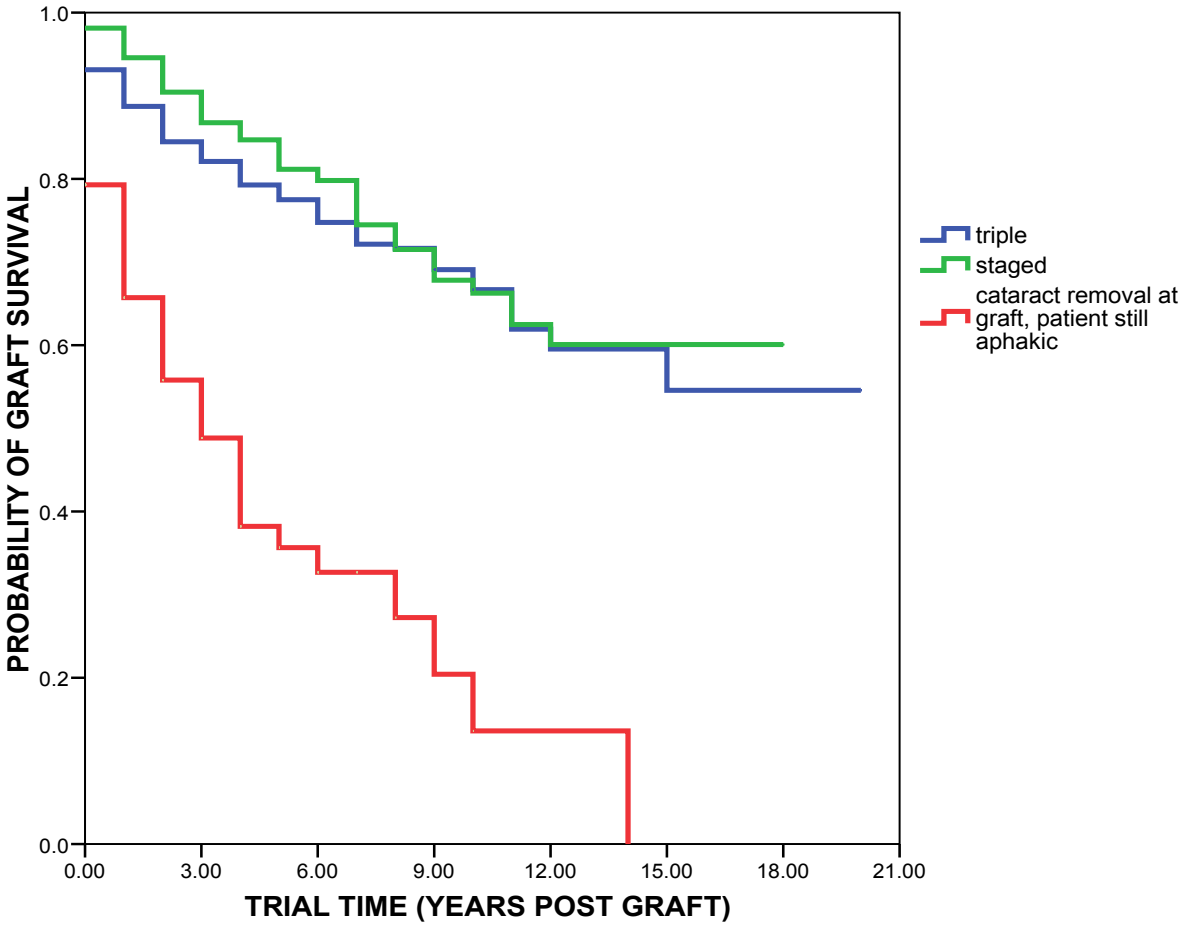
n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

4.1.4.1 Triple and staged procedures

Figure 4.4 compares the graft survival of triple and staged procedures with graft survival in those patients who underwent cataract removal at graft but who have remained aphakic (Log Rank Statistic=110.38. df=2, p<0.00001).

Triple procedures are defined as cataract removal and IOL insertion at the time of corneal graft. Staged procedures are defined as cataract removal at time of corneal graft and IOL insertion at some time after the graft, during the follow-up period.

Figure 4.4 Triple versus staged versus cataract removal and continuing aphakic



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Triple procedure	1325	533	255	112	52	12	1	n/a
Staged procedure	372	220	121	58	26	8	1	n/a
Cataract removal at graft, still aphakic	114	32	12	4	1	n/a	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Triple procedure	1325	.887	.775	.667	.546	n/a
Staged procedure	372	.948	.813	.664	n/a	n/a
Cataract removal at graft, still aphakic	114	.657	.358	.137	n/a	n/a

We did not observe any significant difference in graft survival between the cohort who underwent a triple procedure compared with the cohort who underwent a staged procedure (Log Rank Statistic=2.63; df=1, p=0.1049). However, both cohorts show significantly better graft survival than the cohort in whom a cataract was removed at the time of corneal transplantation, but who have remained aphakic (Log Rank Statistic=106.26; df=1, p<0.00001). The main reasons for corneal graft failure in the group who underwent cataract removal at graft and who remained aphakic were: rejection (33%), endothelial defects (11%), glaucoma (9%), bullous keratopathy and endophthalmitis (6%) each (excludes cases (47) with an unspecified reason for failure).

PENETRATING CORNEAL GRAFT SURVIVAL
TRIPLE AND STAGED PROCEDURES

Triple procedure:	**89% at 1 year**
Mean Survival 13.73 years	**77% at 5 years**
(SE=0.45; 95% CI: 12.84, 14.61)	**67% at 10 years**
Median Survival approx. 16 years	**55% at 15 years**
Staged Procedure:	**95% at 1 year**
Mean Survival 13.21 years	**81% at 5 years**
(SE=0.51; 95% CI: 12.22, 14.21)	**66% at 10 years**
Median Survival approx. 17 years	
Cataract removal at graft, still aphakic:	**66% at 1 year**
Mean Survival 4.92 years	**36% at 5 years**
(SE=0.65; 95% CI: 3.64, 6.21)	**14% at 10 years**
Median Survival 3 years	

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

4.2 SUMMARY OF EFFECT OF PROCEDURES AT TIME OF GRAFT AND INFLUENCE OF INTRAOCULAR LENSES

- Graft size is correlated with graft survival. Grafts within the size range of about 7.5 to 8.5 mm in diameter fare best. By comparison, larger and smaller grafts show reduced survival. Rejection is a major cause of graft failure across all groups, but infection also causes the loss of large grafts.

- In 40% of corneal grafts, some other specified procedure was carried out at the same time. The most frequently-performed of these procedures were a manipulation involving the crystalline lens or an intraocular lens (14%) and vitrectomy (10%).

- Graft survival is poorer in aphakes than in phakic or pseudophakic recipients.

- Graft survival does not differ between the cohorts who have undergone a triple procedure or a staged lens implant.

5. POST-GRAFT EVENTS

5.1 REASONS FOR GRAFT FAILURE

Table 5.1 lists the main reasons for failure of 2894 failed penetrating grafts.

Table 5.1 Reason for graft failure

Reason	Sub-total	Total	%
Rejection		**886**	**31%**
not specified	707		
with endothelial cell failure	45		
with glaucoma	36		
with vascularisation	17		
with HSV	17		
with abscess	16		
with ulcer (includes 2 perforated)	12		
with corneal degeneration	5		
with epithelial defect	4		
with scars and opacities	4		
with retinal detachment	3		
with keratoconus/keratoglobus	2		
with ICE syndrome	2		
with trauma	2		
other	14		
Endothelial cell failure		**602**	**21%**
primary graft failure	130		
with pseudophakic bullous keratopathy	142		
with bullous keratopathy	63		
with aphakic bullous keratopathy	8		
not specified	259		
Infection		**377**	**13%**
HSV	92		
unspecified	57		
with rejection	8		
with endothelial cell failure	5		
with ulcers	5		
with perforation	4		
with abscess	3		
with neovascularisation	3		
with glaucoma	2		
with band-shaped keratopathy	1		
with ectasia	1		
with hypotony	1		
with scars	1		
with uveitis	1		
HZO	1		
Mycotic ulcers (3 of which were perforated)	25		
Perforated ulcers	57		
unspecified	37		
with abscess	6		
with HSV	3		
with corneal degeneration	2		
with Stevens-Johnson syndrome	2		
other	7		

Reason	Sub-total	Total	%
Corneal abscess	120		
unspecified	72		
with perforation	10		
with endophthalmitis	6		
with pseudomonas infection	6		
with rejection	5		
with scars	4		
with glaucoma	3		
with endothelial cell failure	2		
with dehiscence	2		
Other	10		
Endophthalmitis	55		
Pseudomonas	10		
Acanthamoeba	6		
Streptococcus	5		
Unspecified viral infection	2		
Epidemic keratoconjunctivitis (Shipyard eye)	1		
Fusarium	1		
Gonococcus	1		
Trachoma	1		
Glaucoma		**235**	**8%**
with endothelial cell failure	30		
with rejection	18		
with congenital defect	4		
with epithelial defect	3		
with implantation cysts	3		
with uveitis	3		
with vascularisation	3		
with HSV	2		
with perforated ulcer	2		
with endophthalmitis	2		
Other	14		
not specified	151		
Vascularisation		50	2%
Ulcers (unspecified)		47	2%
Trauma		65	2%
Epithelial defect		49	2%
Scars and opacities		31	1%
Unspecified corneal degeneration		29	1%
Astigmatism		36	1%
Phthisis bulbi		15	<1%
Retinal detachment		10	<1%
Iris disorders		21	<1%
Wound dehiscence		10	<1%
Hypotony		9	<1%
Band-shaped keratopathy		8	<1%
Descemetocoele		8	<1%
Keratoconus		8	<1%
Miscellaneous *		91	3%
Unknown to ACGR		307	11%
TOTAL		**2894**	**100%**

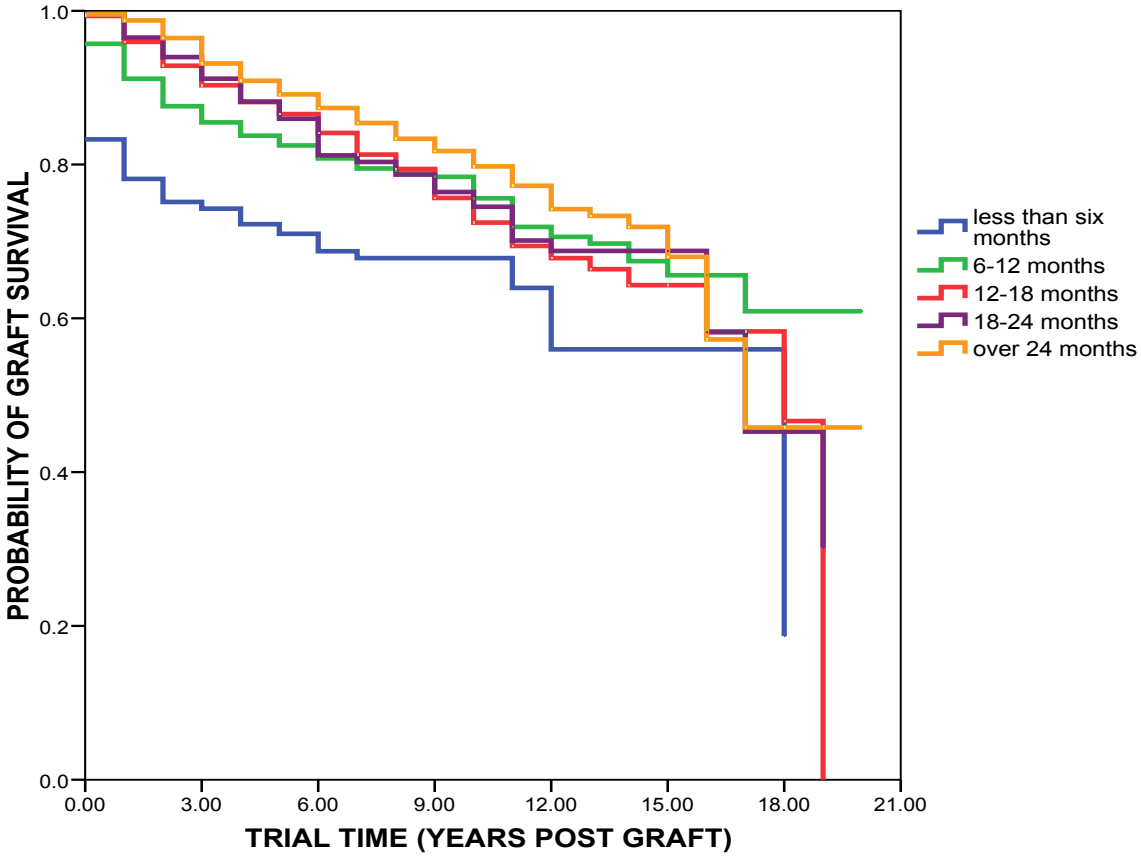
* expulsive choroidal haemorrhage (7); dystrophies (7); corneal ectasia (6); keratitis (6); corneal membrane changes (5); calcareous degeneration of cornea (4); phthisical cornea (4); cataract (3); recurrent erosion of cornea (3); retinal vein occlusion (3); rheumatoid arthritis (3); squamous cell carcinoma (3); congenital defect (2); dacryoadenitis (2); dry eye syndrome (2); hypopyon (2); ICE syndrome (2); Stevens-Johnson syndrome (2); vitreous haemorrhage (2); aniridia (1); aphakia (1); anterior segment ischaemia (1); conjunctival cornea (1); conjunctival melanoma (1); conjunctival scarring (1); dysplasia (1); erythroderma (1); flat anterior chamber (1); keratoconus with hydrops (1); keratoglobus (1); lipid keratopathy (1); meibomianitis (1); Munchausen syndrome (1); ocular pemphigus (1); Peters' anomaly (1); pneumonia due to streptococcus (1); recurrent pterygium (1); Reis-Bucklers dystrophy (1); scleral necrosis (1); secondary cataract (1); silicone oil (1); trichiasis (1).

5.2 TIME TO SUTURE REMOVAL

All Kaplan-Meier plots and associated tables in this chapter have been calculated using penetrating grafts only.

Figure 5.1 shows the influence of time of suture removal on graft survival (Log Rank Statistic=161.80; df=4; p<0.0001). As observed in previous analyses, early suture removal is associated with an increased risk of graft failure. Of the 538 grafts in which sutures were removed by 6 months post graft, 138 (25%) failed.

Figure 5.1 Time from graft to suture removal



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Less than 6 months	538	172	94	49	24	9	3	n/a
6-12 months	1681	751	389	205	110	37	6	n/a
12-18 months	2648	1275	562	274	132	49	5	n/a
18-24 months	1178	601	252	104	52	22	4	n/a
Over 24 months	1279	989	502	263	127	37	7	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Less than 6 months	538	.781	.710	.640	n/a	n/a
6-12 months	1681	.912	.825	.756	.656	n/a
12-18 months	2648	.959	.866	.725	.643	n/a
18-24 months	1178	.965	.860	.745	.582	n/a
Over 24 months	1279	.987	.891	.798	.680	n/a

The reasons for failure of these grafts are shown in Table 5.2. Reasons for graft failure in the cohort for early suture removal were very similar to that of the whole cohort.

Table 5.2 Reasons for graft failure associated with removal of all sutures by <6 months post-operatively

Reason for failure	Sub-total	Total	%
Rejection		43	32%
with oedema	3		
with recurrent ulceration	3		
with vascularisation	2		
with unspecified corneal degeneration	2		
with pannus	1		
with dry eye syndrome	1		
with stromal melt	1		
with glaucoma	1		
unspecified	29		
Endothelial cell failure		12	9%
Infection		18	13%
Mycotic ulcer	2		
Abscess	7		
HSV	5		
Endophthalmitis	4		
Glaucoma		12	9%
with PBK	1		
with neovascularisation	1		
with chronic uveitis	1		
with peripheral synechiae	1		
with keratitis	1		
unspecified	7		
Neovascularisation		5	4%
Ulcer		10	8%
perforated	5		
central	2		
unspecified	3		
Trauma		2	1%
Epithelial defect		3	2%
Scars and opacities		2	1%
Astigmatism		4	3%
Phthisical eye		4	3%
Miscellaneous[1]		9	7%
Unknown to ACGR		10	8%
TOTAL		**134**	**100%**

[1] Includes: retinal detachment (2); expulsive haemorrhage (1); descemetocoele (1); band shaped keratopathy (1); corneal ectasia (1); striate keratitis (1); recurrence of dystrophy (1); corneal melt (1); ocular ischaemia (1).

PENETRATING CORNEAL GRAFT SURVIVAL
TIME TO SUTURE REMOVAL

Less than 6 months:	**78% at 1 year**
Mean Survival 11.94 years	**71% at 5 years**
(SE=0.50; 95% CI: 10.96, 12.92)	**64% at 10 years**
Median Survival 18 years	
6-12 months:	**91% at 1 year**
Mean Survival 15.13 years	**82% at 5 years**
(SE=0.33; 95% CI: 14.48, 15.79)	**76% at 10 years**
Median Survival approx. 17 years	**66% at 15 years**
12-18 months:	**96% at 1 year**
Mean Survival 14.42 years	**87% at 5 years**
(SE=0.28; 95% CI: 13.87, 14.96)	**72% at 10 years**
Median Survival 18 years	**64% at 15 years**
18-24 months:	**96% at 1 year**
Mean Survival 14.41 years	**86% at 5 years**
(SE=0.42; 95% CI: 13.59, 15.22)	**74% at 10 years**
Median Survival 17 years	**58% at 15 years**
Over 24 months:	**99% at 1 year**
Mean Survival 15.45 years	**89% at 5 years**
(SE=0.40; 95% CI: 14.67, 16.23)	**80% at 10 years**
Median Survival 17 years	**68% at 15 years**

KEY:

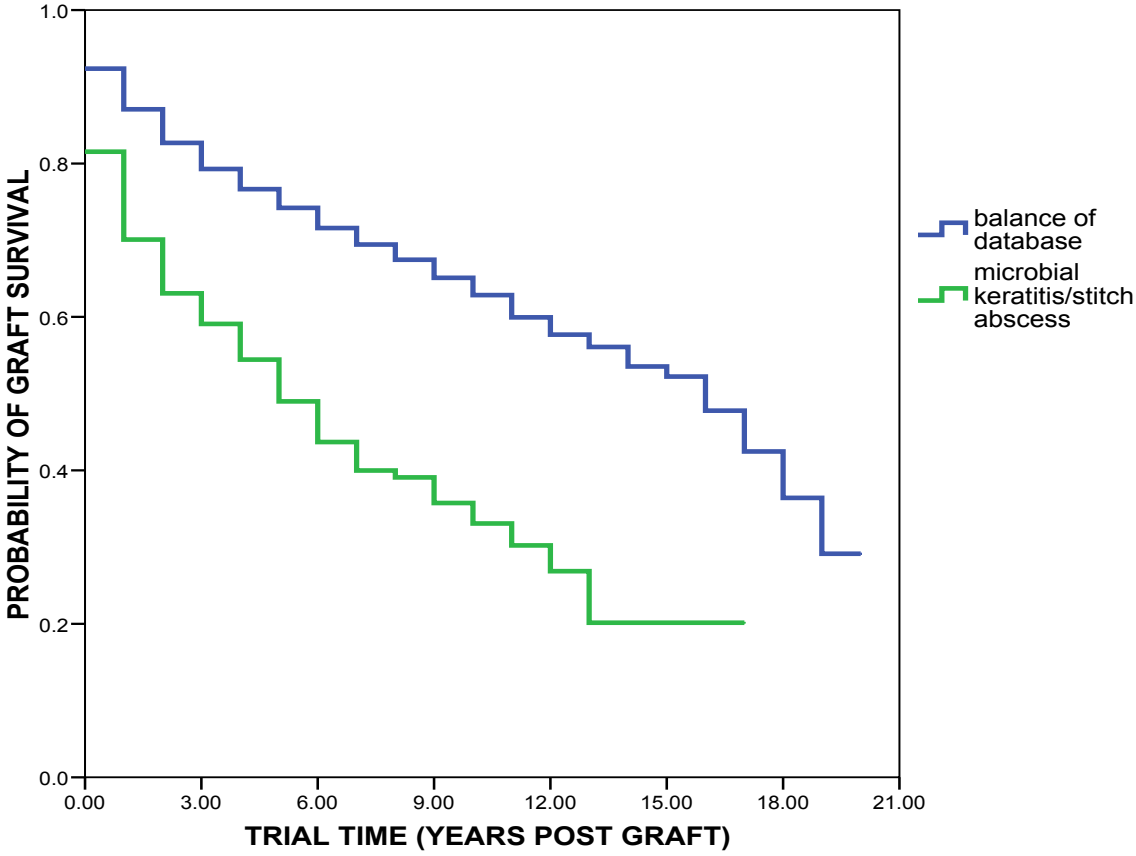
n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

5.3 POST-GRAFT COMPLICATIONS

5.3.1 Microbial keratitis/stitch abscess

The development of microbial keratitis or stitch abscess is associated with poor corneal graft survival (Log Rank Statistic=145.73; df=1; p<0.00001).

Figure 5.2 Microbial keratitis/stitch abscess



Number at Risk

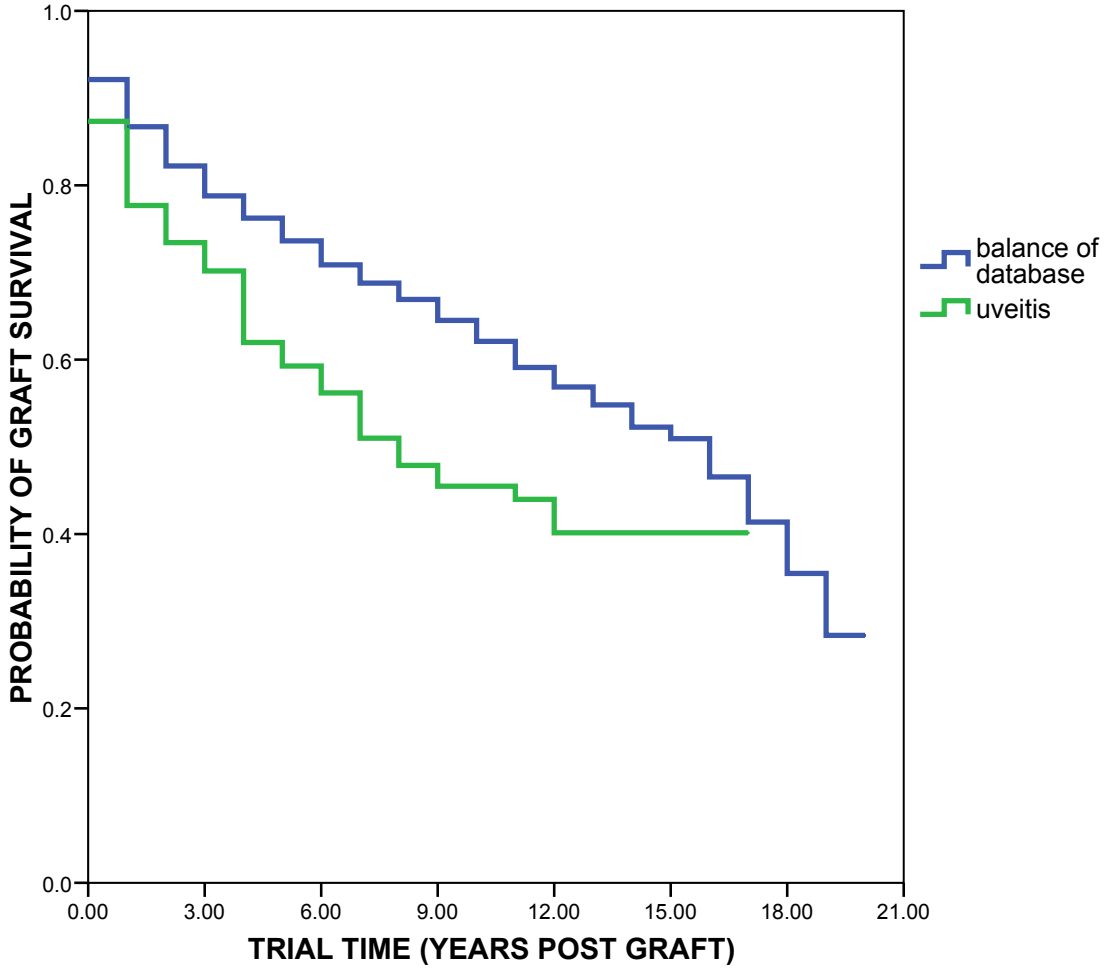
Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Balance of database	12971	5007	2286	1086	509	163	28	n/a
Microbial keratitis or stitch abscess	379	174	83	36	18	4	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Balance of database	12971	.871	.742	.628	.522	n/a
Microbial keratitis or stitch abscess	379	.701	.490	.331	n/a	n/a

5.3.2 Uveitis

Post-operative uveitis is another risk factor for corneal graft failure (Log Rank Statistic= 22.99; df=1; p=<0.00001).

Figure 5.3 Uveitis



Number at Risk

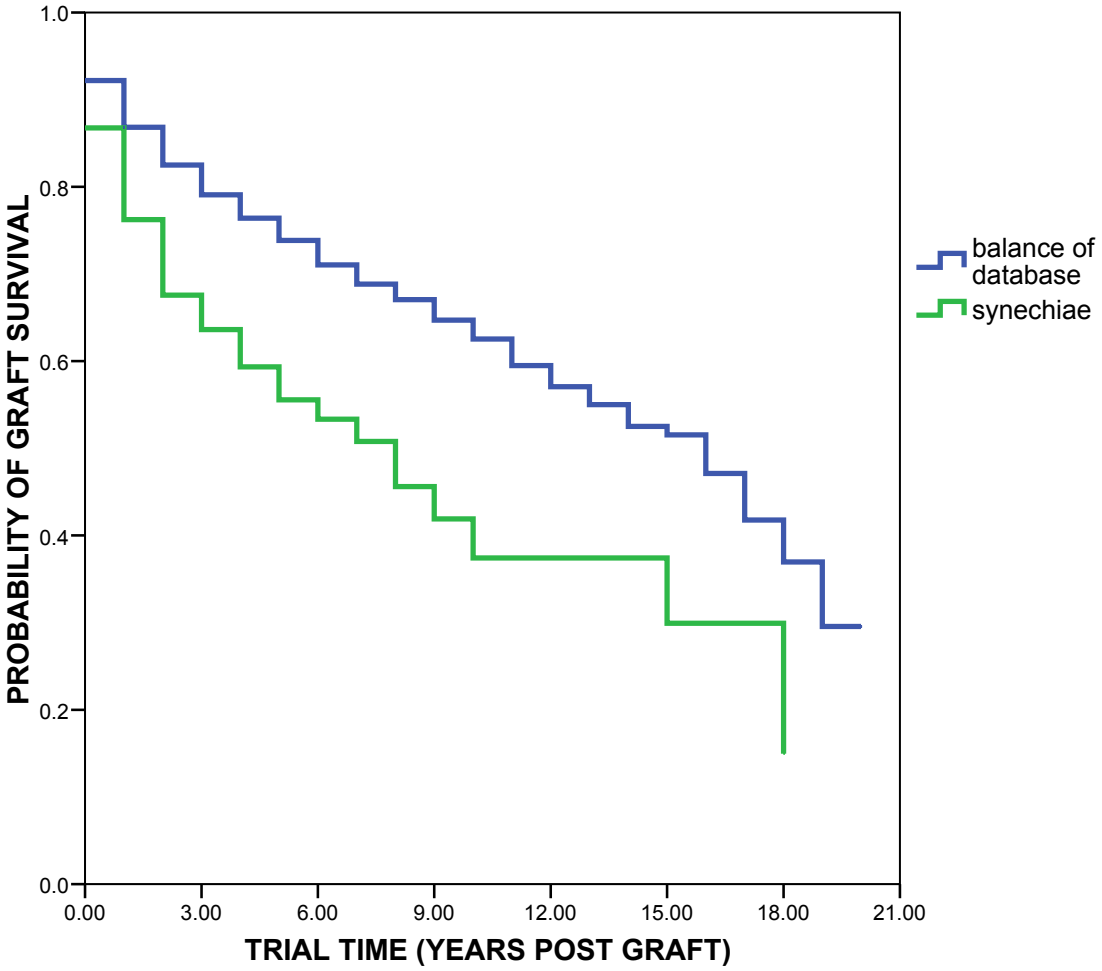
Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Balance of database	13113	5045	2292	1081	504	159	28	n/a
Uveitis	237	136	77	40	23	8	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Balance of database	13113	.867	.736	.621	.509	n/a
Uveitis	237	.777	.593	.440	n/a	n/a

5.3.3 Synechiae

Development of synechiae is a risk factor for graft failure, as shown in Figure 5.4 (Log Rank Statistic= 56.45; df=1; p=<0.00001).

Figure 5.4 Synechiae



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Balance of database	13018	5027	2294	1084	514	162	26	n/a
Synechiae	332	154	75	37	13	5	1	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Balance of database	13018	.868	.738	.625	.515	n/a
Synechiae	332	.762	.555	.374	.299	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
MICROBIAL KERATITIS/STITCH ABCESS

Balance of database:	**87% at 1 year**
Mean Survival 12.64 years	**74% at 5 years**
(SE=0.16; 95% CI: 12.33, 12.95)	**63% at 10 years**
Median Survival 16 years	**52% at 15 years**
Microbial keratitis or stitch abscess:	**70% at 1 year**
Mean Survival 7.06 years	**49% at 5 years**
(SE=0.43; 95% CI 6.22, 7.91)	**33% at 10 years**
Median Survival 5 years	

PENETRATING CORNEAL GRAFT SURVIVAL
UVEITIS

Balance of database:	**87% at 1 year**
Mean Survival 12.49 years	**74% at 5 years**
(SE=0.16, 95% CI: 12.18, 12.79)	**62% at 10 years**
Median Survival approx. 16 years	**51% at 15 years**
Uveitis:	**78% at 1 year**
Mean Survival 9.21 years	**59% at 5 years**
(SE=0.54, 95% CI: 8.14, 10.27)	**44% at 10 years**
Median Survival 8 years	

PENETRATING CORNEAL GRAFT SURVIVAL
SYNECHIAE

Balance of database:	**87% at 1 year**
Mean Survival 12.56 years	**74% at 5 years**
(SE=0.16, 95% CI: 12.25, 12.87)	**62% at 10 years**
Median Survival 16 years	**51% at 15 years**
Synechiae:	**76% at 1 year**
Mean Survival 8.78 years	**55% at 5 years**
(SE=0.56, 95% CI: 7.68, 9.87)	**37% at 10 years**
Median Survival 8 years	**30% at 15 years**

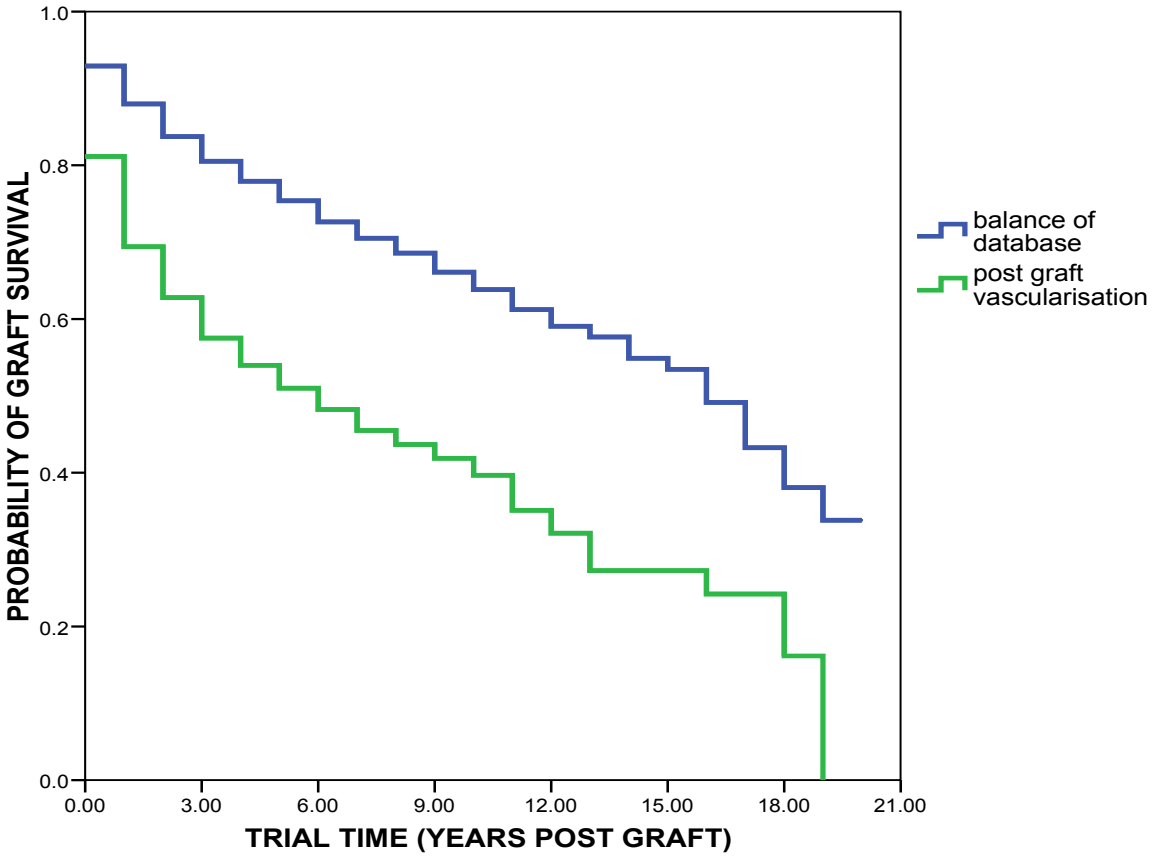
KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

5.3.4 Post-graft vascularisation

The effect of post-graft vascularisation on graft survival is shown in Figure 5.5 (Log Rank Statistic=318.07; df=1; p<0.00001). Graft neovascularisation is a significant risk factor for graft failure.

Figure 5.5 Post-graft vascularisation



Number at Risk

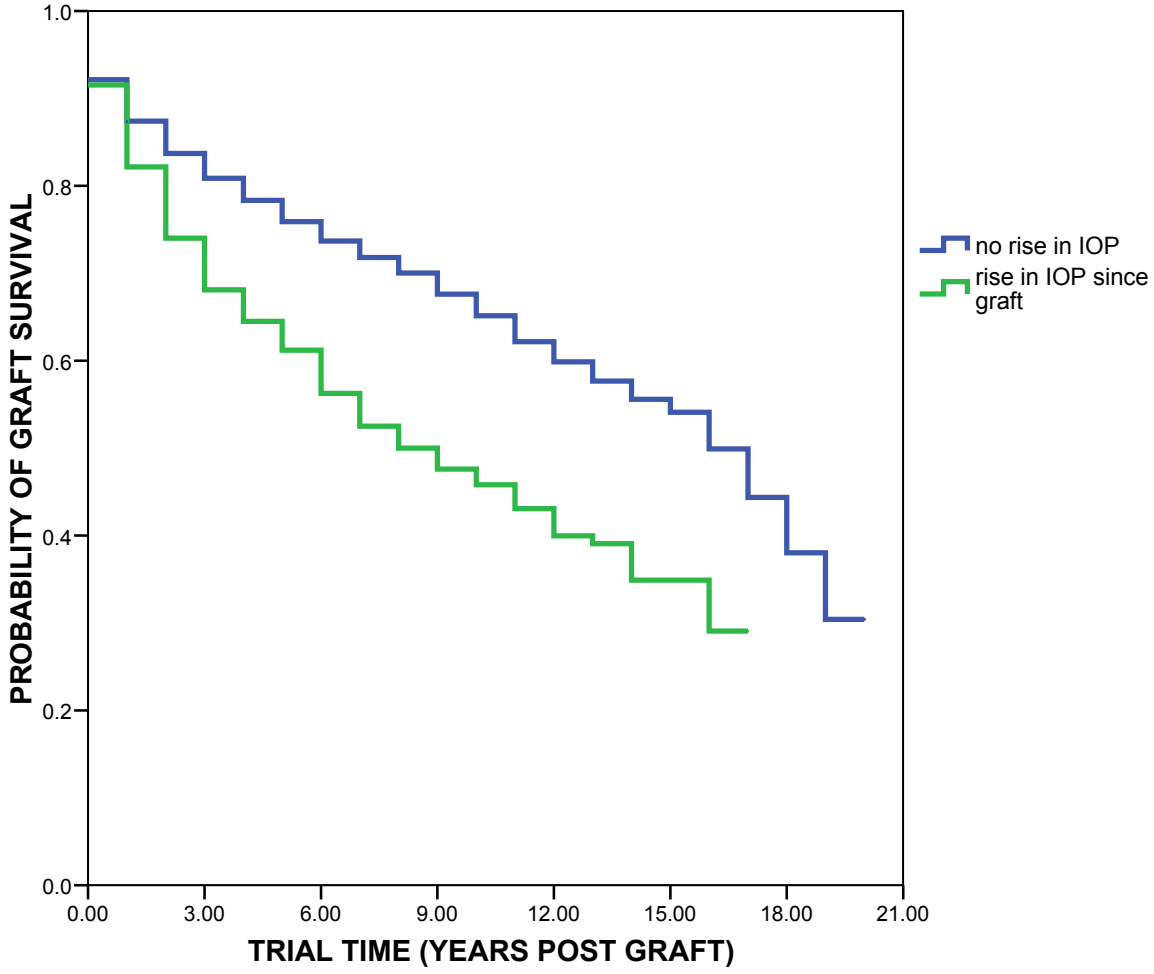
Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Balance of database	12367	4775	2168	1024	481	153	25	n/a
Post-graft vascularisation	983	406	201	98	47	14	3	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Balance of database	12367	.880	.754	.638	.534	n/a
Post-graft vascularisation	983	.694	.510	.397	.242	n/a

5.3.5 Post operative rise in intraocular pressure

A post-operative rise in intraocular pressure is a significant risk factor for corneal graft failure (Log Rank Statistic=151.25; df=1; p<0.00001).

Figure 5.6 Post-operative rise in intraocular pressure



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
No rise in intraocular pressure since graft	11304	4295	1976	957	460	151	28	n/a
Post-operative rise in intraocular pressure	2046	888	396	167	69	16	0	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
No rise in intraocular pressure since graft	11304	.874	.759	.651	.541	n/a
Post-operative rise in intraocular pressure	2046	.822	.612	.458	.291	n/a

5.3.5.1 Effect of post-operative rise in intraocular pressure

Of the 2046 grafts recording a rise in intraocular pressure in the post-graft period, 748 (37%) have failed. The main reasons for failure of these grafts are shown in Table 5.3.

Table 5.3 Reasons for graft failure in cases where raised intraocular pressure was recorded in the post-graft period

Reason	Sub-total	Total	%
Glaucoma		220	29%
no other indication reported	144		
with endothelial decompensation	27		
with rejection	18		
with vascularisation	3		
with endophthalmitis	2		
with perforated ulcer	2		
with epithelial defect	2		
with HSV	2		
with uveitis	2		
with implantation cysts	2		
Miscellaneous	16		
Graft rejection		215	29%
no other indication reported	149		
with glaucoma	32		
with endothelial decompensation	15		
with vascularisation	4		
with abscess	4		
with ulcer	2		
Miscellaneous	9		
Endothelial failure		175	23%
unspecified	99		
with pseudophakic bullous keratopathy	32		
with aphakic bullous keratopathy	21		
with glaucoma	12		
primary non-function	5		
Miscellaneous	6		
Infections		47	6%
abscess	19		
HSV	15		
endophthalmitis	5		
perforated ulcer	3		
mycotic ulcer	2		
Acanthamoeba keratitis	1		
streptococcus	1		
unspecified viral infection	1		
Epithelial failure		13	2%
Neovascularisation		12	2%
Unspecified ulcers		11	1.5%
Trauma		10	1.5%
Phthisis bulbi		8	1%
Miscellaneous		37	5%
TOTAL		**748**	**100%**

Glaucoma was the primary reason for graft failure in 29% of failed grafts. This disease featured as a primary or secondary cause of failure in 298 (40%) of the cases listed.

5.3.5.2 Post-graft operative procedures for glaucoma

Post-graft operative surgery for glaucoma has been performed on 406 (20%) of grafts in which a post-operative rise in IOP was recorded. Table 5.4 lists the procedures that have been performed.

Table 5.4 Operative procedures used to control post-graft raised intraocular pressure

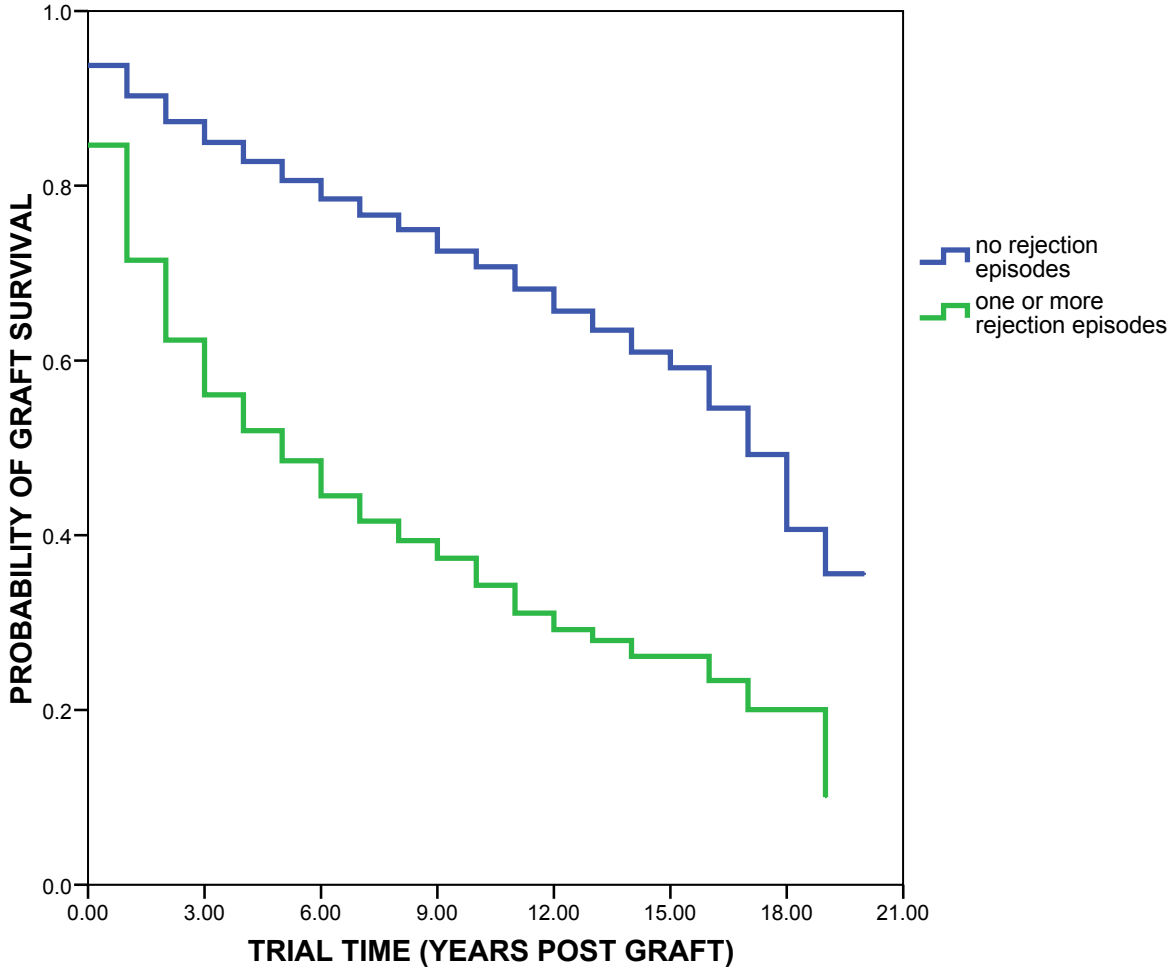
Name	No.	% of grafts
Trabeculectomy	174	40%
Valve implant	103	24%
Other glaucoma procedures	40	9%
Miscellaneous	29	7%
Not specified	85	19%
TOTAL PROCEDURES	**437 over 406 grafts (100%)**	

* Please note that in many cases surgeons have performed two or three operative procedures, and in these cases, all procedures have been included.

5.3.6 Rejection episodes since graft

The effect of occurrence of a rejection episode during the post-operative period is shown in Figure 5.7 (Log Rank Statistic=1034.58; df=1; p<0.00001).

Figure 5.7 Rejection episodes since graft



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
No rejection episodes	10856	4147	1878	889	430	136	23	n/a
One or more rejection episodes	2494	1036	494	235	99	30	5	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
No rejection episodes	10856	.903	.806	.707	.592	n/a
One or more rejection episodes	2494	.715	.485	.343	.234	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
POST-GRAFT VASCULARISATION

Balance of database:	**88% at 1 year**
Mean Survival 12.91 years	**75% at 5 years**
(SE=0.17, 95% CI: 12.58, 13.23)	**64% at 10 years**
Median Survival 16 years	**53% at 15 years**
Post-graft vascularisation:	**69% at 1 year**
Mean Survival 8.08 years	**51% at 5 years**
(SE=0.34, 95% CI: 7.42, 8.75)	**40% at 10 years**
Median Survival 6 years	**24% at 15 years**

PENETRATING CORNEAL GRAFT SURVIVAL
RISE IN IOP

No rise in intraocular pressure since graft:	**87% at 1 year**
Mean Survival 12.99 years	**76% at 5 years**
(SE=0.17; 95% CI: 12.66, 13.32)	**65% at 10 years**
Median Survival 16 years	**54% at 15 years**
Post-operative rise in intraocular pressure:	**82% at 1 year**
Mean Survival 9.15 years	**61% at 5 years**
(SE=0.23; 95% CI: 8.69, 9.61)	**46% at 10 years**
Median Survival 8 years	**29% at 15 years**

PENETRATING CORNEAL GRAFT SURVIVAL
REJECTION EPISODES

No rejection episodes:	**90% at 1 year**
Mean Survival 13.90 years	**81% at 5 years**
(SE=0.19; 95% CI: 13.54, 14.27)	**71% at 10 years**
Median Survival 17 years	**59% at 15 years**
One or more rejection episodes:	**71% at 1 year**
Mean Survival 7.76 years	**48% at 5 years**
(SE=0.21; 95% CI: 7.34, 8.18)	**34% at 10 years**
Median Survival 5 years	**23% at 15 years**

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

5.4 POST-GRAFT OPERATIVE PROCEDURES

Table 5.5 Post-graft operative procedures

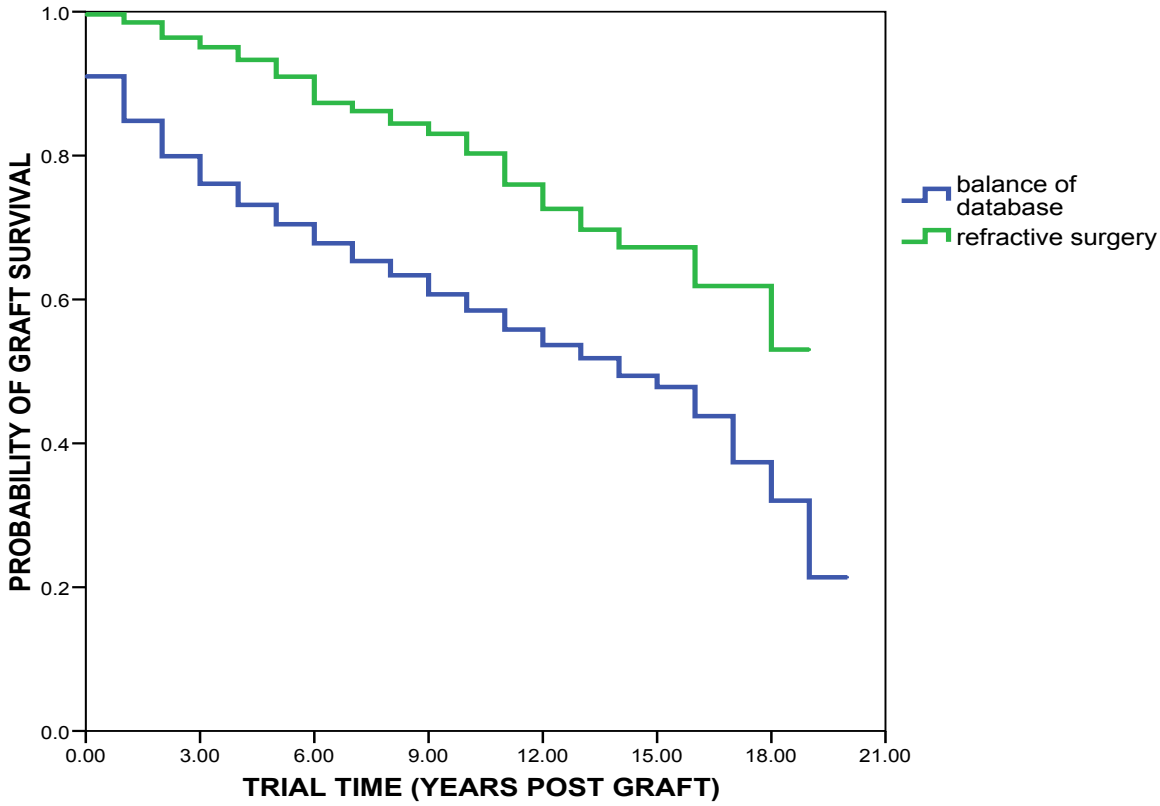
Procedure	Sub-total	Number of procedures [2]	% of followed
Refractive surgery		1613	12%
Repeat graft (reported to ACGR in follow-up[1])		1116	8%
Cataract extraction and IOL implant		620	5%
Yag laser		485	4%
Glaucoma surgery		484	4%
Trabeculectomy	200		
Valve implant	113		
Cyclocryotherapy	38		
Vitrectomy	2		
Miscellaneous	43		
Type of surgery not advised to ACGR	88		
Wound repair		438	3%
Enucleation following graft failure		137	1%
Remove IOL - eye left aphakic		126	<1%
Vitrectomy/anterior vitrectomy		94	<1%
Gunderson/conjunctival flap		68	<1%
Tarsorrhaphy		66	<1%
IOL implant into aphakic eye		65	<1%
Retinal surgery		49	<1%
Cataract extraction - no IOL implant		26	<1%
Laser (unspecified)		23	<1%
Ectropion/entropion repair		17	<1%
Exchange IOL and replace new IOL		16	<1%
Scraping/biopsy		11	<1%
Ptosis repair		11	<1%
Strabismus surgery		10	<1%
Division of anterior synechiae		5	<1%
Miscellaneous procedures		146	1%
Total procedures		**5626**	
Total grafts followed		**13350**	

1 This figure is probably higher as surgeons do not always advise of regrafts on follow-up forms.
2 Some grafts have had more than one operative procedure since graft. This table lists all procedures and provides a percentage calculated from the total number of grafts followed.

5.4.1 Refractive surgery

Figure 5.8 shows the effect of any form of post-graft refractive surgery on graft survival (Log Rank Statistic=242.63; df=1; p<0.00001). Data were carried over from one follow-up to the next.

Figure 5.8 The effect of refractive surgery



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Balance of database	11737	4254	1894	885	414	126	21	n/a
Any refractive surgery post-graft	1613	927	476	237	113	41	7	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Balance of database	11737	.848	.705	.585	.478	n/a
Any refractive surgery post-graft	1613	.985	.910	.803	.619	n/a

PENETRATING CORNEAL GRAFT SURVIVAL
EFFECT OF REFRACTIVE SURGERY

Balance of database:	**85% at 1 year**
Mean Survival 11.84 years	**70% at 5 years**
(SE=0.17, 95% CI: 11.51, 12.18)	**58% at 10 years**
Median Survival 14 years	**48% at 15 years**
Any refractive surgery post-graft:	**98% at 1 year**
Mean Survival 15.25 years	**91% at 5 years**
(SE=0.30, 95% CI: 14.65, 15.84)	**80% at 10 years**
Median Survival approx. 19 years	**62% at 15 years**

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

5.5 SUMMARY OF POST-GRAFT EVENTS

- The major reasons for failure of penetrating grafts are irreversible rejection (31%), endothelial cell failure (21%), infection including recurrent HSV keratitis (13%), and glaucoma (8%).
- Removal of graft sutures within 6 months of the time of transplantation is a risk factor for graft failure.
- A variety of post-operative events are associated with graft failure. These include development of microbial keratitis or a stitch abscess (affecting 3% of grafts), uveitis (2%), synechiae (3%), graft neovascularisation (7%), rejection episodes (19%) and a rise in intraocular pressure (15%) in the grafted eye.
- Over 42% of grafted eyes have undergone some form of operative procedure since the time of corneal transplantation.
- In 12% of cases, a refractive procedure has been performed on the grafted eye.

6. VISUAL OUTCOME

6.1 DESIRED OUTCOME

The Australian Corneal Graft Registry has recorded a desired outcome for 14,321 (79%) of the 18,205 penetrating grafts entered. These outcomes are shown in Figure 6.1 and Table 6.1.

Figure 6.1 Reasons for graft

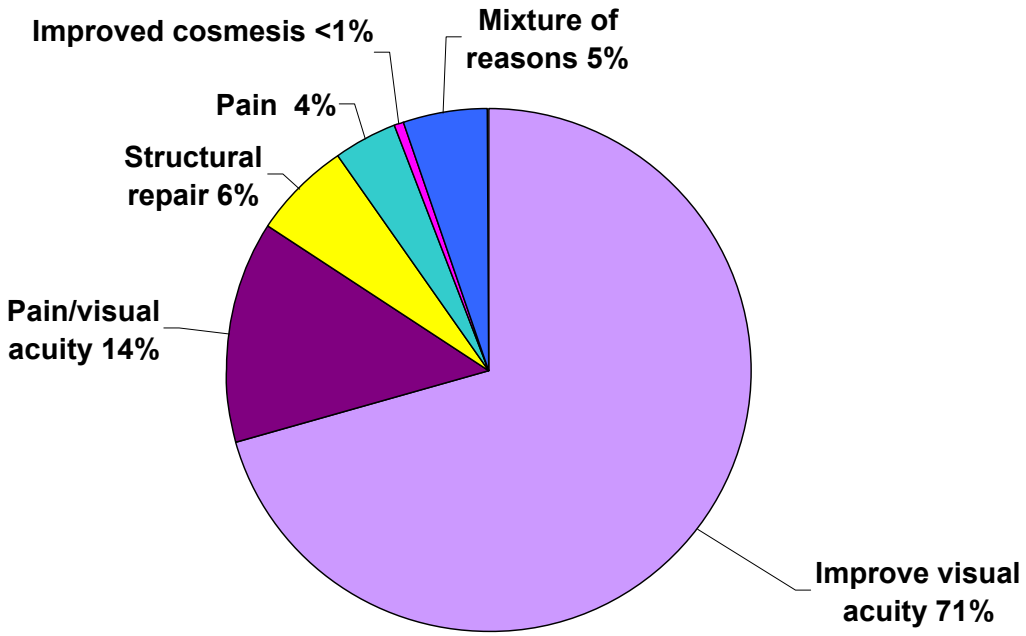


Table 6.1 Reasons for graft

Reason for Graft	Number	%
Improvement in visual acuity	10095	70%
Pain and visual acuity	1975	14%
Structural repair	858	6%
Pain relief	566	4%
Improved cosmesis	58	<1%
Mixture of reasons	769	5%
TOTAL	**14321**	**100%**

6.1.1 Desired outcome and actual visual outcome achieved

Table 6.2 shows whether visual acuity in the grafted eye at the most recent follow-up was better, worse or the same as before graft. Categories marked with an asterisk are mutually exclusive.

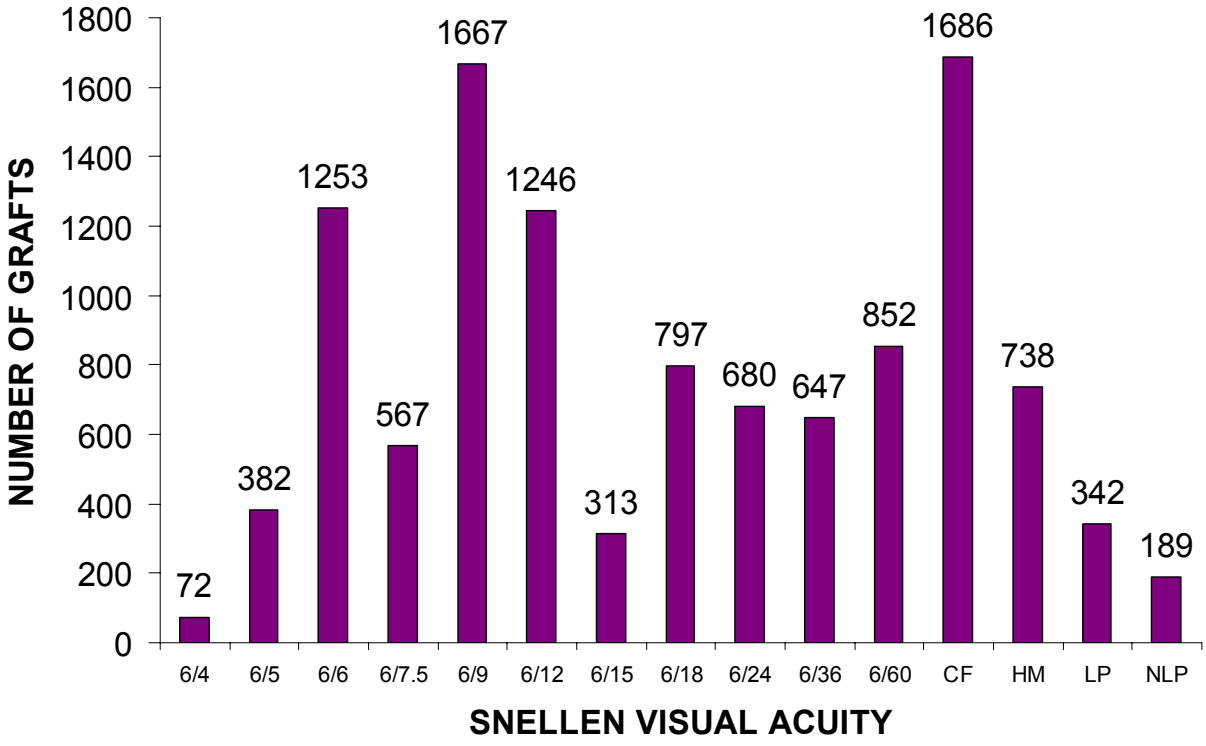
Table 6.2 Visual outcome compared with reason for graft

Reason for Graft	Number followed	VA Better	VA Same	VA Worse	Not known
* Where the **only** reason for graft was to improve visual acuity	7384 (100%)	4187 (56%)	499 (7%)	571 (8%)	2127 (29%)
Where **one** of the reasons for graft was to improve visual acuity	9214 (100%)	5184 (57%)	757 (8%)	776 (8%)	2497 (27%)
* Where the **only** reason for graft was to relieve pain	457 (100%)	150 (33%)	72 (16%)	45 (10%)	190 (41%)
* Where the **only** reason for graft was cosmesis	19 (100%)	4 (21%)	3 (16%)	3 (16%)	9 (47%)
* Where the **only** reason for graft was structural repair	342 (100%)	91 (27%)	52 (15%)	43 (12%)	156 (46%)
Where the reason for graft was vision **and** pain	1438 (100%)	784 (55%)	208 (14%)	167 (12%)	279 (19%)
Where the reason for graft was vision **and** repair	228 (100%)	115 (50%)	25 (11%)	25 (11%)	63 (28%)
Where there were a mixture of reasons for graft, not stated above	39 (100%)	13 (33%)	6 (15%)	8 (20%)	12 (32%)

6.2 OVERALL VISUAL ACUITY

Figure 6.2 shows the best corrected visual acuity in the grafted eye at the time of the most recent follow-up. Post-graft visual acuity has been recorded for 11,431 penetrating grafts. Of these 5,187 (45%) have recorded a best corrected acuity of 6/12 or better; 6,297 (55%) have achieved 6/18 or better; and 2,955 (26%) record a visual acuity of less than 6/60. In an additional 1919 cases, information was not available.

Figure 6.2 Best corrected visual acuity in grafted eye at last follow-up



CF = count fingers at 1 metre, HM = hand movements, LP = light perception, NLP = no light perception

BEST CORRECTED SNELLEN ACUITY AT MOST RECENT POST-OPERATIVE VISIT		
6/12 or better	**5187**	**39%**
6/18 or better	**6297**	**47%**
6/24 - 6/60	**2179**	**16%**
Less than 6/60	**2955**	**22%**
Unknown/not recorded	**1919**	**14%**

Percentages shown in this box are for all 13350 followed penetrating grafts

6.2.1 Comparison of recipient characteristics where post-graft visual acuity is ≥ 6/18 or <6/18

The categories below are not mutually exclusive for either set of comparisons.

Table 6.3 Comparison where post-graft vision is ≥6/18 or <6/18

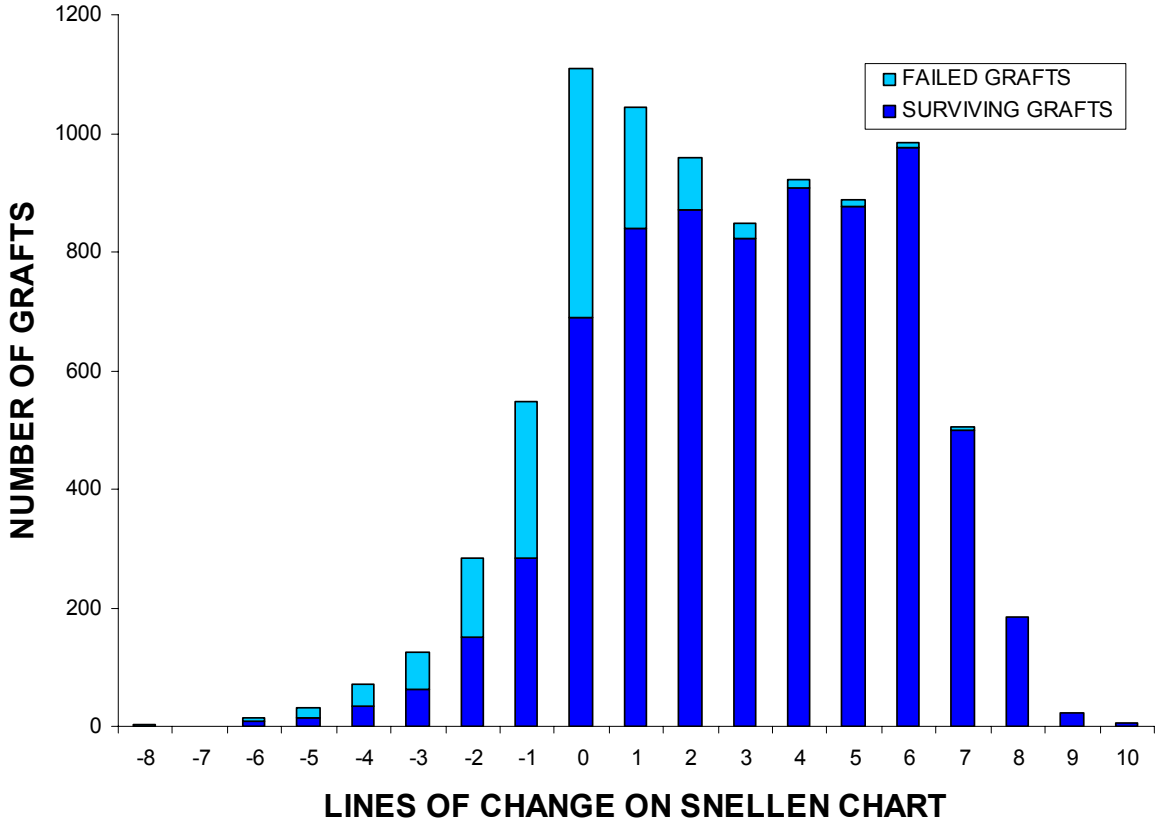
Description	VA equal to or better than 6/18		VA is worse than 6/18	
	No.	%	No.	%
Reasons for grafting				
Vision	4299	66%	2249	34%
Pain/Vision	454	37%	782	63%
Pain	67	18%	301	82%
Other (combinations)	122	35%	228	65%
Tectonic	43	17%	204	83%
Cosmesis	6	38%	10	62%
Not advised	1306	49%	1360	51%
Presenting disease				
Keratoconus	3462	83%	731	17%
Keratoconus with hydrops	98	72%	39	28%
Fuchs' dystrophy	738	62%	453	38%
HSV - history (not at graft)	288	52%	271	48%
Non herpetic scar	281	49%	296	51%
Previous graft failure	770	37%	1274	63%
Pseud. bullous keratopathy	810	31%	1814	69%
HSV – active at graft	48	28%	122	72%
Aphakic bullous keratopathy	90	24%	289	76%
Perforation	58	22%	211	78%
Lens at last follow-up				
Phakic	4335	75%	1460	25%
Pseudophakic	1803	38%	2995	62%
Aphakic	159	19%	679	81%
Operative procedure at graft				
Triple procedure	627	55%	520	45%
Cataract removed	661	54%	633	46%
Peripheral iridectomy	183	46%	214	54%
Anterior vitrectomy	251	23%	824	77%
Trabeculectomy	10	22%	35	78%
Operative procedure post-graft				
Refractive surgery performed	1057	70%	450	30%
Cataract removed; IOL inserted	329	65%	178	35%
Insertion of IOL	160	57%	123	44%
Yag/mechanical capsulotomy	240	55%	194	45%
Cataract removed; no IOL	7	27%	19	73%
Complications in follow-up				
Major astigmatism	1471	63%	844	37%
Cataract affecting VA	149	46%	177	54%
Rejection episodes	810	39%	1273	61%
Amblyopia	147	38%	235	62%
Uveitis	68	34%	133	66%
Raised IOP post-graft	580	31%	1323	69%
Neovascularisation	267	31%	601	69%
Stitch abscess/microbial keratitis	97	30%	224	70%
HSV in post-operative period	72	27%	192	73%
Maculopathy	321	25%	977	75%
Synechiae	65	21%	234	79%
CME	154	18%	713	82%
Retinal detachment	22	12%	170	88%
Graft has failed	67	3%	1840	97%
Recipient age				
Recipient age ≥80 years	443	28%	1111	72%
TOTAL	**6297**	**(55%)**	**5134**	**(45%)**

In summary, for those recipients who achieved 6/18 or better in their graft, proportionately more were grafted to improve their vision, suffered from keratoconus as the indication for graft, were phakic, and had undergone a refractive surgical procedure to the graft, compared with recipients who achieved worse than 6/18 in their graft. In the latter group, there was a relative excess of grafts performed for pain relief or structural repair, bullous keratopathy, perforation or previous failed graft, together with more aphakes, pseudophakes and elderly recipients, and more recipients who had suffered cystoid macular oedema, retinal detachment or whose graft had failed.

6.2.2 Post-graft changes in visual acuity

In 8546 of cases, both pre-operative and post-operative Snellen visual acuities were available. Figure 6.3 shows the number of lines of improvement or worsening in visual acuity since graft, as measured at the most recent follow-up.

Figure 6.3 Changes in Snellen acuity after graft.



Number of lines on the Snellen Chart	Surviving grafts No.	%	Failed grafts No.	%	Total Grafts No.	%
VA worse by 5-10 lines	22	<1	28	<1	50	<1
VA worse by 2-4 lines	245	3	235	3	480	6
VA worse by 1 line	284	3	264	3	548	6
VA unchanged	689	8	420	5	1109	13
VA better by 1 line	841	10	203	2	1044	12
VA better by 2-4 lines	2602	30	127	2	2729	32
VA better by 5-10 lines	2565	30	21	<1	2586	30
Sub Totals	**7248**	**85%**	**1298**	**15%**	**8546**	**100%**
TOTAL	**8546 (100%)**					

Of the 1078 grafts for which acuity had decreased, 527 (49%) had failed, and of the 1109 grafts for which visual acuity remained unchanged, 420 (38%) had failed. Interestingly, 351 grafts reported as having failed actually recorded a better visual acuity at the last follow-up than they did at the time of graft. No post-operative change from the pre-graft visual acuity was recorded for 1109 grafts. These data are examined more closely in Table 6.4. Categories are not mutually exclusive.

Table 6.4 No change in visual acuity post-graft

Description	Number	%
Reasons for graft		
Vision	516	46%
Pain & vision	208	19%
Pain	72	6%
Tectonic	52	5%
Cosmesis	3	<1%
Not advised	201	18%
Other combinations	57	5%
Presenting disease		
Pseudophakic bullous keratopathy	412	37%
Previous graft failure	274	25%
Keratoconus	186	17%
Fuchs' dystrophy	105	9%
Non herpetic scar	58	5%
Aphakic bullous keratopathy	56	5%
HSV - history - not active at time of graft	55	5%
Perforation	37	3%
HSV - active at time of graft	26	2%
Lens status at last follow-up		
Pseudophakic	666	60%
Phakic	328	30%
Aphakic	115	10%
Operative procedure at graft		
Anterior vitrectomy	177	16%
Cataract removed	127	11%
Triple procedure	113	10%
Peripheral iridectomy	42	4%
Operative procedure post-graft		
Refractive surgery performed	94	8%
Yag/mechanical capsulotomy	31	3%
Cataract removed; IOL inserted	31	3%
Cataract removed; no IOL	20	2%
Complications in follow-up		
Graft has failed	420	38%
Raised IOP post-graft	289	26%
Any rejection episodes since graft	285	26%
Maculopathy	218	20%
Major astigmatism	162	15%
Neovascularisation	127	11%
CME	126	11%
Synechiae	59	5%
Stitch abscess or microbial keratitis	44	4%
Cataract affecting VA	40	4%
Amblyopia	38	3%
HSV in post-operative period	36	3%
Retinal detachment	31	3%
Uveitis	17	1%
Recipient age		
Recipient age ≥80	253	23%
TOTAL GRAFTS	**1109**	

CHANGE IN SNELLEN ACUITY AFTER GRAFT

Better	**6359**	**(48%)**
Same	**1109**	**(8%)**
Worse	**1078**	**(8%)**
VA not advised to ACGR	**4804**	**(36%)**

[Calculated as a percentage of all followed penetrating grafts (13,350)]

In most cases in which the change in Snellen acuity after graft cannot be determined, the Registry is unaware of the pre-operative acuity.

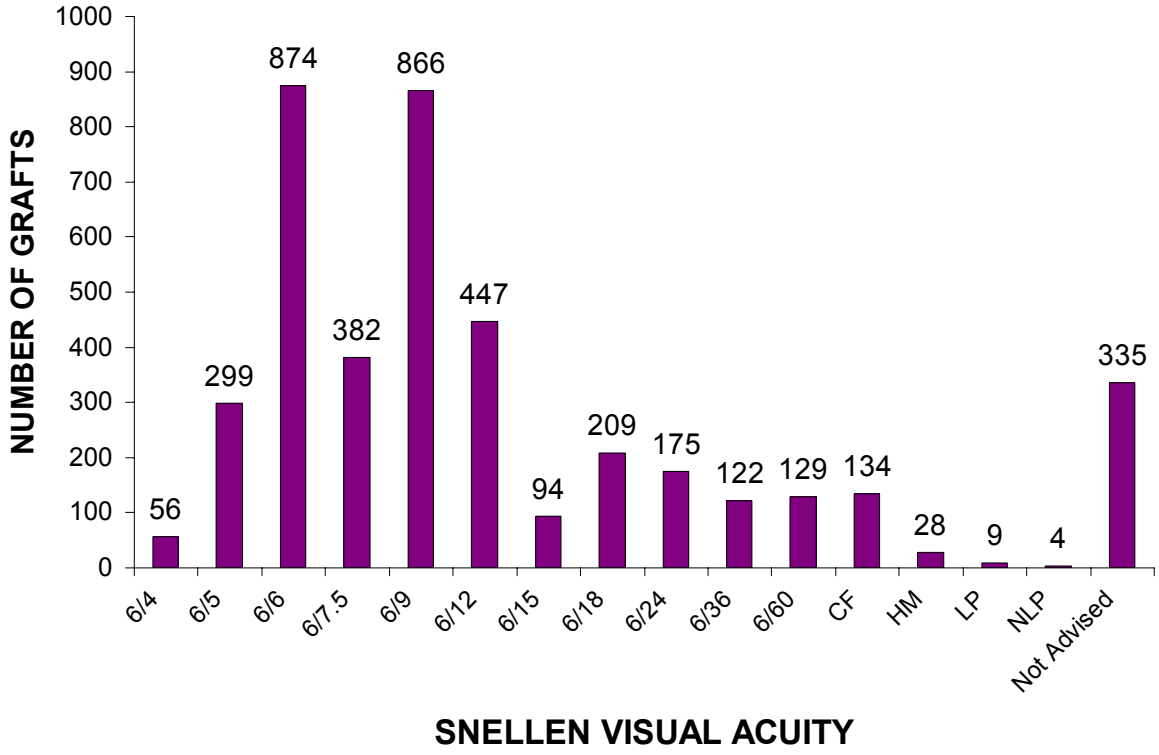
6.3 VISUAL OUTCOME RELATED TO PRESENTING DISEASE

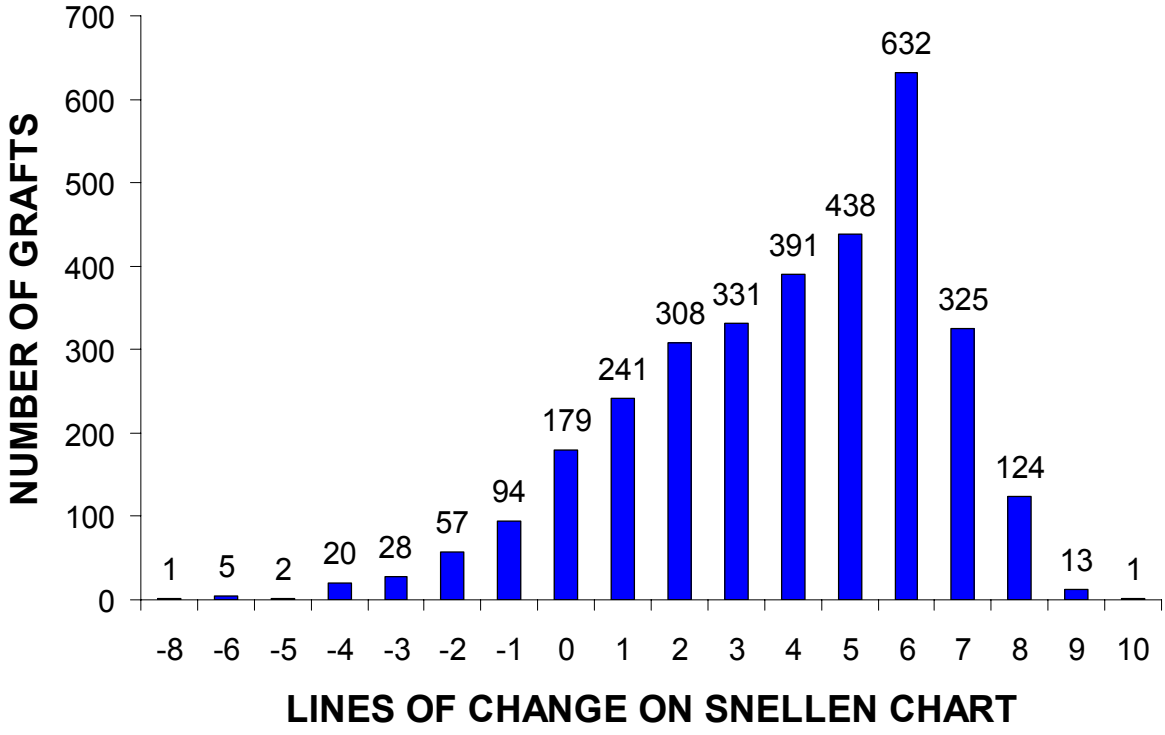
The following pages show the visual outcome of penetrating grafts performed for keratoconus, Fuchs' dystrophy, aphakic or pseudophakic bullous keratopathy, previously failed grafts or herpetic infection. These are the most common indications for penetrating corneal transplantation in our database.

In each case we provide two charts - the first showing the post-graft Snellen visual acuities, and the second showing the number of lines of improvement or worsening in visual acuity compared with the pre-operative acuity. Failed grafts are included where information is available.

6.3.1 Keratoconus

Figure 6.4 Visual outcome: keratoconus

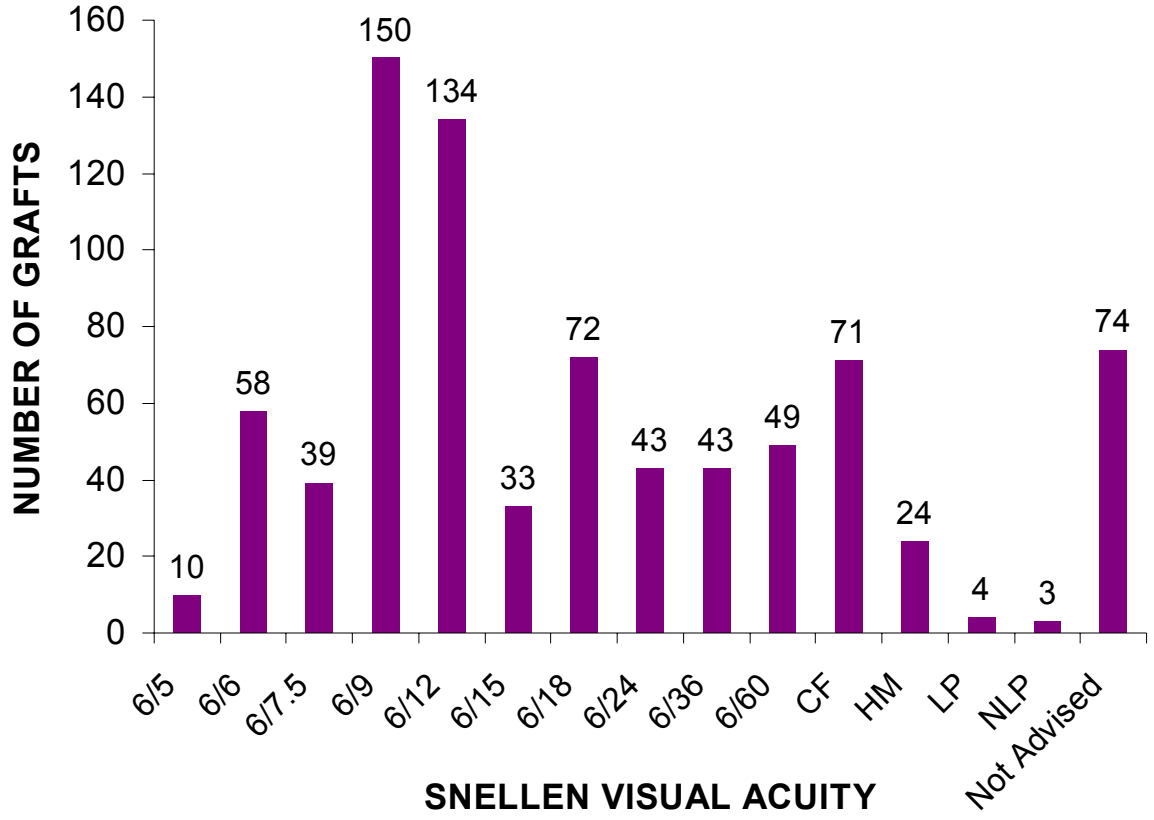


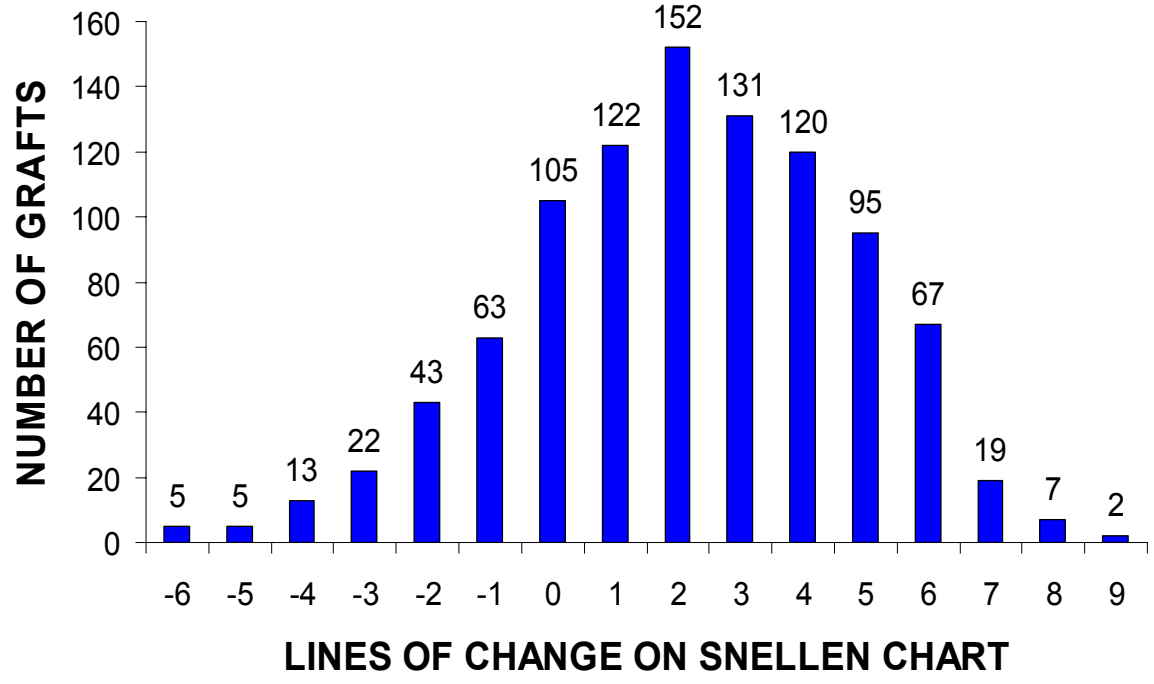


Seventy percent of all grafts performed for keratoconus achieved a post-graft visual acuity of 6/12 or better, and 78% achieved 6/18 or better. In the 88% of cases where the visual acuity was provided both before and after graft, at least one line of improvement on the Snellen chart was achieved after graft.

6.3.2 Fuchs' dystrophy

Figure 6.5 Visual outcome: Fuchs' dystrophy

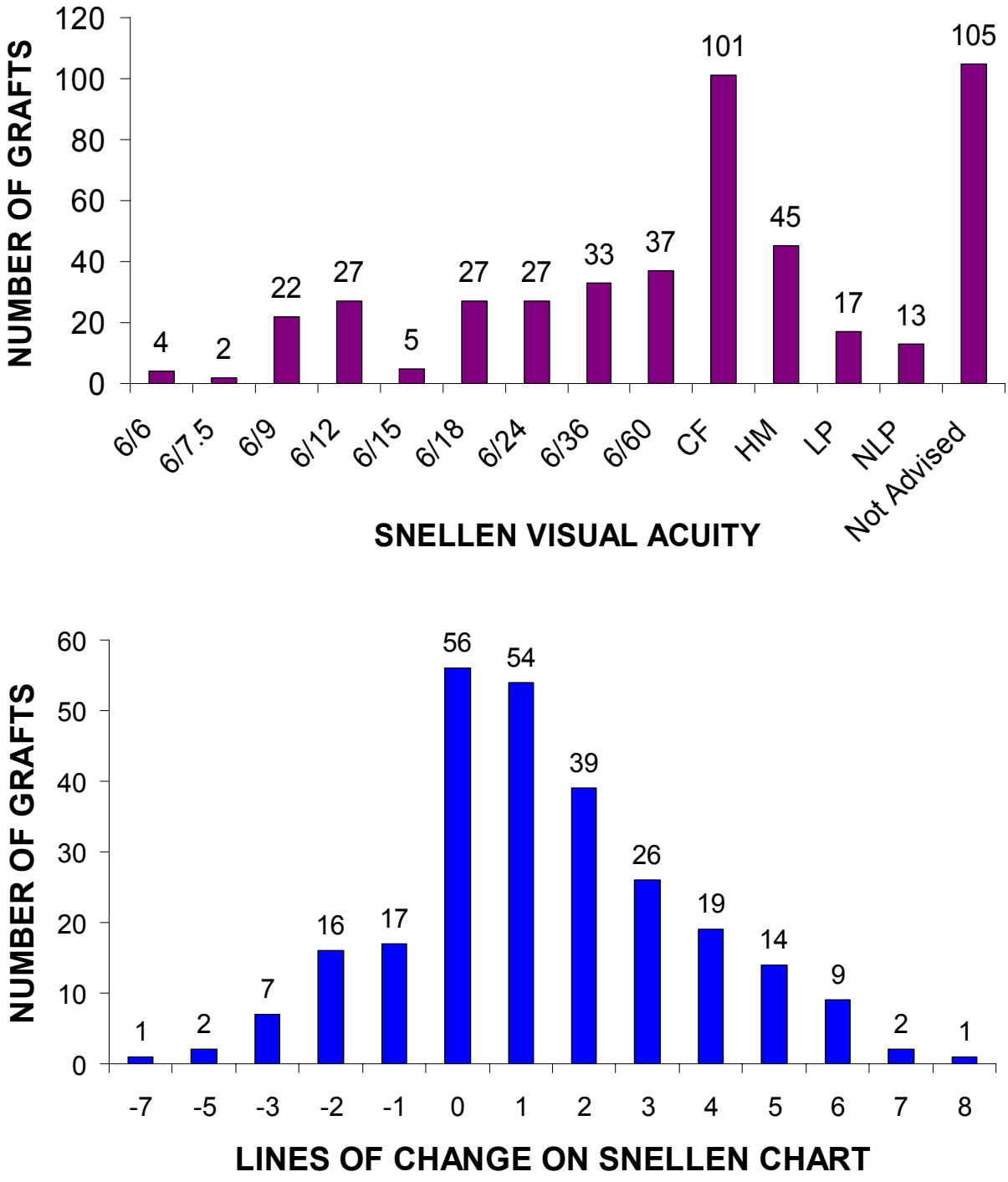




Forty eight percent of all grafts performed for Fuchs' dystrophy achieved a post-graft visual acuity of 6/12 or better, 61% achieved 6/18 or better and 78% achieved 6/60 or better. In the 74% of cases where the ACGR was provided with VA both before and after graft, at least one line of improvement on the Snellen chart was achieved after graft.

6.3.3 Aphakic bullous keratopathy

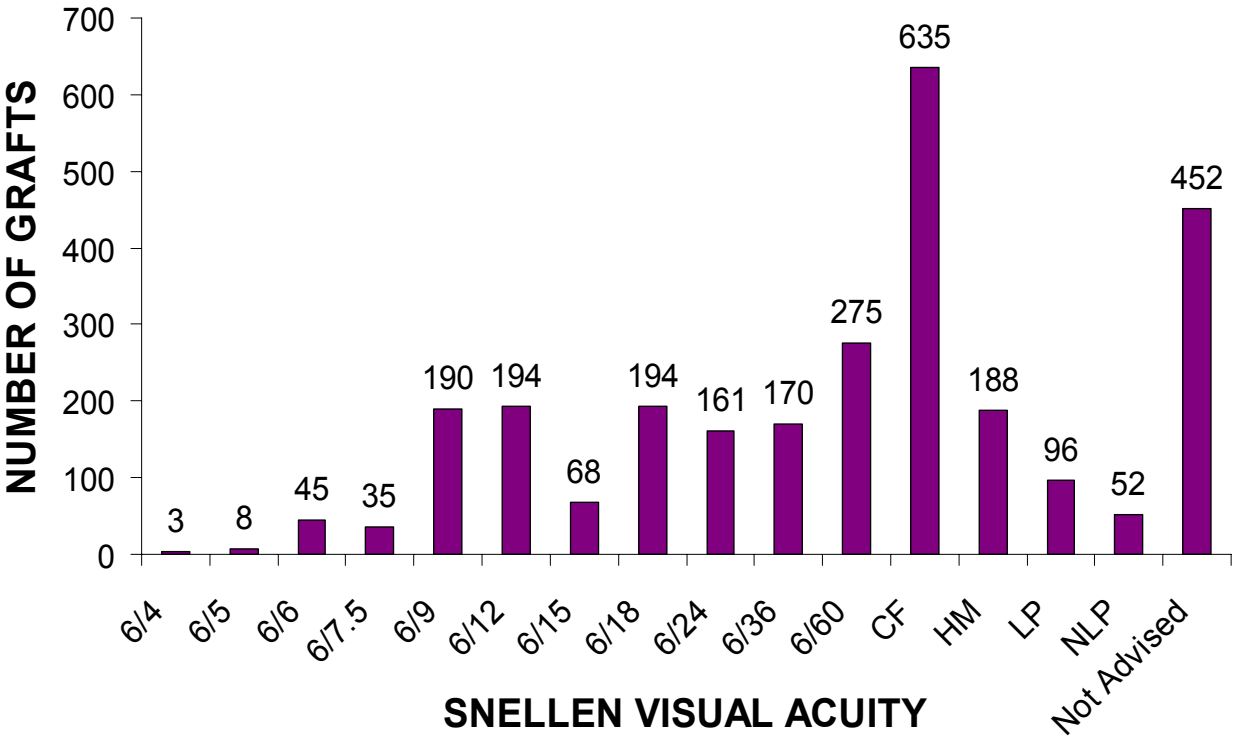
Figure 6.6 Visual outcome: aphakic bullous keratopathy

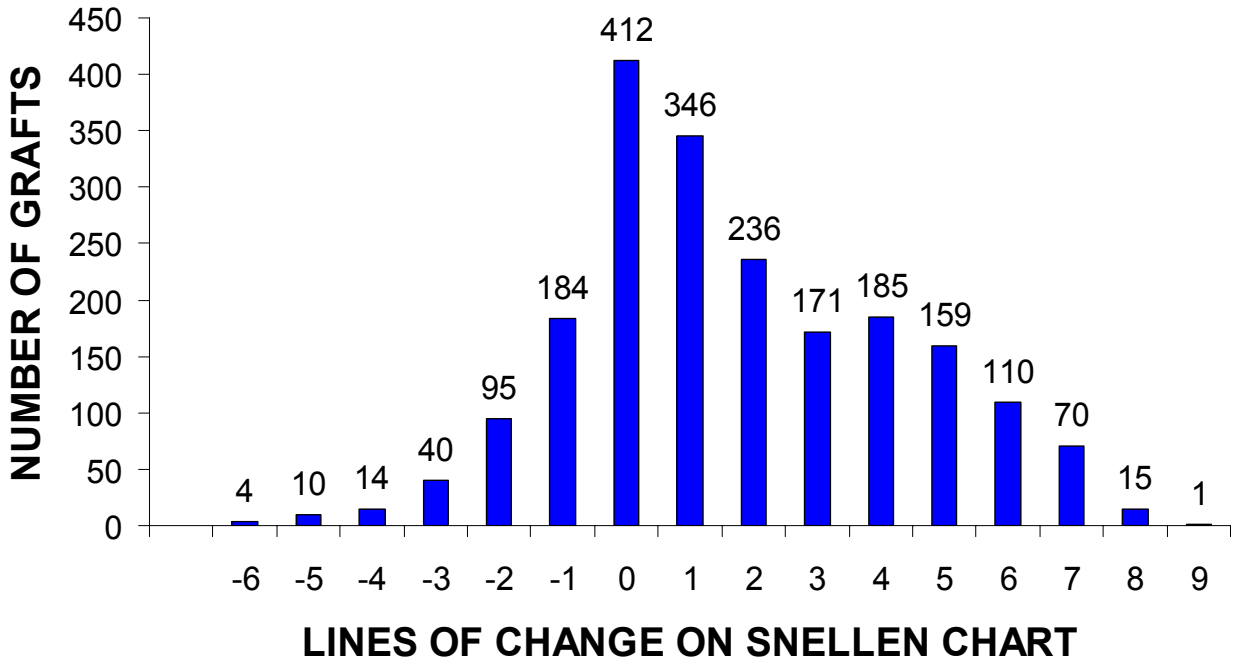


Twelve percent of grafts performed for aphakic bullous keratopathy achieved a visual acuity of 6/12 or better, 19% achieved 6/18 or better and 40% achieved 6/60 or better. In the 62% of cases where visual acuities were provided both before and after grafting, at least one line of improvement on the Snellen chart was achieved after graft.

6.3.4 Pseudophakic bullous keratopathy

Figure 6.7 Visual outcome: pseudophakic bullous keratopathy

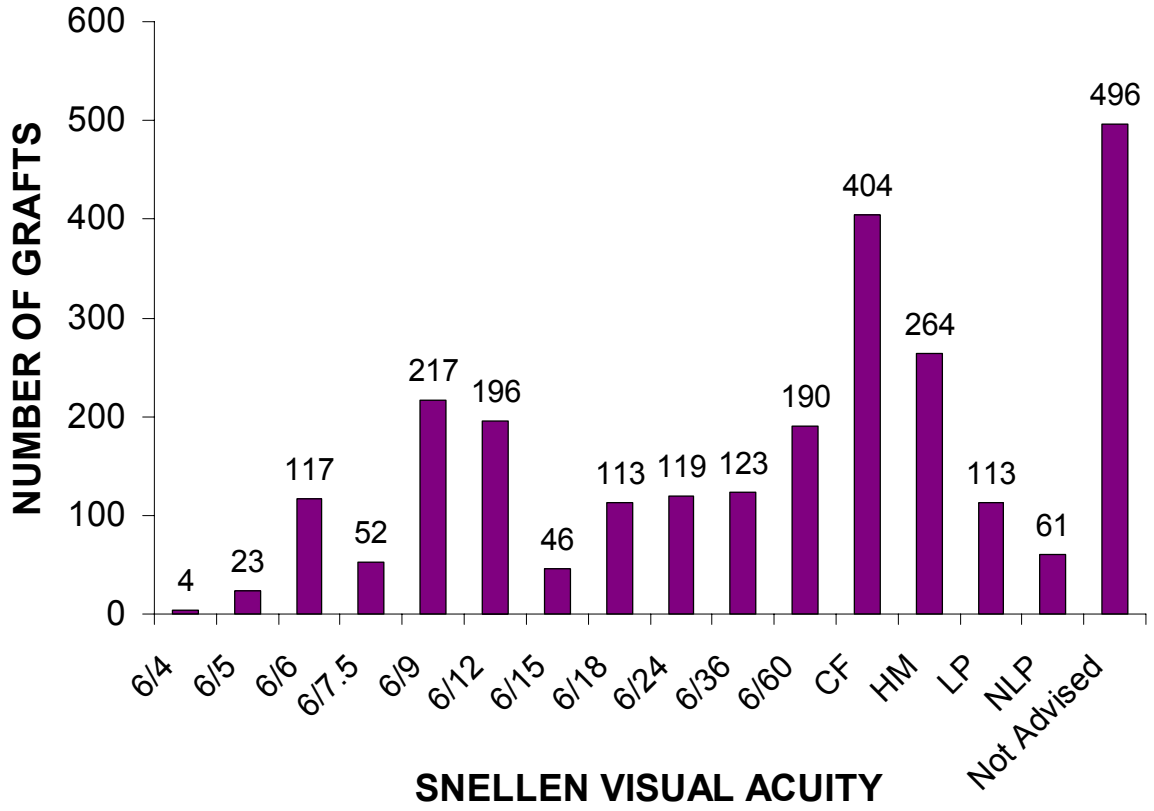


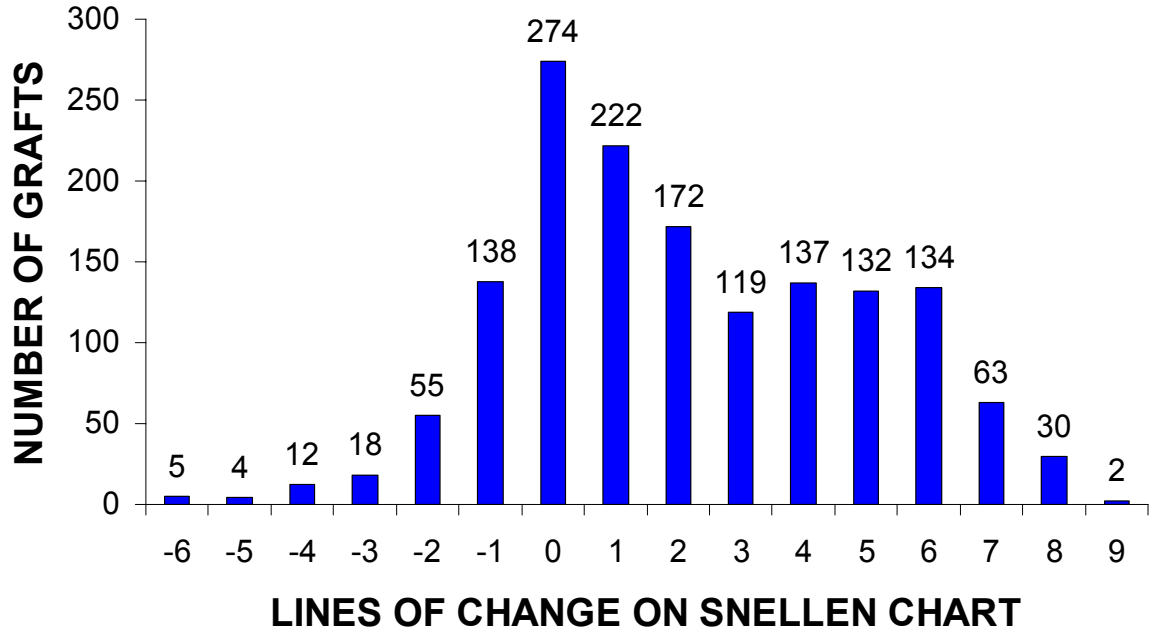


Seventeen percent of grafts performed for pseudophakic bullous keratopathy achieved a post-graft visual acuity of 6/12 or better, 27% achieved 6/18 or better and 49% achieved 6/60 or better. In 63% of cases, at least one line of improvement on the Snellen chart was achieved after graft.

6.3.5 Previous failed graft

Figure 6.8 Visual outcome: previous failed graft

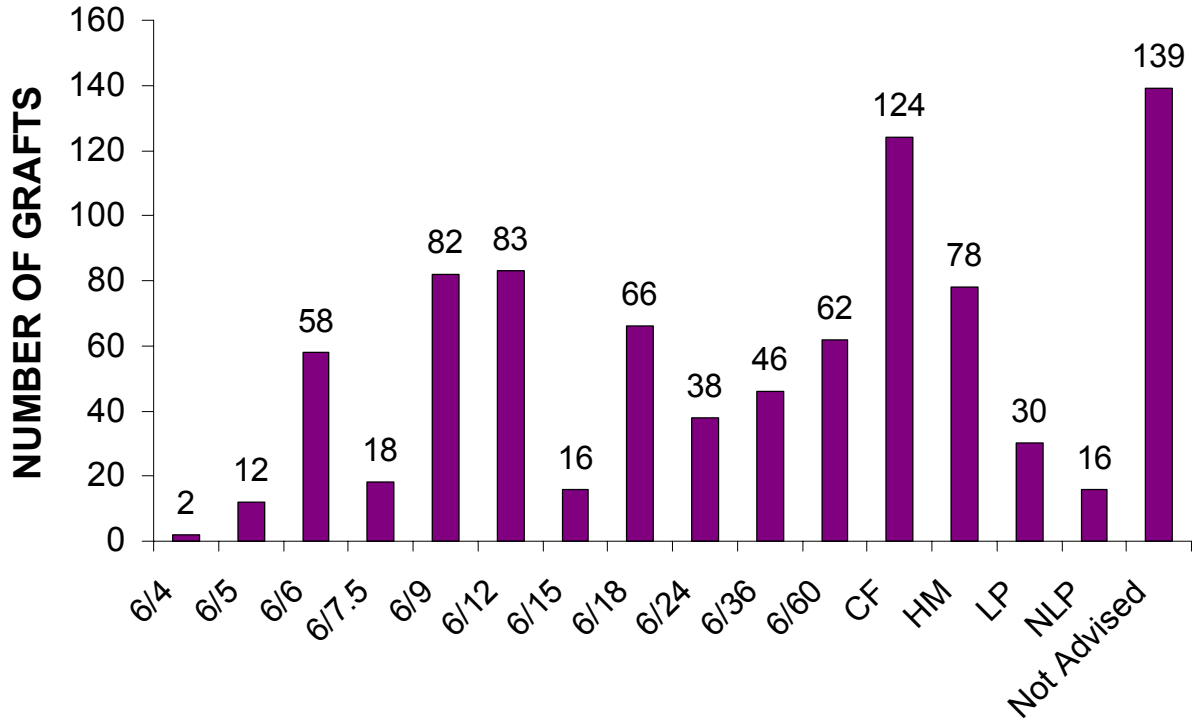


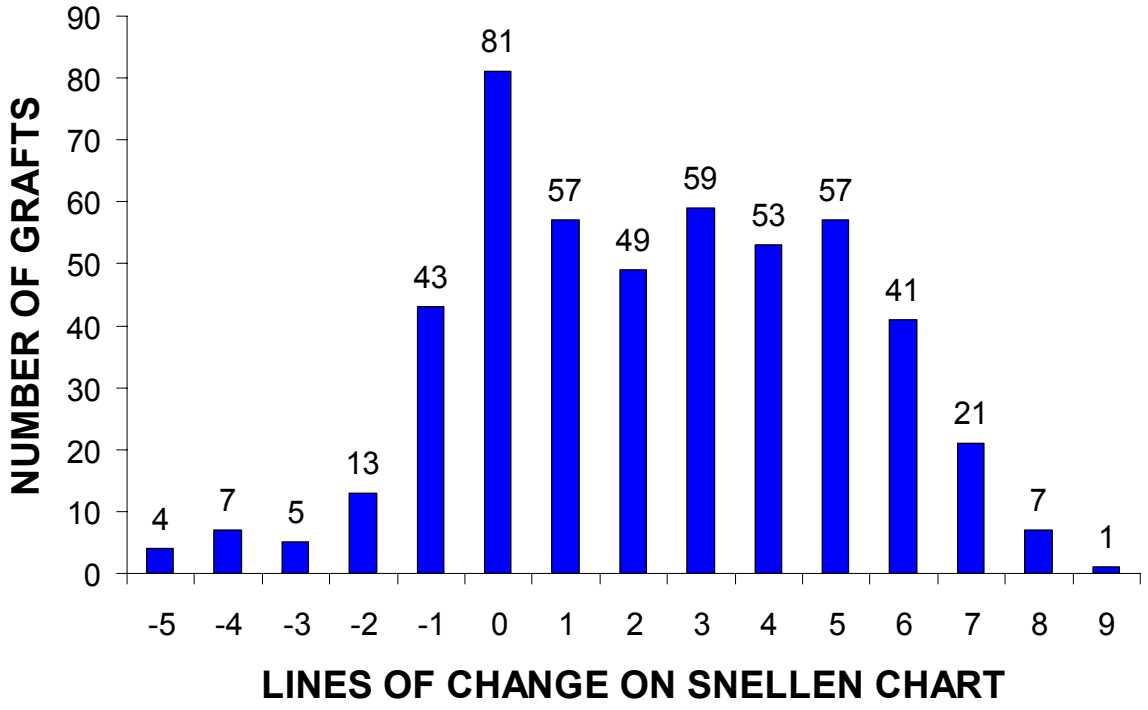


Twenty four percent of grafts performed for a previously failed graft achieved a post-graft visual acuity of 6/12 or better, 30% achieved 6/18 or better and 47% achieved 6/60 or better. In the 67% of cases in which visual acuity was reported both before and after graft, at least one line of improvement on the Snellen chart was achieved after graft.

6.3.6 Herpetic infection

Figure 6.9 Visual outcome: herpetic infection





In recipients in whom HSV infection had been recorded at any time pre-graft, 29% of the cohort achieved a post-graft visual acuity of 6/12 or better, 39% achieved 6/18 or better and 56% achieved 6/60 or better. In the 69% of cases where visual acuity was provided both before and after graft, at least one line of improvement on the Snellen chart was achieved after graft.

In those cases where HSV *was* active at the time of graft, 16% achieved a visual acuity of 6/12 or better, 23% achieved 6/18 or better and 42% achieved 6/60 or better (not illustrated).

In those cases where HSV *was not* active at time of graft, 21% achieved a visual acuity of 6/12 or better, 48% achieved 6/18 or better and 70% achieved 6/60 or better (not illustrated).

6.4 FACTORS AFFECTING VISUAL POTENTIAL OF THE GRAFTED EYE

Table 6.5 lists some of the factors which have affected the visual potential of the grafted eye (penetrating grafts only). The factors are not necessarily mutually exclusive.

Table 6.5 Factors affecting visual potential of the grafted eye

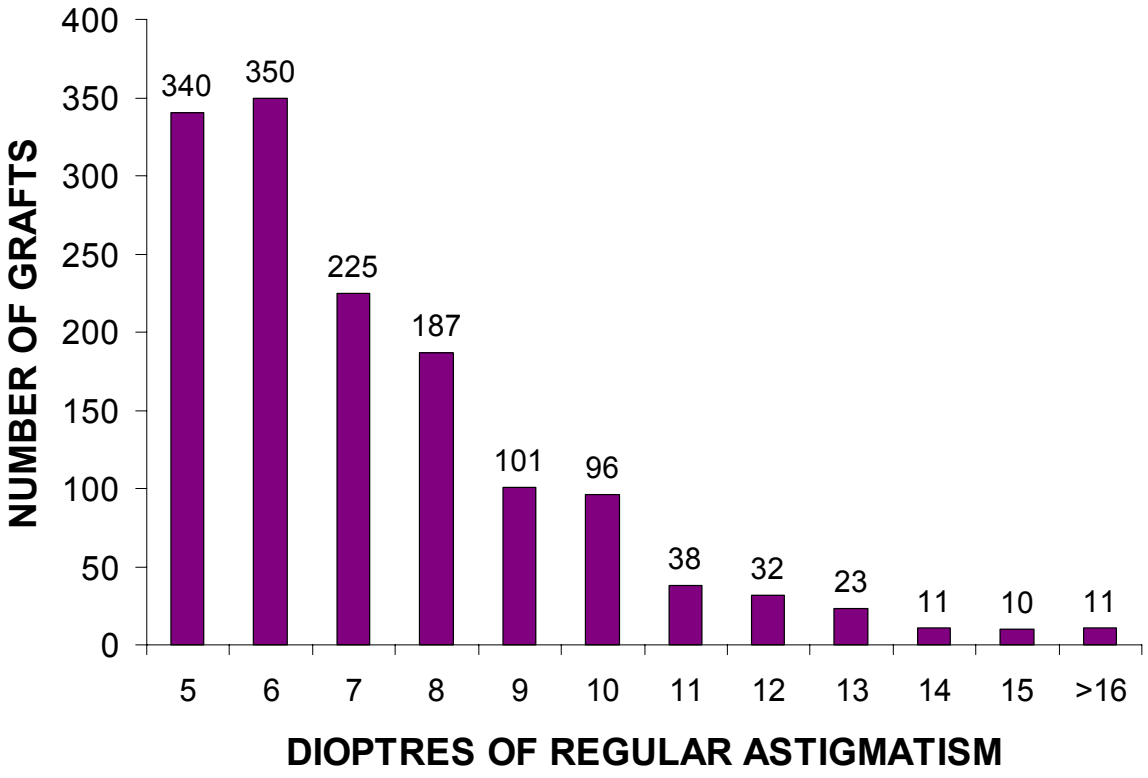
Description	Total	%
Astigmatism (>5D = 2457) (irregular = 451)	2908	22%
Graft failure	2894	22%
Maculopathy (unspecified)	1415	11%
Anisometropia	1104	8%
Cystoid macular oedema	952	7%
Glaucoma	851	6%
Opacity/scar	422	3%
Amblyopia	416	3%
Myopia	343	3%
Cataract	341	3%
Aphakia	276	2%
Retinal detachment	216	2%
Other retinal problem	76	<1%
Diabetic retinopathy	59	<1%
Other factors	339	3%
Total penetrating grafts	= 13350 (100%)	

6.5 ASTIGMATISM

Figure 6.10 is a histogram of the most recent post-operative measure of regular astigmatism, where recorded. Keratometry was available for 2,237 (17%) of the penetrating grafts in the Australian Corneal Graft Register. For 1,424 (64%) of these grafts, the post-operative astigmatism was ≥5 dioptres.

Post-operative astigmatism of less than 5 dioptres is no longer recorded in the Registry.

Figure 6.10 Dioptres of regular astigmatism in the grafted eye at last follow-up



6.6 REFRACTIVE SURGERY

Table 6.6 lists refractive surgical procedures performed on penetrating grafts. One or more procedures were carried out on 1,613 grafts (12% of penetrating grafts followed).

Table 6.6 Refractive surgery

Procedure	Number	%
Suture adjustment	688	34%
Relaxing incisions	656	31%
Compression sutures	286	14%
LASIK	112	5%
Excimer/PARK/laser	83	4%
Wedge resection	66	3%
Other	83	4%
Unknown procedure	111	5%
Total procedures	2085	100%
2085 procedures over 1613 grafts (12% of all followed grafts)		

6.6.1 Correction following refractive surgery

Table 6.7 shows the method of correction used for the 1,613 grafts that have undergone refractive surgery.

Table 6.7 Correction following refractive surgery

Method of correction	Number	%
Spectacles	869	54%
Contact lens	113	7%
Spectacles and contact lens	53	3%
No correction/not advised	578	36%
TOTAL	**1613**	**100%**

6.6.2 Has refractive surgery improved visual acuity?

Figure 6.11 shows the Snellen acuities in those 1,613 penetrating grafts that have undergone refractive surgery. Visual acuity is equal to or better than 6/12 in 878 (54%) of these cases, better than or equal to 6/18 in 1,056 (65%), and better than or equal to 6/60 in 1,317 (82%). This compares with 45% for 6/12 or better, 55% for 6/18 or better and 74% for 6/60 or better in the database as a whole.

Figure 6.11 Snellen visual acuities for grafts that have undergone refractive surgery

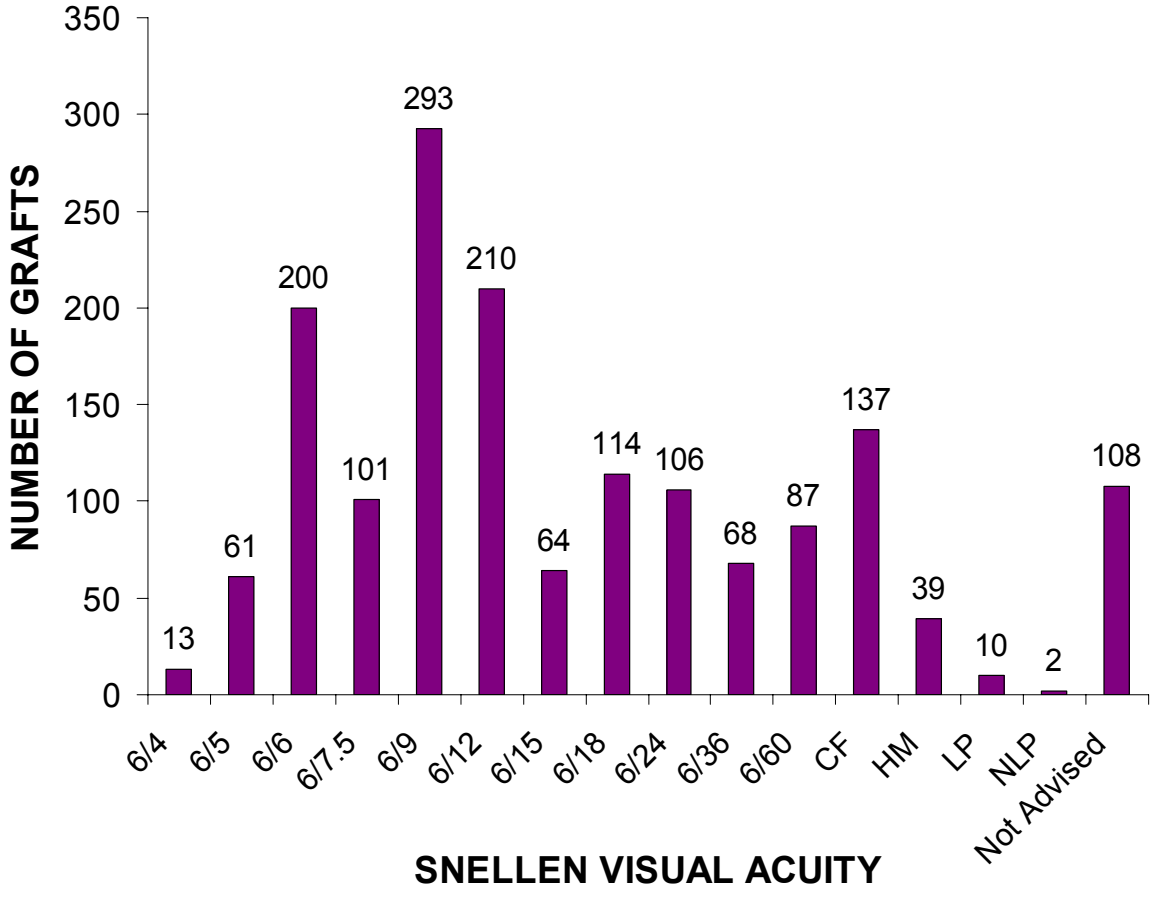
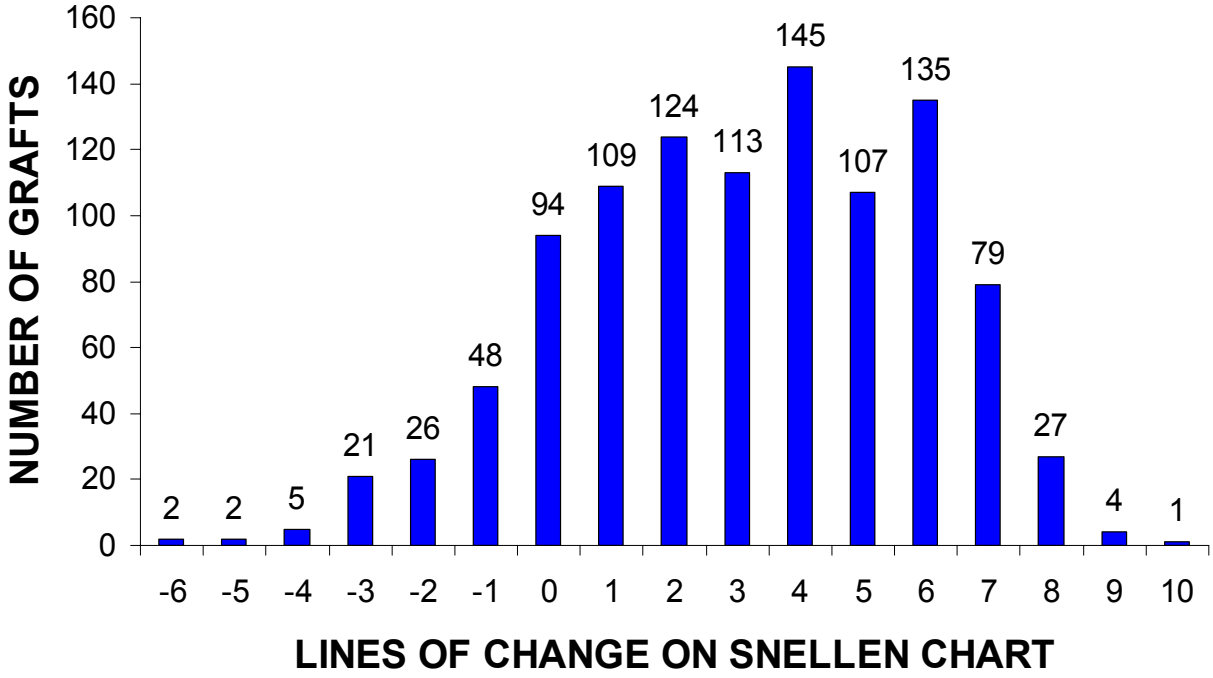


Figure 6.12 shows the number of lines of improvement on the Snellen chart for those grafts where visual acuity has been provided both pre-graft and post-graft, and which underwent refractive surgery.

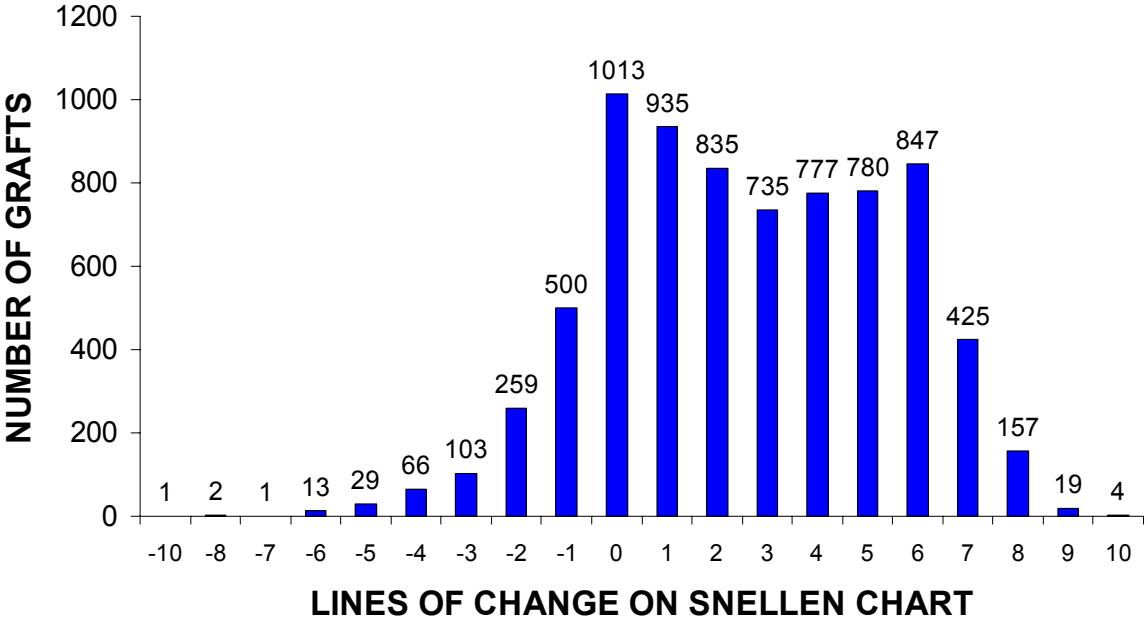
In comparison, Figure 6.13 shows grafts that have not undergone refractive surgery post-operatively. Snellen acuity appears slightly better in the group that has undergone refractive surgery to the graft.

Figure 6.12 Change in lines on the Snellen chart for grafts that have undergone refractive surgery



Of the 1,042 for whom we have information, 844 (81%) show an improvement in visual acuity, 94 (9%) are unchanged since before graft and 104 (10%) are worse.

Figure 6.13 Change in lines on the Snellen chart for grafts that have not undergone refractive surgery



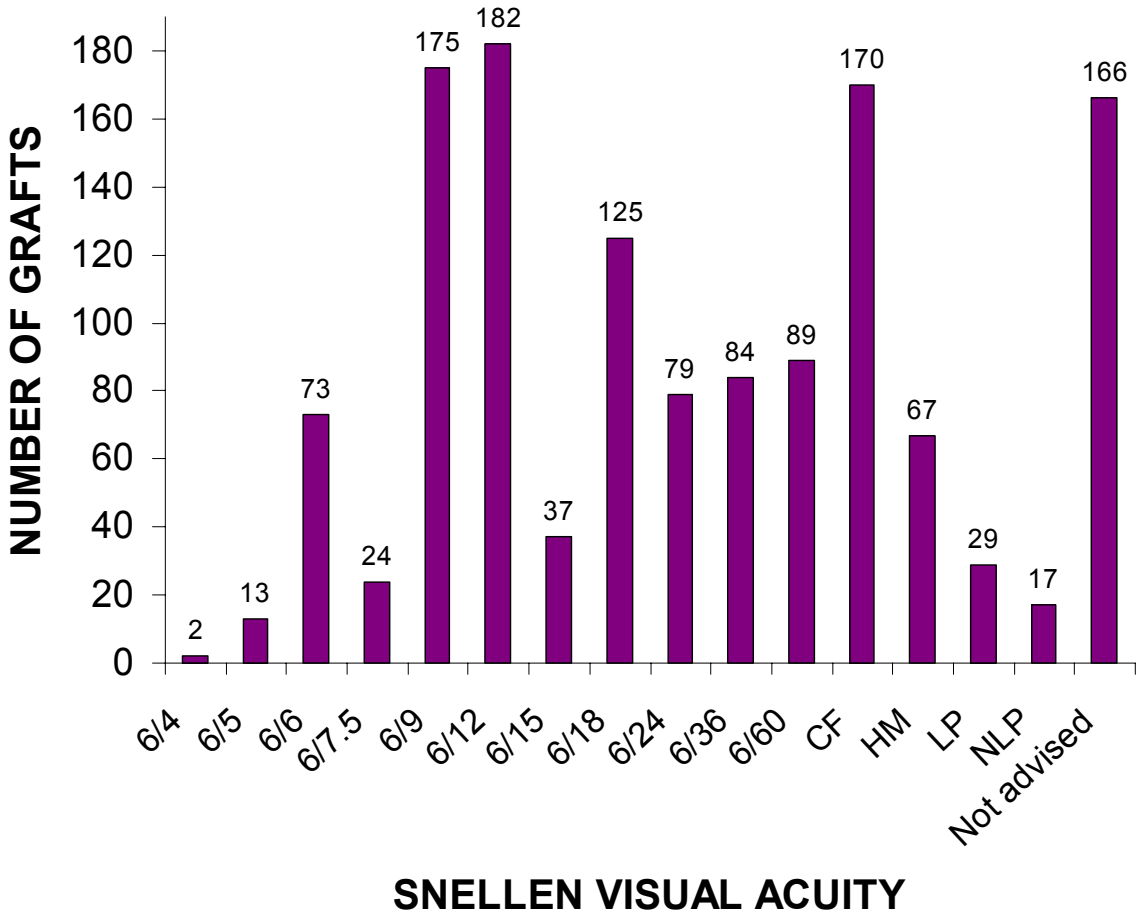
Of those 11,737 grafts that have not undergone refractive surgery, visual acuities both before and after graft have been provided for 7,501. Of these, 5,514 (74%) show an improvement in visual acuity, 1,013 (13%) show no change since before graft and 974 (13%) are worse.

6.7 TRIPLE PROCEDURES

6.7.1 Snellen acuity

Figure 6.14 shows the visual acuity at most recent follow-up for 1332 triple procedures.

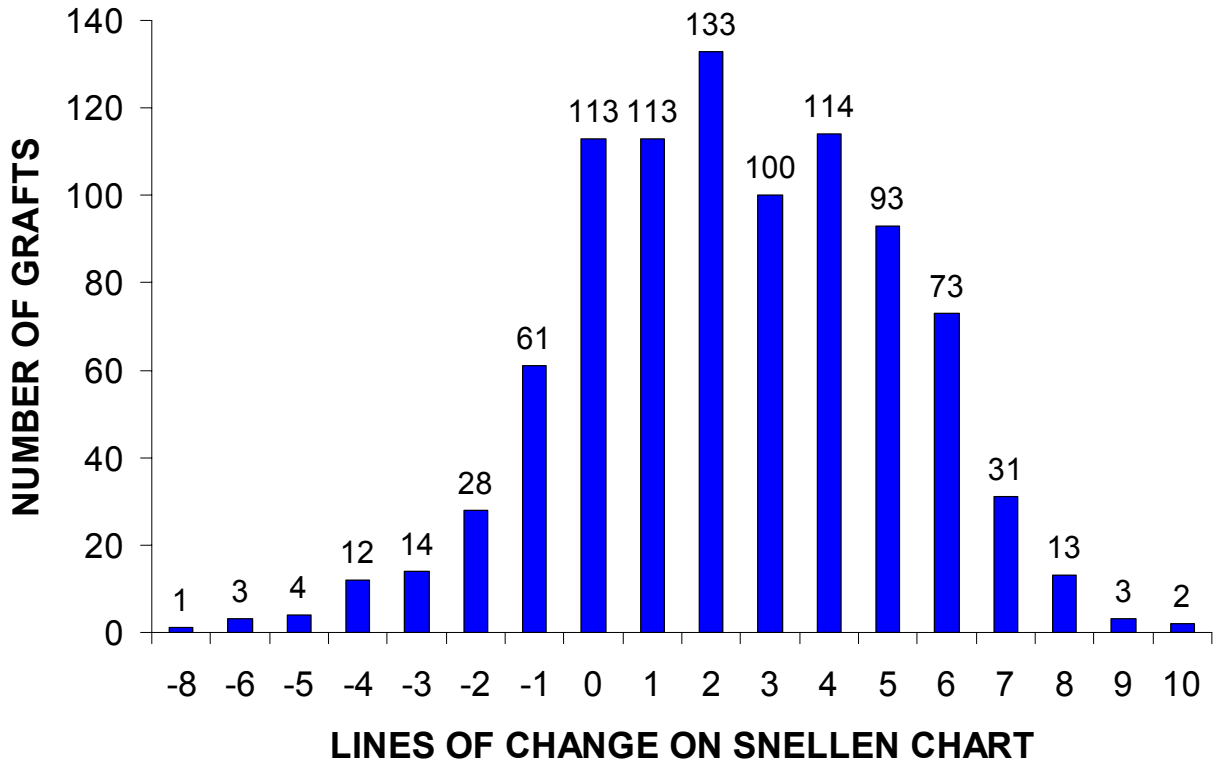
Figure 6.14 Visual acuities for all triple procedure grafts



6.7.2 Visual improvement after graft: triple procedure

Figure 6.15 shows the number of lines of change on the Snellen chart for triple procedures.

Figure 6.15 Triple procedures - lines of change



6.8 POST-GRAFT CORRECTION

Table 6.9 shows the post-graft correction prescribed for grafts that have survived for less than 2 years; between 2 and 5 years; between 5 and 10 years and over 10 years.

Table 6.9 Post-graft correction dependent on survival time

Method of correction	Survival time of graft							
	<2 years		2 – 5 years		5 – 10 years		>10 years	
	No.	%	No.	%	No.	%	No.	%
None or none advised	1197	28%	696	19%	278	16%	103	14%
Glasses only	876	20%	1011	28%	583	33%	290	40%
Contact lens only	188	4%	219	6%	141	8%	76	10%
IOL only	1097	26%	547	15%	252	14%	57	8%
Glasses & contact lens	37	<1%	80	2%	52	3%	20	3%
Glasses and IOL	873	20%	1054	29%	454	25%	170	23%
Contact lens and IOL	17	<1%	34	<1%	20	1%	7	<1%
Glasses, contact lens and IOL	9	<1%	12	<1%	3	<1%	3	<1%
Sub-total	**4294**	**100%**	**3653**	**100%**	**1783**	**100%**	**726**	**100%**
TOTAL	**10456 surviving penetrating grafts**							

The data suggest that visual rehabilitation following corneal transplantation may take several years, and that adjustments continue to be made for as long as 10 years.

6.9 SUMMARY OF VISUAL OUTCOME AFTER CORNEAL TRANSPLANTATION

- Information on the desired outcome after corneal transplantation was available for 79% of the cohort. In 70% of cases, the major reason for transplantation was improved vision and in a further 14%, the reasons were improved vision plus relief of pain.

- A best-corrected Snellen acuity of 6/12 or better at the time of most recent follow-up was achieved in 45% of grafted eyes, of 6/18 or better by 55% of grafted eyes, and of less than 6/60 by 26% of grafted eyes. No information was available in 17% of cases.

- Where information was available, Snellen acuity improved after corneal transplantation in 74% of cases, remained the same in 13% of cases and worsened in 13% of cases.

- Visual outcome after corneal transplantation depends to some extent on indication for graft, lens status and on co-morbidities.

Indication for graft	Percent achieving 6/18 or better in the grafted eye *
Keratoconus	84%
Fuchs' dystrophy	68%
History of HSV infection	46%
Previous failed graft	39%
Pseudophakic bullous keratopathy	32%
Aphakic bullous keratopathy	24%

* unknowns excluded from calculations

- The most important factors with a negative influence on the visual outcome of the grafted eye were: >5D astigmatism, graft failure, and retinal disease.

- A refractive surgical procedure was performed on 12% of grafts.

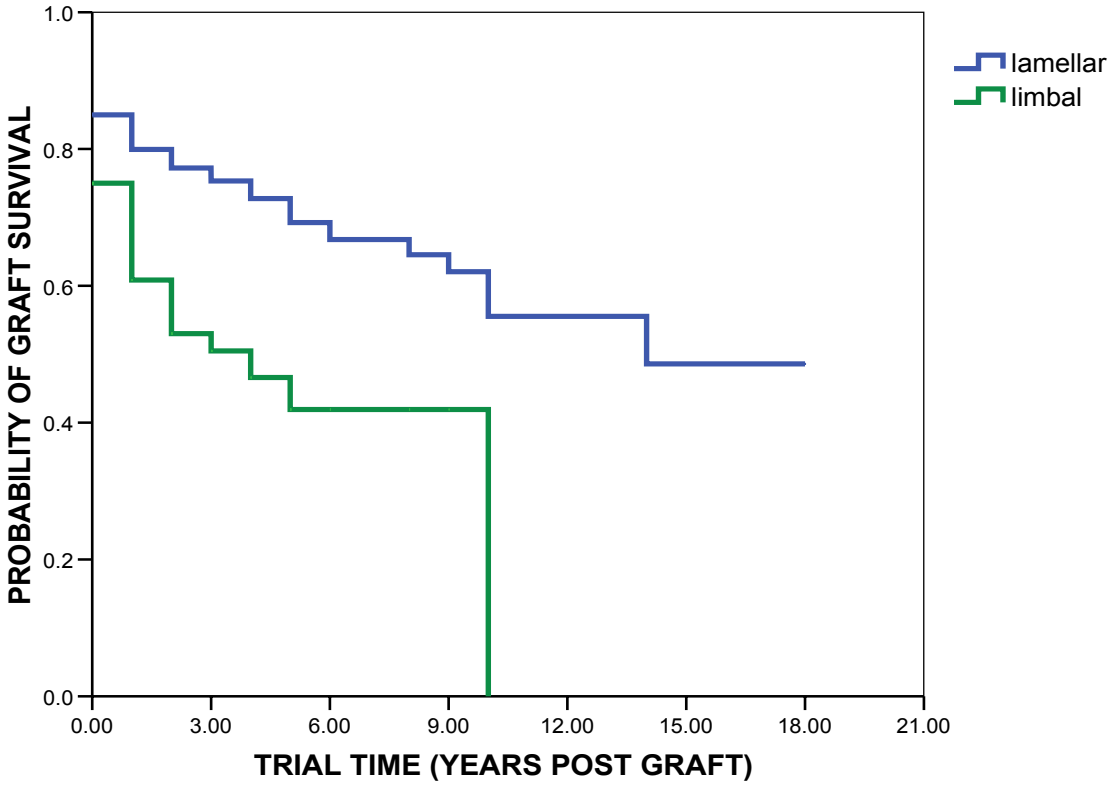
- By 10 years post-graft, 14% of grafted eyes either required no form of correction or had been prescribed none, while a further 8% of eyes had an IOL in situ but were otherwise uncorrected.

7. LAMELLAR AND LIMBAL GRAFTS

7.1 SURVIVAL OF LAMELLAR AND LIMBAL GRAFTS

We have had many recent registrations of lamellar procedures but no significant follow-up as yet. We will produce an interim report to examine the outcome of these procedures in 2008. The majority of lamellar procedures analysed in this chapter were performed some years ago. Survival of lamellar and limbal corneal grafts are presented in Figure 7.1 (Log Rank Statistic=20.24; df=1; p<0.00001). At ten years post graft all limbal grafts have failed, although there are some limbal grafts surviving at periods less than ten years.

Figure 7.1 Survival of lamellar and limbal corneal grafts



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Lamellar	720	162	56	26	11	4	1	n/a
Limbal	88	21	4	2	n/a	n/a	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Lamellar	720	.799	.693	.555	n/a	n/a
Limbal	88	.608	.419	.000	n/a	n/a

LAMELLAR AND LIMBAL CORNEAL GRAFT SURVIVAL
TYPE OF GRAFT

Lamellar grafts:	**80% at 1 year**
Mean Survival 11.36 years	**69% at 5 years**
(SE=0.64; 95% CI 10.12, 12.61)	**55% at 10 years**
Median Survival 14 years	
Limbal grafts:	**60% at 1 year**
Mean Survival 4.96 years	**42% at 5 years**
(SE=0.60; 95% CI: 3.79, 6.12)	**0% at 10 years**
Median Survival 4 years	

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

7.2 DESIRED OUTCOME

The Australian Corneal Graft Registry has recorded a desired outcome for 824 (74%) of the 1115 lamellar and limbal grafts entered. These outcomes are shown in Figure 7.2 and Table 7.1.

Figure 7.2 Reason for graft

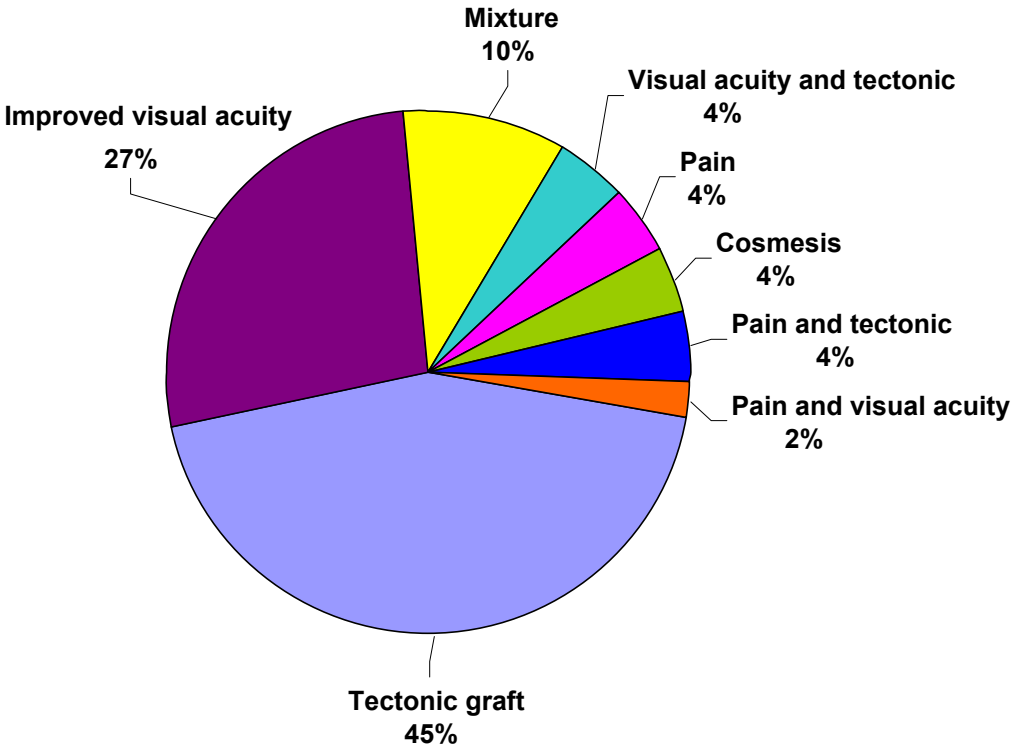


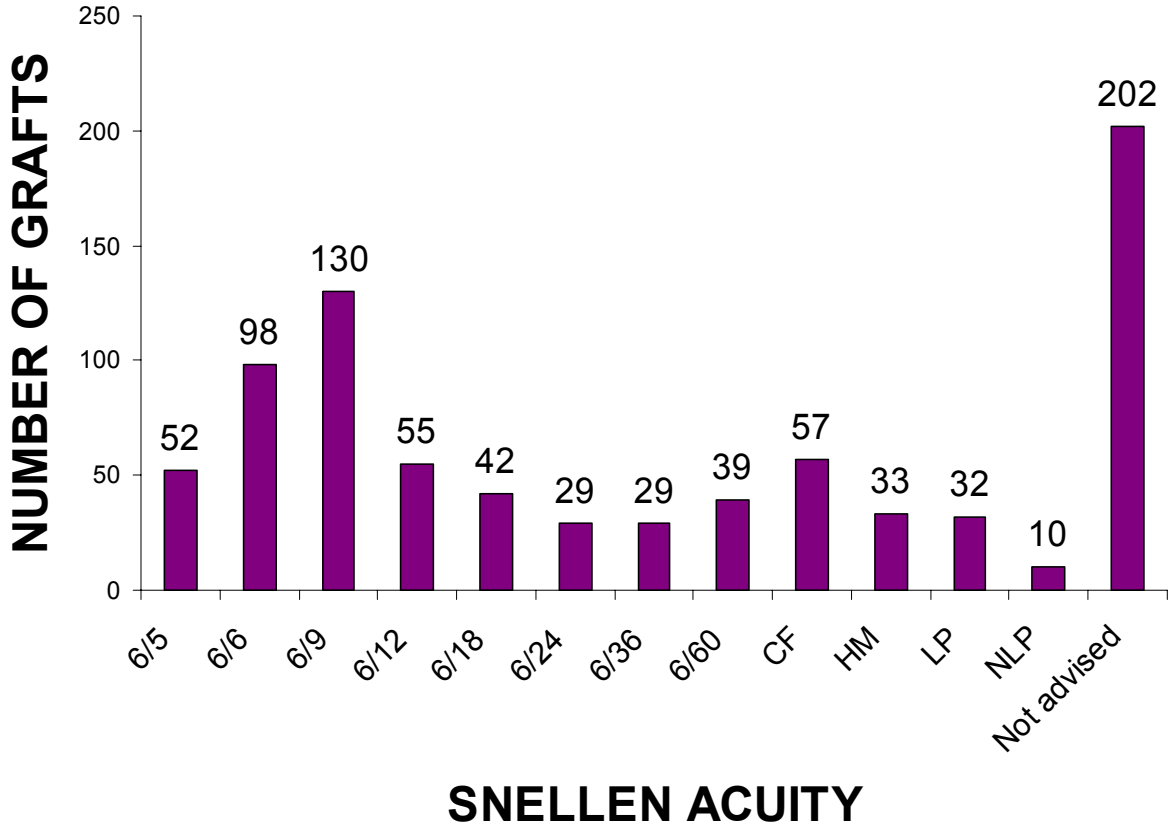
Table 7.1 Reasons for graft

Reason for Graft	Number	%
Structural repair	361	45%
Improvement in visual acuity	223	27%
Mixture of reasons	81	10%
Improved visual acuity and structural/tectonic repair	37	4%
Pain relief	35	4%
Pain relief and structural repair	34	4%
Cosmesis	34	4%
Pain and visual acuity	19	2%
TOTAL	**824**	**100%**

7.3 OVERALL VISUAL ACUITY

Figure 7.3 shows the best corrected visual acuity in the grafted eye at the time of the most recent follow-up. Post graft visual acuity has been recorded for 606 lamellar and limbal grafts. A best corrected Snellen acuity of 6/12 or better was achieved in 55% of cases at most recent follow-up; 62% achieved 6/18 or better, and 22% recorded a visual acuity of less than 6/60 at last follow-up. Follow-up visual acuities were not advised in 25% of cases.

Figure 7.3 Best corrected visual acuity in grafted eye at last follow-up

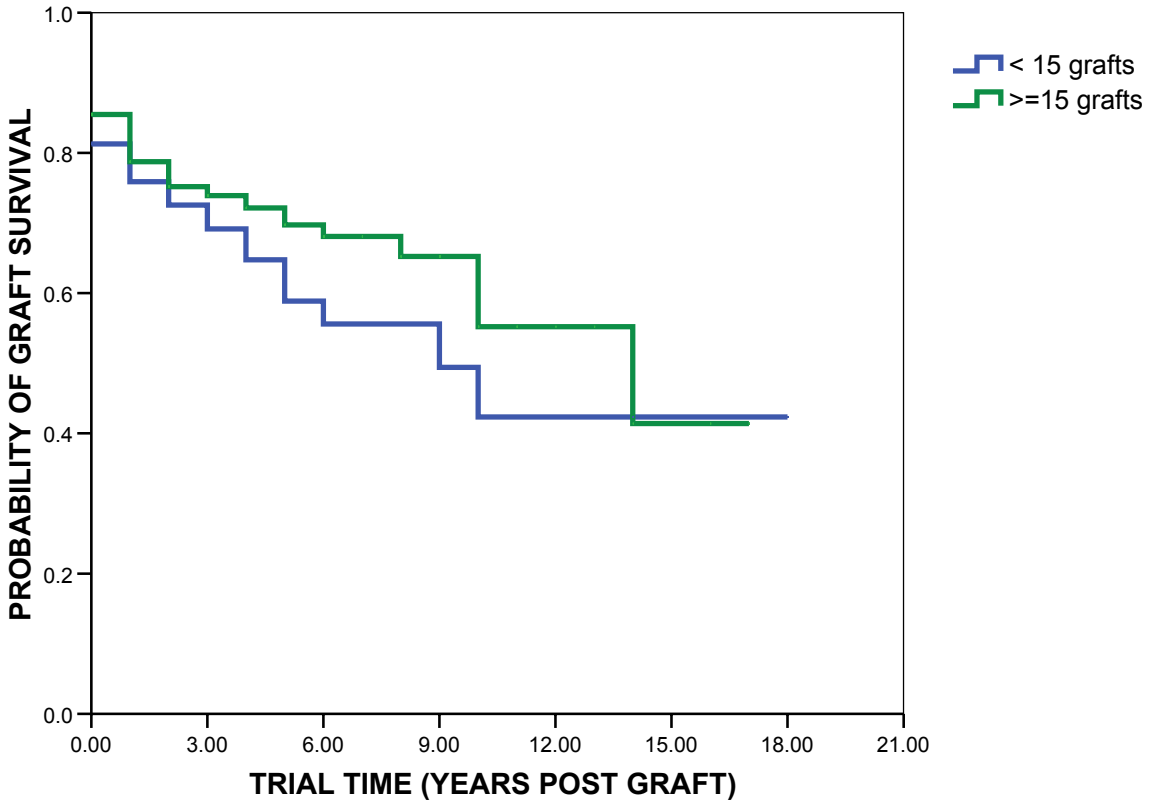


7.4 EFFECT OF SURGEON WORKLOAD

7.4.1 Outcome: number of grafts performed

Figure 7.4 shows the survival of lamellar and limbal grafts (considered together), performed by surgeons who have grafted 15 or more, compared with surgeons who have performed fewer than 15 grafts (Log Rank Statistic=2.75; df=1; p=.098) the difference is not significant.

Figure 7.4 Outcome according to number of grafts performed



Number at Risk

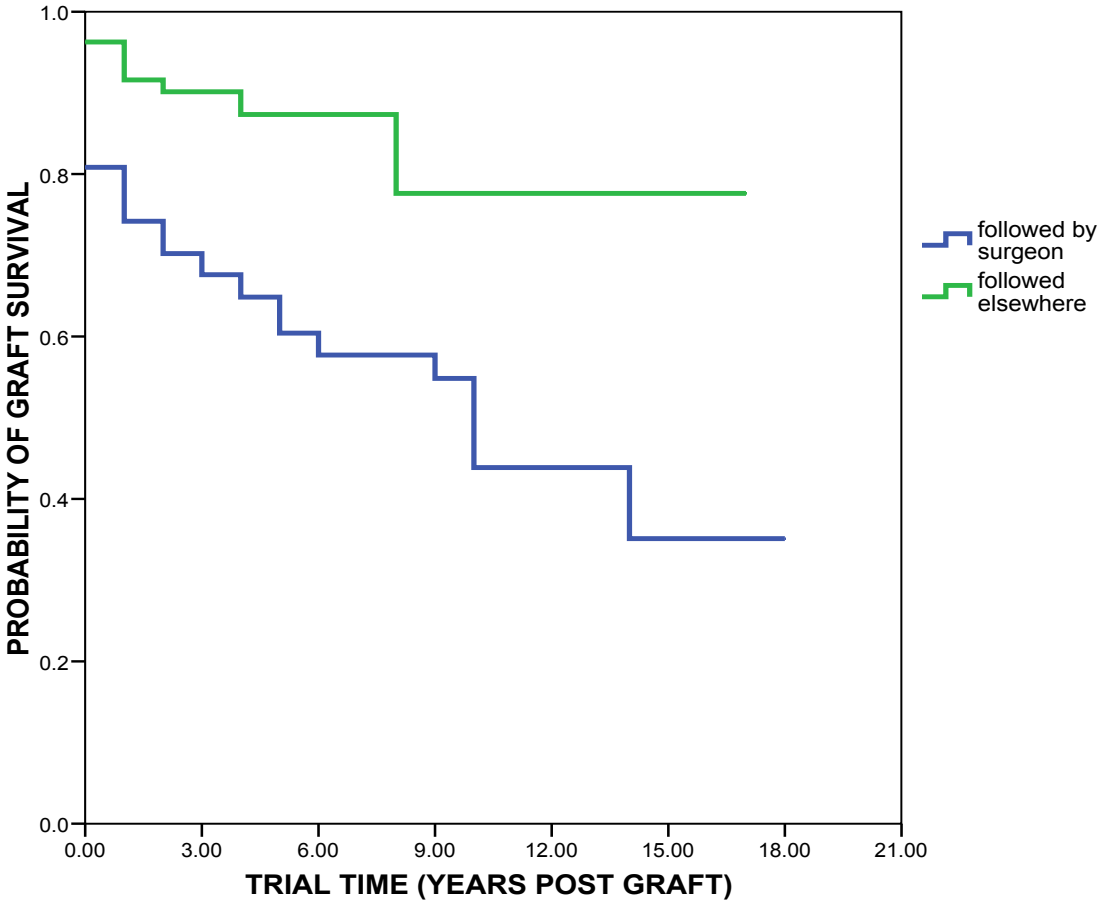
Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Less than 15 grafts	299	64	18	9	5	2	1	n/a
More than 15 grafts	509	119	42	19	6	2	0	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Less than 15 grafts	299	.759	.589	.423	n/a	n/a
More than 15 grafts	509	.787	.697	.552	n/a	n/a

7.4.2 Outcome: follow-up surgeon

Figure 7.5 shows survival of grafts followed by the surgeon who performed the graft, compared with grafts followed by a surgeon or practitioner who did not perform the graft (Log Rank Statistic=27.27; df=1; p<.00001).

Figure 7.5 Follow up surgeon/practitioner



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Surgeon	647	135	45	20	7	1	n/a	n/a
Followed elsewhere	161	48	15	8	4	n/a	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Surgeon	647	.742	.604	.439	n/a	n/a
Followed elsewhere	161	.916	.873	n/a	n/a	n/a

LAMELLAR AND LIMBAL CORNEAL GRAFT SURVIVAL
EFFECT OF CASE LOAD

Less than 15 grafts:	**76% at 1 year**
Mean Survival 9.77 years	**59% at 5 years**
(SE=0.98; 95% CI 7.86, 11.69)	**42% at 10 years**
Median Survival 9 years	
More than 15 grafts:	**79% at 1 year**
Mean Survival 10.67 years	**70% at 5 years**
(SE=0.71; 95% CI: 9.28, 12.05)	**55% at 10 years**
Median Survival 14 years	

LAMELLAR AND LIMBAL CORNEAL GRAFT SURVIVAL
FOLLOWUP SURGEON

Surgeon**:**	**74% at 1 year**
Mean Survival 9.62 years	**60% at 5 years**
(SE=0.69; 95% CI 8.27, 10.97)	**44% at 10 years**
Median Survival 10 years	
Followed elsewhere**:**	**91% at 1 year**
Mean Survival 14.16 years	**87% at 5 years**
(SE=0.98; 95% CI: 12.24, 16.08)	
Median Survival approx 16 years	

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

7.5 LAMELLAR GRAFTS

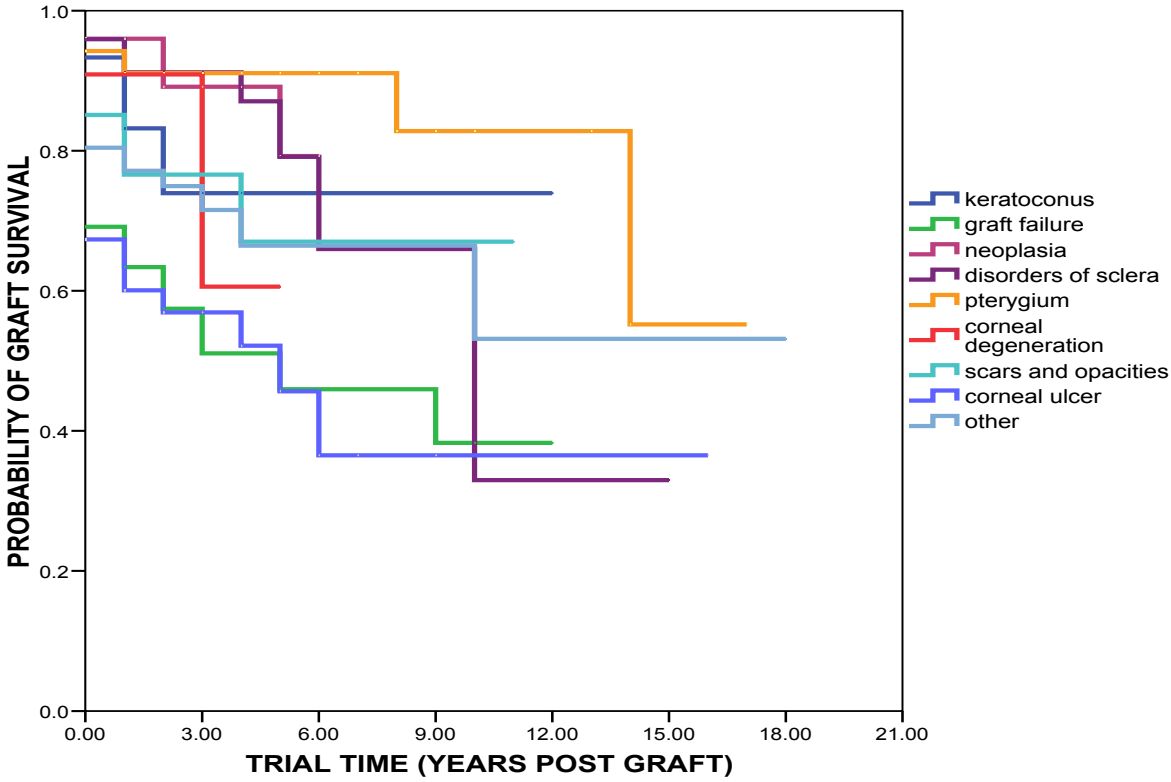
Table 7.2 Main indications for lamellar grafts

Indication for graft	Sub-total	Total	%
Pterygium		**195**	**19%**
Recurrent	171		
Unspecified	21		
Peripheral	1		
Pseudopterygium	2		
Corneal Ulcers		**143**	**14%**
Unspecified	21		
Marginal	2		
Central	7		
Mycotic	1		
Perforated	110		
Mooren's ulcer	2		
Disorders of sclera		**138**	**14%**
Scleromalacia perforans	11		
Scleral abscess	11		
Scleral ectasia	5		
Other degeneration of sclera	111		
Previous failed graft	131	**134**	**13%**
Primary graft failure	3		
Keratoconus		**123**	**12%**
Uncomplicated	117		
Keratoglobus	5		
With hydrops	1		
Neoplasia		**68**	**7%**
Limbal dermoid	34		
Malignancy, unspecified	21		
Squamous cell carcinoma	9		
Conjunctival SCC	3		
Benign	1		
Scars and Opacities	57	**57**	**6%**
Corneal degenerations		**28**	**3%**
Corneal melt	15		
Terrien's degeneration	5		
Salzmann's nodular dystrophy	3		
Keratomalacia	1		
Recurrent erosions	1		
Band shaped keratopathy	1		
Unspecified	2		
Effects of radiation therapy	25	**25**	**2%**
Dystrophies		**15**	**1%**
Fuchs' endothelial dystrophy	4		
Macular dystrophy	3		
Granular dystrophy	3		
Lattice corneal dystrophy	1		
Unspecified corneal dystrophy	4		
Corneal oedema/PBK	13	**13**	**1%**
Burns	3	**3**	**<1%**
Other*	57	**57**	**6%**
Unknown to ACGR	4	**4**	**<1%**
TOTAL	**1013**		**100%**

* other: corneal ectasia (14); wound dehiscence (9); HSV (5); interstitial keratitis (4); trauma (3); astigmatism (2); corneal abscess (2); corneal deposits (2); endophthalmitis (2); lipid keratopathy (2); scleral fistula (2); vascularization (2); amyloidosis (1); aniridia (1); aphakia (1); corneal membrane change (1); Goldenhaar's bilateral dermoids (1); measles conjunctivitis (1); pseudomonas (1); Sjogren's syndrome (1).

Figure 7.6 shows the survival curves for the main indication for lamellar grafts, as shown in Table 7.2 (Log Rank Statistic= 76.09; df=8; p<0.00001).

Figure 7.6 Main indications for lamellar grafts



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Keratoconus	60	8	2	n/a	n/a	n/a	n/a	n/a
Previous failed graft	94	18	8	6	1	n/a	n/a	n/a
Neoplasia	50	11	3	n/a	n/a	n/a	n/a	n/a
Disorders of sclera	98	30	6	2	n/a	n/a	n/a	n/a
Pterygium	156	44	21	8	4	1	n/a	n/a
Corneal degeneration	22	3	0	n/a	n/a	n/a	n/a	n/a
Scars and opacities	47	12	4	1	n/a	n/a	n/a	n/a
Ulcers	98	13	5	2	n/a	n/a	n/a	n/a
Other	92	22	7	5	3	1	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Keratoconus	60	.832	n/a	n/a	n/a	n/a
Previous failed graft	94	.634	.460	n/a	n/a	n/a
Neoplasia	50	.891	.792	n/a	n/a	n/a
Disorders of sclera	98	.912	.791	.330	n/a	n/a
Pterygium	156	.911	.828	.552	n/a	n/a
Corneal degeneration	22	.606	n/a	n/a	n/a	n/a
Scars and opacities	47	.766	.670	n/a	n/a	n/a
Ulcers	98	.601	.456	n/a	n/a	n/a
Other	92	.772	.664	.531	n/a	n/a

LAMELLAR CORNEAL GRAFT SURVIVAL
MAIN INDICATION FOR GRAFT

Keratoconus:	**83% at 1 year**
Mean Survival 9.16 years	
(SE=0.81; 95% CI: 7.57, 10.75)	
Median Survival approx. 11 years	
Previous failed graft:	**63% at 1 year**
Mean Survival 5.91 years	**46% at 5 years**
(SE=0.73; 95% CI: 4.47, 7.35)	
Median Survival 5 years	
Neoplasia:	**89% at 1 year**
Mean Survival 5.39 years	**79% at 5 years**
(SE=0.31; 95% CI 4.77, 6.00)	
Median Survival approx. 6 years	
Disorders of sclera:	**91% at 1 year**
Mean Survival 9.64 years	**79% at 5 years**
(SE= 1.55; 95% CI: 6.62, 12.67)	**33% at 10 years**
Median Survival 10 years	
Pterygium:	**91% at 1 year**
Mean Survival 13.94 years	**83% at 5 years**
(SE=1.00; 95% CI 11.99, 15.90)	**55% at 10 years**
Median Survival approx. 14 years	
Corneal degeneration:	**61% at 1 year**
Mean Survival 3.94 years	
(SE=0.56; 95% CI: 2.84, 5.04)	
Median Survival approx. 5 years	
Scars and opacities:	**77% at 1 year**
Mean Survival 7.84 years	**67% at 5 years**
(SE=0.90; 95% CI: 6.08, 9.60)	
Median Survival approx. 11 years	
Ulcers:	**60% at 1 year**
Mean Survival 7.04 years	**46% at 5 years**
(SE=1.27; 95% CI 4.56, 9.53)	
Median Survival 5 years	
Other:	**77% at 1 year**
Mean Survival 11.28 years	**66% at 5 years**
(SE= 1.40; 95% CI 8.53, 14.02)	**53% at 10 years**
Median Survival approx.10 years	

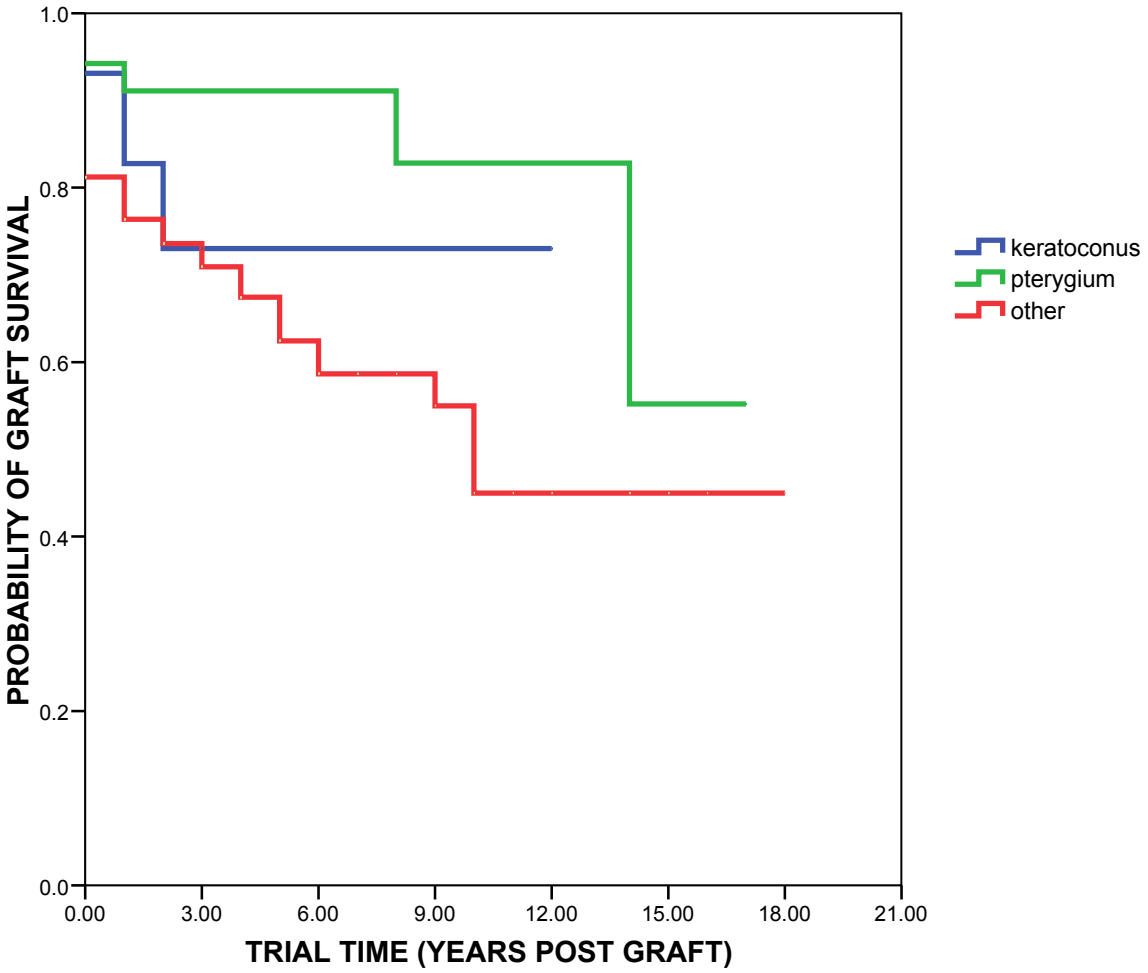
KEY: n/a = not applicable; CI = confidence interval; SE = standard error; p = probability; df = degrees of freedom

Table 7.3 Reason for failure of lamellar grafts

Reason	Sub-total	Total	%
Corneal scleral melt		**29**	**18%**
Graft failure (not specified)		**23**	**14%**
Perforated ulcers		**12**	**8%**
Infection		**12**	**8%**
Endophthalmitis	4		
HSV	4		
HZO	1		
Mycotic ulcers	2		
Pseudomonas	1		
Recurrent pterygium		**9**	**6%**
Pseudopterygium	1		
Astigmatism		**8**	**5%**
Abscess		**8**	**5%**
Primary non function		**8**	**5%**
Rejection		**6**	**4%**
not specified	4		
with pterygium	1		
with trauma	1		
Neoplasia		**6**	**4%**
Scars and opacities		**5**	**3%**
Wound dehiscence		**5**	**3%**
Corneal degeneration		**5**	**3%**
Ulcers		**4**	**3%**
Other		**18**	**11%**
Scleral necrosis	3		
Vascularisation	2		
Implantation cysts	2		
Glaucoma	1		
Advance in keratoconus	1		
Keratoglobus	1		
Aniridia	1		
Cataract	1		
Ocular cicatrial pemphigoid	1		
Wegener's syndrome	1		
Symblepharon	1		
Anisometropia	1		
Sclerosing keratitis	1		
Corneal membrane change	1		
TOTAL		**159**	**100%**

Figure 7.7 shows lamellar graft survival for patients grafted for pterygium or keratoconus, compared with survival in patients with any other indication (Log Rank Statistic= 22.10; df=2; p<0.0001). Lamellar graft survival is significantly better in patients grafted for pterygium than any other category.

Figure 7.7 Effect of pterygium and keratoconus (lamellar grafts only)



Number at Risk

Identity	Initially	3 years	6 years	9 years	12 years	15 years	18 years	21 years
Keratoconus	58	7	1	n/a	n/a	n/a	n/a	n/a
Pterygium	156	44	21	8	4	1	n/a	n/a
Other	506	111	33	16	6	3	n/a	n/a

Identity	No. initially at risk	Graft survival (at years post-graft)				
		1	5	10	15	20
Keratoconus	58	.828	n/a	n/a	n/a	n/a
Pterygium	156	.911	n/a	.828	.552	n/a
Other	506	.764	.624	.450	n/a	n/a

LAMELLAR CORNEAL GRAFT SURVIVAL
PTERYGIUM AND KERATOCONUS

Keratoconus:	**83% at 1 year**
Mean Survival 9.06 years	
(SE=0.84; 95% CI 7.41, 10.71)	
Median Survival 9 years	
Pterygium:	**91% at 1 year**
Mean Survival 13.94 years	
(SE=1.00; 95% CI: 11.99, 15.90)	**83% at 10 years**
Median Survival approx. 14 years	**55% at 15 years**
Other:	**76% at 1 year**
Mean Survival 10.23 years	**62% at 5 years**
(SE=0.78; 95% CI: 8.70, 11.75)	**45% at 10 years**
Median Survival 10 years	

KEY:

n/a	=	not applicable
SE	=	standard error
CI	=	confidence interval
df	=	degrees of freedom
p	=	probability

7.6 LIMBAL GRAFTS

Table 7.4 Main indications for limbal grafts

Indication for graft	Sub-total	Total	%
Previous failed graft		**18**	**18%**
Disorders of sclera		**16**	**16%**
Scleromalacia perforans	2		
Scleral abscess	3		
Other degeneration of sclera	11		
Burns		**10**	**10%**
Scars and Opacities		**9**	**9%**
Corneal ulcers		**6**	**6%**
Unspecified	2		
Perforated	4		
Neoplasia		**5**	**5%**
Limbal dermoid	1		
Malignancy, unspecified	3		
Squamous cell carcinoma	1		
Pterygium		**4**	**4%**
Recurrent	2		
Unspecified	1		
Peripheral	1		
Corneal oedema/PBK	4	**4**	**4%**
Corneal degenerations		**3**	**3%**
Corneal melt	1		
Terrien's degeneration	1		
Band-shaped keratopathy	1		
Keratoconus		**1**	**<1%**
Other*	26	**26**	**25%**
TOTAL		**102**	**100%**

* other: epithelial defect (4); endophthalmitis (3); pannus (3); vascularisation (3); aniridia (2); astigmatism (2); trachoma (2); conjunctival ocular surface (1); eyelid ankyloblepharon (1); limbal dysplasia (1); herpes zoster (1); iris prolapse (1); ocular pemphigus (1); Stevens-Johnson syndrome (1).

Table 7.5 Reason for failure of limbal grafts

Reason	Sub-total	Total	%
Graft failure (not specified)		**9**	**22%**
Rejection		**7**	**17%**
otherwise specified	4		
with epithelial defects	1		
with perforation	1		
with oedema	1		
Epithelial defect		**4**	**10%**
Neoplasia		**3**	**7%**
Infection		**2**	**5%**
HSV	1		
HZO	1		
Corneal scleral melt		**1**	**3%**
Astigmatism		**1**	**3%**
Abscess		**1**	**3%**
Scars and opacities		**1**	**3%**
Ulcers		**1**	**3%**
Other		**10**	**25%**
Vascularisation	3		
Implantation cysts	1		
Glaucoma	1		
Band shaped keratopathy	1		
Ankyloblepharon	1		
Dysplasia	1		
Scleral necrosis	1		
Stromal thickening	1		
TOTAL		**40**	**100%**

7.7 SUMMARY OF FACTORS RELATING TO LAMELLAR AND LIMBAL GRAFTS

- Limbal grafts do not fare as well as lamellar grafts in terms of graft survival.

- A best corrected Snellen acuity of 6/12 or better was achieved in 55% of cases at most recent follow-up, 62% of cases achieved a follow-up visual acuity of 6/18 or better, and 22% recorded a visual acuity of less than 6/60 at last follow-up. Follow-up visual acuities were not advised in 25% of cases.

- No significant difference in graft survival is apparent amongst surgeons who have performed a larger number of lamellar and limbal grafts (over 15 grafts) and surgeons who have performed fewer grafts.

- Grafts followed by a surgeon or practitioner who did not perform the graft fare better than grafts that are followed by the surgeon who performed the graft. A likely explanation for this difference is that surgeons are likely to continue to follow patients with a higher risk of failure.

- The main indications for lamellar graft are pterygium (19%), corneal ulcers (14%), disorders of the sclera (14%), failed previous graft (13%), keratoconus (12%) and neoplasia (7%). These broad categories account for 79% of lamellar grafts.

- The main reasons for failure of lamellar grafts are corneal scleral melt (18%), unspecified graft failure (14%), perforated ulcers (8%) and infection (8%).

- The main indications for limbal graft are “other” (26%), failed previous graft (18%), disorders of the sclera (16%), burns (10%), scars and opacities (9%), corneal ulcers (6%), and neoplasia (5%). These broad categories account for 90% of limbal grafts.

- The main reasons for failure of limbal grafts are unspecified graft failure (23%), rejection of a previous corneal graft (17%), epithelial defect (10%) and neoplasia (8%).

MULTIVARIATE ANALYSIS: METHODS AND FINAL MODEL

8. COX PROPORTIONAL HAZARDS REGRESSION ANALYSIS

8.1 METHODS

A multivariate model was used to investigate the combined effect of variables of penetrating graft survival, adjusted for all the other variables in the model. Further analysis of the data was undertaken using Stata version 9.

In the preceding univariate analyses, each registered penetrating graft together with its archival follow-up records was treated as a separate and independent entity. Some patients had a history of more than one ipsilateral corneal graft and some had a record of one or more grafts in the contralateral eye (Table 8.1).

Table 8.1 Number of grafts and patients in the cohort with penetrating corneal grafts

Group	Number	Percentage of total
Registered penetrating *grafts*	17090	94%
Number of *patients* with penetrating grafts	13879	93%
Patients with *one* registered graft	11194	81%
Patients with *more than one* registered graft	2685	19%

Following on from the results of the Kaplan-Meier analyses, which were used to indicate variables of interest, Cox Proportional Hazards regression models were used to investigate the joint effects of a subset of variables on penetrating corneal graft failure. To control for potential inter-graft and/or inter-eye dependence in the multivariate analyses, the Cox models were adjusted to allow for clustering by individual patient [see reference 5, Chapter 10.8]. Limbal and lamellar grafts were excluded from consideration. Some variables which were indicated as significant in the univariate analysis were omitted due to non-convergence of the model or collinearity.

The selected variables were: surgeons with more than 25 grafts per year on average, state, donor age, recipient age, indicator for graft, number of previous ipsilateral grafts, graft era, lens status, corneal vascularisation at time of graft, history of inflammation in the grafted eye, history of raised IOP, graft diameter*, time to removal of graft sutures (transformed)*, post-operative neovascularisation of the graft, post-operative rise in IOP, post-operative episodes of immunological rejection, post-operative synechiae, microbial keratitis, uveitis or stitch abscess, refractive surgery in follow-up, where follow-up occurred, vitrectomy at time of graft, multi-organ donor, cause of donor death, corneal storage medium, donor-recipient gender match, eye bank.

The best model was found by a backward elimination process, removing variables not appearing to be predictors of graft failure. The assumption of proportional hazards appeared reasonable as assessed by Kaplan-Meier plots.

* see page 180.

8.2 FINAL MODEL

Two models were used, depending on the rejection criteria for the variables. The first model excluded variables with a p-value of p>0.05 (or global p-value of p>0.5 for variables with more than two categories) in a stepwise manner, beginning with the least significant variable. The second model excluded variables with a p- value or global p-value of p>0.1. The second model is more comprehensive but has the potential to increase confidence intervals for the model parameters. The variables retained in the final Cox proportional hazards regression models are presented in Table 8.2.

Table 8.2 Variables retained in final models

- Surgeons with more than 25 grafts per year (model 2 only)
- State
- Indication for graft
- Number of previous ipsilateral grafts
- Lens status (phakic, pseudophakic or aphakic)
- Corneal neovascularization at the time of graft
- History of inflammation in the grafted eye
- History of raised intraocular pressure in the grafted eye
- Graft diameter
- Time of removal of graft sutures
- Post-operative microbial keratitis
- Post-operative neovascularization of the graft
- Corneal storage medium
- Refractive surgery in follow-up
- Post-operative episodes of immunological rejection
- Arrangements for follow-up

Tables 8.3 and 8.4 tabulate the parameter estimates resulting from the fit of the best clustered Cox models. The tables show the variable, the hazard ratio, the standard error of the regression coefficient, the corresponding probability value and the 95% confidence interval for the hazard ratio. The first level of each categorical variable was taken as the referent. The hazard ratios for a given variable are adjusted for all other variables in the model.

8.2.1 Model 1

This model includes variables with a p-value of p<0.05, with variables eliminated in a stepwise manner, beginning with the leat significant variable. For categorical variables, a global test was applied to calculate the overall p-value.

Table 8.3 Parameter estimates from final Cox regression model 1: factors influencing the survival of penetrating corneal grafts

Variable	Hazard ratio	Standard error	P	global P	95% confidence intervals
State					
State 1	1.00			0.01	
State 2	0.91	0.11	0.40		0.72 - 1.14
State 3	1.06	0.12	0.58		0.85 - 1.32
State 4	1.44	0.22	0.02		1.07 - 1.94
State 5	1.25	0.12	0.03		1.02 - 1.52
State 6	0.95	0.15	0.74		0.69 - 1.30
Indication for graft					
Keratoconus	1.00			<0.001	
Failed graft	2.40	0.49	<0.001		1.61 - 3.58
Corneal dystrophy	2.84	0.50	<0.001		2.01 - 4.02
Bullous keratopathy	3.73	0.74	<0.001		2.53 - 5.51
Herpetic eye disease	2.18	0.40	<0.001		1.52 - 3.11
Corneal scars and opacities	2.04	0.46	0.001		1.32 - 3.16
Other	2.65	0.56	<0.001		1.75 - 4.00
Number failed previous ipsilateral grafts					
Each additional failure	1.16	.08	0.04		1.01 - 1.33
Lens status					
Phakia	1.00			0.002	
Aphakia	1.59	0.21	0.001		1.22 - 2.07
Pseudophakia	1.37	0.15	0.004		1.11 - 1.68
Corneal vascularization at the time of graft					
Three quadrants or less	1.00				
Four quadrants	1.41	0.15	0.002		1.14 - 1.75
Inflammation in the grafted eye at time of graft					
Eye not inflamed	1.00			<0.001	
Inflamed in past only	1.46	0.22	0.01		1.08 - 1.96
Inflamed at graft only	2.15	0.47	<0.001		1.40 - 3.31
Inflamed both in past and at graft	1.67	0.27	0.001		1.23 - 2.29

Variable	Hazard ratio	Standard error	P	Global P	95% confidence intervals
History of raised intraocular pressure in grafted eye					
IOP never raised in past	1.00			<0.001	
Raised in past only	1.45	0.12	<0.001		1.23 - 1.72
Raised at graft only	3.15	0.98	<0.001		1.72 - 5.79
Raised in past and at graft	1.44	0.25	0.03		1.03 - 2.01
Graft diameter					
8.0 mm	1.00				
Every square root mm change from 8.0 mm	1.97	0.27	<0.001		1.50 – 2.57
Post-operative microbial keratitis or stitch abscess					
No microbial keratitis/stitch abscess	1.00				
Microbial keratitis/stitch abscess	1.88	0.24	<0.001		1.47 - 2.40
Removal of graft sutures					
Every one unit increase in ln(years from graft to suture removal)	0.61	0.03	<0.001		0.56 - 0.67
Neovascularization of the graft					
Avascular graft	1.00				
Vascularized graft	2.20	0.21	<0.001		1.87 - 2.71
Graft era					
1985-1989	1.00			<0.001	
1990-1994	0.98	0.09	0.80		0.68 - 1.41
1995-1999	0.79	0.08	0.03		0.50 - 0.76
2000-2006	0.55	0.08	<0.001		0.42 - 0.72
Refractive surgery in follow-up					
No refractive surgery	1.00				
Refractive surgery	0.63	0.07	<0.001		0.49 - 0.79
Rejection episodes					
None	1.00				
One or more episodes	3.45	0.26	<0.001		2.98 - 3.99
Arrangements for follow-up					
Follow-up by surgeon	1.00				
Follow-up elsewhere	0.47	0.07	<0.001		0.35 - 0.64
Time varying change (per year of follow up)	1.08	0.03	0.002		1.03 - 1.13

8.2.2 Model 2

This model excludes variables with a p-value of p>0.1 in a stepwise manner.

Table 8.4 Parameter estimates from final Cox regression model 2

Variable	Hazard ratio	Standard error	P	Global P	95% confidence intervals
Surgeons with a high workload					
All other surgeons	1.00			0.06	
Surgeon 1	1.21	0.30	0.45		0.74 - 1.97
Surgeon 2	1.03	0.17	0.86		0.74 - 1.42
Surgeon 3	0.91	0.17	0.62		0.62 - 1.32
Surgeon 4	2.17	0.85	0.05		1.00 - 4.68
Surgeon 5	1.43	0.55	0.34		0.68 - 3.02
Surgeon 6	0.90	0.21	0.66		0.57 - 1.42
Surgeon 7	0.63	0.21	0.17		0.33 - 1.21
Surgeon 8	0.87	0.22	0.58		0.53 - 1.43
Surgeon 9	0.67	0.14	0.07		0.44 - 1.03
Surgeon 10	2.25	0.89	0.04		1.04 - 4.87
Surgeon 11	1.22	0.36	0.50		0.68 - 2.19
State					
State 1	1.00			0.01	
State 2	0.54	0.20	0.10		0.26 - 1.12
State 3	1.03	0.15	0.84		0.78 - 1.36
State 4	1.41	0.22	0.03		1.04 - 1.92
State 5	1.30	0.15	0.02		1.04 - 1.64
State 6	0.88	0.17	0.50		0.60 - 1.28
Indication for graft					
Keratoconus	1.00			<0.001	
Failed graft	2.32	0.47	<0.001		1.55 - 3.46
Corneal dystrophy	2.82	0.50	<0.001		2.00 - 3.98
Bullous keratopathy	3.70	0.73	<0.001		2.51 - 5.46
Herpetic eye disease	2.15	0.40	<0.001		1.50 - 3.09
Corneal Scars and Opacities	2.06	0.47	0.001		1.32 - 3.20
Other	2.53	0.54	<0.001		1.66 - 3.84
Number failed previous ipsilateral grafts					
Each additional failure	1.17	.08	0.03		1.02 - 1.34
Lens status					
Phakia	1.00			<0.001	
Aphakia	1.61	0.22	<0.001		1.24 - 2.10
Pseudophakia	1.41	0.15	0.001		1.14 - 1.74
Corneal vascularization at the time of graft					
Three quadrants or less	1.00				
Four quadrants	1.39	0.15	0.003		1.12 - 1.72
Inflammation in the grafted eye at time of graft					
Eye not inflamed	1.00			<0.001	
Inflamed in past only	1.45	0.22	0.01		1.08 - 1.95
Inflamed at graft only	2.20	0.48	<0.001		1.44 - 3.37
Inflamed in past and at graft	1.65	0.26	0.002		1.21 – 2.26

Variable	Hazard ratio	Standard error	P	Global P	95% confidence intervals
History of raised intraocular pressure in grafted eye					
IOP never raised in past	1.00			<0.001	
Raised in past only	1.45	0.12	<0.001		1.22 - 1.71
Raised at graft only	3.34	0.97	<0.001		1.90 - 5.89
Raised in past and at graft	1.43	0.25	0.04		1.01 - 2.00
Graft diameter					
8.0 mm	1.00				
Every square root mm change from 8.0 mm	1.96	0.28	<0.001		1.47 – 2.59
Post-operative microbial keratitis					
No microbial keratitis	1.00				
Microbial keratitis	1.88	0.24	<0.001		1.47 - 2.42
Removal of graft sutures					
Every one unit increase in ln(years from graft to suture removal)	0.61	0.03	<0.001		0.56 - 0.67
Neovascularization of the graft					
Avascular graft	1.00				
Vascularized graft	2.20	0.22	<0.001		1.82 - 2.67
Graft era					
1985-1989	1.00			<0.001	
1990-1994	0.96	0.09	0.70		0.80 - 1.16
1995-1999	0.78	0.08	0.03		0.62 - 0.98
2000-2006	0.52	0.08	<0.001		0.39 - 0.69
Refractive surgery in follow-up					
No refractive surgery	1.00				
Refractive surgery	0.61	0.07	<0.001		0.48 - 0.77
Rejection episodes					
None	1.00				
One or more episodes	3.47	0.26	<0.001		2.99 - 4.03
Arrangements for follow-up					
Follow-up by surgeon	1.00				
Follow-up elsewhere	0.45	0.07	<0.001		0.34 - 0.61
Time varying change (per year of follow up)	1.08	0.03	0.002		1.03 - 1.13

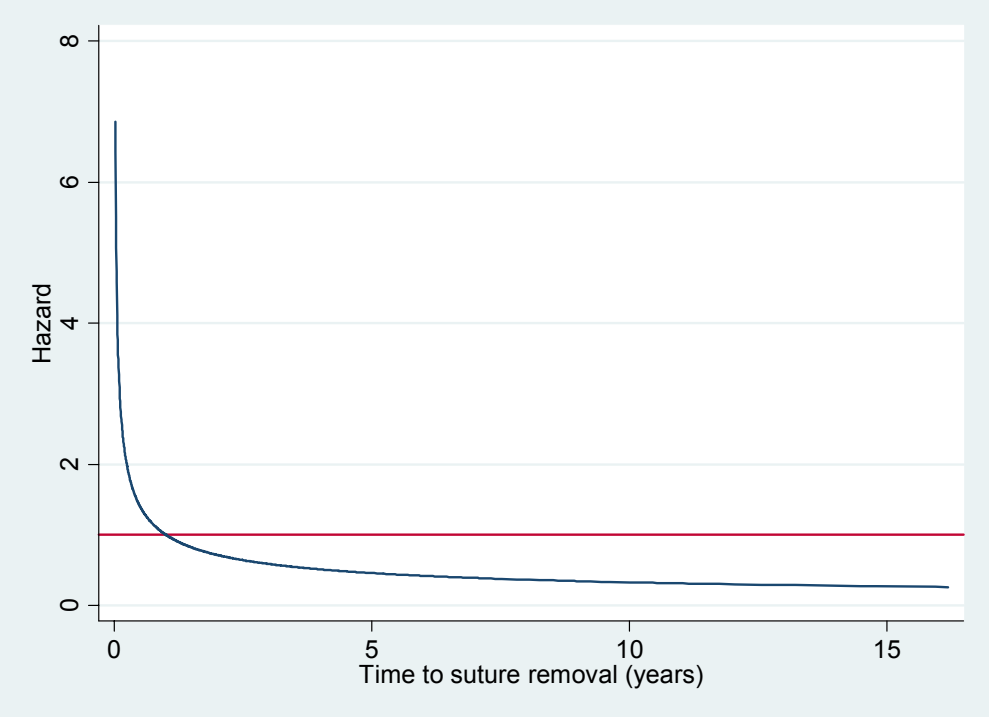
When model 1 is compared with model 2, there is no marked change in hazard ratios for most of the variables except for certain states (most notably state 2). This suggests that there is confounding between state and surgeon, with some of the variation between states explained by the performance of individual surgeons in that state. It should be noted that in most of the cases of individual surgeons compared with all other surgeons, the hazard ratios were not statistically significant.

8.3 TRANSFORMATION OF VARIABLES

The final model includes variables that have been transformed to improve the model fit. These variables are graft size and time to suture removal, which have non-linear hazard ratios. Graft size has a minimum hazard ratio (or relative risk) at a size of 8.0 mm, with increasing risk for grafts both larger and smaller than this. The increase in hazard ratio has a square root relationship with the change in diameter of the corneal graft from the optimal size of 8.0 mm.

Suture removal has a very skewed distribution, with the mean time to suture removal being 1.5 years, but with some very large positive values. Suture removal was modelled as a continuous variable, but log-transformed to account for the large positive tail. The log-transformation of suture removal means that the hazard ratio is greater than 1.0 for suture removal times of less than 1 year (increased risk), but greater than 1.0 for suture removal times greater than 1.0 years (reduced risk). The risk increases sharply for suture removal times significantly less than 1 year. Conversely the risk reduces more slowly for suture removal times significantly greater than 1 year (see Fig 8.1).

Figure 8.1 Suture removal hazard ratio



In addition, the variable for arrangements for follow-up includes a time varying component which models a change in hazard ratio between follow-up by surgeon or elsewhere over time.

8.4 INTERPRETATION OF THE MODEL

The hazard ratio can be interpreted in the same manner as a relative risk – the relative hazard of a variable compared with the reference. To calculate the hazard ratio for a combination of variables, the individual hazard ratios are multiplied together. For example, if a graft is aphakic and has had more than one rejection episodes the combined hazard ratio using model 2 is:

Relative hazard (combined) = HR (aphakic) x HR (one or more rejection episodes) = 1.61 x 3.57 = 5.59
compared with a reference graft (phakic with no rejection episodes).

For continuous variables, the hazard ratio is raised to the power of the value of the continous variable. For example, for three ipsilateral grafts, the total hazard ratio using model 2 is:

Relative hazard (3 ipsilateral grafts) = HR (1 ipslateral graft)^3 = 1.17^3 = 1.60
compared with a reference graft with no previous ipsilateral grafts.

For the transformed variables time to suture removal and graftsize, the transformation needs to be taken into account when comparing hazard ratios.

For graftsize, the hazard ratio can be found using the following formula (for model 2):

Relative hazard (graftsize = g mm) =$1.96^{\sqrt{(|g-8.0|)}}$

For example for a graftsize of 6.5 mm:

Relative hazard (6.5 mm) =$1.96^{\sqrt{(|6.5-8.0|)}}$ = $1.96^{1.22}$ = 2.28

To find the hazard ratio of follow-up elsewhere compared with follow-up by the surgeon, the time-varying component should be incorporated:

Relative hazard (after t yrs) = HR (follow-up) x HR (time - varying follow-up)^t

For example, at 5 years post-graft the relative hazard using model 2 is:

Relative hazard (after t = 5yrs) = HR (follow-up) x HR (time-varying follow-up)^t = 0.47 x $(1.08)^5$ = 0.69
At 5 years post-graft, the hazard ratio increases from 0.47 (in the first year after graft) to 0.69.

9. SUMMARY

9.1 GRAFTS, CONTRIBUTORS AND ERA

Analyses were performed on cumulative data entered into the ACGR from its inception until the census date for this report of 01/09/2006. Data were available on 18,205 corneal grafts, 94% of which were penetrating, 5.5% of which were lamellar and 0.5% of which were limbal. Of the penetrating corneal grafts, 78% had been followed at least once. Of the lamellar grafts, follow-up was available for 71% and for the limbal grafts, follow-up was available for 86%. Kaplan-Meier survival of penetrating and lamellar grafts was 73% and 69%, respectively, at 5 years. Kaplan-Meier survival of limbal grafts was 42% at 5 years.

Grafts were recorded from each Australian state and territory, with about 60% of all grafts being entered from two states, New South Wales and Victoria. A total of 623 individuals contributed data to the Registry. Of the contributors, 345 performed corneal graft procedures and 278 were involved in patient follow-up. Approximately 82% of all records of graft were registered by 62 ophthalmologists (18% of contributing surgeons).

Examination of penetrating corneal graft survival according to era (four year blocks of time) showed that graft survival appears significantly worse for those grafted in the 1993-1996 period.

9.2 CORNEAL DONORS AND EYE BANKING

Historically, corneas were procured privately and from hospital-based banks, but surgeons currently procure donor corneas almost exclusively from Therapeutic Goods Administration-licensed Eye Banks in NSW, QLD, VIC, SA and WA.

Causes of donor death related to the cardiac/circulatory system in 31% of cases, the cerebrovascular system in 17%, to malignancy in 16%, to trauma, accident, poisoning or medical misadventure in 11%, to the respiratory system in 6%, to other specified causes in 13%, and to causes unknown to the ACGR in 6%. Most corneas were retrieved from cadaveric donors, with 6% of all corneas obtained from multi-organ donors. 61% of donors were male and 34% were female. Donors ranged in age from infancy to 99 years at the time of death, but the majority (65%) were aged from 51-80 years.

The median death-to-enucleation time for corneas used for penetrating keratoplasty was 6 hours. Historically, most donor corneas were preserved in McCarey-Kaufman medium but for the past 10 years, Australian eye banks have predominantly used Optisol storage. Corneas stored in Optisol appear to have significantly better graft survival than those stored in other media. The median time between donor death and penetrating corneal graft surgery for corneas stored in Optisol was 98 hours.

9.3 CORNEAL GRAFT RECIPIENTS

Recipient age varied from less than one month old to greater than 97 years, with peaks at 20-40 years and 60-80 years. Approximately equal numbers of women and men received a corneal graft. Recipients under 4 years and over 80 years appear to have poorer graft survival than other age groups. The main indications for penetrating keratoplasty were keratoconus (32%), bullous keratopathy (26%), failed previous graft (19%), corneal dystrophy (7%), herpetic eye disease (4%), corneal opacity or scar (3%), ulcers (2%), and accidental injury (1.7%). Corneal grafts performed for keratoconus have significantly better graft survival than for any other indication.

Approximately one third of recipients displayed evidence of corneal neovascularization at the time of graft. In about 36% of cases where information on past history was available, the eye to be grafted had been inflamed in the past or was inflamed at the time of graft. In about 15% of cases, the intraocular pressure in the eye to be grafted had been raised at some time in the past or was raised at graft. Raised intraocular pressure at any time prior to, or at graft, is a significant risk factor for corneal graft failure. About one-fifth of recipients had previously had a corneal graft in the ipsilateral eye. Graft survival falls with increasing number of ipsilateral grafts performed.

9.4 OPERATIVE PROCEDURES

Graft size ranged from 2.0 mm to 16.0 mm in diameter. Grafts within the size range of about 7.5 to 8.5 mm in diameter fare best. In 40% of cases, an additional operative procedure was carried out at the time of transplantation. The most common of these procedures were manipulations associated with the lens (24%), vitrectomy (10%) and peripheral iridectomy (6%). Graft survival is poorer in aphakes than in phakic or pseudophakic recipients.

9.5 CAUSES OF GRAFT FAILURE

The major causes of failure of penetrating corneal grafts were rejection (31%), endothelial cell failure (21%), infection (13%) and glaucoma (8%). Removal of graft sutures within 6 to 12 months of the time of transplantation is a risk factor for graft failure. A penetrating corneal graft that never clears and thins in the immediate post-operative period is considered to be a primary non-functioning graft. Thus far, 137 such grafts have been reported to the ACGR, representing 1% of followed grafts.

9.6 VISUAL OUTCOME AFTER CORNEAL TRANSPLANTATION

In 70% of cases, the sole desired outcome for corneal transplantation was to improve vision in the grafted eye. In a further 18% of cases, the desired outcome was pain relief, with or without the possibility of visual improvement after surgery.

For patients with penetrating grafts, 45% of the cohort achieved a Snellen acuity of 6/12 or better at the time of the most recent follow-up and 55% achieved 6/18 or better, but for 26%, Snellen acuity was less than 6/60. Where both pre-operative and post-operative Snellen acuities were available an improvement in acuity of at least one line on the Snellen chart was recorded by 74% of recipients after corneal transplantation. In 13% there was no change, and in 13% the acuity was worse after graft.

Factors affecting the visual potential of the grafted eye included astigmatism of more than 5 dioptres (22%), graft failure (22%) and one or more co-morbidity in the grafted eye. Refractive surgery was carried out on 12% of all penetrating grafts with follow-up. At 10 years or more after corneal transplantation, 40% of recipients had been prescribed spectacles and approximately 10% had a contact lens. An intraocular lens was in place in the grafted eye in about 33% of the cohort.

9.7 LAMELLAR AND LIMBAL GRAFTS

Limbal grafts did not fare as well as lamellar grafts.

A best corrected Snellen acuity of 6/12 or better was achieved in 55% of cases at most recent follow-up, 62% of cases achieved a follow-up visual acuity of 6/18 or better, and 22% recorded a visual acuity of less than 6/60 at last follow-up.

The main indications for lamellar and limbal graft were pterygium (18%), disorders of the sclera (14%), rejection of a previous graft (14%), corneal ulcers (14%), neoplasia (6%) and scars and opacities (6%). These broad categories accounted for 72% of lamellar and limbal grafts.

The main reasons for failure of lamellar and limbal grafts were failure of a previous corneal graft (27%), corneal scleral melt (14%) and infection (11%).

9.8 RISK FACTORS FOR FAILURE OF PENETRATING GRAFTS

The variables best predicting penetrating corneal graft failure in Cox proportional hazards regression analysis were surgeons with a high workload (a variable with marginal significance), state, indication for graft, number of failed previous ipsilateral corneal grafts, lens status, history of inflammation in the grafted eye, history of raised intraocular pressure in the grafted eye, graft diameter, time of removal of graft sutures, corneal neovascularization at the time of the graft, post-operative corneal vascularization, number of corneal graft rejection episodes, post-operative microbial keratitis or stitch abscess, graft era and follow-up arrangements. Further information on these variables, with the associated relative risks for graft failure, are presented in Table 9.1. More comprehensive information is found in Chapter 8.

A number of potential risk factors for graft failure were identified in univariate analyses. The factors that did *not* influence penetrating corneal graft survival significantly in multivariate analysis were: cause of donor death, corneal retrieval from a multi-organ donor, identity of eye bank, donor age, recipient age, post-operative uveitis, post-operative rise in intra-ocular pressure, development of synechiae after transplantation, vitrectomy at time of graft, corneal storage medium and donor-recipient gender match .

Table 9.1 Variables best predicting penetrating corneal graft failure (from model 2)

Variable	Hazard ratios
Surgeons with a high workload (11 compared with all others)	0.33-4.87
State	0.54-1.41
Failed previous ipsilateral graft (each additional graft)	1.17
Indication for graft	1.00-3.70
Lens status	1.00-1.61
Corneal vascularization at graft	1.00-1.39
History of inflammation in the eye to be grafted	1.00-2.20
History of raised intraocular pressure	1.00-3.34
Graft diameter, every square root mm change from 8.0mm	1.96
Post-operative microbial keratitis or stitch abscess	1.88
Removal of graft sutures, every one unit increase in ln(years from graft) (removal before 1 year associated with greater risk)	0.61
Graft neovascularization	2.20
Graft era	0.52-1.00
Refractive surgery in follow-up	0.61
One or more rejection episodes	3.47
Arrangements for follow-up	0.45
(follow-up by transplant surgeon associated with greater risk, with the risk decreasing every year after graft)	1.08

10. METHODS AND DEFINITIONS

10.1 ENTRY AND FOLLOW-UP

Data are entered into the Registry by the contributing surgeon as soon as possible after the graft and follow-up information is requested at intervals of about 12 months. Information is obtained by mail; missing data are routinely sought by follow-up letter. Each graft is followed until graft failure or until the death or loss to follow-up of the patient. The study period for the present analyses was May 1985 to September 2006 (21 years).

10.2 DEFINITION OF RISK FACTORS

A history of past inflammation is recorded if the individual is specifically reported to have had such an episode, if the patient has had one or more previous grafts in the ipsilateral eye, if any intraocular surgery has ever been performed on that eye, or if there is a history of the use of topical corticosteroids in that eye in the weeks immediately preceding the graft.

Vessel ingrowth into the cornea at the time of graft is scored on a scale of 0-4, with 0 representing no growth in any quadrant extending to the graft-host junction, 1 representing such growth in 1 quadrants, 2 representing growth in 2 quadrants, 3 being vessel ingrowth in 3 quadrants and 4 being vessel ingrowth in 4 quadrants. No distinction is made between superficial or deep vessels, patent or ghost vessels, or single or multiple vessel leashes. After corneal transplantation, the presence of even one vessel leash extending into the graft is considered enough to classify that graft as vascularized.

The intraocular pressure (IOP) is generally considered to be raised if a reading of 25 mm of mercury or greater is made by applanation tonometry, but the decision is at the discretion of the ophthalmologist.

Presenting diseases, indications for graft, post-operative complications and reasons for graft failure are coded using the ICD.9.CM system (US Department of Health and Human Services).

Information is collected on both recipient bed size and donor button size, but for the purpose of examining the influence of graft size, the former is used.

10.3 DEFINITION OF GRAFT FAILURE, REJECTION AND COMPLICATIONS

Primary graft non-functions are defined as grafts that never thin and clear in the post-operative period. The trial time for such grafts is arbitrarily adjusted to one day. Any existing graft that is replaced by another in the same eye, irrespective of graft clarity and for whatever reason, is classified as a failed graft. An example in this category would be a clear graft with an unacceptably high degree of irregular astigmatism, not improved by refractive surgery, which is then replaced. In all other cases, graft failure is defined as oedema and irremediable loss of clarity in a previously thin, clear graft. The day of failure is the first day the patient is seen with an oedematous, opaque graft that subsequently fails to thin and clear.

Rejection is defined as the development of a rejection line (epithelial or endothelial) or a unilateral anterior chamber reaction with corneal infiltrates and spreading corneal oedema in a previously thin, clear graft.

Any development with the potential to compromise graft outcome is considered to be a complication. Post-operative complications are collected in two ways. First, a number of specified complications (stitch abscess, microbial keratitis, neovascularization of the graft, synechiae, uveitis, rise in IOP, cataract, rejection episode, herpetic recurrence, early changes of bullous keratopathy), refractive and related errors (anisometropia, $\geq$5 dioptres astigmatism) and factors potentially affecting visual outcome but unrelated to the graft (cataract, amblyopia, retinal detachment, age related macular degeneration and diabetic retanopathy) are listed, requiring a yes/no answer. Second, contributors are asked to specify any other relevant complications, information or departures from their preferred treatment.

10.4 STATISTICAL ANALYSES

Kaplan-Meier survival functions are constructed to provide a graphical record of graft survival. For surviving grafts, trial time is calculated as the time between the date of graft and the date on which the patient was last seen. For failed grafts, trial time is calculated as the time between the date of graft and the date of failure. For grafts for which we have never received follow-up, the default graft survival period is 0.1 day. Kaplan-Meier plots were constructed using SPSS versions 12, 14 and 15. Cox proportional hazards regression analysis was performed using Stata version 9.

10.5 COMPUTER HARDWARE AND SOFTWARE

Existing hardware comprises a HP Compaq dc7600 computer with 2 hard drives: 74.5 GB, and 149 GB, and HP LaserJet 4 printer.

The database is constructed in Microsoft Access. The Access database was designed by Ms Sandra Bobleter and has subsequently been modified by Mrs Helene Holland, Ms Ngaere Hornsby, Ms Carmel McCarthy and Mrs Chris Bartlett. Kaplan-Meier curves generated for the 2007 Report were prepared using SPSS versions 12, 14 and 15. The report was prepared using Microsoft Office 2003.

10.6 CORNEAL GRAFT REGISTRATION FORM

Registry No. Registry use only	**THE AUSTRALIAN CORNEAL GRAFT REGISTRY GRAFT REGISTRATION FORM**

SURGEON STATE

RECIPIENT IDENTIFICATION

Patient's name _____
SURNAME FIRST NAME

Patient's record No. _____ (if applicable)

Patient's date of birth / /	Patient gender	Male	Female
Date of graft / /	Eye grafted	R	L

RECIPIENT HISTORY

Original pathology/past history/underlying diseases (in words)	**Office use only**
Current pathology/current indications for graft (in words)	

Desired outcomes	Pain Relief	Improved Visual Acuity	Cosmesis	Tectonic/ Structural Repair

Please circle or tick as many as apply

Pre-graft visual acuity	R	L

Please advise acuity in both eyes

No. of previous grafts in grafted eye (excluding this graft) _____

If this is a **repeat** graft in the grafted eye, please give the reason and date of failure of previous graft	Reason for failure:	Date of failure: / /

Presence of vessels in the recipient cornea	4 Quadrant	3 Quadrant	2 Quadrant	1 Quadrant	None

Please circle/tick the applicable box

	Yes	No	Unknown
Current inflammation of eye			
Use of topical steroids in 2 weeks prior to graft			
History of intraocular surgery in grafted eye (not including a previous graft procedure)			
Active HSV infection at time of graft			
Does patient have a history of raised intraocular pressure?			
Was intraocular pressure raised at the time of this graft?			
Immediately **prior** to graft, was the eye to be grafted	Phakic	Aphakic	Pseudo phakic

DONOR INFORMATION

Donor age (in years) ☐ Donor gender ☐ Male ☐ Female

Multiple Organ Donor ☐ Yes ☐ No

Eye Bank Source

☐ SA	☐ NSW
☐ QLD	☐ VIC
☐ WA	☐ VIC - Forensic

Please circle/tick applicable box

Eyebank No. (if applicable) _____

Cause of donor death

	OFFICE USE ONLY

(Please fill in as many as are known using a 24 hour clock)

Time and date of donor death		Time		Date
Time and date of enucleation		Time		Date
Time and date of storage of cornea		Time		Date

Storage method

Moist Pot ☐ Organ culture ☐ CSM ☐ Optisol ☐ Other ☐ (Please state)

Endothelial cell count (per mm^2) ☐

OPERATIVE DETAILS

Type of graft Penetrating ☐ Lamellar ☐ Limbal or stem cell /conjunctival ☐

Size of graft Recipient ☐ mm Donor Button ☐ mm

Time of day graft performed _____

ACCOMPANYING PROCEDURES: (Tick as many as apply)

Peripheral Iridectomy	☐	Removal of cataract	☐
Trabeculectomy	☐	Triple procedure	☐
Vitrectomy	☐		

Other procedures _____

Immediately **following** the graft, was the eye grafted ☐ Phakic ☐ Aphakic ☐ Pseudophakic

COMMENTS _____

CONSENT: *Please remember that you should gain consent from your patient for data to be forwarded to the ACGR*

PLEASE RETURN THIS FORM TO:

Australian Corneal Graft Registry
Department of Ophthalmology, Flinders Medical Centre
BEDFORD PARK S.A. 5042
PHONE: (08) 8204 5321 FAX: (08) 8277 0899

Ver Dec 2005

10.7 CORNEAL GRAFT FOLLOW-UP FORM

Registry No. Registry use only	**THE AUSTRALIAN CORNEAL GRAFT REGISTRY FOLLOWUP**		Date Rec'd Ver Dec 2005

SURGEON STATE

PATIENT IDENTIFICATION AND GRAFT OUTCOME

GRAFT STATUS

DATE PATIENT LAST SEEN BY YOU / /

GRAFT SURVIVING ON DATE LAST SEEN | Yes | No | (Please mark correct box)

GRAFT FAILED | Yes | No | DATE GRAFT FAILED / /

		Office use only
REASONS FOR GRAFT FAILURE	1.	
	2.	

PATIENT STATUS

Status	Please tick applicable box		Date
DECEASED/LOST TO FOLLOWUP (please circle)	YES	NO	/ /

FOLLOW-UP ELSEWHERE? (Please advise the name and address of the follow-up doctor, if known)

POST OPERATIVE EVENTS

DATE OF FINAL SUTURE REMOVAL: / /

HAVE ANY OF THE FOLLOWING OCCURRED:

NEOVASCULARIZATION OF GRAFT		SYNECHIAE	
SIGNIFICANT RISE IN IOP		UVEITIS	
CATARACT DEVELOPED SINCE GRAFT		STITCH ABSCESS	
RECURRENT HERPETIC DISEASE		OEDEMA	
MICROBIAL KERATITIS			

NO., AND DATES, OF ANY REJECTION EPISODES SINCE LAST FOLLOWUP					
No. of rejections	/ /	/ /	/ /	/ /	/ /

	Office use only
ANY OTHER SIGNIFICANT EVENTS?	

OPERATIVE PROCEDURES ON THE GRAFTED EYE

HAS AN OPERATIVE PROCEDURE BEEN PERFORMED ON THE GRAFTED EYE SINCE THE LAST RECORDED FOLLOW-UP?

YES	NO

(Please mark which is applicable)

IF "yes", PLEASE TICK AS MANY AS APPLY:

CATARACT REMOVAL	
INSERTION IOL	
YAG LASER/MECH. CAPSULOTOMY	

GLAUCOMA SURGERY (Please specify)	OTHER OPERATIVE PROCEDURE (Please specify)

HAS ANY REFRACTIVE SURGERY BEEN PERFORMED?

Please mark applicable box	
YES	NO

IF "yes" PLEASE TICK WHERE APPLICABLE:

SUTURE ADJUSTMENT		EXCIMER LASER - PRK	
COMPRESSION SUTURES		EXCIMER LASER - LASIK	
RELAXING INCISION		OTHER (Please state)	
WEDGE RESECTION			

POST-GRAFT VISUAL OUTCOME

SNELLEN ACUITY (with preferred correction and without pinhole)

GRAFTED EYE

	Please mark all applicable boxes	
ARE SPECTACLES WORN?	YES	NO
ARE CONTACT LENS WORN?	YES	NO
DOES PATIENT HAVE AN IOL IN PLACE IN THE GRAFTED EYE?	YES	NO

ANISOMETROPIA			
MAJOR DEGREE ASTIGMATISM (>=5D)			
K-READING (if available)			
CENTRAL GRAFT PACHYMETRY		ENDOTHELIAL CELL COUNT (per mm^2)	

FACTORS AFFECTING VISUAL ACUITY IN GRAFTED EYE (Please tick all that apply)

CATARACT		CME		RETINAL DETACHMENT	
AMBLYOPIA		MYOPIA		ARMD	
GLAUCOMA		OPACITY/SCAR		DIABETIC RETINOPATHY	

OTHER (please specify)

EYE HAS NO VISUAL POTENTIAL

IF GRAFTED FOR PAIN, HAS PAIN BEEN RELIEVED?

Yes	No

OTHER COMMENTS

PLEASE RETURN THIS FORM TO:

AUSTRALIAN CORNEAL GRAFT REGISTRY
Department of Ophthalmology, Flinders Medical Centre
BEDFORD PARK S.A. 5042
PHONE: (08) 8204 5321 FAX: (08) 8277 0899

10.8 REFERENCES

1 Kaplan EL, Meier P. Nonparametric estimation from incomplete observations. J Am Stat Assoc 1958; 53; 475-81.

2 Peto R, Pike MC, Armitage P, Breslow NE, Cox DR, Howard SV, Mantel N, McPherson K, Peto J, and Smith PG. Design and analysis of randomized clinical trials requiring prolonged observation of each patient. I Introduction and design. Br J Cancer 1976; 34:585-612.

3 Peto R, Pike MC, Armitage P, Breslow NE, Cox DR, Howard SV, Mantel N, McPherson K, Peto J, and Smith PG. Design and analysis of randomized clinical trials requiring prolonged observation of each patient. II Analysis and examples. Br J Cancer 1977; 35:1-39.

4 Cleves MA, Gould WW and Gutierrez RG. An introduction to Survival Analysis using Stata.

5 Williams RL. A note on robust variance estimation for cluster-correlated data. *Biometrics* 2000*;* 56:645.

11. ACGR PUBLICATIONS

11.1 JOURNAL ARTICLES

Williams KA, Sawyer M, Alfrich SJ, Joseph L, White MA, Coster DJ, Mahmood M, on behalf of all contributors. First report of the Australian Corneal Graft Registry. Aust NZ J Ophthalmol 1987; 15: 291-302.

Williams KA, Sawyer MA, White MA, Mahmood MI, Coster DJ, on behalf of all contributors. Report from the Australian Corneal Graft Registry. Transplant Proc 1989; 21: 3142-3144.

Williams KA, Muehlberg SM, Coster DJ, on behalf of all contributors. Visual outcome after corneal transplantation. Transplant Proc; 1992; 24: 178.

Williams KA, Roder D, Esterman A, Muehlberg SM, Coster DJ, on behalf of all contributors. Factors predictive of corneal graft survival: report from the Australian Corneal Graft Registry. Ophthalmology 1992; 99: 403-414.

Williams KA, Muehlberg SM, Wing SJ, Coster DJ, on behalf of all contributors. The Australian Corneal Graft Registry, 1990-1992 report. Aust NZ J Ophthalmol 1993; 21 (suppl): 1-48.

Coster DJ, Williams KA, on behalf of all contributors to the ACGR, The Australian Corneal Graft Registry (ACGR). Klin Monatsbl Augenheilkd 1994;205: 271-274.

Williams KA, Muehlberg SM, Lewis RF, Coster DJ, on behalf of all contributors to the Australian Corneal Graft Registry (ACGR). How successful is corneal transplantation? A report from the Australian Corneal Graft Register. Eye 1995; 9: 219-227.

Williams KA, Muehlberg SM, Lewis RF, Coster DJ, on behalf of all contributors to the Australian Corneal Graft Registry (ACGR). Influence of lens status on graft and visual outcome within a corneal graft register. Transplant Proc 1995; 27: 1389-91.

Williams KA, Muehlberg SM, Lewis RF, Coster DJ, on behalf of all contributors to the Australian Corneal Graft Registry (ACGR). Graft survival after corneal transplantation: role of factors with the potential for recipient presensitisation. Transplant Proc 1995; 27: 2141-2.

Williams KA, Muehlberg SM, Lewis RF, Coster DJ, on behalf of all contributors to the Australian Corneal Graft Registry. The long term outcome in corneal allotransplantation. Transplant Proc 1997; 29: 983.

Williams KA, Muehlberg SM, Lewis RF, Coster DJ, on behalf of all contributors to the Australian Corneal Graft Registry. Influence of advanced recipient and donor age on the outcome of corneal transplantation. Br J Ophthalmol 1997; 81: 835-839.

Williams KA, Esterman AJ, Bartlett C, Holland H, Hornsby NB, Coster DJ, on behalf of all contributors to the Australian Corneal Graft Registry. How effective is penetrating corneal transplantation? Factors influencing long-term outcome in multivariate analysis. Transplantation 2006; 81: 896-901.

11.2 REPORTS

Williams KA, Sawyer MA, Joseph L, Alfrich S, White M, Coster DJ, Mahmood M. First report of the Australian Graft Registry, 1986.

Williams KA, Sawyer MA, White MA, Coster DJ. Report from the Australian Corneal Graft Registry, 1988. Flinders Press, Adelaide.

Williams KA, Sawyer MA, White MA, Muehlberg SM, Mahmood M, Coster DJ. Report from the Australian Corneal Graft Registry, 1989. Flinders Press, Adelaide.

Williams KA, Muehlberg SM, Lewis RF, Coster DJ. Report from the Australian Corneal Graft Registry, 1994. Mercury Press, Adelaide.

Williams KA, Muehlberg SM, Lewis RF, Giles LC, Coster DJ. Report from the Australian Corneal Graft Registry, 1996. Mercury Press, Adelaide.

Williams KA, Muehlberg SM, Bartlett CM, Esterman A, Coster DJ. Report from the Australian Corneal Graft Registry, 1999. Snap Printing, Adelaide.

Williams KA, Hornsby NB, Bartlett CM, Holland HK, Esterman A, Coster DJ. Report from the Australian Corneal Graft Registry, 2004. Snap Printing, Adelaide.
URL link to permanent repository to view 2004 Report:
http://dspace.flinders.edu.au/dspace/handle/2328/1002