SCIENTIFIC REPORT

The indications and outcome of paediatric corneal transplantation in New Zealand: 1991–2003

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Aim: To evaluate patient characteristics, indications, surgical details, and outcome of paediatric keratoplasty in New Zealand.

Methods: As part of a prospective longitudinal study, paediatric keratoplasty data collected by the New Zealand National Eye Bank (NZNEB) was analysed for the 13 year period 1991–2003.

Results: During the study period the NZNEB supplied 2547 corneas for keratoplasty, of which 65 (3%) were used for paediatric patients (14 years or younger). The 65 keratoplasties were performed in 58 eyes of 52 patients (66% male, 34% female, mean age 10.6 years, SD 4.3 years). Indications were classified into three groups: congenital (16%, n = 9), acquired non-traumatic (74%, n = 43), and acquired traumatic (10%, n = 6). Peters' anomaly (7% of total), keratoconus (67%), and penetrating trauma (8%) were the most common indications in each group, respectively. 82% of keratoplasties with known outcome survived (clear graft) 1 year postoperatively, 16% failed, and one patient died. Keratoplasty for congenital indications had a lower 1 year survival rate (78%) compared to acquired non-traumatic (85%) and traumatic (100%) indications, although the difference was not statistically significant (p = 0.65). 38% of patients with known outcome had a 1 year postoperative best corrected Snellen visual acuity (BCSVA) of 6/9 or better, and 60% had a BCSVA of 6/18 or better. Visual outcome was significantly better for acquired compared to congenital indications (p = 0.03).

Conclusion: Analysis of the NZNEB database provided valuable information in relation to paediatric keratoplasty in New Zealand. In particular, this study highlighted an unusually high prevalence of keratoconus as an indication for keratoplasty. In addition, a high 1 year survival rate and good visual outcome were identified, especially in cases of keratoplasty for acquired conditions.

Paediatric keratoplasty is a difficult undertaking which presents a wide range of challenges preoperatively, intraoperatively, and postoperatively.[1–6] The presence of amblyopia, associated ocular pathology, and greater severity of disease may significantly limit visual outcome.[1–6] The surgical procedure is technically more complex owing to the decreased rigidity and increased elasticity of the infant cornea and sclera, the smaller size of the infant eye, the increased intraoperative fibrin formation and the positive vitreous pressure.[1–6] Postoperative follow up and management may be more complicated, and graft rejection is often difficult to detect and treat.[1–6]

The New Zealand National Eye Bank (NZNEB), founded in 1991, is the major supplier of donated ocular tissue for transplantation in New Zealand. A standard protocol of the NZNEB since 1991 has been the maintenance of a comprehensive database, supported by New Zealand ophthalmic surgeons, in which prospective data are collected on all aspects of corneal donation and transplantation. In this study the NZNEB database was analysed for the 13 year period 1991 to 2003 with respect to patient characteristics, indications, surgical details, and outcome of paediatric keratoplasty.

METHODS

As part of a longitudinal, prospective study, the electronic records of the NZNEB were analysed for the 13 year period 1991–2003 with respect to demographics of recipients, indications, donor information, surgical details, and outcome of paediatric keratoplasty.

Data are entered into the computerised NZNEB database in a prospective manner by eye bank staff. Donor information is entered at the time of donor tissue procurement. Recipient and surgical information is collected from surgeons at the time of operation. Follow up data are obtained at 1 and 2 years postoperatively and are collected from surgeons by way of a mailed questionnaire sent out at the appropriate time point.

Statistical analysis was performed in consultation with a medical statistician from the epidemiology department of the University of Auckland. The SPSS V 12 software package was used. Statistical methods were the Fisher's exact test (when total number of observations were less than 20) and χ^2 testing to compare proportions between groups, the Student's *t* test to compare means between groups, and logistic regression modelling to identify factors associated with decreased keratoplasty survival. The level of statistical significance was $p<0.05$ unless stated otherwise. Visual acuity was converted to a logMAR scale for the purposes of statistical analysis.

RESULTS

Patient demographics

During the 13 year study period the NZNEB supplied 2547 corneas for keratoplasty, of which 65 (3%) were used for patients within the paediatric age group (14 years or younger). The 65 keratoplasties were performed in 58 eyes of 52 patients. The mean age of patients at the time of operation was 10.6 (SD 4.3) years, median age 12.0 years, and range 2 weeks to 14.0 years. The sex distribution was 66% (n = 34) male and 34% (n = 18) female.

Indications

The indications for paediatric keratoplasty are presented in table 1. The diagnostic classification system developed by Stulting *et al*[1] was used to facilitate comparison with other

Abbreviations: BCSVA, best corrected Snellen visual acuity; CHED, congenital hereditary endothelial dystrophy; ECD, endothelial cell density; NZNEB, New Zealand National Eye Bank

Table 1 Indications for paediatric keratoplasty

Preoperative diagnosis	Number of eyes	% of total
Congenital	**9**	**15.5**
Peters' anomaly	4	6.9
CHED	2	3.4
Limbal dermoid	1	1.7
Congenital corneal opacity not otherwise specified	2	3.4
Acquired non-traumatic	**43**	**74.1**
Keratoconus	39	67.2
Viral keratitis	4	6.9
Acquired traumatic	**6**	**10.3**
Penetrating trauma	5	8.6
Aphakic corneal oedema	1	1.7

CHED, congenital hereditary endothelial dystrophy.

Table 2 Age and sex distribution for each diagnostic group

Diagnosis group	Mean age (SD) (years)	Median age (years)	Age range	Male (%)
Congenital	3.0 (3.2)	2	2 weeks–10 years	44
Acquired non-traumatic	12.4 (2.2)	13.0	6–14 years	64
Acquired traumatic	10.8 (3.6)	12	5–14 years	80
Regraft	9.0 (4.9)	8.0	5 months–14 years	71

published reports. Indications were classified into three groups: congenital, acquired non-traumatic, and acquired traumatic conditions. The congenital group accounted for 16% (n = 9) of keratoplasties, the acquired non-traumatic group 74% (n = 43), and the acquired traumatic group 10% (n = 6). Peters' anomaly (7% of total, n = 4) was the most common indication in the congenital group, keratoconus (67% of total, n = 39) in the acquired non-traumatic group, and penetrating trauma (9% of total, n = 5) in the acquired traumatic group. There were seven regraft procedures performed during the study period with original indications being keratoconus (n = 3), viral keratitis (n = 1), Peters' anomaly (n = 2), and penetrating trauma (n = 1). Keratoplasty was performed to improve visual acuity in 86% (n = 56) of cases, for tectonic reasons in 6% (n = 4), and for a combination of reasons in 8% (n = 5).

The age and sex distribution for each diagnostic group are presented in table 2. There was no significant association between preoperative diagnosis and sex identified (congenital, p = 0.16; acquired non-traumatic, p = 0.26; acquired traumatic, p = 0.43; regraft, p = 0.41, χ^2 test). The indications for different age groups (using stratified 5 year intervals) are presented in table 3. Peters' anomaly was the leading indication in the less than 5 years age group and keratoconus in the remaining two groups.

Surgical details

Keratoplasty was performed by 22 different surgeons in 10 centres throughout New Zealand. Penetrating keratoplasty was performed in 62 cases and lamellar keratoplasty in the remaining three cases. The indications for lamellar keratoplasty were limbal dermoid, Peters' anomaly, and congenital corneal opacification not otherwise specified. Donor information was available for all corneal tissue used with mean donor age 44.4 (SD 18.0) years, median age 46.5 years, and range 10–77 years. Mean endothelial cell density (ECD) was 3074 cells/mm^2 (SD 386 cells/mm^2), median 3065 cells/mm^2, and range 2578–4210 cells/mm^2. The donor cornea button was sutured to the recipient corneal rim with 10-0 Nylon in 95% (n = 62) and a combination of Nylon and Prolene in 5% (n = 3). An interrupted suture technique was used in 40% (n = 26), a single continuous suture in 26% (n = 17), and a combined interrupted/continuous technique in 34% (n = 22).

Reported preoperative ocular conditions included corneal vascularisation in 19% (n = 12), previous intraocular surgery

Table 3 Indications for keratoplasty for different age groups

Age group	Most common diagnoses	Number of eyes
Less than 5 years	Peters' anomaly	3
	CHED	2
	Congenital corneal opacity not otherwise specified	2
Aged 5–9 years	Keratoconus	5
	Penetrating trauma	2
	Viral keratitis	2
	Peters' anomaly	1
Aged 10–14 years	Keratoconus	34
	Penetrating trauma	3
	Viral keratitis	2
	Aphakic corneal oedema	1
	Limbal dermoid	1

CHED, congenital hereditary endothelial dystrophy.

Table 4 Outcome of keratoplasty 1 year postoperatively

Outcome and visual acuity	Number of patients (%)
Survived	**42 (82.0)**
>6/6	1 (2.0)
6/6–6/9	17 (33.3)
6/12–6/18	12 (23.5)
6/36–6/60	4 (7.8)
<6/60	4 (7.8)
Not tested	4 (7.8)
Failed	**8 (16.0)**
Patient died	**1 (2.0)**

in 14% (n = 9), a history of elevated intraocular pressure in 6% (n = 4), and active ocular inflammation at the time of operation in 9% (n = 6). Additional operative procedures performed were anterior vitrectomy in 5% (n = 3), cataract extraction and intraocular lens insertion in 3% (n = 2), iridectomy in 2% (n = 1), and iridectomy plus synechiolysis in 2% (n = 1). No significant intraoperative complications were reported. Early postoperative complications (within 3 weeks) included wound leak in 5% (n = 3), wound infection in 2% (n = 1), corneal ulcer in 3% (n = 2), and early graft rejection in 2% (n = 1). Postoperative medical management consisted of Maxitrol (dexamethasone 0.1%, neomycin 0.35%) in 60% (n = 39), prednisone acetate 1% plus chloramphenicol 0.5% in 32% (n = 21), with other antibiotic-steroid combinations in 8% (n = 5).

Outcome

Outcome was evaluated 1 year postoperatively with follow up data available for keratoplasties performed from 1991 to 2001. There were 58 keratoplasties during this interval with follow up data available for 88% (n = 51). The remaining 12% (n = 7) were lost to follow up. The survival rate was determined by analysing the percentage of keratoplasties that were surviving (clear graft) at 1 year postoperatively. Eighty two per cent (n = 42) of keratoplasties survived, 16% (n = 8) failed, and one patient died. Survival rates for different diagnostic groups were: congenital, 78%; acquired non-traumatic, 85%; acquired traumatic, 100%; and regraft procedures, 80%. Survival rates for different age groups were: less than 5 years, 82%; 5–9 years, 78%; and 10–14 years, 83%. The differences between diagnostic groups (p = 0.65) and age groups (p = 0.51) were not statistically significant. There was no statistical difference in survival rate based on suture method (p = 0.50) or type of postoperative medication used (p = 0.91).

The most common reason for keratoplasty failure was irreversible rejection (10% of total, n = 5), followed by presumed primary tissue failure (defined as failure of the graft to clear) (4%, n = 2) and trauma (2%, n = 1). Episodes of reversible rejection were reported in 22% (n = 9) of cases that survived 1 year postoperatively. Logistic regression analysis was performed in an attempt to identify factors which may be associated with decreased keratoplasty survival. Factors included were pre-existing corneal vascularisation, preoperative glaucoma, active inflammation at keratoplasty, small or large graft size, additional intraoperative procedures, immediate postoperative complications, and episodes of reversible rejection. However, no individual factor was identified from this analysis which resulted in a statistically significant decrease in keratoplasty survival.

Best corrected Snellen visual acuity (BCSVA) was reported in 90% (n = 38) of cases that survived 1 year postoperatively (table 4). Of all paediatric keratoplasties, 38% (n = 18) achieved a BCSVA of 6/9 (20/30) or better and 60% (n = 30) had a BCSVA of 6/18 (20/60) or better. Spectacles (n = 14) or contact lens (n = 2) were provided in 38% of cases. Visual outcome for each diagnostic group is presented in table 5. Visual outcome was significantly better for acquired (mean logMAR 0.2, 6/10) compared to congenital indications (mean logMAR 1.1, 6/75) (p = 0.03). Unfortunately preoperative visual acuity was not available for analysis as this was not recorded in the NZNEB database.

DISCUSSION

New Zealand is a multicultural society with a population of approximately four million, served by 110 ophthalmologists, distributed over a geographical area slightly greater than the United Kingdom. Over 200 keratoplasties are performed annually in New Zealand and the NZNEB was established in 1991 to support this demand. Over the 13 year study period it was estimated that the NZNEB supplied at least 90% of all donated ocular tissue. Therefore, analysis of the NZNEB

Table 5 Keratoplasty outcome for each diagnostic group and for regraft procedures

	Number of eyes					
Diagnostic group	**≥6/9**	**6/12–6/18**	**6/36–6/60**	**<6/60**	**VA not reported**	**Failed**
Congenital	1	–	2	2	2	2
Acquired non-traumatic	13	11	2	–	2	5
Acquired traumatic	2	1	–	–	–	0
Regraft	2	–	–	2	–	1

Table 6 Indications for paediatric keratoplasty reported in the literature

Study	Age criteria	Number of eyes*	Congenital	Acquired non-traumatic	Acquired traumatic
Stulting *et al*[1]	<15 years	107	45 (42%)	31 (29%)	31 (29%)
Cowden *et al*[3]	<15 years	57	25 (44%)	16 (28%)	16 (28%)
Aasuri *et al*[4]	<15 years	154	47 (31%)	85 (55%)	22 (14%)
Dana *et al*[2]	<12 years	131	84 (64%)	25 (19%)	22 (17%)
Dada *et al*[7]	<13 years	370	51 (14%)	296 (80%)	23 (6%)
Current study	<15 years	58	9 (16%)	43 (74%)	6 (10%)

*Excludes regraft procedures.

Table 7 Summary of published survival rates in paediatric keratoplasty

Study	Mean follow up period (years)	Survival rate (%)			
		Congenital	Acquired non-traumatic	Acquired traumatic	Overall
Stulting *et al*[1] 1984	1	60	73	70	66
Dana *et al*[2] 1995	1	80	76	84	80
Aasuri *et al*[4] 2000	1.3	64	71	55	66
Legeais *et al*[12] 1990	2.1	38	79	71	72
Erlich *et al*[13] 1991	1.7	29	40	71	46
Cowden *et al*[3] 1990	1–10*	56	50	56	54
Current study	1	78	85	100	82

*Only follow up range reported.

database provides an accurate representation of corneal disease and keratoplasty in New Zealand.

The indications for paediatric keratoplasty vary significantly in the literature. Table 6 provides a comparison between this study and the major studies published over the past two decades. Most studies used the age criteria of 14 years or younger. The proportion of keratoplasties performed for congenital indications ranged from 14–64%, for acquired non-traumatic 19–80%, and for acquired traumatic 6–29%.[1–4 7] In this study, the proportion of keratoplasties performed for acquired non-traumatic indications (74%) was significantly greater than that for congenital (16%) and acquired traumatic (10%) indications. This is in contrast with the majority of published reports, in which congenital indications contribute a significantly greater proportion.[1–4 7]

Keratoconus was the most common acquired non-traumatic indication in this study, accounting for 67% of all keratoplasties. This was notably higher than other published reports where keratoconus accounted for only 0–11% of paediatric keratoplasties, with post-infectious corneal scarring the most common acquired non-traumatic indication reported in the literature.[1–4 7] Similar to previous studies,[1–4 7] the most common congenital indication identified in this study was Peters' anomaly followed by congenital hereditary endothelial dystrophy, and the most common indication in the acquired traumatic diagnostic group was penetrating trauma.

The notably high prevalence of keratoconus as an indication for paediatric keratoplasty reflects that which was identified by Edwards *et al*,[8] who reported that keratoconus was the leading indication (45%) for keratoplasty in the adult population in New Zealand, accounting for a significantly higher proportion of keratoplasties compared to other published reports. Ethnic differences in keratoconus prevalence, severity, and rate of disease progression have been well recognised,[9–11] and keratoconus is thought to be particularly prevalent in Maori and Pacific Island communities, which constitute a large proportion of the New Zealand population. Edwards *et al*[8] postulated that this high prevalence, and possibly more rapid disease progression and severity, has led to the uniquely high prevalence of keratoconus as an indication for keratoplasty in New Zealand. Similarly, this may explain the high prevalence of keratoconus identified in this study. Over the past 4 years the NZNEB database has incorporated recipient ethnicity data to further investigate the relation between ethnicity and keratoconus in New Zealand.

Survival rates published by the foremost studies of paediatric keratoplasty are presented in table 7. Mean follow up generally ranged from 1–2 years and the reported survival rates ranged from 46–80%.[1–4 12 13] Keratoplasty performed for congenital indications had a lower survival rate compared to acquired non-traumatic and acquired traumatic indications.[1–4 12 13] The overall survival rate of 82% in this study was high when compared to other published reports.[1–4 12 13] This may be because of the longer follow up period at which survival rates were reported in some of the other studies.[3 4 12 13] Another contributing factor may be the high proportion of keratoplasties performed for acquired non-traumatic indications. In concurrence with other published reports, a higher survival rate for acquired compared to congenital indications was identified in this study,[1–4 12 13] although this did not reach statistical significance, possibly owing to the small size of the congenital group. Of particular note, keratoplasty performed for keratoconus had an excellent prognosis with a 1 year survival rate of 90%.

In other published reports, several factors have been identified which increase the risk of failure in paediatric keratoplasty.[1–4 14–19] Performance of an additional surgical procedure at the time of keratoplasty was most significantly associated with a decreased survival rate, with other factors reported including preoperative glaucoma, associated ocular conditions, and corneal vascularisation.[1–4 14–19] In this study, no factor was independently associated with a statistically significant increase in failure rate. However, the relatively small number of subjects limited this analysis. The influence of age alone on paediatric keratoplasty survival has been evaluated with conflicting reports in the literature. Aasuri *et al*[4] identified a correlation between age under 5 years and allograft rejection, and commented that this may be because of a more active immune system in younger patients. Other studies, including this one, did not identify such an association.[1 2]

Poor visual outcome in a surviving keratoplasty (clear graft) is well recognised within the paediatric age group and is most commonly a result of amblyopia, non-corneal ocular abnormalities, and postoperative astigmatism.[1–4 17–19] In concordance with other published reports, this study identified a poorer visual outcome for congenital compared to acquired indications.[1–4 17–19] A higher prevalence of amblyopia and associated ocular abnormalities in the congenital group has been cited as the reason for the less successful visual outcome in this group.[1–4 17–19] We suspect that this may also be the case in this study. Important considerations therefore are the timing of keratoplasty which should not be delayed unnecessarily and the high priority of postoperative amblyopia management in at risk patients.

Analysis of the New Zealand National Eye Bank database has provided valuable information in relation to paediatric keratoplasty in New Zealand. In particular, this study identified an unusually high prevalence of keratoconus as an indication for paediatric keratoplasty in New Zealand. High success rates at 1 year postoperatively, in terms of both keratoplasty survival and visual outcome were identified, especially in cases of keratoplasty for acquired corneal conditions.

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