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Research Article

Corneal Transplantation Outcomes at a Teaching Hospital: Residents vs Experts

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Abstract

Background: Corneal transplantation is the most successful procedure among human tissue transplants and is the most widely practiced and taught form of allograft in the world. Although it is generally successful, some cases may progress to graft failure, and even in transplants with corneal transparency, refractive outcomes are not always satisfactory, which is often related to the surgical technique.

Methods: The medical records of all patients undergoing corneal transplantation from 2011 to 2013 at Hospital de Clinicas de Porto Alegre were reviewed, and clinical data were collected from the preoperative period up to 36 months after transplantation. For visual acuity, groups were created according to the best corrected visual acuity (BCVA): group 1 (worse than 20/200), group 2 (between 20/200 and 20/60) and group 3 (20/40 or better).

Results: A total of 567 transplants were included, 315 (55.5%) performed by training surgeons and 252 (44.4%) by experts; 140 (24.6%) were classified as high-risk transplants. A significant difference was observed in the subgroups with low and high risk: 88.9% and 68.8% for residents ($p<0.001$) and 91.4% and 78.4% for experienced surgeons, respectively ($p=0.005$). Rejection within 36 months was greater among residents ($p=0.001$), especially in low-risk transplants. There was a significant improvement in visual acuity both in the training group (Kappa=0.935) and experienced group (Kappa=0.112).

Conclusion: The corneal transplantation learning curve in a teaching hospital is quite safe, with visual outcomes and graft survival results for residents comparable to those for experienced surgeons. Rejection episodes were significantly higher among residents.

Keywords: Corneal transplantation; Graft survival; Training surgeons; Visual outcomes

Abbreviations: BCVA: Best Corrected Visual Acuity; DALK: Deep Anterior Lamellar Keratoplasty; HCPA, Hospital de Clinicas de Porto Alegre; PK: Penetrating Keratoplasty

Introduction

Corneal transplantation is one of the oldest and most commonly performed kind of human tissue transplantation worldwide because of the existing corneal immune privilege. Corneal transplantation is usually a successful surgical procedure, although immunologic rejection is still one of the most common causes of graft failure after penetrating keratoplasty [1-5]. The indications for corneal transplantation vary in different countries. The most common are keratoconus, bullous keratopathy, corneal dystrophies, keratitis, trauma and previous transplant failure [6-10]. The survival of corneal grafts is largely dependent on the technique used, the base pathology, the preoperative condition of corneal neovascularization and complications during follow-up [2,11]. Some variables were linked to an increased risk of graft failure: preoperative diagnosis, clinical history of ocular

inflammation or infection, pseudophakic and aphakic eyes, vitrectomy during keratoplasty, Descemet folds during follow-up, and low surgeon caseload. Previous graft failure was seen as the most significant risk factor for secondary failure, and the risk of failure significantly decreased with increased postoperative time [11-13].

Among the indications for corneal transplantation, keratoconus presents the highest survival rates: 98% for 12-month survival, 84% for 9-year survival [2,14-16]. Despite postoperative corneal transparency, proportional visual improvement often cannot be achieved. The improvement in visual acuity postgraft varies according to the different pathologies; in fact, postsurgery for keratoconus showed the best improvement in gain of letters [2]. In a retrospective study of hands-on keratoplasty training, at the last follow-up, the best-corrected visual acuity was 20/20 to 20/60 in 25.5% of patients, 20/60 to 20/200 in 40.4% of patients, 20/200 to 20/400 in 8.5% of patients, and less than 20/400 in 25.5% of patients, with a mean follow-up of 32 months [4]. Although corneal procedures have matured over the years, information regarding visual outcomes and graft survival from major academic centers in South America is limited. This study aimed to compare the graft survival curve and visual outcomes of corneal transplants performed by experienced and inexperienced surgeons under supervision in a teaching hospital.

Material and Methods

Design Overview, Setting and Participants

In this retrospective cross-sectional study, a record review was conducted, including reviews of clinical and pathological records of all corneal transplants performed at the Hospital de Clínicas de Porto Alegre (HCPA) during the period from January 2011 to December 2013. All keratoplasties performed during this period were included. Patients younger than 10 years old, tectonic transplantations or scleral patch cases, as well as emergency transplants and endophthalmitis cases, were excluded. Cases that progressed with primary failure (absence of transparency after 14 days postoperative) were also excluded. All surgeries were performed at HCPA using the same microscope, physical structure, support staff and surgical supplies. Residents were always under the supervision of experts during surgery. Experts operated on their private patients, and residents operated on patients from the public health system.

Graft survival and visual acuity outcomes

The following data were analyzed: demographics, transplant indication, surgery technique, surgeon experience, preoperative risk of rejection, occurrence of secondary failure and rejection events within the 36-month follow-up period. All patients' corneal viability was classified for survival curve analysis during the last follow-up visit.

Expert surgeons had more than ten years of experience in corneal transplants, and the training surgeon group was composed of 3rd- and 4th-year residents. The high-risk transplant criteria included patients younger than 14 years old, previous corneal transplant, glaucoma, corneal neovascularization in two or more quadrants, and large grafts near the limbus. Visual acuity was classified into 3 groups according to the Best Corrected Visual Acuity (BCVA): group 1 (worse than 20/200), group 2 (between 20/60 and 20/200), and group 3 (20/40 or better). BCVA was evaluated preoperatively and at 12, 24 and 36 months of follow-up. In visual acuity analyses, patients with visual quality impairment due to other causes not related to the cornea, such as retinal detachment, optic nerve atrophy, age-related macular degeneration, maculopathies and others, were excluded. This study was registered and authorized by the hospital ethics committee.

Statistical Analysis

The SPSS 22.0® program was used for database storage and statistical analysis. The type 1 error rate was 0.05. The descriptive data were evaluated by calculating means, frequencies and proportions. In analyses of categorical variables, the chi-square test was performed. In addition, corneal graft survival curves were determined using the Kaplan-Meier product limit method, and the differences between surgeon groups were compared using log-rank tests [17]. For analysis of visual improvement, the kappa measure of concordance was calculated.

Results

Five hundred sixty-seven corneal transplants were included. Of these, 63.3% (n=359) were PK (penetrating keratoplasty), 21,2% (n=120) were DALK (deep anterior lamellar keratoplasty) and 13,1% (n=74) were PK combined with cataract surgery. The average age at transplantation was 43 years (range 10-88 years); 55% (n=312) were male; the average follow-up was 28.59 months. Overall, there were 496 clear grafts (87.5%) in the last visit. The main indications for transplantation were keratoconus (45.5%), previous transplant failure (14.1%), bullous post cataract surgery (10.9%), corneal scars (7.4%) and Fuchs dystrophy (6%). A total of 140 grafts (24.6%) were considered high-risk transplants. A total of 315 surgeries (55.6%) were performed by training surgeons under supervision, and 252 (44.4%) were performed by experts. All the descriptive analyses are shown in Table 1. Overall, rejection episodes (one or more) during the first 36 months postoperative were observed in 28.4% (161) of all transplants, 21.4% (54) when the surgery was performed by experts and 33.9% (107) when it was performed by residents (p=0.001). In low-risk transplants (n=427), rejection episodes occurred in surgery performed by 17.8% of experts and 30.4% of residents (p=0.002). In high-risk transplants, rejection episodes were similar between experts and training surgeons (p=0.289) (Table 2).

Characteristics	Total grafts (n=567)	Experts (n=252)	Training (n=315)	P value
Age in years (range)	43.13 (10-88)	43.49 (10-87)	46.42 (11-88)	0.084
Male	55.0% (n=312)	57.9% (n=146)	52.7% (n=166)	0.213
Glaucoma preoperative	7.93% (n=45)	9.92% (n=25)	6.35% (n=20)	0.159
PREOP RISK OF REJECTION				0.157
High	24.7% (n=140)	13.89% (n=35)	26.98% (n=85)	
Low	75.3% (n=427)	86.11% (n=217)	73.02% (n=230)	
SURGEON EXPERIENCE				
Experts	44.4% (n=252)	-	-	
Training	55.6% (n=315)	-	-	
INDICATIONS				0.154
Keratoconus	45.5% (n=258)	57.5% (n=145)	35.87% (n=113)	
Previous transplant failure	14.1% (n=80)	14.3% (n=36)	13.97% (n=44)	
Bullous keratopathy	10.9% (n=62)	6.35% (n=16)	14.60% (n=46)	
Corneal scars	7.4% (n=42)	5.16% (n=13)	9.20% (n=29)	
Fuchs´ dystrophy	6.0% (n=34)	5.16% (n=13)	6.67% (n=21)	
Other dystrophies	5.6% (n=32)	1.59% (n=4)	8.89% (n=28)	
Herpes Simplex	4.8% (n=27)	3.6% (n=9)	5.71% (n=18)	
Other	5.7% (n=32)	6.35% (n=16)	5.07% (n=16)	
SURGERY TECHNIQUE				0.642
PK	63.3% (n=359)	53.97% (n=136)	70.79% (n=223)	
DALK	21.2% (n=120)	32.94% (n=83)	11.75% (n=37)	
Combined surgery	13.1% (n=74)	9.12% (n=23)	16.19% (n=51)	
EK	2.4% (14)	3.97% (10)	1.27% (n=4)	

Table 1: Sample Characteristics.

Rejection episodes	Total grafts (n=567)	Experts (n=252)	Training (n=315)	P value
All cases	28.4% (in=161)	21.43% (n=54)	33.97% (n=107)	0.001*
Low risk (n=427)	24.6% (n=105)	17.8% (n=35)	30.4% (n=70)	0.002*
High risk (n=140)	40% (n=56)	34.5% (n=19)	43.5% (n=37)	0.289

Table 2: Rejection Rates.

Graft general survival at 36 months was 85.9%, while it was 83.7% in transplants performed by residents and 88.6% among those performed by experts, with no statistically significant difference between these two groups (p=0.123). The Kaplan-Meier survival plot is shown in Figure 1. Analyzing survival by the risk of failure and surgeon group, the graft survival after 36 months in transplants performed by surgeons in training was 88.9% in the low-risk group and 68-8% in the high-risk group (p<0.001), while the graft survival in transplants performed by experts was 91.4% in the low-risk group and 78,4% in the high-risk group (p=0.005). When analyzed by surgeon group, the survival rate in low-risk cases was 88.9% in the surgeons in training group and 91.4% in the expert surgeon group (p=0.367); the survival rates in high-risk cases were 68,8% and 78,4%, respectively (p=0.344). The Kaplan-Meier survival plot by these groups is shown in Figure 1. The graft survival curve did not show a statistically significant difference between surgeon groups when analyzed by surgery technique. In the PK group (n=359), the graft survival curve was 82.7% for surgeons in training and 88.7% for experienced surgeons (p=0.168); in the DALK group (n=120), the curves were 97.3% and 9.4%, respectively; (p=0.94); and in the combined surgery group (n=72), the curves were 75.3% and 73.0%, respectively (p=0.865).

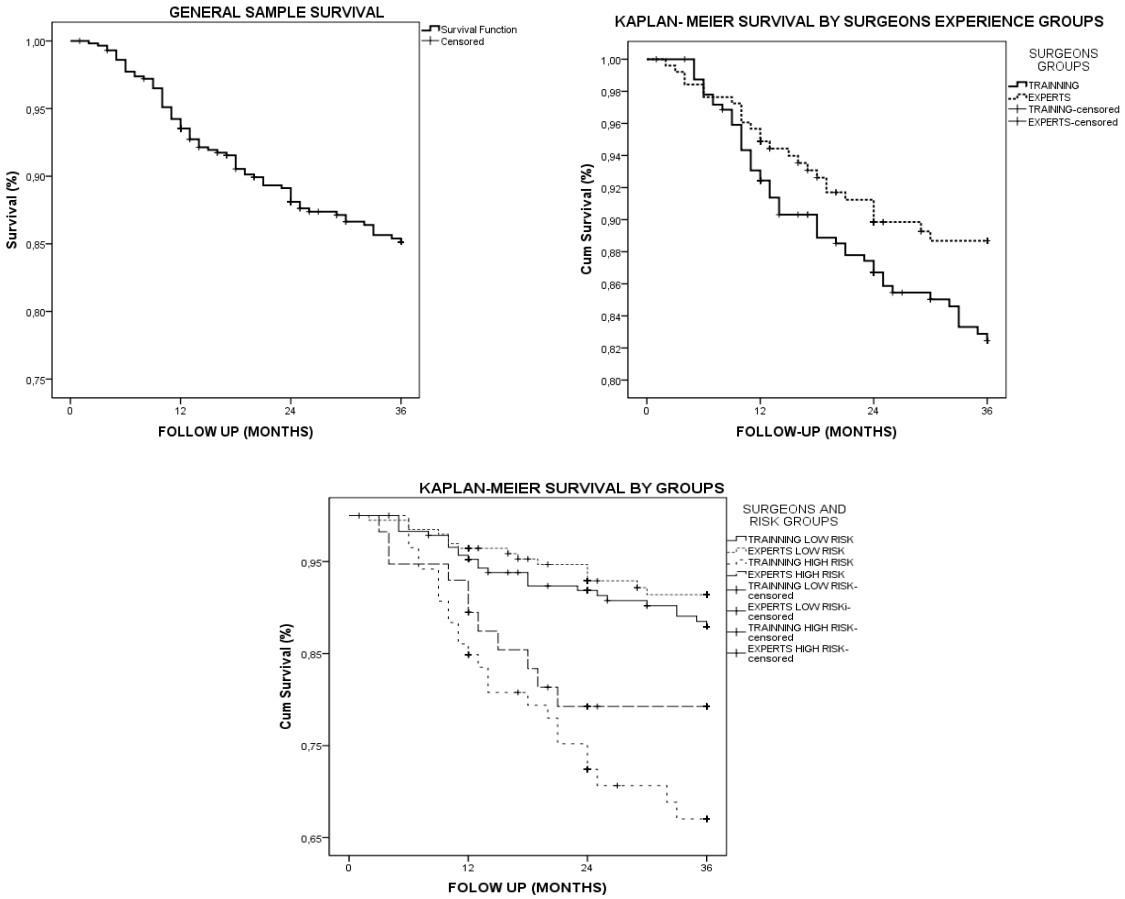

Figure 1: Kaplan-Meier general survival curve in 36 months. **A:** General survival curve in 36 months; **B:** Survival data by surgeons experience group. (p=0.367); **C:** Survival curves in high and low risk failure cases by surgeon experience groups.

The change in visual acuity was analyzed by progression in the groups from BCVA preoperative and after 36 months of follow-up (n=295). The percentages in the preoperative groups were 66.4% (196) for group 1 (worse than 20/200), 25.4% (75) for group 2 (between 20/200 and 20/40) and 8.1% (24) for group 3 (20/40 or better). After a 36-month follow-up, the percentages changed to 9.8% (29), 12.9% (38) and 77.3% (228) respectively (p=0.026). Among surgeons in training (n=152), the percentages of cases were 88.8% (135) for group 1, 9.2% (14) for group 2, and 2.0% (3) for group 3 preoperative BCVA, and 13.8% (21), 17.8% (27) and 68.4% (104) in postoperative, respectively (Kappa=0.935). Among experts (n=143), the percentages were 42.7% (61) for group 1, 42.7% (61) for group 2 and 14.7% (21) for group 3 in preoperative and 5.60% (8) for group 1, 7.70% (11) for group 2 and 86.7% (124) for group 3 after 36-month follow-up (Kappa=0.112) (Figure 2).

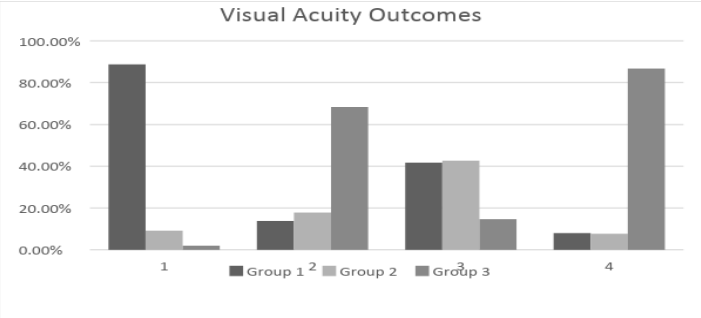

Figure 2: Improvement in visual acuity by surgeons group in 36 months follow up.

Discussion

Few studies in the literature have compared surgical outcomes between surgeons in training and experienced surgeons in corneal transplantation. We believe that knowledge of corneal transplantation outcomes at a teaching hospital is of great importance to evaluate the learning curve of residents. Analysis of graft survival and visual outcomes at longer follow-up are crucial to understanding the real degree of visual rehabilitation that is being offered to patients. Our sample showed quite similar sample characteristics between the two groups, with almost identical values for age, sex, and preoperative visual acuity. Although residents had a greater number of high-risk cases compared to experts, no significant differences were found between preoperative risk indications and surgical technique. In 1990, a review of 59 PKs performed by residents under supervision showed that 76% of the grafts remained clear and median visual acuity was 20/50 at 1-year follow-up. The rejection rate was 22% [18]. Another observational retrospective study compared outcomes from primary and repeated transplant cases performed by supervised residents and found 64.6% of clear grafts for an average follow-up of 21.9 months. In this study, visual outcomes overall were 19 (47.5%) of 20/40 or better, 18 (45%) of 20/50 to 20/150, and 3 (7.5%) of 20/200 or worse [19].

In another study involving corneal transplant resident learning with a 15-month follow-up, a 92.5% survival rate was found but in a small sample (n=40) [20]. In our cases, we found similar overall graft survival rates for a mean follow-up of 29 months: 83.7% survival and 68.4% vision 20/40 or better. However, our sample is much more significant due to the number of participants compared to the number of samples in other studies involving training of cornea surgeons (training n=350). Gross et al. analyzed outcomes in cornea transplant by PK for supervised surgeons in training by analyzing the astigmatism vector and asymmetric surface regularity postoperative in a 166-individual sample and did not find a significant difference compared to experienced surgeons. They also saw that improved astigmatic outcomes occurred in the last 6 months of fellowship training, when an average of at least 20 penetrating keratoplasties had been performed [21].

In a similar center for corneal surgeon teaching, supervised residents´ transplant outcomes were compared to their instructors' outcomes in keratoconus cases (low-risk grafts), and no significant difference was found when the refractive resulting vector, graft transparency and topographic pattern were analyzed postoperatively. Only the rejection rate was significantly higher among residents [22]. It is believed that longer surgical time, as well as more severe trauma, could be related to these findings. In a recent study from 2017, the performance between residents and experienced surgeons was compared in PK, and surgery time was the only statistically significant difference ($p = 0.007$). This analysis did not demonstrate any significant influence on surgical results [23]. In our study, we found a significantly higher rejection rate after 36 months in transplants performed by surgeons in training ($p=0,001$) among low-risk grafts ($p=0,002$). This result could also be explained by longer surgery times for surgeons in training and greater postoperative inflammation among their patients. Furthermore, patients operated on by residents were from the public health system, which tends to treat patients who have financial difficulty buying medication and are less likely to return to the hospital than private patients.

The rate of rejection episodes varies widely in several studies. The reported incidence of corneal graft rejection varies from 2.3% to 68% [13,24]. The rejection rate for our surgeons in training at 3-year follow-up was 33.9% compared to 21.4% in experienced surgeons, including all cases. The Australian Corneal Graft Registry reported a rejection rate of 20.6% in PK cases and 12.12% in DALK cases at 3-year follow up [2]. In a similar teaching hospital in Brazil, Chalita et al. found a 17.69% rejection rate in a series of grafts performed by residents [25]. Our study was the first to analyze low- and high-risk graft survival curves among surgeons in training, and our analyses indicate no significant difference when compared to surgeries performed by experts (2). Our survival results were much better when compared to another large series from India, another developing country (68.7% in 2-year follow-up) [26].

In our study, transplants performed by supervised cornea surgery residents resulted in similar rates of survival and visual improvement at 36-month follow-up compared to those performed by their instructors, confirming what was shown in earlier studies involving residents under supervision. In our study, however, we presented a larger number of participants [21-23]. In addition, unlike all other previous studies, all surgeries from both groups were performed at the same hospital and using the same structural and material conditions. Only the follow-ups were conducted

separately, as the patients of experienced surgeons were seen in a private clinic. Nevertheless, all follow-ups, treatments, suture removal, reinterventions, and clinical decisions were always supervised by experienced staff.

Conclusions

Keratoplasty outcomes such as graft survival and visual acuity were similar between residents and experienced surgeons both in low- and high-risk transplants when performed at the same teaching hospital and under supervision. Although rejection episodes were significantly more frequent among residents, this did not impact the graft survival rate. This study supports the concept that careful supervised cornea training in teaching hospitals can achieve successful results for keratoplasty patients.

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