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Original Article

Corneal transplant epidemiology in a reference center in Bogotá, Colombia (2010-2017)

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Abstract

Purpose: To describe the characteristics of the donor and recipient, indications, surgical techniques, and survival results obtained from patients with corneal transplants performed at Fundación Oftalmológica Nacional (FUNDONAL) between 2010 and 2017.

Methods: Descriptive, observational study. Medical records of patients who underwent corneal transplantation were reviewed. Demographic data, surgery indication, transplantation technique, graft transparency, and presence of rejection are evaluated. Statistical analysis was performed with the SPSS software version 21.0.

Results: Seven hundred and twelve eyes from 690 patients who underwent corneal transplantation were analyzed. The median age of the recipient was 42 years (interquartile range 21.8 years) and 392 participants (56.8%) were men. Corneal ectasias was the first indication for transplantation. The technique performed most often was penetrating keratoplasty (PK) (89.6%), followed by deep anterior lamellar keratoplasty (5.3%), endothelial keratoplasty (3.5%), and sclerokeratoplasty (1.5%). 22.25% of the cases presented at least one rejection episode. Transparency of the graft is >80% up to 36 months from follow-up.

Conclusions: In 712 eyes that underwent corneal transplantation between 2010 and 2017, the most frequent indications were corneal ectasias, pseudophakic/aphakic bullous keratopathy, and previous graft failure. Although the most common technique is PK, there is a tendency to perform more lamellar transplants over the years. Survival up to the last control was 78% with graft rejection at 22.23%, which are comparable with results reported in the scientific literature. This study constitutes the first corneal transplant registry in Colombia, with survival results and description of variables that will allow for the identification of risk factors for undesirable outcomes.

Keywords: Colombia, corneal grafts, corneal grafts survival, corneal transplantation, corneal transplants, Latin America

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INTRODUCTION

Penetrating keratoplasty (PK) is the oldest transplantation performed on humans and has been the standard technique for corneal transplantation for the decades.[1] It has well-established effectiveness and safety rates and remains to be the most common transplant.[2]

In 1905, Eduard Zirm in Olmutz (Czech Republic) performed the first successful corneal transplant, and from this, it was established as the reference point for the surgical treatments of corneal diseases.[3]

In recent years, partial thickness procedures have been developed as an alternative to total corneal transplantation, replacing only the diseased or compromised corneal layer. For example, in pathologies such as Fuchs' dystrophy, endothelium replacement is proposed with techniques such as automated endothelial keratoplasty (DSAEK) or Descemet's membrane endothelial keratoplasty (DMEK). The stromal layers can be replaced with techniques such as deep anterior lamellar keratoplasty (DALK) in stromal diseases such as keratoconus and in deep corneal scars with descemet and undamaged endothelium.[4-6] With recent technologies such as optical coherence tomography of the anterior segment (AS-OCT), it is possible to better characterize the patients preoperatively to make an adequate choice of the surgical technique to be performed.[7] With femtosecond lasers, lamellar techniques, mainly femtosecond assisted DALK, are performed with greater precision, conferring a better safety profile and better visual results with a reduced postoperative spherical equivalent.[8]

In 2016, Gain *et al*. conducted a review of corneal transplant results from 2012 to 2013, with data from 116 countries. A median of 90% (interquartile range [IQR] 58%–100%) was found for the performance of PK as the surgical technique of choice, the main indications being Fuch's endothelial dystrophy, keratoconus, and infectious keratitis sequelae.[9]

In terms of transplant survival, PK is associated with high rates in different studies. Fasolo *et al*. reported a 5-year graft survival of 83% in 2010.[10] By 2020, Arundhati *et al*. reported graft survival after PK of 91%, 66.8%, 55.4%, 52%, and 44% at 1, 5, 10, 15, and 20 years, respectively.[11] However, better results are increasingly evidenced in lamellar techniques, as reported by the same group of researchers, with a survival for PK of 94.4%, 80.4%, and 72.0% at 1, 5, and 10 years, respectively, as well as 95.8%, 93.9%, and 93.9% at 1, 5, and 10 years, for DALK.[12]

Regarding transplant failure, The Australian Corneal Graft Registry (ACGR), carried out between 2000 and 2014 with a follow-up of 11,741 patients, reported a graft failure rate of 32.3%, the first cause being immune rejection (31%), followed by endothelial failure (15%), nonherpetic infections (8%), and glaucoma (8%).[13]

In our context, there are few publications on the epidemiological characteristics of corneal transplants. The data of the patient's origin, their adherence to the controls, and the characteristics of the donor, among other data, are the factors that must be known to implement conducts that improve the survival rate of transplants.

The purpose of this study is to describe the epidemiological characteristics of the cases of corneal transplants performed in a reference center in Bogotá, Colombia (Fundación Oftalmológica Nacional [FUNDONAL]). This center recorded the data inherent to the donor and the recipient, the indications, the technique surgery, the presence of rejection, and factors related to graft survival. Having this database opens up the possibility to identify potential risk factors for unwanted outcomes, customary to the population of Colombia, and to modify strategies to improve the success rate of transplants.

METHODS

A descriptive observational study has been undertaken, with a retrospective review of the medical records of patients who underwent a corneal transplant between 2010 and 2017 at the FUNDONAL in Bogotá, Colombia. Every type of corneal transplantation performed was included: DSAEK, DMEK, DALK, PK, and Sclerokeratoplasty, as a single procedure or in combination with other procedures such as cataract extraction surgery, intraocular lens (IOL) implantation, vitreoretinal surgery, among others. In addition, those cases that required retransplantation due to primary or secondary failure of a previous graft were included.

This study included patients who completed at least two postoperative follow-up controls, with a complete medical history. Demographic data, recipient characteristics, preoperative vascularization (by quadrants), ocular and systemic comorbidities, indication of the transplantation, as well as the transplantation technique performed were all recorded. Data inherent to the transplanted tissue were recorded such as the sex and age of the donor, cause of death, graft recovery time as well as recovery time until surgery in hours, central endothelial cell count, and preservation medium. Both transparency and rejection,

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or failure, of the graft at each postoperative moment was recorded, as well as the treatment established.

The findings found in follow-ups from the 1st month, 3rd month, 6th month, first postoperative year, and subsequent annual controls were recorded. Adherence to follow-up was quantified by recording the number of controls completed during the 1st year after the procedure was performed. The review of medical records was carried out by two investigators (MCP, DSA). These data were recorded in an Excel database.

Statistical analysis was performed with the Statistical Package for the Social Sciences (SPSS Inc. Version 21.0) (IBM Corp., Armonk, N.Y., USA). Univariate analysis was performed with the distribution of frequency reported as mean, standard deviation, or median and IQR according to their distribution, as well as percentage for the categorical variables.

This study was carried out in accordance with the declaration of Helsinki and received approval by the Research Ethics Committee of FUNDONAL.

RESULTS

Between January 2010 and December 2017, 712 corneal transplants were performed in 690 subjects. Table 1 shows the demographic characteristics of corneal transplant patients.

Figure 1 shows the number of transplants per year in FUNDONAL during the period studied.

Regarding the indications for corneal transplantation, corneal ectasia was primary, including keratoconus, postrefractive surgery ectasia, keratoglobus, and pellucid marginal degeneration. Of these, keratoconus was the most frequent indication, in 36.8% of cases. Another indication for transplantation includes bullous pseudophakic/aphakic keratopathy (17.4%), failure of a previous graft (11.9%), postinfectious leukoma (11.6%), and traumatic leukoma are followed in frequency with 10%.

From the 712 transplantation cases, 584 are included in the cohort of patients with follow-ups at FUNDONAL. Of these, 55 had glaucoma, the main ocular comorbidity before transplantation. The second ocular comorbidity in the present registry was allergic conjunctivitis. Table 2 shows the frequency of the main preoperative ocular comorbidities found in this registry and Table 3 shows the percentage of transparency, edema, or opacity up to the last control for each comorbidity.

Table 1: Demographic data

Variable	Value
Corneal transplants	712
Subjects	690
Median age (years)	43.54 (IQR 37)
Gender, *n* (%)	
Female	298 (43.2)
Male	392 (56.8)
Provenance, *n* (%)	
Urban	543 (78.7)
Rural	147 (13.4)

IQR: Interquartile range

Table 2: Main ocular comorbidities

Ocular comorbidity	*n* (%)
Glaucoma	55 (9.42)
Allergic conjunctivitis	22 (3.77)
Retinal detachment	14 (2.39)
Severe dry eye syndrome	6 (1.03)
Diabetic retinopathy	2 (0.34)
Fellow eye graft failure	2 (0.34)
Uveitis	1 (0.17)
None	482 (82.53)
Total	584 (100)

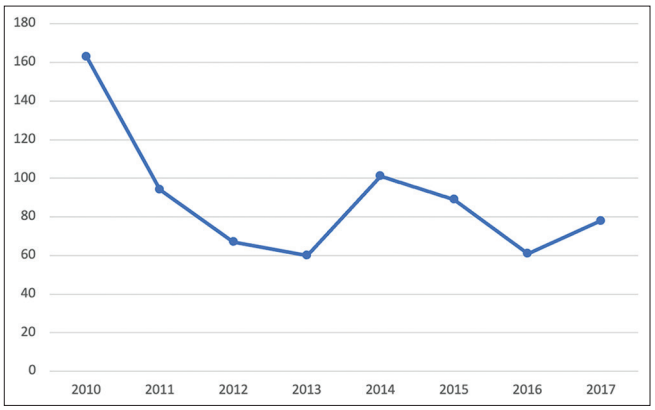

Figure 1: Number of corneal transplants per year

When analyzing the causes of the transplant with the type of transplant and the ocular comorbidities, it is found than 12 of 22 patients with allergic conjunctivitis as a comorbidity underwent a corneal transplantation due to a corneal ectasia. Most of the eyes with glaucoma as an ocular comorbidity had as the primary cause of the transplant bullous pseudophakic/aphakic keratopathy (20 eyes) or failure of previous graft (14 eyes). Table 4 illustrates the relation between the causes of the transplant with the type of transplant and the ocular comorbidities.

Cardiovascular diseases are associated mostly as a systemic comorbidity, found in 14.55% of cases, grouping entities such as arterial hypertension, coronary heart disease, and pulmonary hypertension, among others. In second place was diabetes mellitus. A significant number of cases were also found with some autoimmune disease that could

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affect the ocular surface. Table 5 illustrates the frequency of the main preoperative systemic comorbidities found in this registry.

Reviewing the recipient's preoperative neovascularization, 419 eyes (71.7%) were nonvascularized, 35 eyes (6%) with vascularization in one quadrant, 50 eyes (8.7%) in two quadrants, 21 eyes (3.6%) in three quadrants, and 58 eyes (9.9%) in four quadrants. Table 6 shows the percentage of transparency, edema or opacity up to the last control according to preoperative corneal vascularization.

Regarding specific donor data [Table 7], the median age was 27.5, with a ranging in ages between 10 and 69 years. The vast majority were male. The median recovery time (time from death to preservation of the tissue) was 16.7 h (IQR 5 h) and the median time from recovery to surgery was 72 h (IQR 45.5 h). The median central endothelial cell count was 3109 cells/mm^2. All tissues were preserved in corneal preservation media until the surgery, being the most common (96.5%) Eusol. Table 8 shows the percentage of transparency, edema, or opacity up to the last control according to the age of the donor and Table 9 shows the percentage of transparency, edema, or opacity up to the last control according to the recovery time of the graft.

Table 3: Ocular comorbidity versus graft transparency

Ocular comorbidity	Transparent, *n* (%)	Edema, *n* (%)	Opaque, *n* (%)	Total
Glaucoma	36 (65.4)	10 (18.2)	9 (16.4)	55
Allergic conjunctivitis	18 (81.8)	1 (4.5)	3 (13.6)	22
Retinal detachment	12 (85.7)	2 (14.2)	0	14
Severe dry eye syndrome	3 (50)	1 (16.7)	2 (33.3)	6
Diabetic retinopathy	1 (50)	0	1 (50)	2
Fellow eye graft failure	1 (50)	0	1 (50)	2
Uveitis	1 (100)	0	0	1
None	387 (80.3)	51 (10.6)	44 (9.1)	482

The most common cause of death for donors is gunshot wounds in 287 tissues (40.31%), followed by death from a sharp-edged weapon in 188 tissues (26.4%), and in 74 tissues, the donor was involved in a traffic accident (10.4%). In 58 tissues (8.1%), no information about the cause of death exists and natural causes was identified in 51 tissues (7.2%) (cerebrovascular accident and other cardiovascular causes).

In 490 eyes (83.8%), a corneal transplant was performed for the first time. Of the 94 remaining eyes (16.2%), 74 eyes (12.7%) underwent a second transplant, 15 eyes (2.7%) had a third transplant, and 5 eyes (0.9%) were transplanted for the fourth time.

The most frequently performed technique was PK (89.6%) as the only surgery in 71.1% of cases. A triple procedure was performed in 11.9% (PK + cataract extraction + IOL implantation) and PK was associated with one or more procedures in 6.66% (synechiolysis, vitreoretinal surgery, valve implant, among others). The second most frequently performed technique was DALK in 5.3%. Endothelial keratoplasty was performed in 3.5% and sclerokeratoplasty in 1.5% of the cases [Figure 2].

When analyzing the frequency of transplantation techniques performed per year, PK was the highest of all, in terms of follow-up period. However, there is a gradual increase in the types of lamellar transplants. Figure 3 shows the proportion of each transplant technique performed per year.

Table 4: Causes of the transplant with the type of transplant and the ocular comorbidities

Cause of transplant	Type of transplant	Ocular comorbidities				
		None	Glaucoma	Allergic conjunctivitis	Retinal detachment	Severe dry eye syndrome
Corneal ectasias	PK	189	1	12	3	1
	Triple	1	1	0	0	0
	PK + associated procedure	19	2	0	0	0
	DALK	3	4	7	0	0
	Endotelial	0	0	0	0	0
	Sclerokeratoplasty	1	0	0	0	0
Bullous pseudophakic/ aphakic keratopathy	PK	58	10	0	6	0
	Triple	5	0	0	0	0
	PK + associated procedure	8	5	0	2	0
	DALK	3	0	0	0	0
	Endotelial	17	5	0	0	0
	Sclerokeratoplasty	1	0	0	0	0
Failure of previous graft	PK	51	10	0	2	2
	Triple	9	1	0	0	0
	PK + associated procedure	3	1	0	0	1
	DALK	1	1	0	0	0
	Endotelial	3	1	0	0	0
	Sclerokeratoplasty	0	0	0	0	0

Triple: PK + cataract extraction + IOL. PK: Penetrating keratoplasty, DALK: Deep anterior lamellar keratoplasty, IOL: Intraocular lens

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The corneal transplants included in this registry were performed by 10 corneal and anterior segment surgeons during the years evaluated. When reviewing the surgical technique, the study demonstrates that the median diameter of the recipient is 8.0 mm (IQR 0.5 mm), as well as the median diameter of the donor, also 8.0 mm (IQR 0.5 mm). The most widely used suture technique is that of separate stitches in 60.7% of cases, followed by the combined technique (separate stitches plus continuous anti-torsion suture) in 35.8% of cases. The remaining 3.5% corresponds to endothelial transplantation cases, in which no suture is required.

Figure 4 highlights the number of patients who attend postoperative controls over time, with a downward trend after 12 months of follow-up, and a lower attendance, especially 36 months after the surgical procedure.

In terms of the adherence to follow-up during the 1st year, in 56.5% of the cases the 4 preestablished follow-up controls were met according to the institutional protocol for this registry (1st month, 3rd month, 6th month, and first postoperative year). Figure 5 illustrates the percentage of compliance with the postoperative controls carried out during the 1st year.

Regarding the presence of rejection, 153 of 584 cases (22.26%) presented at least one episode during the postoperative follow-up. Of those, 54.77% were resolved. Immunological rejection occurred, especially at the 3rd month of the postoperative period (POP), in 7.66% of patients, and its percentage remained between 5.5% and 7.7% between the 3rd and 24th months of the POP. It decreases after the 36th month, when the number

Table 5: Main systemic comorbidities

Systemic comorbidity	*n* (%)
Cardiovascular	85 (14.55)
Diabetes mellitus	28 (4.79)
Rheumatoid arthritis	14 (2.39)
Neurocognitive	13 (2.23)
Hypothyroidism	10 (1.71)
Sjogren Sd.	5 (0.86)
Stevens-Johnson Sd.	3 (0.51)
SEL	2 (0.34)
Immunosuppression	2 (0.34)
None	422 (72.26)
Total	584 (100)

Sd: Syndrome, SLE: Systemic lupus erythematosus

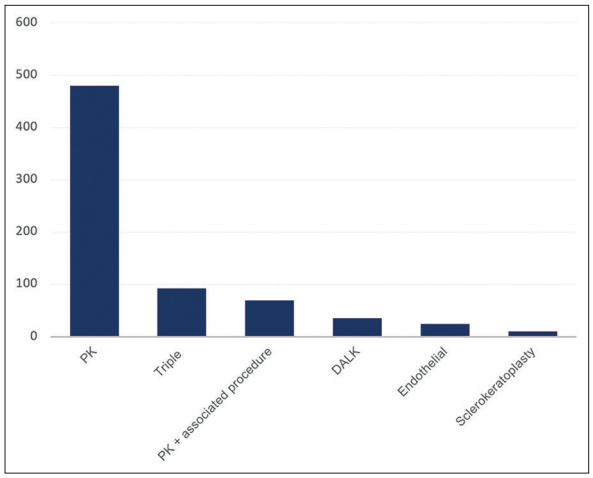

Figure 2: Surgical technique frequency. ¶PK: Penetrating keratoplasty. Triple: PK + cataract extraction + IOL. DALK: Deep anterior lamellar keratoplasty

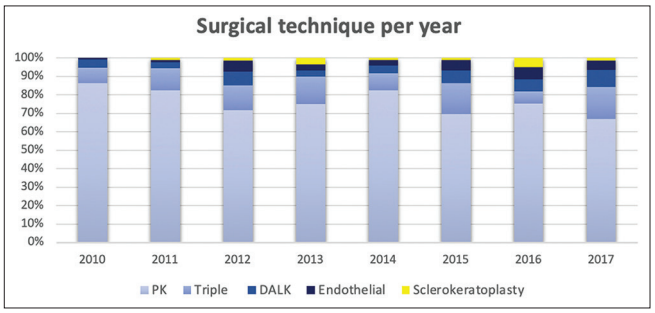

Figure 3: Corneal transplantation surgical technique per year. **PK: Penetrating keratoplasty. Triple: PK + cataract extraction + IOL. DALK: Deep anterior lamellar keratoplasty

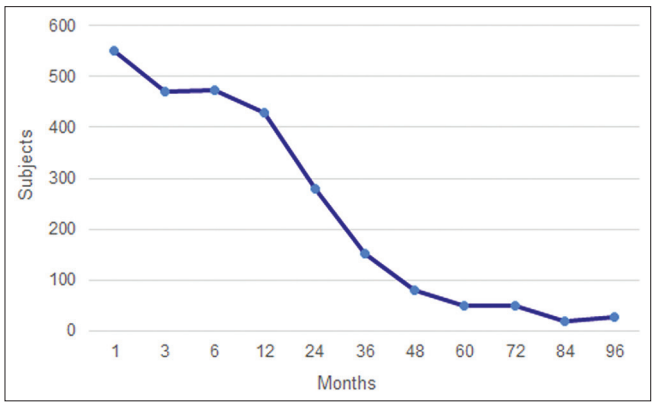

Figure 4: Attendance to postoperative controls over time

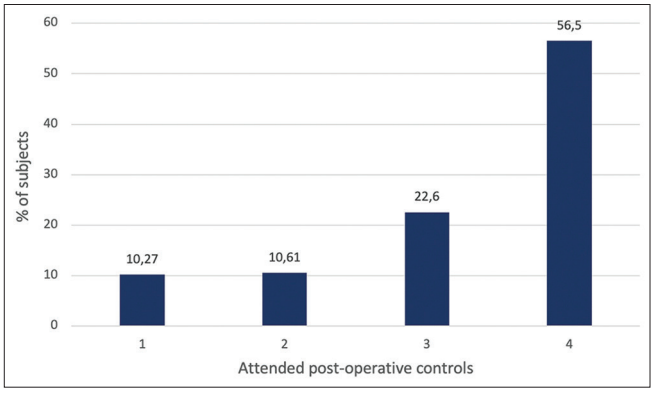

Figure 5: Number of attended postoperative controls during the 1st year of follow-up

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of patients who attend postoperative controls decreases as well. In the first 24 months, it is found an upward trend in the percentage of failure due to rejection. A similar trend is seen for the percentage of graft failure due to other causes. Figure 6 illustrates the presence of rejection during postoperative controls, as well as the percentage of graft failure due to rejection and failure by other causes.

Table 10 highlights graft failure causes up to the last control.

Analyzing the transparency of the graft, it remains crystalline in more than 80% of the cases up to the 36th month of the POP, when this percentage decreases but remains above 70%. The survival of the graft decreases after the 5th year of follow-up, having about 20% of the transplants with the graft opaque. Figure 7 illustrates the behavior of the transparency of the graft throughout the follow-up and Figure 8 shows the graft transparency percentage at the last follow-up control.

Table 6: Preoperative neovascularization versus graft transparency

Quadrants	Transparent, *n* (%)	Edema, *n* (%)	Opaque, *n* (%)	Total
0	361 (86.2)	32 (7.6)	26 (6.2)	419
1	26 (74.3)	3 (8.6)	6 (17.1)	35
2	31 (60.8)	11 (21.6)	9 (17.6)	51
3	14 (66.7)	3 (14.3)	4 (19.0)	21
4	31 (53.4)	9 (15.5)	18 (31.0)	58

§Quadrants: Number of quadrants with neovascularization

Table 7: Donor data

Variable	Value
Corneal transplants	712
Donor subjects	661
Age (years)	
Median	27.5
IQR	16
Gender, *n* (%)	
Female	77 (11.5)
Male	584 (88.4)
Central endothelial cell count (cell/mm^2)	
Median	3109
IQR	508
Recovery time (hours)	
Median	17
IQR	5
Recovery time to surgery (h)	
Median	72
IQR	45.5

Recovery time: Hours from donor death to graft recovery in the preservation medium. IQR: Interquartile range

Table 8: Age of donor versus graft transparency

Age of donor (years)	Transparent, *n* (%)	Edema, *n* (%)	Opaque, *n* (%)	Total
10-29	302 (80.7)	34 (9.1)	38 (10.2)	374
29-50	206 (72.0)	42 (14.7)	38 (13.3)	286
>50	42 (80.8)	7 (13.5)	3 (5.7)	52

Table 9: Recovery time versus graft transparency

Recovery time (h)	Transparent, *n* (%)	Edema, *n* (%)	Opaque, *n* (%)	Total
<12	47 (79.7)	5 (8.5)	7 (11.8)	59
12-24	413 (82.8)	43 (8.6)	43 (8.6)	499
>24	20 (76.9)	4 (15.4)	2 (7.7)	26

DISCUSSION

Although similar reports of corneal transplants in Colombia are found in the international literature, this study is the only one that reports variables of the recipient and donor that may have an influence on transplant survival. Having more information in the registry allows us to carry out a more in-depth analysis on the behavior of corneal transplants in our context, leading to generate possible questions for future research on their outcome and survival, as well as to identify possible risk factors for failure in our environment and to generate behaviors that increase the success rate in corneal transplants.

FUNDONAL is one of the reference centers for corneal transplants in Colombia with a higher number of cases performed within the period of 2010-2017 when compared to those reported by other transplant centers in the country.[14,15] At the regional and global level, the number of transplants performed per year has increased. The findings showed that in Brazil there was an increase of 136% from 2001 to 2016[16] and 150% in Germany in the same period.[2] It is to be expected that corneal transplants will continue to be a surgery of high demand at our institution.

The first indication for transplantation in our study was corneal ectasias, especially keratoconus. It should be noted that, being a reference center in the region, FUNDONAL attends cases of advanced ectasias that could not be recovered with crosslinking or scleral lenses. These cases with very thin corneal thickness, often with the presence of corneal hydrops and/or leukoma with involvement of deep lamellae, are related to the most used technique, PK. The same happens with bullous keratopathies after cataract

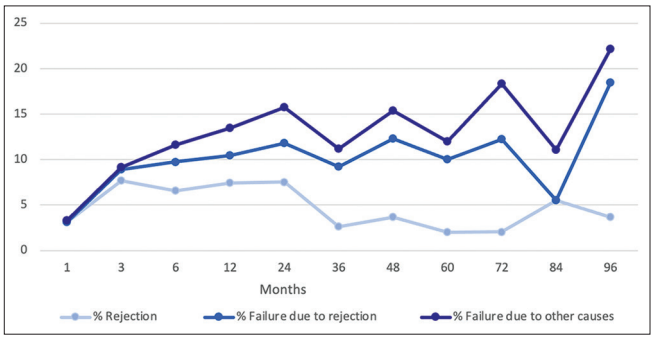

Figure 6: Percentage of immunological rejection, graft failure due to rejection, and failure due to other causes over time

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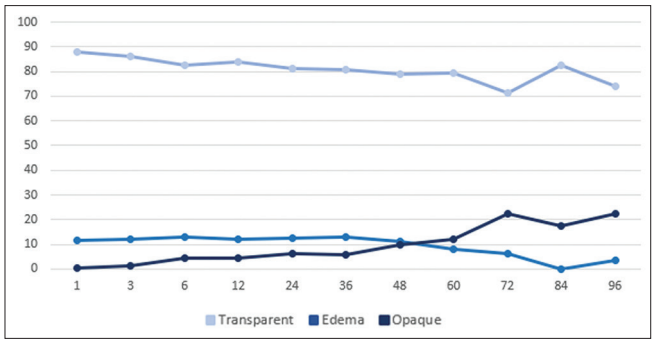

Figure 7: Percentage of graft transparency over time

Table 10: Graft failure causes

Failure cause	*n* (%)
Immunological rejection	67 (11.47)
Glaucoma	19 (3.25)
Infectious ulceration	10 (1.71)
Persistent epithelial defect	9 (1.54)
Retinal detachment	8 (1.37)
Trauma	4 (0.68)
Ocular herpes	3 (0.51)
Primary failure	2 (0.34)
Corneal decompensation	2 (0.34)
Endophthalmitis	1 (0.17)
Uveitis	1 (0.17)
No failure	458 (78.42)
Total	584 (100)

surgery that presents irreversible stromal lesions, which take them out of the group of endothelial techniques. Considering that in the years analyzed in this first report, we did not have the AS-OCT or the femtosecond laser as tools that would allow us to perform lamellar techniques with greater safety in these advanced cases, the PK was then, the first choice for patients with these characteristics.

It should be noted that previous graft failure is the third indication for corneal transplantation both in the current cohort and in the study by Barraquer *et al*.[14] Regarding other reports in Colombia, unlike our results, Galvis *et al*. reported bullous keratopathies as the first indication for transplantation (46.7%), infectious keratitis as the second cause (22.3%) and corneal dystrophies as being third (9%). This largely explains the greater number of partial thickness keratoplasties, especially endothelial, in that institution.[15] On the other hand, Barraquer *et al*. names ectasias as the first cause with 38.3%, endothelial decompensation as the second at 20.9%, and replacement of failed graft in the third position with 17.7%.[14] In the 2019 report of the Australian Corneal Transplant Registry (ACGR), the first indication was Keratoconus in 31% of cases, followed by previous graft failure in 25% and bullous keratopathy in 19%.[17] In the EBAA report,[18] the main indication was endothelial failure at 56% (endothelial dystrophies and corneal edema after cataract surgery), followed by stromal or

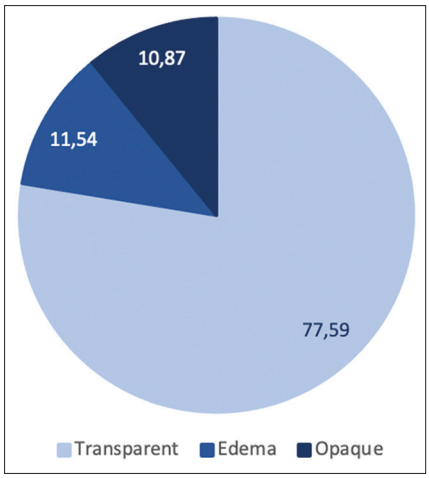

Figure 8: Graft transparency percentage at the last follow-up control

full-thickness diseases at 16% (ectasias, other dystrophies, trauma, infectious and noninfectious keratitis), unknown or unreported causes in 14.8% and failure of previous grafts in 12.8% of cases. In Germany, Fuchs' Endothelial Dystrophy is the main indication in 46% of the cases, bullous keratopathy the second in 13%, previous graft failure is the third in 11%, followed by keratoconus in 8%, and corneal scars in 6% of the cases.[2]

In FUNDONAL's study, about 20% of the cases present ocular comorbidities, which could add additional risk to present unwanted results, as reported by Bayyoud *et al*.[19] They found a higher complication rate and lower transplant survival in patients with ocular comorbidities in a cohort studied for DMEK. The comorbidities found in the current study are correlated with other characteristics registered for transplant patients. It can be noticed that in the present registry, glaucoma is a frequent comorbidity found in patients who underwent keratoplasty due to bullous pseudophakic/aphakic keratopathy and failure of a previous graft. On the other hand, most of the cases of allergic conjunctivitis are seen in patients who underwent PK due to corneal ectasias, which is reasonable with the clinical presentation of the entities causing the corneal transplantation; glaucoma is an important cause of endothelial damage, and allergic conjunctivitis is highly associated with corneal ectasias such as keratoconus. On the other hand, having a younger age compared to other studies, the patients of the present registry showed a lower rate of associated retinal pathologies such as age-related macular degeneration and epiretinal membranes, in comparison with the most common ocular comorbidities in other studies.[19-21]

Glaucoma is also a frequent associated pathology, being in the present study the most frequently associated ocular

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comorbidity, in 9.42% of the cases. The presence of glaucoma has been reported in some studies as a risk factor for graft failure and is statistically significant for endothelial decompensation of patients who had undergone PK for pseudophakic bullous keratopathy, with a relative risk (RR) from 1.5-2.0, or in cases of Fuchs' dystrophy (RR 1.9-3.1). Stewart *et al.* revealed a decompensation rate of 9%−13% in patients with glaucoma, compared to 3% without this comorbidity, with $P < 0.001$.[22] In a 10-year follow-up study of 1090 corneal transplant patients, Sugar *et al.* founded 58% of graft failure for patients with pseudophakic bullous keratopathy and Fuchs Dystrophy if they had glaucoma as a comorbidity compared to 22% without.[23] In the Australian report (ACGR), the average survival of PK at 4 years was 85% compared to 55% for patients with high IOP.[17] In the present study, 65.4% of grafts in eyes with glaucoma were transparent at the last control, compared with 80.3% of transparency in eyes with no comorbidities.

The second most frequent ocular comorbidity is allergic conjunctivitis. Allergic ocular reactions have been found in some studies not to be statistically significant for increased risk of rejection or failure of corneal transplantation.[24,25] In the current study, there is a high percentage of transparency (81.8%) in patients with allergic conjunctivitis at the last control.

Rheumatoid arthritis and Sjögren's syndrome are the third and sixth systemic comorbidities (2.39% and 0.86%, respectively). We found severe dry eye as the fourth ocular comorbidity (1.03%), which can be associated with systemic diseases with an autoimmune component.[26-29] Tear film instability, irregularity of the anterior curvature of the cornea, nerve damage, and decreased blink reflex are the secondary conditions of corneal transplantation. They induce longer periods of recovery on the corneal surface and generate corneal necrosis with an increased risk for graft failure.[30-38] Some studies report alterations of the ocular surface as an important risk factor for infectious keratitis, corneal perforation, rejection, and transplant failure.[39-41]

Recipient's preoperative vascularization is present in 28.2% of the studied cohort, a factor associated with a higher risk of corneal transplant rejection. It can be noticed that the higher percentage of transparency at the last control is found in those eyes with no preoperative neovascularization (86,2%), and the lowest percentage of transparency (53,4%) as well as the higher percentage of opacity at the last control (31,0%) are found in eyes with four quadrants involved. It has been reported a risk of 2.07 for corneal rejection and 1.32 for graft failure related to preoperative vascularization. This risk can vary according to the number of quadrants involved, ranging from 1.37 to 2.67 for rejection, and from 0.83 to 1.67 for transplant failure.[42-44] These findings support the institutional policies for the use of subconjunctival antiangiogenics (ANTI-VEGF) previous to corneal transplant and open the door for and open the door for new combined techniques such as fine-needle thermal cauterization combined with subconjunctival injection of bevacizumab before high-risk keratoplasty.[45]

Donor tissue data is an essential part of this registry and a differential factor when compared with other registries in Colombia.[14,15] It has a majority of male donors, aged under 40, with a cause of violent death in approximately 75% and high endothelial cell count. In the ACGR a third were female donors, the most of them over 50 years of age and in association with natural causes of death in about 80%.[17] Very similar to the data found in the USA. Younger donor grafts show better survival for PK and DSAEK, not for DMEK.[18] Other studies did not find significant differences in clinical results or safety with the use of young donors.[46-48] In the present registry, it can be noticed that there are similar percentages of transparency at the last control when donor age was between 10 and 29 years and over 50 years (80.7% and 80.8%, respectively).

In FUNDONAL's report, all donor tissues meet the internationally established criteria to be suitable for transplantation: An average of endothelial cell count >2500 cells/mm^2 and a recovery time to surgery <120 h (5 days).[49] The median time from death to preservation of the tissue in the present registry was slightly longer than that recommended in some international studies.[50] However, recovery time longer than 12 h is related to epithelial damage but not to a lower endothelial cell count. Endothelial cell count and tissue survival are not affected with recovery times (death to preservation) even up to 72 h.[51] It can be noticed that in this registry, most of the donor tissues had a recovery time between 12 and 24 h, showing a higher percentage of transparency when compared with donors with recovery time under 12 h (82.8% and 79.7%, respectively).

The most frequently performed technique was PK, followed by DALK and endothelial keratoplasty, with 89.6%, 5.3%, and 3.5%, respectively. A higher proportion of lamellar transplants: 54.43%, 26.27%, and 16.93% for PK, DALK, and endothelial transplantation, respectively, were reported in Colombia, by Barraquer *et al.* between 2010 and 2018.[14] Galvis *et al.* reported 73.7% of PK, 21.7% of endothelial keratoplasties, and 3.5% of DALK from 2012 to 2016.[15] Endothelial techniques (DSAEK

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and DMEK) represent just over 50% of transplants performed in recent years (2016–2017) according to the latest ACGR.[17] In the 2019 report of the EBBA, DALK was most frequently performed than PK since 2011; 30.650 endothelial keratoplasties and 17.409 PK were done in the USA during 2019.[18] Partial thickness keratoplasties are more widely used than PK, especially DMEK, since 2014, in Germany.[2] More than 50% of the first indication of transplantation in ACGR and EBBA report, are indications for endothelial keratoplasties, which justifies the increase in these lamellar techniques.[17,18]

In the current cohort, the number of patients who underwent lamellar techniques is low, partly due to the advanced stage of the pathologies of the cases referred to FUNDONAL. In recent years, the femtosecond laser (FEMTO LDV Ziemer's Z8) represents an important tool for these types of transplantation, with a better safety profile with functional anatomical results similar to manual techniques.[52-54] An additional aid also recently acquired in our institution is the AS-OCT, which were not available at the time of the procedures included in this registry. AS-OCT provides valuable information in the preoperative planning process.[55,56] In addition, the AS-OCT allows the results to be objectively evaluated in the POP, allowing to accurately and promptly identify possible complications such as a double anterior chamber or partial or total detachment of the corneal transplant.[57] In future reports of this registry, a greater number of these partial thickness keratoplasty techniques is likely, with the progressive implementation of these technologies.

In the present registry, there were identified rejection events in 22.26%. More than half of them were resolved. In the ACGR, the multivariate analysis has allowed them to determine that there is a lower survival rate for PK and DSAEK after a rejection episode.[17] In addition, we found a higher frequency of episodes of immune rejection in the first 3 months, a fact that differs from that reported in the literature for early rejection episodes in 26.9% compared to 73.1% with late rejection episodes, although the characteristics and responses management in both groups is similar.[58]

In the current registry, the survival rate for transplants is 78% to the last follow-up control. These data are similar to the Australian registry series (ACGR), with an estimated survival rate of 79% at the last control.[17] In this registry, the attendance to the 12-month follow-up control is 82%, compared with 78% in the ACGR.[17]

This first report from the corneal transplant registry of FUNDONAL provides valuable information about the results of corneal transplants performed between 2010 and 2017 at this institution as a local and national reference center. This type of registry gives us a local background of corneal transplantation and constitutes the first corneal transplant registry in Colombia, with survival results and description of variables that will allow for the identification of risk factors for undesirable outcomes.

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Conflicts of interest

There are no conflicts of interest.

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