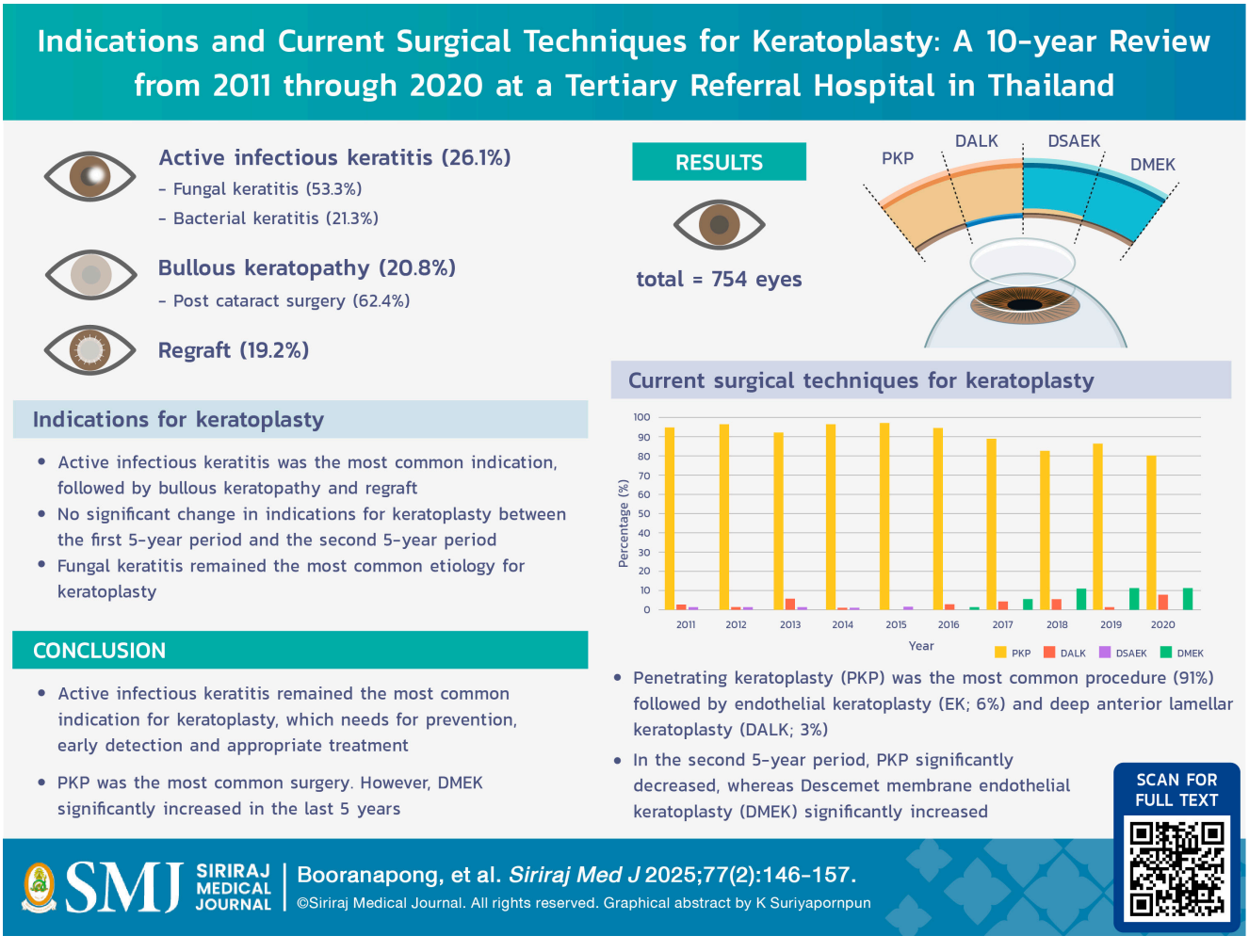
Indications and Current Surgical Techniques for Keratoplasty: A 10-year Review from 2011 through 2020 at a Tertiary Referral Hospital in Thailand

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ABSTRACT

Objective: To report the indications and current trends in surgical techniques for keratoplasty over 10 years at Siriraj Hospital.

Materials and Methods: We retrospectively reviewed the medical records of hospitalized patients who underwent keratoplasty from 2011 to 2020. The collected data comprised demographics, indications for keratoplasty, and surgical techniques used.

Results: A total of 754 eyes were included. Active infectious keratitis was the most common indication (26.1%), followed by bullous keratopathy (20.8%) and regraft (19.2%). There was no significant change in indications for keratoplasty between the first 5-year period and the second 5-year period. Fungal keratitis remained the most common etiology for keratoplasty. Penetrating keratoplasty (PKP) was the most common procedure overall (90.7%), followed by endothelial keratoplasty (EK; 5.7%) and deep anterior lamellar keratoplasty (DALK; 3.6%). However, surgical techniques used in the second 5-year period differed significantly from those in the first 5-year period ($P < 0.05$). The use of PKP decreased from 96.0% to 86.7%; however, EK increased from 1.5% to 8.9%, while DALK rose slightly from 2.5% to 4.4%.

Conclusion: Active infectious keratitis was the most common indication for keratoplasty, followed by bullous keratopathy and regraft. These indications may be reduced through collaborative efforts among government leaders, public health officers, and ophthalmologists. PKP remained the most common surgical technique due to the high incidence of infectious keratitis. However, the use of lamellar keratoplasty, including EK and DALK, significantly increased for other indications. Descemet membrane endothelial keratoplasty was performed mostly in eyes with Fuchs endothelial dystrophy.

Keywords: Indications for keratoplasty; corneal transplantation; penetrating keratoplasty; deep anterior lamellar keratoplasty; Descemet membrane endothelial keratoplasty (Siriraj Med J 2025; 77: 146-157)

INTRODUCTION

According to the World Health Organization, blindness is defined as a corrected visual acuity of 3/60 or less in the better eye using Snellen's chart.[1] In 2015, the global prevalence of blindness was estimated at 36 million people, with 1.3 million cases attributed to corneal opacity.[2] The most common causes of blindness worldwide include cataract (51%), glaucoma (8%), age-related macular degeneration (5%), and corneal opacities (4%).[3,4]

The cornea is a transparent and avascular connective tissue that plays a critical role in visual function by providing protective and refractive components. Corneal blindness results from diseases that alter corneal transparency, leading to opacities and visual loss.[5] The etiology of corneal blindness varies significantly across geographical regions and is influenced by local ocular diseases, environmental factors, and socioeconomic status.[4,6-13] For example, trachoma is the leading cause of bilateral blindness in Africa, whereas bacterial and fungal infectious keratitis are the most common etiologies in East, South, and Southeast Asia. In contrast, pseudophakic bullous keratopathy—corneal edema following cataract surgery—is the leading cause of corneal blindness in the United States, while keratoconus is the primary cause in Europe.[6-13]

In Thailand, the first Rapid Assessment of Avoidable Blindness survey reported a blindness prevalence of 0.6%, with corneal opacities accounting for 2% of total blindness cases.[14] A multicenter retrospective review by Prabhasawat et al found that the prevalence of corneal blindness was 1.7%. The leading causes were corneal infection (35.6%), surgical bullous keratopathy (27.8%), and trauma (14.0%).[6]

The management of corneal blindness depends on the underlying disease causing the vision loss. Corneal transplantation, or keratoplasty, is a preferred clinical modality and is the most common surgery performed for visual rehabilitation. Keratoplasty is also the most successful form of allogeneic organ transplantation because the avascular nature of the cornea minimizes graft rejection risk.[15] The procedure has evolved from replacing the full-thickness cornea—penetrating keratoplasty (PKP)—to replacing only the diseased layer—lamellar keratoplasty (LK).[16-19] The outcomes of keratoplasty vary based on the etiologies of corneal diseases in different regions, donor cornea quality, availability of skilled surgeons and medical teams, and effective long-term postoperative care.[20]

Currently, in many parts of the world, patients requiring donor corneas may wait 4 to 5 years due to a

shortage of donor tissue. The number of patients with corneal blindness has increased substantially in recent years, leading to a demand for corneal transplants that exceeds the availability of suitable donor corneas.[7,12,21] Relying solely on surgical intervention, even with increased donor corneas and intensive keratoplasty training for surgeons, may not suffice to address the growing waiting lists. Therefore, reviewing the leading indications for keratoplasty over the past decade is critical. Such analysis helps determine trends in preventable etiologies and assists in planning healthcare systems to mitigate these causes.

Meanwhile, keratoplasty techniques have evolved from PKP to LK. LK offers several advantages, including reduced astigmatism, increased postoperative structural stability, shorter rehabilitation time, decreased risk of immunological graft rejection, and the effective utilization of one donor cornea for two patients with different corneal layer diseases. This approach potentially reduces the number of patients waiting for donor corneas by half.[22-24]

This study aimed to explore the indications for keratoplasty from 2011 to 2020 to determine trends in preventable etiologies. Additionally, we sought to report the current keratoplasty techniques employed at our tertiary-care hospital.

MATERIALS AND METHODS

Study design and patient selection

We conducted a retrospective review of medical records of hospitalized patients who underwent keratoplasty at the Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand, between January 2011 and December 2020. Data were retrieved from the Medical Information Department's database using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes:[25] 11.60 ("Corneal transplant, not otherwise specified"), 11.61 ("Lamellar keratoplasty with autograft"), 11.62 ("Other lamellar keratoplasty"), 11.63 ("Penetrating keratoplasty with autograft"), and 11.64 ("Other penetrating keratoplasty with homograft"). All keratoplasty procedures were performed by six cornea specialists and three cornea fellows at our hospital.

Ethical approval

This study was approved by the Siriraj Institutional Review Board (IRB number 452/2565 [IRB2]; approval number Si 599/2022).

Data collection

We collected data on patients' age, sex, indications for keratoplasty, and surgical techniques employed.

Exclusion criteria

Patients who underwent keratoplasty using tissues other than fresh donor corneas—such as sclera, amniotic membrane, or corneoscleral rim—were excluded from the study.

Classification of indications

Indications for keratoplasty were defined based on preoperative clinical diagnoses. These indications were categorized into 11 diagnostic groups, as detailed in Table 1 and illustrated in Fig 1.

Active infectious keratitis cases were further classified according to the pathogenic microorganisms involved: bacteria, fungus, Acanthamoeba, herpes virus (herpes simplex and herpes zoster), Mycobacterium species, and others.

Bullous keratopathy cases were subclassified based on etiology, including post-infection, post-cataract surgery, post-glaucoma surgery, post-vitreoretinal surgery, post-laser iridotomy or iridoplasty, and others, as shown in Table 1.

Regraft was defined as a repeat corneal transplantation due to irreversible loss of graft clarity. These cases were further subclassified based on the original or primary diagnosis that led to the first corneal transplantation (Table 1). The number of repeat keratoplasties, including the current operation, was recorded.

Other indications for keratoplasty were subclassified as presented in Table 1.

Classification of surgical techniques

The surgical techniques for keratoplasty were classified as PKP and LK. LK was subcategorized as deep anterior lamellar keratoplasty (DALK), Descemet stripping automated endothelial keratoplasty (DSAEK), and Descemet membrane endothelial keratoplasty (DMEK). The indications for each type of keratoplasty were recorded.

Statistical analysis

All statistical analyses were carried out using IBM SPSS Statistics for Windows, version 27.0. (IBM Corp., Armonk, NY, USA).

The indications for keratoplasty and the surgical techniques used over the 10-year study period are reported as numbers and percentages. For descriptive and analytical purposes, the study period was divided into two 5-year periods: from January 2011 to December 2015, and from January 2016 to December 2020.

We used Pearson's chi-square test and Fisher's exact test to assess differences in the types of indications for keratoplasty and the surgical techniques between the two

TABLE 1. Indications for keratoplasty over the ten-year study period (2011–2020).

Indications	N (%) (Total 754 eyes)	
Active infectious keratitis	197 (26.1)	
Fungus	105	(53.3)
Bacteria	42	(21.3)
Acanthamoeba	7	(3.6)
Mixed bacteria and fungus	6	(3.0)
Herpes	4	(2.0)
Mycobacteria	2	(1.0)
Unidentified organism	31	(15.7)
Bullous keratopathy	157 (20.8)	
Post cataract surgery	98	(62.4)
Post infection	18	(11.5)
Post glaucoma surgery	10	(6.4)
Post vitreoretinal surgery	9	(5.7)
Post laser iridotomy/iridoplasty	6	(3.8)
Post cataract and glaucoma surgery	5	(3.2)
Post cataract and retinal surgery	2	(1.3)
Unknown	9	(5.7)
Regraft	145 (19.2)	
Original diagnosis		
Bullous keratopathy	59	(40.7)
Active infectious keratitis	38	(26.2)
Corneal dystrophy	20	(13.8)
Corneal scar	10	(6.9)
Congenital opacity	10	(6.9)
Mechanical trauma	3	(2.0)
Corneal thinning/melting (non-infectious)	2	(1.4)
Burn	1	(0.7)
Unknown	2	(1.4)
Corneal dystrophy	86 (11.4)	
Fuchs endothelial dystrophy	64	(74.4)
Avellino dystrophy	10	(11.6)
Lattice dystrophy	8	(9.3)
Macular dystrophy	2	(2.3)
Unknown	2	(2.3)
Corneal scar	73 (9.7)	
Post infection	44	(60.3)
Post trauma	11	(15.1)
Post pterygium excision	2	(2.7)
Post ocular surface surgery	1	(1.4)
Unknown	15	(20.5)

TABLE 1. Indications for keratoplasty over the ten-year study period (2011–2020). (Continue)

Indications	N (%) (Total 754 eyes)	
Congenital opacity and anterior segment dysgenesis	23 (3.1)	
Iridocorneal endothelial syndrome	10	(43.5)
Peters anomaly	9	(39.2)
Sclerocornea	2	(8.7)
Corneal dermoid	1	(4.3)
Mucopolysaccharidosis	1	(4.3)
Corneal thinning/melting (non-infectious)	18 (2.4)	
SJS	9	(50.0)
Exposure keratopathy	3	(16.7)
Terrien marginal degeneration	3	(16.7)
Neurotrophic keratopathy	1	(5.5)
Unknown	2	(11.1)
Burn	17 (2.3)	
Chemical	15	(88.2)
Thermal	2	(11.8)
Corneal ectasia	16 (2.1)	
Keratoconus	15	(93.7)
Pellucid marginal degeneration	1	(6.3)
Mechanical trauma	12 (1.6)	
Immune keratitis	10 (1.3)	
Peripheral ulcerative keratitis	8	(80.0)
Mucous membrane pemphigoid	1	(10.0)
Chronic anterior uveitis	1	(10.0)

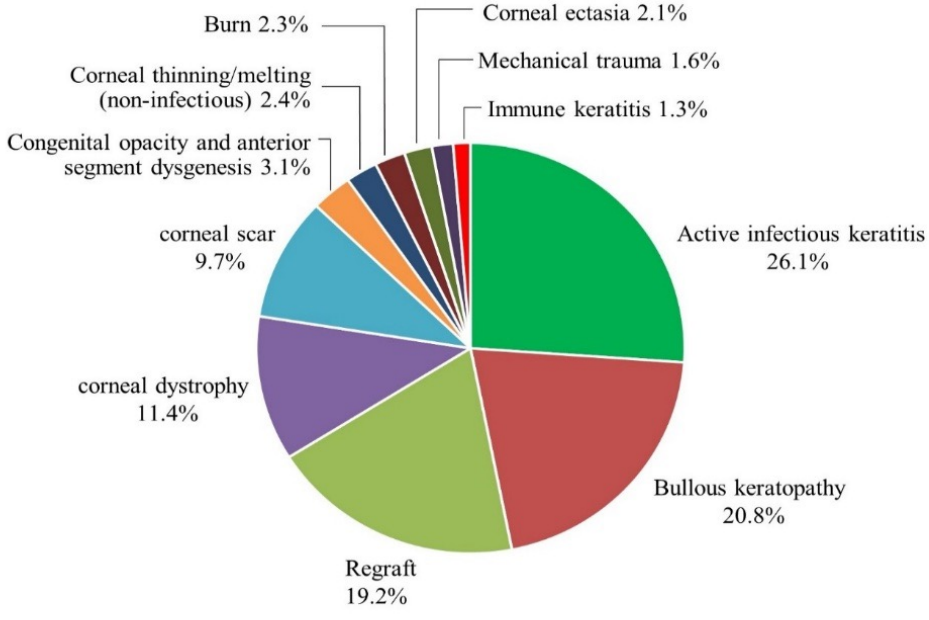


Fig 1. Indications for keratoplasty between 2011 and 2020

time periods. A *P* value less than 0.05 was considered statistically significant.

RESULTS

Demographic characteristics

A total of 754 eyes were included in the study. The mean age of the patients was 57.4 ± 18.0 years. The sex distribution was 434 male eyes (57.6%) and 320 female eyes (42.4%).

Overall distribution of keratoplasty indications

Over the 10-year study period, the most common indication for keratoplasty was active infectious keratitis (26.1%). This was followed by bullous keratopathy (20.8%), regraft (19.2%), corneal dystrophy (11.4%), and corneal scar (9.7%; Table 1 and Fig 1).

Infectious Keratitis: microbial analysis

The predominant etiology of active infectious keratitis was fungal infection, accounting for 53.3% of total microorganisms identified. The most frequently isolated fungus was *Fusarium* species (32.4% of fungal cases), followed by *Aspergillus* (13.3%), *Pythium* (8.6%), *Candida* (5.7%), and other fungi (40%).

Bacterial infections were the second most common cause of active infectious keratitis, representing 21.3% of total microorganisms. The most common causative bacterium was *Pseudomonas aeruginosa* (45.2% of bacterial cases). This was followed by other Gram-negative bacteria excluding *P. aeruginosa* (23.8%), Gram-positive bacteria (23.8%), and mixed bacterial infections (7.1%).

Bullous Keratopathy: etiological factors

Bullous keratopathy was the second most common indication for keratoplasty. It most frequently occurred after cataract surgery (62.4%), followed by post-infection cases (11.5%), post-glaucoma surgery (6.4%), and post-vitreoretinal surgery (5.7%; Table 1).

Regraft analysis

Regraft was the third most common indication for keratoplasty. The original diagnoses leading to regraft were bullous keratopathy (40.7%), active infectious keratitis (26.2%), corneal dystrophy (13.8%), and other conditions (19.3%; Table 1). The mean interval between the initial keratoplasty and the regraft was 7.0 ± 6.8 years.

Multiple keratoplasty procedures

Multiple keratoplasty procedures were performed on many patients. The distribution of repeat keratoplasties, including the current operation, was as follows: second keratoplasty (80.6% of regraft cases), third keratoplasty (16.6%), fourth keratoplasty (2.1%), and fifth keratoplasty (0.7%). The most frequent original diagnosis for the second, third, fourth, and fifth repeat keratoplasties was bullous keratopathy (38.5%, 45.8%, 66.7%, and 100%, respectively). The second most frequent original diagnosis for the second, third, and fourth repeat keratoplasties was active infectious keratitis (24.8%, 33.3%, and 33.3%, respectively).

Corneal dystrophy and scarring

Corneal dystrophy was the fourth most common indication for keratoplasty. Among these cases, Fuchs endothelial corneal dystrophy (FECD) was the most prevalent, accounting for 74.4% of corneal dystrophy instances (Table 1).

Corneal scar was the fifth most common indication. The majority of corneal scars resulted from post-infection (60.3%) and post-trauma (15.1%) events (Table 1).

TABLE 2. Comparison of the indications for keratoplasty between the first and the second five-year periods.

Indications	Number (%)			*P* value
	2011–2015 (n=326)	2016–2020 (n=428)	Total (n=754)	
Active infectious keratitis	85 (26.1)	112 (26.2)	197 (26.1)	0.115
Bullous keratopathy	67 (20.6)	90 (21.0)	157 (20.8)	
Regraft	58 (17.8)	87 (20.3)	145 (19.2)	
Corneal dystrophy	33 (10.1)	53 (12.4)	86 (11.4)	
Corneal scar	43 (13.2)	30 (7.0)	73 (9.7)	
Others	40 (12.3)	56 (13.1)	96 (12.8)	

TABLE 3. Comparison of the surgical techniques of keratoplasty between the first and the second five-year periods.

Surgical technique	Number (%)				*P* value
	2011–2015 (n=326)		2016–2020 (n=428)		
PKP	313	(96.0)	371	(86.7)	<0.001
DALK	8	(2.5)	19	(4.4)	0.58
DSAEK	5	(1.5)	0		0.06
DMEK	0		38	(8.9)	<0.001

Temporal trends in keratoplasty indications

The top five indications for keratoplasty in the first 5-year period (2011–2015) were similar to those in the second 5-year period (2016–2020). The percentages of keratoplasties performed for each indication did not differ significantly between the two periods ($P > 0.05$; Table 2).

Surgical techniques and their indications

Regarding surgical techniques over the entire study period, PKP was the most common procedure (90.7%). This was followed by DMEK (5.0%), DALK (3.6%), and DSAEK (0.7%).

Indications for PKP included active infectious keratitis (28.5%), bullous keratopathy (22.1%), regraft (20.2%), corneal scar (9.5%), corneal dystrophy (6.7%), congenital corneal opacity (3.2%), non-infectious corneal thinning or melting (2.6%), and other conditions (7.2%).

Indications for DALK were stromal corneal dystrophy (29.6%), corneal scar (25.9%), corneal ectasia such as keratoconus (22.2%), regraft (11.1%), active infectious keratitis (7.4%), and other causes (3.8%).

Indications for endothelial keratoplasty (EK), including DSAEK and DMEK, were FECD (74.4%), bullous keratopathy (14.0%), regraft (9.3%), and corneal scar (2.3%).

Changes in surgical techniques over time

The surgical techniques employed in the second 5-year period differed significantly from those in the initial 5-year period ($P < 0.01$; Table 3). The use of PKP decreased from 96.0% in the initial period to 86.7% in the second period. Conversely, the utilization of DMEK and DSAEK increased from 1.5% to 8.9%, and DALK slightly increased from 2.5% to 4.4%. DSAEK was performed only in the initial 5-year period. In the subsequent period, all EK procedures transitioned to DMEK, which was predominantly performed in cases of FECD.

DISCUSSION

According to the Thai Red Cross Eye Bank—the only eye bank in Thailand—the number of keratoplasties performed using corneas from eye bank donors increased from 759 in 2022 to 1546 in 2023. This rise resulted from proactive efforts in sourcing corneal tissues and providing intensive keratoplasty training courses. Nevertheless, as of June 2023, the waiting list for donor corneas comprised 7931 eyes, with patients potentially waiting 4 to 5 years for transplantation. Moreover, the number of new patients with corneal diseases requiring keratoplasty has increased rapidly, adding to the existing waiting lists.

Given this context, our study aimed to review the indications for keratoplasty over the decade from January 2011 to December 2020. We divided the data into two 5-year periods to identify trends in preventable or avoidable causes of corneal blindness. We also sought to determine whether the indications for keratoplasty had changed between the two periods. These findings should aid in strategic planning at the national level to prevent such corneal diseases.

Our study found that the three most common indications for keratoplasty during 2011–2020 were active infectious keratitis (26.1%), bullous keratopathy (20.8%), and regraft procedures (19.2%). This ranking mirrors the leading indications for keratoplasty in Asia reported by a systematic review of 34 years of global data.[10] In contrast, in the United States, the top three indications for corneal transplantation in 2014 were pseudophakic bullous keratopathy, regraft, and keratoconus, respectively.[10] Conversely, keratoconus was the primary indication for

corneal transplantation in Europe, Australia, the Middle East, Africa, and South America.[8,10]

Interestingly, the overall indications for keratoplasty in the second 5-year period did not significantly differ from those in the first 5-year period ($P > 0.05$). Active infectious keratitis remained the leading indication for keratoplasty throughout the decade. This trend aligns with findings from other studies in Asia,[7,10,26] including China,[26] India,[10] Nepal,[27] and Vietnam.[11] Previous reports in Thailand also indicated that corneal ulcers were the leading cause for keratoplasty.[6,28,29] Additionally, other studies showed that corneal ulcers were among the top three indications for keratoplasty in central and other regions of Thailand.[21,30]

Furthermore, the percentage of total infectious keratitis cases would actually increase if we included corneal scar cases resulting from inactive or healed keratitis (5.9%) along with active infectious keratitis (26.1%).

Infectious keratitis has both local and systemic risk factors. Local risk factors include contact lens wear, ocular trauma, ocular surface diseases, post-ocular surgery, and topical steroid administration. Systemic risk factors encompass conditions such as diabetes mellitus and autoimmune diseases.[31] Understanding these major risk factors in different countries is crucial for developing effective public health policies aimed at reducing the incidence of infectious keratitis.

Ting et al[31] reported that in the United Kingdom, Europe, North America, and Australia, the most common risk factor for infectious keratitis was contact lens wear. The predominant infectious microorganisms in these regions were bacteria, including *Staphylococcus spp*. and *Pseudomonas spp*. In contrast, in Asia, Africa, and the Middle East, the majority of infectious keratitis cases were caused by trauma, particularly exposure to vegetative materials, organic matter, and animal products in agricultural communities.[31-35] Consequently, the most common pathogens were fungi, such as *Fusarium spp*. and *Aspergillus spp*.

Similarly, a prospective multicenter study by the Asia Cornea Society reported that trauma was the most common risk factor for infectious keratitis in Asia (34.7%), followed by contact lens wear (10.7%).[36] The most frequently isolated microorganisms were *Fusarium* species (18.3%), *Pseudomonas aeruginosa* (10.7%), and *Aspergillus flavus* (8.3%).[36] Our results align with these findings, as fungi—including *Fusarium*, *Aspergillus*, *Pythium*, and *Candida*—remained the most common causative organisms.

The high prevalence of fungal keratitis in agricultural countries may be attributed to factors such as corneal trauma from plants or vegetative matter, hot climates, and socioeconomic status. Fungal keratitis is particularly challenging to treat due to delayed diagnosis, limited availability of effective antifungal agents, difficult access to new antifungal medications, and poor corneal penetration of existing treatments. These challenges result in a poor therapeutic response to current antifungal medications.

Bacterial pathogens were the second most common cause of infectious keratitis in our study, with *Pseudomonas aeruginosa* being the most prevalent, followed by other Gram-negative bacteria, Gram-positive bacteria, and mixed bacterial infections. Generally, bacterial keratitis responds well to antibacterial medications. However, some patients require keratoplasty due to large perforated corneal ulcers or severe bacterial keratitis at the time of referral, especially in diabetic or immunocompromised patients.

Infectious keratitis—particularly fungal keratitis—remains the leading indication for keratoplasty and has persisted as a significant problem for decades. Addressing this issue requires serious recognition and collaborative efforts among government leaders, public health officials, and ophthalmologists. Strategies should include increasing public education through social media, promoting early diagnosis and prompt, appropriate treatment of corneal ulcers by general ophthalmologists, providing research funding for the development of new effective antifungal agents, and implementing universal health coverage schemes that permit free access to antifungal medications such as liposomal amphotericin B, voriconazole, posaconazole, and future antifungal agents.

Bullous keratopathy emerged as the second leading indication for keratoplasty in our study, aligning with reports from Thailand[6,28] and other regions in Asia,[7,10] as well as Europe, Australia, the Middle East, and South America.[10] Notably, bullous keratopathy was reported as the most prevalent indication for keratoplasty in Japan,[7] Singapore,[7,37] and the United States.[10] While the primary indication for keratoplasty may vary based on geographical location, environmental factors, and socioeconomic status, bullous keratopathy consistently ranks as the first or second most common indication worldwide.[6-12,21]

The most frequent cause of bullous keratopathy is corneal endothelial injury following cataract surgery. This was evident in our study, where 62.4% of bullous keratopathy cases were attributed to post-cataract surgery, and our results align with findings in the literature.[6-12] Several factors contribute to this trend, including greater corneal endothelial damage resulting from both increasing

cataract surgery rates and a growth in the number of trainees, anterior chamber intraocular lens implantations,[38] and phacoemulsification surgery in hard nucleus or brunescent cataracts. Patients at high risk for corneal endothelial decompensation—such as those with elderly corneas, FECD, shallow anterior chambers, or histories of multiple intraocular surgeries—are particularly susceptible.

To mitigate this issue, preventative strategies could include the implementation of surgical simulators in cataract surgery training programs for residents and discontinuing the use of anterior chamber intraocular lens implantation. Additionally, converting phacoemulsification procedures to extracapsular cataract extraction or manual small incision cataract surgery in high-risk patients may also minimize endothelial damage.[39,40] Preoperative evaluations should assess central corneal thickness and corneal endothelial cell count and morphology in these patients to determine the most appropriate surgical approach—whether phacoemulsification, extracapsular cataract extraction, or manual small incision cataract surgery. Furthermore, utilizing advanced phacoemulsification machines with enhanced safety features, when possible, may decrease the risk of endothelial injury.

Regraft procedures were the third most common indication for keratoplasty in our study, mirroring findings from previous reports in Thailand[28,30] and regions such as Asia, Australia, and South America.[10] Interestingly, in New Zealand, regraft or repeat corneal transplantation was the most prevalent indication.[41] In our cohort, the primary diagnoses preceding the first keratoplasty were bullous keratopathy (40.7%), active infectious keratitis (26.2%), corneal dystrophy (13.8%), and other conditions (Table 1). This suggests that active infectious keratitis not only remains the first leading indication but also contributes significantly to the need for regrafts.

Bullous keratopathy was the foremost indication for regraft in our study, consistent with findings from Mezaine et al in Saudi Arabia.[42] In contrast, infectious keratitis was the primary indication for single and multiple repeat keratoplasties in China,[43] and it was the second most common indication for regrafts in our study. Several factors may contribute to corneal graft failures in bullous keratopathy cases, including immunological rejection, corneal vascularization, secondary glaucoma, donor corneal endothelial cell function, surgical techniques, and postoperative follow-up and management.[44,45]

In cases where keratoplasty was performed due to active infectious keratitis, graft failure or rejection was often associated with recurrent infections on the corneal graft, persistent inflammation at the time of surgery, vascularization in recipient corneas, and secondary elevated intraocular pressure—more common in fungal keratitis. Additional factors include the use of lower-quality donor corneas (as high-quality corneas are typically reserved for patients with better prognoses) and the omission of corticosteroids or immunosuppressive drugs in early postoperative treatment for fungal keratitis patients. Therefore, active infectious keratitis significantly influences both the primary and tertiary indications for keratoplasty, underscoring the need to address it as a national public health concern to reduce the demand for corneal transplants. Notably, multiple repeat keratoplasties were also frequently necessitated by infectious keratitis.

Addressing these challenges may reduce regraft rates. Prevention of infectious keratitis—particularly fungal keratitis—is crucial. Improvements can be achieved by providing high-quality donor corneas, enhancing surgical techniques and instruments to prevent recurrent infections and minimize endothelial damage, and ensuring robust long-term postoperative care and follow-up by medical teams. Patient education on the importance of regular follow-up, medication adherence, and recognition of symptoms indicative of graft rejection is essential. Additionally, implementing universal health coverage that grants free access to immunosuppressive medications—such as cyclosporine, mycophenolate mofetil, and tacrolimus—could aid in preventing and treating graft rejection.

Patients with corneal blindness awaiting keratoplasty suffer from long-term vision loss, reduced quality of life, loss of income, and a need for assistance. This condition represents not only a social burden but also an economic one. Therefore, preventive measures are crucial public health strategies to reduce corneal blindness and diminish the necessity for corneal transplants.

During the study period, PKP accounted for 90.7% of all keratoplasties performed. It remains the most common form of keratoplasty in Thailand[21] and Asia.[7,10] LK constituted 9.3% of procedures, including DMEK at 5.0%, DALK at 3.6%, and DSAEK at 0.7%.

LK was already being performed in 2011, at the start of our study period, with DALK and DSAEK as the available options. Later, DMEK was introduced in 2016. The surgical techniques employed in the second 5-year study period differed significantly from those in the initial 5-year period ($P < 0.05$). PKP decreased from 96.0% to 86.7%, while EK—including DMEK and DSAEK—increased from 1.5% to 8.9%. DALK slightly increased from 2.5% to 4.4%. Notably, DSAEK was performed only during the initial 5-year period (2011–2015). After 2015, all EK procedures transitioned to DMEK in the second 5-year period.

Surgeons preferred DMEK over DSAEK, considering it superior in several aspects. DMEK involves fewer surgical steps and instruments, resulting in less time-consuming operations. Surgeons at our hospital have found that DMEK achieves faster visual recovery, better visual outcomes, reduced interface irregularity, less refractive error, and lower rates of immune rejection, similar to a report by the American Academy of Ophthalmology.[46] Currently, DMEK is performed mostly in eyes with FECD. These LK techniques can reduce regraft rates, lessen the use of immunosuppressive drugs, and allow one donor cornea to benefit more than one patient on the waiting list.

This study has several limitations. First, as a retrospective study, it may have incomplete data due to inadequate documentation in medical records. Second, it was conducted at a single tertiary referral hospital in central Thailand, which may not reflect the national situation of corneal blindness among patients awaiting keratoplasty. However, reviews of multiple reports in Thailand,[6,28-30] including a report from the Thai Red Cross Eye Bank,[21] allowed us to summarize that the primary indication for keratoplasty was infectious keratitis (corneal ulcer) or corneal scar, depending on the research institute. Infectious keratitis was the most common indication in tertiary referral hospitals, whereas corneal scar was the most prevalent indication in non-referral hospitals and the Thai Red Cross Eye Bank. Bullous keratopathy and regraft (graft failure) consistently ranked within the top three indications for keratoplasty in all reports.

Lastly, due to the evolution of EK, corneal dystrophy—mainly FECD—has significantly increased the rates of keratoplasty, especially DMEK. In the future, FECD may become a more common indication for keratoplasty, although perhaps not as high as for active infectious keratitis.

CONCLUSIONS

Active infectious keratitis was the most common indication for keratoplasty, followed by bullous keratopathy and regraft respectively. This study highlights the critical need for prevention, early detection, and appropriate management of infectious keratitis, especially fungal keratitis. Achieving this requires collaborative efforts among government leaders, public health officials, and ophthalmologists. Promoting public education through social media and facilitating free access to antimicrobial agents and immunosuppressive drugs for post-keratoplasty management are also essential.

PKP remained the most common surgical technique due to severe infectious keratitis. However, the use of LK—including EK and DALK—significantly increased for other indications during the second 5-year study period. Moreover, DMEK was primarily performed in eyes with FECD.

Data Availability Statement

The participants of this study did not give written consent for their data to be shared publicly, so due to the sensitive nature of the research supporting data is not available.

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DECLARATION

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Conflicts of Interest

All authors declare that there are no personal or professional conflicts of interest relating to any aspect of this study.

Author Contributions

Conceptualization and methodology, W.B., C.J., C.C., P.N., and S.K.; data collection, C.J.; data analysis and interpretation, W.B., C. J.; writing—original draft, W.B., and C.J.; writing—review and editing, W.B., C.C., and P.N. All authors read and agreed to the published version of the manuscript.

Use of Artificial Intelligence

Not applicable

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