ORIGINAL ARTICLE

# Factors Associated with Vision Impairment in Patients with Corneal Infection at a Secondary Hospital in Thailand

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**Objective:** To examine factors associated with vision impairment (VI) in patients with corneal infections at the end of treatment.

**Materials and Methods:** A retrospective descriptive study was conducted by reviewing the medical records of all patients with corneal infections treated by ophthalmologists at Phichit Medical Education Center, Faculty of Medicine, Naresuan University, a secondary hospital in Thailand between July 1, 2021, and June 30, 2023, a two year period.

**Results:** Eighty-seven patients were included in the study, and included 57 males and 30 females, with an average age of 50 years. Of these, 36.8% contracted corneal infections due to agricultural work. The majority of infections were caused by bacteria, in 55.2%, followed by fungi, in 31.0%, and protozoa for 13.8%. Additionally, 16.7% of patients required referral to tertiary hospitals due to uncontrolled infections, and 6.9% needed enucleation to prevent further infection, all due to bacterial infections. After treatment, 35.5% of patients experienced VI, including 17.2% with blindness. Significant factors associated with VI were a longer duration before treatment (p=0.027) and blindness at initial presentation (p=0.001).

**Conclusion:** VI after the treatment of corneal infections was prevalent. The duration before treatment and the initial level of vision loss were significant predictors of outcomes. Early detection, timely intervention, and prompt referral in rural areas are essential to prevent long-term disability.

**Keywords:** Corneal infection; Keratitis; Vision impairment; Blindness

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Vision impairment (VI) can cause significant disability, severely limiting an individual's ability to perform daily activities, which can affect the quality of life. An estimated 1.5 to 2 million new cases of monocular blindness occur each year as a result of corneal infections, which are a major cause of corneal blindness. These corneal opacities infections are the top five most common causes of blindness globally[1]. The main pathogens involved are viruses, fungi, and bacteria. In developing nations, fungal infections are the most prevalent[2]. While trauma, particularly from agricultural activities, is common in developing countries, contact lens usage is a regular risk factor in developed nations[3].

VI following corneal infection can be influenced by several prognostic factors. Fungal keratitis, particularly from Fusarium and Candida species, is prevalent and often leads to poor visual outcomes, especially when co-occurring with bacterial infections[4,5]. Aging, a history of ocular conditions, the presence of hypopyon, larger infiltrative size, and surgical intervention are associated with a poorer prognosis[4]. Reports from Thai tertiary hospitals, such as university hospitals, have shown that advanced age, poor initial visual acuity, delayed treatment, and larger lesion sizes are predictors of poor final vision[6,7].

In Thailand, secondary hospitals, known as general hospitals, are typically located in provincial capitals or major districts. These hospitals provide secondary care, including ophthalmology services by handling more complex cases than primary care facilities but referring highly specialized cases to tertiary hospitals.

However, no studies have focused on secondary hospitals that manage cases referred from primary healthcare units in rural areas. Therefore, the

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present study aimed to examine the characteristics of patients with corneal infections in a secondary hospital in Thailand and identify factors associated with VI after treatment. Addressing this gap is crucial for improving patient outcomes and ensuring effective management of corneal infections in rural populations.

## Materials and Methods

The present study utilized a retrospective descriptive design, analyzing data from the medical records of all patients diagnosed with corneal infection at Department of Ophthalmology, Phichit Medical Education Center, Faculty of Medicine, Naresuan University, a secondary hospital in Thailand between July 1, 2021, and June 30, 2023, spanning two years. The department was staffed by only three ophthalmologists, none of whom was a corneal specialist.

The study was ethically approved by the Phichit Hospital Ethics Committee (COE No. 0198/2566). It encompassed both outpatient and inpatient cases. Patients with grade 3 corneal infections, based on the modified Jones' criteria[8], required hospital admission. Inclusion criteria were defined according to the Community Eye Health classification of corneal infections[9], which included all clinically diagnosed corneal ulcers. All patients underwent corneal scraping for Gram staining, potassium hydroxide (KOH) preparation, bacterial culture for Chocolate agar, Blood agar, and MacConkey agar, and fungal culture with Sabouraud dextrose agar. Based on these diagnostic findings, patients were classified into three categories, bacterial keratitis, fungal keratitis, and protozoan keratitis. Treatment regimens were aligned with the type and severity of the infection as bacterial infections were managed with either 5% Moxifloxacin eye drops or a combination of 5% Fortified ceftazidime and 5% Fortified vancomycin. Fungal infections were treated with 5% Natamycin eye drops paired with 0.15% Fortified amphotericin B. Protozoan infections, all of which were diagnosed as microsporidial keratitis, were uniformly treated with 5% Moxifloxacin eye drops. No patient received a mixed treatment regimen. Complex cases requiring keratoplasty were referred to tertiary hospitals. Patients who refused treatment or did not attend follow-up appointments as scheduled were excluded from the study, resulting in the exclusion of four cases.

Collected data included patient demographics for gender, age, residence, and occupation, medical history with underlying diseases, incident location, nature of the incident, clinical details such as duration of symptoms before hospital, initial visual acuity, and post-treatment visual acuity, follow-up details such as number of follow-up visits conducted weekly until recovery, and laboratory results for Gram stain and culture results for bacteria, fungi, and protozoa. Data was also collected for three patients who wore contact lenses. Vision loss levels were categorized based on the World Health Organization (WHO) 2015[10] criteria for blindness and VI. Mild vision loss was defined as best-corrected visual acuity (BCVA) of less than 20/70, while moderate vision loss was classified as BCVA between 20/70 and less than 20/200. Severe vision loss was defined as BCVA between 20/200 and less than 20/400, and blindness was defined as BCVA of 20/400 or less. Moderate-to-severe vision loss and blindness were classified as VI[10] in the present study.

Statistical analysis included descriptive statistics, including mean, standard deviation (SD), frequency, percentage, median, and range. Univariate analysis was performed using Fisher's exact test for categorical variables, the t-test for normally distributed continuous variables, and the Mann-Whitney U test for non-normally distributed continuous variables. Statistically significant variables in the univariate analysis and from literature reviews were entered into the multivariable logistic regression analysis to identify factors associated with VI at the end of treatment. The significance level was set at 0.05. Data analysis was performed using IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA).

## Results

The present study consisted of 57 males (65.5% of the population) with a mean age of 50 years (SD 15.7) and 30 females (34.5%) with a mean age of 51 years (SD 16.9). The predominant occupations were agriculture in 42.5% of the cases, and general labor in 26.5%. Most of the patients (63.2%) were referred from other districts and neighboring provinces for 6.9%. The majority of patients (92.0%) were non-smokers. A small number of patients were found to have underlying conditions such as diabetes mellitus in 10.3%, and hypertension in 9.2%. These demographic and clinical characteristics are detailed in Table 1.

Over the two years, 87 eyes from 87 patients with corneal infections were examined, with no instances of bilateral infections reported. Infections were more prevalent in the left eye, at 62.0%, than in the

**Table 1.** General characteristics of patients (n=87)

| Characteristics | |
|---|---|
| Sex; n (%) | |
| Male | 57 (65.5) |
| Female | 30 (34.5) |
| Age (years); mean±SD (min-max: 10 to 78) | 50.6±16.52 |
| Occupation; n (%) | |
| Agriculture | 37 (42.5) |
| General laborer/craftsman | 23 (26.5) |
| Civil servant/company employee | 11 (12.6) |
| Students | 4 (4.6) |
| Monk | 1 (1.2) |
| Unemployed | 11 (12.6) |
| District of residence; n (%) | |
| Muang (Central) District | 26 (29.9) |
| Other districts | 55 (63.2) |
| Other provinces | 6 (6.9) |
| Underlying illnesses; n (%) | |
| Diabetes | 9 (10.3) |
| Hypertension | 8 (9.2) |
| Mental illness | 3 (3.4) |
| Others | 2 (2.3) |
| Smoking | 7 (8.0) |

SD=standard deviation

**Table 2.** Corneal infection characteristics (n=87)

| Characteristics | Number of eyes |
|---|---|
| Infected eye; n (%) | |
| Left | 54 (62.0) |
| Right | 33 (38.0) |
| Clinical diagnostic type; n (%) | |
| Bacteria | 48 (55.2) |
| Fungus | 27 (31.0) |
| Protozoa | 12 (13.8) |
| Foreign body as the cause; n (%) | |
| Leaves/branches/grass clipping | 32 (36.8) |
| Dust | 16 (18.4) |
| Unidentified | 14 (16.1) |
| Insects | 7 (8.0) |
| Metal fragments | 6 (6.9) |
| Dirty water | 4 (4.6) |
| Contact lens | 3 (3.4) |
| Others (cosmetic products, rubbing eye) | 5 (5.7) |
| Detection of microorganisms by tests; n (%) | |
| Gram stain | 9 (10.3) |
| KOH | 7 (8.0) |
| Wright stain | 0 (0.0) |
| Bacterial culture* | 18 (20.7) |
| Fungal culture* | 6 (6.9) |
| Initial level of vision loss (visual acuity by Snellen system); n (%) | |
| Mild (<20/70) | 28 (32.2) |
| Moderate (20/70 to <20/200)** | 19 (21.8) |
| Severe (20/200 to <20/400)** | 11 (12.6) |
| Blindness (≤20/400)** | 29 (33.3) |
| Time to first medical consultation (days); median [IQR] (min-max: 1 to 60) | 5 [7] |

KOH=potassium hydroxide; IQR=interquartile range

* Bacterial culture (chocolate agar, blood agar, MacConkey agar) and fungal culture (Sabouraud dextrose agar); ** Vision impairment (VI)[9] classified as moderate-to-severe vision loss (best correct visual acuity ≤20/70) and blindness (best correct visual acuity ≤20/400)

right, at 38.0%. Bacterial infections emerged as the most common etiology, affecting 48 eyes (55.2%), followed by fungal infections in 27 eyes (31.0%), and protozoan infections in 12 eyes (13.8%).

The etiology of corneal infections was closely linked to occupational and routine activities. Agricultural work was the predominant cause, implicated in 36.8%. Daily exposure to dust accounted for 18.4%, and unidentified incidents were responsible for 16.1%. At the initial assessment of visual acuity before treatment, the largest proportion of patients (33.3%) presented with blindness, nearly equal to those with mild vision loss, at 32.2%. The median time before the first ophthalmological consultation was five days. Initial laboratory investigation found only 10.3% of positive gram stain and 8.0% of positive KOH stain. Substantial results from culture showed 20.7% of positive bacterial culture and 6.9% of positive fungal culture. These findings are detailed in Table 2.

Specific bacterial cultures among patients with bacterial corneal infections revealed *Pseudomonas* spp. in 12 cases (13.8%), *Staphylococcus aureus* in three cases (3.4%), *Streptococcus mitis* in two cases (2.3%), and *Kocuria rosea* in one case (1.1%). Among patients with fungal corneal infections, fungal cultures identified *Curvularia* spp. in four cases (4.6%), *Fusarium* spp. in one case (1.1%), and *Sarocladium* spp. in one case (1.1%).

Among all patients treated for corneal infections, those with fungal infections had the longest median hospital stay at six days, whereas patients with bacterial infections had a median stay of three days. Only two patients with protozoal infections required hospitalization for five days, while others with similar infections were managed as outpatients. Notably, Wright stain for protozoa did not yield any positive results in the present study, despite clinical examination under slit-lamp microscopy revealing irregular shape, variable size, and scattered clusters of corneal lesions characteristic of protozoal keratitis.

In terms of referrals to tertiary hospitals for

**Table 3.** Outcomes of treatment by types of infection (n=87)

| Outcomes of treatment | Bacterial (n=48) | Fungus (n=27) | Protozoa (n=12) | Total (n=87) |
|---|---|---|---|---|
| Level of vision loss (visual acuity by Snellen system); n (%) | | | | |
| Mild (<20/70) | 28 (58.3) | 16 (59.3) | 12 (100) | 56 (64.4) |
| Moderate (20/70 to <20/200) | 6 (12.5) | 5 (18.5) | 0 (0.0) | 11 (12.6) |
| Severe (20/200 to <20/400) | 2 (4.2) | 3 (11.1) | 0 (0.0) | 5 (5.7) |
| Blindness (≤20/400) | 12 (25.0) | 3 (11.1) | 0 (0.0) | 15 (17.2) |
| Length of hospital stay for treatment (days); median [IQR] (min-max) | 3 [7] (0 to 30) | 6 [10] (0 to 47) | 0 [2] (0 to 7) | 3 [7] (0 to 47) |
| Referrals to tertiary hospitals; n (%) | 8 (16.7) | 6 (22.2) | 0 (0.0) | 14 (16.1) |
| Eye enucleations; n (%) | 6 (12.5) | 0 (0.0) | 0 (0.0) | 6 (6.9) |
| Duration of treatment (weeks); median [IQR] (min-max) | 3 [2] (1 to 8) | 3 [2] (1 to 8) | 2 [2] (1 to 4) | 3 [2] (1 to 8) |

IQR=interquartile range

**Table 4.** Univariate analysis of factors associated with level of vision loss at the end of treatment

| Factors | Vision impairment after treatment | | p-value |
|---|---|---|---|
| | Mild (n=56) | Moderate/severe/blindness (n=31) | |
| Female; n (%) | 22 (39.3) | 10 (32.3) | 0.664 |
| Hypertension; n (%) | 4 (7.1) | 4 (12.9) | 0.448 |
| Diabetes; n (%) | 5 (8.9) | 4 (12.9) | 0.715 |
| Smoking; n (%) | 4 (7.1) | 3 (9.7) | 0.696 |
| Bacterial infection; n (%) | 28 (50.0) | 20 (64.5) | 0.261 |
| Vision loss at the initial; n (%) | | | <0.001* |
| Mild | 27 (48.2) | 1 (3.2) | |
| Moderate | 14 (25.0) | 5 (16.1) | |
| Severe | 8 (14.3) | 3 (9.7) | |
| Blindness | 7 (12.5) | 22 (71.0) | |
| Age; n (%) | 45.6±15.5 | 59.6±14.5 | <0.001* |
| Time to treatment (days); median [IQR] | 5 [5] | 8 [11] | 0.001* |

IQR=interquartile range
* p<0.05, considered statistically significant

advanced care, 14 patients (16.1%) required transfer due to the unavailability of a corneal specialist at the authors' secondary hospital and the inability to perform keratoplasty. These included eight patients (16.7% of all bacterial infection cases) with bacterial infections and six patients (22.2% of all fungal infection cases) with fungal infections. Additionally, six patients (6.9%) underwent eye enucleation to prevent the spread of infection, all of whom had bacterial infections, accounting for 12.5% of bacterial infection cases. The median duration of treatment until recovery was three weeks for both bacterial and fungal infections, while protozoal infections required a median treatment duration of two weeks. After completing treatment, the majority of patients (64.4%) regained normal vision. However, 18.3% of patients were left with moderate-to-severe VI, while another 17.2% experienced blindness. Proportions of VI after treatment in bacterial and fungal groups were comparable while protozoal infection demonstrated 100% of no VI (Table 3).

Age, level of VI at the initial, and duration before treatment were found to be associated with VI in the univariable analysis (Table 4). The multivariable logistic regression analysis identified two significant factors associated with VI at the end of treatment, time to treatment (p=0.027) and blindness at the initial presentation (p=0.001) (Table 5). The model demonstrated moderate explanatory power, with an adjusted $R^2$ of 0.430 (Cox & Snell) and 0.590 (Nagelkerke), indicating that the included factors accounted for approximately 59% of the variance in VI outcomes.

## Discussion

The present study examined the characteristics of patients, and the factors associated with VI after treatment for corneal infections in a secondary

**Table 5.** Multivariable logistic regression of factors associated with vision impairment (moderate-to-severe vision loss and blindness) after treatment

| Factors | Adjusted OR | Lower 95% CI | Upper 95% CI | p-value |
|---|---|---|---|---|
| Age | 1.036 | 0.991 | 1.082 | 0.110 |
| Bacterial infection (compared to non-bacterial infections) | 2.127 | 0.513 | 8.812 | 0.298 |
| Ln time to treatment# | 2.788 | 1.125 | 6.910 | 0.027* |
| Vision loss at the initial | | | | |
| Mild | 1 | - | - | - |
| Moderate | 7.473 | 0.698 | 80.009 | 0.096 |
| Severe | 6.778 | 0.540 | 85.054 | 0.138 |
| Blindness | 49.551 | 4.819 | 509.524 | 0.001* |
| Constant | 0.001 | | | <0.001 |

OR=odds ratio; CI=confidence interval

Adjusted $R^2$ 0.430 by Cox & Snell, 0.590 by Nagelkerke

# ln is a natural logarithm of time to treatment

* $p<0.05$, considered statistically significant

hospital in one province in Thailand over two years. Eighty-seven cases were recorded, with the causes of infection linked to both occupational and daily activities, emphasizing the importance of environmental exposure in developing countries.

Bacterial infections were the most common in the present study, accounting for approximately 55.2% of cases, consistent with the findings from Kowalski et al.[11] and Shekhawat et al.[12] and aligned with a study from Southern Thailand by Ngarmsom & Horatanaruang[13], where bacteria were identified in 46.7% of corneal infection cases, underscoring the regional burden of bacterial pathogens. This demonstrated the need for heightened vigilance in managing bacterial keratitis, especially in tropical areas where environmental exposure plays a significant role.

Fungal infections, while less prevalent, were also significant in the present study cohort. Globally, the prevalence of fungal infections dominates the microbial landscape in rural keratitis cases, as noted by Bhagath et al.[14], and Ojha et al[15]. The result of the present study showed that fungal cases required longer hospital stay and more referrals to tertiary hospitals, which aligned with the previous report that fungal keratitis often requires prolonged treatment, with patients frequently needing multiple antifungal medications, leading to extended recovery times[16].

All of the patients who needed eye enucleations suffered from bacterial infections. A previous study in Sydney[17] reported that *Pseudomonas aeruginosa* was the predominant isolate in cases leading to evisceration or enucleation. Fungal keratitis, while less common, was noted in 12.5% of cases in Hungary[18].

The prevalence of VI following bacterial, fungal, and protozoan corneal infection is a significant concern, particularly in tropical regions. Nearly 40% of bacterial and fungal cases in the present study remained VI after treatment. A South Indian cohort revealed that 24% of patients with fungal keratitis had visual acuity worse than 20/60 four years post-treatment, compared to 20% in bacterial cases, indicating a higher risk of severe impairment from fungal infections[19].

Results from the current study showed that duration before treatment and level of vision loss at initial, especially blindness were found to be significant factors associated with VI after treatment in the multivariable model while aging had only association in the univariable model. Aligning with the previous studies, older age, worse presenting visual acuity, and the more severe lesion or size of the infiltrative lesion were associated with increased VI[17,20,21]. Studies in Korea also found that a history of ocular conditions[22], the presence of hypopyon, and surgical treatments, especially in cases of severe infection significantly increased the risk of poor visual prognosis[4].

Delayed treatment is consistently found to be associated with poorer prognoses, as evidenced by multiple studies[23,24]. In cases of fungal keratitis in Northern Thailand, delayed antifungal treatment significantly correlates with treatment failure, particularly in patients with larger lesions[7]. Timely intervention is essential in managing corneal infections, as delays can exacerbate the condition and lead to unfavorable outcomes. As the present study was conducted in a secondary hospital, appropriate community detection and intervention may help

to decrease pre-treatment time and lead to better treatment outcomes. Community intervention[25] such as public education and a prompt referral system from primary care units can be strategized to improve treatment outcomes for corneal infection and decrease disability from VI.

The factor most significantly affecting visual outcomes after treatment was the duration of infection before receiving care from an ophthalmologist. This finding aligns with research from the United States in 1995[26] and the most recent study published in 2024[23], both of which identified the delay in seeking medical attention and the time before receiving proper ophthalmologic treatment as statistically significant factors. Additionally, the present study found that bacterial infections, the most common cause of corneal infections, were a major risk factor associated with severe visual impairment and disability at the end of treatment.

The present study has limitations. It was a retrospective study and treatment regimens were not strictly controlled, potentially affecting the outcomes. Additionally, most cases included in the study were of mild severity, which may limit the generalizability of the findings to more severe cases. Furthermore, the study was conducted at a single secondary hospital in Thailand over a two-year period, which may not fully capture long-term trends or variations in disease patterns. Another limitation was the small sample size in certain subgroups, which resulted in a wide 95% confidence interval in the logistic regression model. This suggested some degree of variability and reduced precision in the effect estimates, though the overall findings remain informative. Future research with a longer data collection period and a broader study population is necessary to enhance the robustness of the findings.

## Conclusion

Patients with corneal infections in the present study were predominantly male and, in the working-age group. The infections were primarily linked to occupational and daily activities, with bacterial infections being more common than fungal ones. The hospital stay for fungal infections was longer compared to bacterial infections. Additionally, 7% of patients required enucleation to prevent the spread of bacterial infections. Patients who experienced VI after treatment had a significantly longer delay before seeing an ophthalmologist and presented with poorer initial visual acuity compared to those who fully recovered. Therefore, it is recommended that appropriate detection and referral systems for patients should be established for timely and effective treatment to prevent long-term disability.

## What is already known about this topic?

Previous reports from tertiary hospitals in Thailand showed that VI following corneal infections is influenced by several factors, including fungal keratitis, aging, a history of ocular conditions, the presence of hypopyon, larger infiltrative size, and the need for surgical intervention. These factors are associated with a poorer prognosis for final vision outcomes.

## What does this study add?

This study, conducted at the Phichit Medical Education Center, a secondary hospital, emphasizes that patients who developed VI after treatment experienced significantly longer delays before consulting an ophthalmologist and presented with poorer initial visual acuity.

## Conflicts of interest

The authors declare no conflict of interest.

## References


1. Ting DSJ, Ho CS, Deshmukh R, Said DG, Dua HS. Infectious keratitis: an update on epidemiology, causative microorganisms, risk factors, and antimicrobial resistance. Eye (Lond) 2021;35:1084-101.
2. Sharma A, Sati A, Bhatt P, Ninawe S, Mahajan P, Patel A, et al. Microbiological profile of infectious keratitis in a tertiary care hospital. J Mar Med Soc 2024;26:220-4.
3. Roongpoovapatr V, Prabhasawat P, Isipradit S, Shousha MA, Charukamnoetkanok P. Infectious keratitis: the great enemy. (Chapter 1) In: Lo Giudice G, Catalá A, editors. Visual impairment and blindness. Rijeka, Croatia: IntechOpen; 2019. p. 3-28.
4. Cho SI, Park YM, Ahn M, Cho NC, You IC. Clinical manifestations and prognostic factors of fungal keratitis: analysis in patients over a 20-year period. J Korean Ophthalmol Soc 2021;62:910-21.
5. Menard M, Shah YS, Stroh IG, Zafar S, Sriparna M, Zhang N, et al. Microbial profile and clinical outcomes of fungal keratitis at a single-center tertiary care hospital. Clin Ophthalmol 2022;16:389-99.
6. Dhirachaikulpanich D, Soraprajum K, Boonsopon S, Pinitpuwadol W, Lourthai P, Punyayingyong N, et al. Epidemiology of keratitis/scleritis-related endophthalmitis in a university hospital in Thailand. Sci Rep 2021;11:11217. doi: 10.1038/s41598-021-90815-1.

7. Tananuvat N, Upaphong P, Tangmonkongvoragul C, Niparugs M, Chaidaroon W, Pongpom M. Fungal keratitis at a tertiary eye care in Northern Thailand: Etiology and prognostic factors for treatment outcomes. J Infect 2021;83:112-8.
8. Al-Mujaini A, Al-Kharusi N, Thakral A, Wali UK. Bacterial keratitis: perspective on epidemiology, clinico-pathogenesis, diagnosis and treatment. Sultan Qaboos Univ Med J 2009;9:184-95.
9. Garg P, Rao GN. Corneal ulcer: diagnosis and management. Community Eye Health 1999;12:21-3.
10. Hirsch LR, Holzer JR, Finnin MS, Cazares SM. WHO categories of visual impairment. In: Significance of retinal lesions potentially caused by dazzling lasers. Alexandria, VA: Institute for Defense Analyses (IDA); 2015. p. 21.
11. Kowalski RP, Nayyar SV, Romanowski EG, Shanks RMQ, Mammen A, Dhaliwal DK, et al. The prevalence of bacteria, fungi, viruses, and acanthamoeba from 3,004 cases of keratitis, endophthalmitis, and conjunctivitis. Eye Contact Lens 2020;46:265-8.
12. Shekhawat NS, Hall LN, Sulewski ME Jr, Woreta F, Wang J, Smith K, et al. Corneal culture and antibiotic susceptibility results for microbial keratitis in the Mid-Atlantic Region of the United States, 2016 to 2020. Eye Contact Lens 2023;49:267-74.
13. Ngarmsom R, Horatanaruang O. Epidemiology of microbial keratitis at a tertiary care hospital in Southern Thailand. Clin Ophthalmol 2024;18:1267-75.
14. Bhagath BC, Prasad S, Natarajan A. Microbial spectrum of keratitis at a rural tertiary care teaching hospital. Cureus 2024;16:e55055.
15. Ojha S, Tandon A, Shukla D, Saraswat N, Joshi S. Etiology of supparative corneal ulcer in rural population of northern India. Indian J Clin Exp Ophthalmol 2015;1:62-7.
16. Radhakrishnan N, Pathak N, Subramanian KR, Das DR, Ningombam R, Khaitan I, et al. Comparative study on costs incurred for treatment of patients with bacterial and fungal keratitis - A retrospective analysis. Indian J Ophthalmol 2022;70:1191-5.
17. Cabrera-Aguas M, Khoo P, Watson SL. Presumed microbial keratitis cases resulting in evisceration and enucleation in Sydney, Australia. Ocul Immunol Inflamm 2023;31:224-30.
18. Tóth G, Pluzsik MT, Sándor GL, Németh O, Lukáts O, Nagy ZZ, et al. Clinical review of microbial corneal ulcers resulting in enucleation and evisceration in a Tertiary Eye Care Center in Hungary. J Ophthalmol 2020;2020:8283131. doi: 10.1155/2020/8283131.
19. Prajna NV, Srinivasan M, Mascarenhas J, Lalitha P, Rajaraman R, McClintic SM, et al. Visual impairment in fungal versus bacterial corneal ulcers 4 years after successful antimicrobial treatment. Am J Ophthalmol 2019;204:124-9.
20. Woodward MA, Niziol LM, Ballouz D, Lu MC, Kang L, Thibodeau A, et al. Prediction of visual acuity in patients with microbial keratitis. Cornea 2023;42:217-23.
21. Zbiba W, Baba A, Bouayed E, Abdessalem N, Daldoul A. A 5-year retrospective review of fungal keratitis in the region of Cap Bon. J Fr Ophtalmol 2016;39:843-8.
22. Kim WJ, Kweon EY, Lee DW, Ahn M, You IC. Prognostic factor and antibiotic susceptibility in bacterial keratitis: results of an eight-year period. J Korean Ophthalmol Soc 2009;50:1495-504.
23. Kodali S, Khan B, Zong AM, Moon JY, Shrivastava A, Daily JP, et al. Prognostic indicators of corneal ulcer clinical outcomes at a tertiary care center in the Bronx, New York. J Ophthalmic Inflamm Infect 2024;14:18. doi: 10.1186/s12348-024-00392-3.
24. Almulhim A, Alkhalifah MI, Kalantan H, Alsarhani WK. Bacterial keratitis: Clinical features, causative organisms, and outcome during a 13-year study period. Cornea 2023;42:702-7.
25. Naseriasl M, Janati A, Amini A, Adham D. Referral system in rural Iran: improvement proposals. Cad Saude Publica 2018;34:e00198516.
26. McLeod SD, LaBree LD, Tayyanipour R, Flowers CW, Lee PP, McDonnell PJ. The importance of initial management in the treatment of severe infectious corneal ulcers. Ophthalmology 1995;102:1943-8.