Clinical profile and treatment outcomes of *Fusarium* keratitis

Ashi Khurana, Ajit Kumar, Lokesh Chauhan

**Purpose:** To determine the seasonality, clinical profile, and treatment outcome of *Fusarium* keratitis.

**Methods:** A retrospective medical chart review of 97 patients with culture-proven *Fusarium* keratitis at a tertiary eye care institution from January 2018 to December 2019. **Results:** The median (SD) age at enrollment was 44.6 (16) years; 75 (79.8%) of them were male. Presence of infiltrate less than 4 mm² at baseline indicated 4.4 times the odds of achieving final BCVA more than 20/60 (95% CI: 1.4–13.3; P = 0.008). The absence of surgical management indicated 8.1 times the odds of achieving final BCVA of more than 20/60 (95% CI: 0.9–71.5; P = 0.06). The visual acuity at presentation, duration between symptoms and presentation, history of ocular trauma, previous use of topical medications, and presence of hypopyon were not identified as significant predictors of final BCVA in the multivariable regression analysis.

**Conclusion:** Smaller infiltrate size and absence of surgical management are the significant predictors of good visual outcome. Visual outcome of *Fusarium* keratitis is poor, and a significant number of patients did not respond to anti-fungal therapy and had to undergo surgeries. To the best of our knowledge, this is the largest case series on *Fusarium* keratitis to date.

**Key words:** *Fusarium* sp, hypopyon, keratitis, sugarcane leaf injury, trauma

Fungal keratitis is one of the most important infectious diseases causing visual disability and accounts for up to 50% of total microbial keratitis. Since the last two decades, all studies from India on fungal keratitis reported that *Aspergillus* and *Fusarium* species have been the most common isolates in fungal keratitis. Use of contact lenses is a major risk factor for fungal keratitis in developed countries but not in most of the studies from India. In developing countries like India, ocular trauma caused by vegetative matter has been reported to be one of the major risk factors for fungal keratitis. Tropical environment of India is an additional predisposing factor for fungal keratitis.

*Fusarium* species are ubiquitous in air, soil, and plants. They cause a broad spectrum of infections in humans who are infected with direct inhalation or contact with *Fusarium*-contaminated materials. In 2006, there was an outbreak of *Fusarium* keratitis in the United States, Singapore, and Hong Kong. Chang et al. reported its association with the use of contact lens solution. In India, the proportion of fungal keratitis attributable to *Fusarium* species varies from 24% to 47%. The incidence of *Fusarium* keratitis is seasonal and peaks during harvesting season. *Fusarium* keratitis can lead to complications such as descemetocele, perforation, and even progression to endophthalmitis.

Many studies describing the predisposing factors, clinical characteristics, and treatment outcome of fungal keratitis have been published from India during the last decade. There are no published reports exclusively on the profile of *Fusarium* keratitis from India. A higher incidence of *Fusarium* keratitis has been observed at our institute. Thus, this study was undertaken to retrospectively analyze seasonality, predisposing factors, clinical characteristics, and treatment outcome of culture-confirmed *Fusarium* keratitis, diagnosed and treated at a tertiary eye care institute located in Moradabad (India).

**Methods**

The study has been approved by the institutional ethics committee. This study adhered to the principles of the Declaration of Helsinki. A medical chart review of consecutive patients presenting with corneal ulcers to the department of cornea between January 2018 and December 2019 was carried out. The institute is a tertiary eye care referral center and caters to patients from the agricultural belt of western Uttar Pradesh (India). All patients with a positive culture of *Fusarium* species obtained from corneal scraping were included in the analysis.

At the baseline visit, a complete medical history (i.e., age, sex, trauma, previous ocular surgery, and underlying systemic disease) was obtained from patients. A detailed examination of both eyes was performed using a slit-lamp biomicroscope. The visual acuity at presentation, symptoms, and size of epithelial defect (with or without hypopyon), and infiltrate as measured...

---

**Correspondence to:** Dr. Ajit Kumar, Department of Cornea and Anterior Segment Services, C L Gupta Eye Institute, Ram Ganga Vihar, Phase 2 (Ext), Moradabad - 244 001, Uttar Pradesh, India. E-mail: ajitk963@gmail.com

**Received:** 26-Apr-2021  **Revision:** 17-Aug-2021  **Accepted:** 06-Dec-2021  **Published:** 25-Feb-2022
by the variable slit on the biomicroscope were documented on each visit, along with detailed posterior segment examination or B-scan ultrasonography where indicated, in all cases on the first visit. A standard case report form was developed to capture pre-identified variables. Sociodemographic data, predisposing risk factors, clinical details, prior treatment modalities (if any), and visual outcomes were noted. For further analysis, details were transcribed into Microsoft Excel. Incomplete records were excluded from the analysis.

Specimen collection and laboratory procedures

Corneal scrapings were obtained from the base and edge of the ulcer by using a sterile surgical blade (# 15 on a Bard–Parker handle) under topical anesthesia (0.5% proparacaine hydrochloride) and slit-lamp magnification in every case on the first visit. Gram stain and 10% potassium hydroxide mount were included as part of the standard protocol for microscopic evaluation of corneal smears. Gram-stained smears were examined at >400 and >1000 magnification; the KOH preparations were examined at >200 and >400 magnification under a light microscope. Scrapings for smears were collected prior to those for culture.

For cultures, the materials were inoculated onto chocolate agar, blood agar, brain heart infusion, and thioglycolate and incubated at 37°C, and Sabouraud dextrose Agar (SDA) was inoculated on two media and incubated at 25°C and 37°C and examined daily during the 1st week, twice weekly for the next 3 weeks, and discarded after 3–4 weeks if there was no growth. Fungi were identified by their colony characteristics on SDA and by the morphological appearance of the spores in lactophenol cotton blue stain, and in some cases by slide culture method. All laboratory methods were performed under standard protocols, which have been discussed in detail in the previous studies.[5,8]

Treatment protocol

Initially, the eyes were treated based on the clinical evaluation and microbiological smear examinations. The eyes were treated with 5% natamycin suspension on an hourly basis along with cycloplegics and oral analgesics in cases where smear examinations show fungal filament/hyphae. Topical voriconazole 1% (Vozole, Aurolab, India) was supplemented for larger and deeper ulcers. In cases of no hyphae/filaments fortified cefuroxime (5%) per hourly and ciprofloxacin (0.3%) eye drops per hourly along with cycloplegics were prescribed.

Statistical analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) software, version 21. Demographic data were presented as mean, standard deviation, and percentage. Univariate analysis was done to assess associations between baseline patient and ulcer characteristics and BCVA at final follow-up. For analysis, duration between symptom and presentation, infiltrate size, and duration of antifungal therapy were grouped into different categories. Comparison of BCVA at final follow-up among different groups was done using an independent t test. Levene’s test was used to assess the equality of variance among independent groups. The Mann–Whitney test was performed to compare the mean of the identified variable among two groups. Categorical data were presented as the number and percentage, and the differences between groups were tested using cross-tabulation, Chi-square test, or Fisher’s exact test. Statistically significant predictors identified in univariate analysis (P < 0.05) were included in a subsequent binary logistic regression model. A Hosmer–Lemeshow test was used to test the goodness of fit of the model.

Results

Epidemiological characteristics

Of the 485 clinically suspected fungal keratitis patients, 94 (19.4%) were positive for Fusarium species. The median age of patients with Fusarium keratitis was 44.6 ± 16 years (range: 10–72 years). Of them, 79 (84%) belonged to rural locations and 15 (16%) to urban locations. There were 75 male patients (79.8%) and 19 female patients (20.2%) (P = 0.00; one sample binomial test). The left eye was involved in 52 (55.3%) patients, and the right eye was involved in 42 (44.7%) patients [Table 1]. There were 61 (64.8%) cases of antecedent ocular trauma prior to the onset of ulceration. Among patients with a history of injury, trauma with vegetative matter was found in 22 (36%) patients. Sugarcane leaf (n = 16/22; 72.7%) was the most common cause among vegetative reasons. Dust particles (n = 20/94; 21.3%) was the main nonvegetative cause of trauma. Distribution of inciting causes is presented in Fig. 1.

The median number of days from onset of symptoms to presentation was 10 days (range: 0–90 days). A total of 38 (40.4%) patients presented within 7 days, 25 (26.6%) between 8 and 14 days, 19 (20.2%) between 15 and 30 days, and 12 (12.8%) after 30 days. Maximum patients presented during summer (Apr–Jun) 32 (34%) and during autumn (Oct–Nov) 28 (29.8%). During winter (Dec–Jan) 9 (9.6%) patients, spring (Feb–Mar) 3 (3.2%) patients and monsoon (Jul–Sep) 22 (23.4%) patients had presented. A total of 41 (43.6%) patients presented during the Kharif cropping season (June–Nov monsoon crop) Table 1.

Seventy-nine (84%) patients had used some topical medications before presentation. Fifty six (n = 56/79; 70.8%) patients were on antibiotics, 44 (n = 44/79; 55.6%) on fluoroquinolone, 26 (n = 26/79; 32.9%) on natamycin, and 29 (n = 29/79; 26.7%) were using antifungal eye drops along with a cocktail of antibiotics and antiviral. Four patients were using steroids and nine were using anesthetic eye drops in combination with other antibiotics and antifungals. Details of medications at presentation are presented in Table 2. The mean duration between onset of symptom and presentation in

![Figure 1: Distribution of inciting causes of Fusarium keratitis](image-url)
patients who were not taking any medicine was 8.6 days and of patients who were on medication was 42.3 days ($P = 0.002$).

Clinical characteristics
At presentation, white-colored infiltrate was noted in 56 (59.5%) eyes, yellow in 21 (22.3%), grey in 16 (17.1%), and brown in 1 (1.1%) eye. Infiltrate edges were feathery in 67 (71.3%) and rounded in 27 (28.7%) eyes. Epithelial plaque was present in 41 (43.6%) eyes. Infiltrate margin was active in 63 (67%), resolving in 22 (23.4%), and scarred in 9 (9.7%) eyes. Thinning was present in 14 (14.9%) eyes. Surrounding cornea was edematous in 46 (48.9%), satellite lesions in 26 (27.7%), and scarred in 18 (19.1%) eyes. Descemetocele was present in 4 (4.3%) eyes.

The location of the ulcer was central in 58 (61.7%) patients and paracentral/peripheral in 36 (38.3%) patients. The median infiltrate size (length × breadth) was 8.0 mm$^2$ (IQR: 16 mm$^2$). The mean infiltrate size of centrally located ulcer eyes was 17.5 mm$^2$ and of eyes with paracentral/peripheral ulcers was 8.1 mm$^2$ ($P = 0.003$). Hypopyon was present in 12 (12.8%) patients ranging from 0.5 to 2 mm. Clinical characteristics of Fusarium keratitis are presented in Fig. 2.

The presenting visual acuity in the affected eye was more than 20/30 in 16 (17%) eyes, less than 20/30 to 20/60 in 12 (12.8%) eyes, less than 20/60 to 20/200 in 13 (13.8%) eyes, and less than 20/200 in 53 (56.4%) eyes. A total of 10 (83.3%) patients with hypopyon had presenting visual acuity of less than 20/200. Although all scrapings grew fusarium on culture, only sixty-six (70.2%) were found to be positive for fungal hyphae on KOH staining of the corneal scrapings on the initial visit and Gram stain smears of the same smears were positive for fungal hyphae in only 30 (31.9%) cases. No mixed infection was reported in these patients.

Management and treatment outcome
The BCVA at last follow-up was more than 20/30 in 16 (17%) eyes, less than 20/30 to 20/60 in 15 (15.9%) eyes, less than 20/60 to 20/200 in 18 (19.1%) eyes, and less than 20/200 in 45 (47.8%) eyes. A comparison between presenting visual acuity and visual acuity at last follow-up is presented in

| Variable                                  | Category | Frequency | Percent |
|-------------------------------------------|----------|-----------|---------|
| Age (years)                               | <18      | 4         | 4.3     |
|                                           | 18-25    | 10        | 10.6    |
|                                           | 26-35    | 11        | 11.7    |
|                                           | 36-45    | 18        | 19.1    |
|                                           | 46-55    | 24        | 25.5    |
|                                           | 56-65    | 19        | 20.2    |
|                                           | >65      | 8         | 8.5     |
| Gender                                    | Female   | 19        | 20.2    |
|                                           | Male     | 75        | 79.8    |
| Location                                  | Rural    | 79        | 84.0    |
|                                           | Urban    | 15        | 16.0    |
| Duration between onset of symptoms and presentation (days) | <7 | 30 | 40.4 |
|                                           | 8-14     | 25        | 26.6    |
|                                           | 15-30    | 19        | 20.2    |
|                                           | >30      | 12        | 12.8    |
| Season                                    | Winter   | 9         | 9.6     |
|                                           | Spring   | 3         | 3.2     |
|                                           | Summer   | 32        | 34.0    |
|                                           | Monsoon  | 22        | 23.4    |
|                                           | Autumn   | 28        | 29.8    |
| Medication before presentation            | Yes      | 79        | 84.0    |
|                                           | No       | 15        | 16.0    |

Figure 2: Clinical characteristics of Fusarium keratitis (a) feathery margin, (b) grey infiltrate, (c) active edges, (d) resolving infiltrate, (e) ring infiltrate, (f) dry plaque
Table 3. The median duration of antifungal therapy given was 18 days (IQR: 26 days). Details of adjuvant therapy are presented in Table 4. A total of 69 (73.4%) patients were managed medically, and surgery was performed in 25 (26.5%) patients. A total of 23 (n = 23/58; 39.6%) patients with centrally located ulcer required surgery as compared to 2 (n = 2/36; 5.5%) with paracentral/peripheral ulcer (P = 0.00; Fisher exact test). Tissue adhesive and bandage contact lenses were applied in 6 (6.4%) eyes, therapeutic penetrating keratoplasty (TPK) was performed in 14 (14.8%) eyes, and intraocular antibiotics were given in 3 (3.2%) eyes. Resurgery was done in 14 (14.9%) eyes. Visual acuity at last follow-up was improved or remained unchanged in 79 (84%) patients, and decreased in 15 (15.9%) patients. A total of 4 (n = 4/58; 6.8%) patients with centrally located ulcer achieved BCVA of more than 20/30 at last follow-up as compared to 12 (n = 12/36; 33.3%) with paracentral/peripheral ulcer (P = 0.00; Fisher exact test).

Univariate analyses comparing baseline characteristics of those who achieved BCVA of >20/60 at last follow-up compared with those who did not are outlined in Table 5. The best-corrected visual acuity at the last follow-up was 1.75 ± 1.2 logMAR in patients with infiltrate size of >4 mm² and 0.53 ± 0.86 log MAR in patients with infiltrate size of ≤4 mm² was (P = 0.00; Mann–Whitney test). Seven patients had total infiltrate at the time of presentation, and six of them required therapeutic penetrating keratoplasty. The BCVA at last follow-up of these patients was less than 20/200. Similarly, BCVA at last follow-up in patients who had undergone surgery was 2.27 ± 1.0 as compared to 1.01 ± 1 logMAR in medically managed patients (P = 0.00; Mann–Whitney test). The mean BCVA at last follow-up was 2.43 ± 0.8 logMAR in the patients in whom resurgery was performed as compared to 1.18 ± 1.1 logMAR in others (P = 0.00; Mann–Whitney test). The median infiltrate size of patients who were managed surgically was 9.5 mm², and of patients who were managed

| Table 2: Medications at the time of presentation |
|----------------------|------------|----------------------|----------------------|----------------------|----------------------|
| Drug 1 | Drug 2 | Drug 3 | Drug 4 | No of Pts |
| Fluoroquinolones | Nil | | | 7 |
| Anthhistamine | | | | 1 |
| Anesthetic | | | | 2 |
| Azole antifungal | Nil | | | 4 |
| Chloramphenicol | | | | 1 |
| Quinolone | | | | 1 |
| Aminoglycoside | Nil | | | 4 |
| Quinolone | | | | 1 |
| Anesthetic | | | | 2 |
| Aminoglycoside | Nil | | | 4 |
| Quinolone | | | | 1 |
| Anesthetic | | | | 2 |
| Natamycin | Nil | | | 4 |
| Aminoglycoside | | | | 1 |
| Anesthetic | | | | 2 |
| Triazole antifungal | Nil | | | 4 |
| Azole antifungal | | | | 1 |
| Triazole antifungal | | | | 2 |
| Aminoglycoside | | | | 2 |
| Triazole antifungal | | | | 2 |
| Imidazole antifungal | Anesthetic | | | 3 |
| Natamycin | | | | 1 |
| Chloramphenicol | | | | 2 |
| Azole Antifungal | | | | 3 |
| Polymyxins | | | | 1 |
| Antiviral | | | | 1 |
| Quinolone | Nil | | | 1 |
| Steroid | | | | 1 |
| Azole antifungal | | | | 1 |
| Aminoglycoside | Nil | | | 1 |
| Imidazole antifungal | | | | 1 |
| Triazole antifungal | | | | 1 |
| Azole antifungal | Beta-lactams | | | 1 |
| Chloramphenicol | Steroid | | | 1 |
| Antiviral | Nil | | | 1 |
| Anesthetic | Nil | | | 1 |
medically was 8 mm² (P = 0.11). A total of 92% of surgically managed patients had central location of ulcer as compared to 50% of medically managed patients (P = <0.001). Similarly, 88% of surgically managed patients had BCVA of <20/200 as compared to 44% of medically managed patients (P = 0.003). Only 3 (12%) surgically managed patients had a presentation time of less than 7 days as compared to 24 (34%) medically managed patients (P = 0.03). Hypopyon was present in 24% surgically managed patients and in 8.6% medically managed patients (P = 0.07) [Table 6].

Results of the multivariate model reported that the presence of infiltrate <4 mm² at baseline indicated 4.4 times the odds of achieving final BCVA more than 20/60 (95% CI: 1.4–13.3; P = 0.008). The absence of surgical management indicated 8.1 times the odds of achieving final BCVA of more than 20/60 (95% CI: 0.9–71.5; P = 0.06). At last follow-up, scarring was present in 23 (24.4%) patients and healed cornea in 24 (25.5%) patients.

Discussion

Fusarium species is a leading cause of fungal keratitis. Reports of Fusarium keratitis are mainly from countries that experienced its outbreak during 2005–06 and also one recent report from Germany. Fusarium has been isolated in almost every study on fungal keratitis published from India. Keratitis due to filamentous fungus mainly occurs during harvesting and other agriculture work in rural settings and in field/construction workers in urban settings. In our study, the majority of the patients belonged to rural areas. Seasonal variation in the incidence of Fusarium keratitis was identified in our study. Majority of patients presented to us during the Kharif crop season. Sugarcane is the main crop of the Kharif season in the study area. In our study, injury by sugarcane leaf accounted for 72% of all ocular trauma caused by vegetative reasons. The seasonality of fungal keratitis has also been reported in previous studies. Bharathi et al also reported that wind and crop harvesting play an important role in ocular injuries caused

Discussion

Fusarium species is a leading cause of fungal keratitis. Reports of Fusarium keratitis are mainly from countries that experienced its outbreak during 2005–06 and also one recent report from Germany. Fusarium has been isolated in almost every study on fungal keratitis published from India. Keratitis due to filamentous fungus mainly occurs during harvesting and other agriculture work in rural settings and in field/construction workers in urban settings. In our study, the majority of the patients belonged to rural areas. Seasonal variation in the incidence of Fusarium keratitis was identified in our study. Majority of patients presented to us during the Kharif crop season. Sugarcane is the main crop of the Kharif season in the study area. In our study, injury by sugarcane leaf accounted for 72% of all ocular trauma caused by vegetative reasons. The seasonality of fungal keratitis has also been reported in previous studies. Bharathi et al also reported that wind and crop harvesting play an important role in ocular injuries caused

Discussion

Fusarium species is a leading cause of fungal keratitis. Reports of Fusarium keratitis are mainly from countries that experienced its outbreak during 2005–06 and also one recent report from Germany. Fusarium has been isolated in almost every study on fungal keratitis published from India. Keratitis due to filamentous fungus mainly occurs during harvesting and other agriculture work in rural settings and in field/construction workers in urban settings. In our study, the majority of the patients belonged to rural areas. Seasonal variation in the incidence of Fusarium keratitis was identified in our study. Majority of patients presented to us during the Kharif crop season. Sugarcane is the main crop of the Kharif season in the study area. In our study, injury by sugarcane leaf accounted for 72% of all ocular trauma caused by vegetative reasons. The seasonality of fungal keratitis has also been reported in previous studies. Bharathi et al also reported that wind and crop harvesting play an important role in ocular injuries caused

Discussion

Fusarium species is a leading cause of fungal keratitis. Reports of Fusarium keratitis are mainly from countries that experienced its outbreak during 2005–06 and also one recent report from Germany. Fusarium has been isolated in almost every study on fungal keratitis published from India. Keratitis due to filamentous fungus mainly occurs during harvesting and other agriculture work in rural settings and in field/construction workers in urban settings. In our study, the majority of the patients belonged to rural areas. Seasonal variation in the incidence of Fusarium keratitis was identified in our study. Majority of patients presented to us during the Kharif crop season. Sugarcane is the main crop of the Kharif season in the study area. In our study, injury by sugarcane leaf accounted for 72% of all ocular trauma caused by vegetative reasons. The seasonality of fungal keratitis has also been reported in previous studies. Bharathi et al also reported that wind and crop harvesting play an important role in ocular injuries caused

Discussion

Fusarium species is a leading cause of fungal keratitis. Reports of Fusarium keratitis are mainly from countries that experienced its outbreak during 2005–06 and also one recent report from Germany. Fusarium has been isolated in almost every study on fungal keratitis published from India. Keratitis due to filamentous fungus mainly occurs during harvesting and other agriculture work in rural settings and in field/construction workers in urban settings. In our study, the majority of the patients belonged to rural areas. Seasonal variation in the incidence of Fusarium keratitis was identified in our study. Majority of patients presented to us during the Kharif crop season. Sugarcane is the main crop of the Kharif season in the study area. In our study, injury by sugarcane leaf accounted for 72% of all ocular trauma caused by vegetative reasons. The seasonality of fungal keratitis has also been reported in previous studies. Bharathi et al also reported that wind and crop harvesting play an important role in ocular injuries caused
Table 5: Best-corrected visual acuity at the last follow up in different groups

| Variable                        | Category                | n     | BCVA at last follow-up | P       |
|---------------------------------|-------------------------|-------|------------------------|---------|
|                                 |                         |       | Mean [log MAR]         | Std. Dev. |
| Days from onset of symptoms to presentation | ≥7 Days                 | 56    | 1.52                   | 1.250    | 0.15    |
|                                 | <7 Days                 | 38    | 1.13                   | 1.119    | 0.72    |
| Inciting Cause                  | Yes                     | 61    | 1.39                   | 1.187    | 0.00*   |
|                                 | No                      | 33    | 1.30                   | 1.262    | 0.00*   |
| Infiltrate Size                 | >4 mm²                  | 64    | 1.75                   | 1.155    | 0.00*   |
|                                 | ≤4 mm²                  | 30    | 0.53                   | 0.860    | 0.00*   |
| Hypopyon                        | Yes                     | 12    | 1.75                   | 1.215    | 0.21    |
|                                 | No                      | 82    | 1.30                   | 1.204    | 0.00*   |
| Surgery                         | Yes                     | 26    | 2.27                   | 1.002    | 0.00*   |
|                                 | No                      | 68    | 1.01                   | 1.099    | 0.00*   |
| Re-surgery                      | Yes                     | 14    | 2.43                   | 0.852    | 0.00*   |
|                                 | No                      | 80    | 1.18                   | 1.167    |         |

*Statistically significant

Table 6: Distribution of characteristics among medically and surgically managed patients

| Variable                        | Category | Medical Management | Surgical Management | Total | P       |
|---------------------------------|----------|--------------------|---------------------|-------|---------|
|                                 |          |                    |                     |       |         |
|                                 |          |                    |                     |       |         |
| Ulcer Location                  | Central  | 35                 | 23                  | 58    | <0.001  |
|                                 | Paracentral | 34            | 2                   | 36    |         |
| Infiltrate Category             | <4 mm    | 19                 | 3                   | 22    | 0.11    |
|                                 | >4 mm    | 50                 | 22                  | 72    |         |
| Presenting VA                   | >20/30   | 15                 | 1                   | 16    | 0.003   |
|                                 | 20/30‑20/60 | 11           | 1                   | 12    |         |
|                                 | 20/60‑20/200 | 12         | 1                   | 13    |         |
|                                 | <20/200  | 31                 | 22                  | 53    |         |
| Hypopyon                        | No       | 63                 | 19                  | 82    | 0.04    |
|                                 | Yes      | 6                  | 6                   | 12    |         |
| Medication at Presentation      | No       | 12                 | 3                   | 15    | 0.52    |
|                                 | Yes      | 57                 | 22                  | 79    |         |
| Duration between symptom and presentation | <7 Days | 24                 | 3                   | 27    | 0.03    |
|                                 | >7 Days  | 45                 | 22                  | 67    |         |

by vegetative reasons. Male preponderance was reported in our study with a male:female ratio of 3.9:1. This ratio is higher than reported by Satpathy et al.\[3\] Males are more vulnerable to fungal keratitis due to their work profile in the study area where women do not work in the fields often.

Half of the patients presented after 10 days from onset of symptoms. The mean duration of delay was comparable among patients belonging to rural or urban locations. This delay was largely attributed to having visited other local eye care/health care providers. Self-medication and availing of over-the-counter medication from local pharmacies are also a reason behind this delay in presentation. The majority of the cases were on medication before presenting to us, and a significant number of patients were referred by general ophthalmologists from nearby areas. None of them had undergone a microbiological workup or species identification. This may be due to the limited availability of cornea specialists and ocular microbiology practice in the study area. The delay in diagnosis has also been reported in previous studies.\[28‑30\] Patients who were taking medications were presented late at eye care centers. The significant difference in duration between onset of symptoms and presentation is because patients who are using topical medications without microbiological testing are under a false assurance and delay proper eye care consultation and present later and perhaps with a more advanced stage of ulcer than those who present without any prior medication to the eye care center.

In our study, we noticed that because of lack of microbiology workup, all cases at presentation were using either only antibiotics or anti-fungal therapy with a cocktail of antibiotics and antiviral, thereby causing further delay in healing due to drug toxicity or dilution. The alarming use of anesthetic eye drops was also noted in some cases in our area, which was not noted in other recent reports. These cases had further delay in presentation because of temporary improvement in symptoms but had worse presentation in ulcer size, time to healing, and complications. There was markedly less number of cases with topical corticosteroids abuse reported in our study as compared to older studies even though most cases were from rural background, suggesting
greater awareness about harmful side effects of steroids in ulcers. In a study on fungal keratitis by Cho et al., 36.1% of the study population were using topical corticosteroids previously. Chowdhary et al. from north India also reported the use of previous topical corticosteroids in 21% of patients. However, Kumar et al. from the same geographical area reported previous use of topical corticosteroids in 3.6% of patients of dematiaceous fungal keratitis. The alarmingly high use of fluoroquinolones by physicians in all ulcers without microbiology workup may give rise to concerns about emerging antibiotic resistance.

In our study, the majority of eyes had a central ulcer. Srinivasan et al. also reported Fusarium as the most common fungal isolate among eyes with infectious central corneal ulceration, isolated in 47.1% of cases. Ghosh et al. also reported central location of ulcer in 69.8% of cases of Fusarium keratitis. The infiltrate size of central ulcer was significantly greater than that of paracentral/peripheral ulcer. Half of the patients presented with BCVA of less than 20/200. Approximately 80% of eyes with hypopyon had presenting BCVA of less than 20/200. The BCVA at last follow-up of eyes with central ulcer was worse as compared to paracentral/peripheral ulcer.

Topical natamycin was given in all cases in addition to voriconazole for larger and deeper ulcers. This is consistent with other studies from India and worldwide. Prajna et al. also reported that Natamycin has a better treatment outcome as compared to voriconazole treatment for smear-positive filamentous fungal keratitis. Jones et al. reported 16 of 18 consecutive cases of Fusarium keratitis treated successfully with Natamycin. Forty-seven percent of eyes had not achieved a visual acuity of >20/200. Poorer visual outcomes in cases of fungal keratitis have been reported in previous studies. Surgical intervention was performed in one-fourth of the eyes. TPK was performed in 14% of eyes. In a previous study by Ghosh et al., TPK was performed in 23.3% of Fusarium keratitis eyes. In our study, TPK was performed in 15% of eyes. The visual outcome of most of these eyes was poor (<20/200). All eyes except one undergoing TPK had a central ulcer. Iyer et al. reported final vision of less than 20/200 in 52% of eyes who had undergone TPK. There were a few limitations of this study. The depth of lesion was not included in the analysis as it was not available for all patients.

**Conclusion**

In conclusion, Fusarium keratitis is a serious ophtalmic condition associated with poorer outcomes. Males working in fields were mostly affected. Forty percent of eyes with centrally located ulcers required surgery. Patients who were managed medically had significantly better visual outcomes than patients who had undergone surgeries. Larger ulcer size was found associated with poorer visual outcomes. Location of ulcer, infiltrate size, BCVA at presentation, and eyes undergoing surgery was found significantly associated with BCVA at last follow-up. To the best of our knowledge, our study is the largest compilation of epidemiological features and treatment outcome of Fusarium keratitis.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Srinivasan M, Gonzales CA, George C, Cevallos V, Mascarenhas JM, Asokan B, et al. Epidemiology and aetiological diagnosis of corneal ulceration in Madurai, South India. Br J Ophthalmol 1997;81:965-71.
2. Ung L, Bispo PJM, Shanbhag SS, Gilmore MS, Chodosh J. The persistent dilemma of microbial keratitis: Global burden, diagnosis, and antimicrobial resistance. Surv Ophthalmol 2019;64:255-71.
3. Satpathy G, Ahmed NH, Nayak N, Tandon R, Sharma N, Agarwal T, et al. Spectrum of mycotic keratitis in North India: Sixteen years study from a tertiary care ophthalmic centre. J Infect Public Health 2019;12:367-71.
4. Sharma N, Sahay P, Maharana PK, Singhal D, Saluja G, Bandivadekar P, et al. Management algorithm for fungal keratitis: The TST (Topical, systemic, and targeted therapy) protocol. Cornea 2019;38:141-5.
5. Prajna VN, Prajna L, Muthiah S. Fusgal keratitis: The Aravind experience. Indian J Ophthalmol 2017;65:912-9.
6. Ghosh AK, Gupta A, Rudramurthy SM, Paul S, Hallur VK, Chakrabarti A. Fusarium keratitis in North India: Spectrum of agents, risk factors and treatment. Mycopathologia 2016;181:843-50.
7. Rautary A, Sharma S, Kar S, Das S, Sahu SK. Diagnosis and treatment outcome of mycotic keratitis at a tertiary eye care centre in Eastern India. BMC Ophthalmol 2011;11:39.
8. Tilak R, Singh A, Maurya OP, Chandra A, Tilak V, Gulati AK. Mycotic keratitis in India: A five-year retrospective study. J Infect Dev Ctries 2010;4:171-4.
9. Iyer SA, Tuli SS, Wagoner RC. Fusarial keratitis: Emerging trends and treatment outcomes. Eye Contact Lens 2006;32:267-71.
10. Gower EW, Keay LJ, Oechsler RA, Iovieno A, Alfonso EC, Jones DB, et al. Trends in fungal keratitis in the United States, 2001 to 2007. Ophthalmol Physiol Opt 2010;117:2263-7.
11. Chowdhary A, Singh K. Spectrum of fungal keratitis in North India. Cornea 2005;24:8-15.
12. Ahearn DG, Zhang S, Stulting RD, Schwam BL, Simmons RB, Ward MA, et al. Fusarium keratitis and contact lens wear: Facts and speculations. Med Mycol 2005;46:397-410.
13. Bharathi MJ, Ramakrishnan R, Meenakshi R, Padmavathy S, Shivakumar C, Srinivasan M. Microbial keratitis in South India: Influence of risk factors, climate, and geographical variation. Ophthalmic Epidemiol 2007;14:61-9.
14. Centers for Disease Control and Prevention (CDC). Fusarium keratitis—multiple states, 2006. MMWR Morb Mortal Wkly Rep 2006;55:400-1.
15. Khor W-B, Aung T, Saw S-M, Wong T-Y, Tambyah PA, Tan A-L, et al. An outbreak of Fusarium keratitis associated with contact lens wear in Singapore. JAMA 2006;295:2867-73.
16. Tsang T. Fusarial keratitis among contact lens users. Communicable Diseases Watch. Available from: http://www.info.gov.hk/dh/diseases/CDwatch/CDW_V3_4.pdf. [Last accessed on 2006 Feb 5].
17. Chang DC, Grant GB, O’Donnell K, Wannemuehler KA, Noble-Wang J, Rao CY, et al. Multistate outbreak of Fusarium keratitis associated with use of a contact lens solution. JAMA 2006;296:953-63.
18. Bharathi MJ Ramakrishnan R, Vasu S, Meenakshi R, Palaniappan R. Epidemiological characteristics and laboratory diagnosis of fungal keratitis. A three-year study. Indian J Ophthalmol 2003;51:315-21.
19. Xie L, Zhong W, Shi W, Sun S. Spectrum of fungal keratitis in north China. Ophthalmology 2006;113:1943-8.
20. Dursun D, Fernandez V, Miller D, Alfonso EC. Advanced fusarium keratitis progressing to endophthalmitis. Cornea 2009;22:300-3.
21. Dóczi I, Gyetvai T, Kredics L, Nagy E. Involvement of *Fusarium* spp. in fungal keratitis. Clin Microbiol Infect 2004;10:773-6.

22. Kumar A, Khurana A, Sharma M, Chauhan L. Causative fungi and treatment outcome of dematiaceous fungal keratitis in North India. Indian J Ophthalmol 2019;67:1048-53.

23. Oldenburg CE, Prajna VN, Prajna L, Krishnan T, Mascarenhas J, Vaitilingam CM, et al. Clinical signs in dematiaceous and hyaline fungal keratitis. Br J Ophthalmol 2011;95:750-1.

24. Sengupta S, Rajan S, Reddy PR, Thiruvengadakrishnan K, Ravindran RD, Lalitha P, et al. Comparative study on the incidence and outcomes of pigmented versus non pigmented keratomycosis. Indian J Ophthalmol 2011;59:291-6.

25. Rathi HS, Venugopal A, Rengappa R, Ravindran M. Scedosporium keratitis: An experience from a tertiary eye hospital in South India. Cornea 2016;35:1575-7.

26. Walther G, Stasch S, Kaerger K, Hamprecht A, Roth M, Cornely OA, et al. Fusarium keratitis in Germany. J Clin Microbiol 2017;55:2983-95.

27. Khurana A, Chanda S, Bhagat P, Aggarwal S, Sharma M, Chauhan L. Clinical characteristics, predisposing factors, and treatment outcome of Curvularia keratitis. Indian J Ophthalmol 2020;68:2088-93.

28. Roy P, Das S, Singh NP, Saha R, Kajla G, Snehaa K, et al. Changing trends in fungal and bacterial profile of infectious keratitis at a tertiary care hospital: A six-year study. Clin Epidemiol Global Health 2017;5:40-5.

29. Arunga S, Kintoki GM, Gichuhi S, Onyango J, Newton R, Leck A, et al. Delay along the care seeking journey of patients with Microbial keratitis in Uganda. Ophthalmic Epidemiol 2019;26:311-20.

30. Claerhout I, Goegebuer A, Van Den Broecke C, Kestelyn P. Delay in diagnosis and outcome of Acanthamoeba keratitis. Graefes Arch Clin Exp Ophthalmol 2004;242:648-53.

31. Cho CH, Lee SB. Clinical analysis of microbiologically proven fungal keratitis according to prior topical steroid use: A retrospective study in South Korea. BMC Ophthalmol 2019;19:207.

32. Prajna NV, Krishnan T, Mascarenhas J, Rajaraman R, Prajna L, Srinivasan M, et al. Mycotic Ulcer Treatment Trial Group. The mycotic ulcer treatment trial: A randomized trial comparing natamycin vs voriconazole. JAMA Ophthalmol 2013;131:422-9.

33. Jones DB, Forster RK, Rebell G. Fusarium solani keratitis treated with natamycin (pimaricin): Eighteen consecutive cases. Arch Ophthalmol 1972;88:147-54.