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Colletotrichum truncatum species complex: Treatment considerations and review of the literature for an unusual pathogen causing fungal keratitis and endophthalmitis

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ABSTRACT

We present a case of *Colletotrichum truncatum* species complex fungal keratitis and endophthalmitis in an 87-year-old immunocompetent male in whom oral triazole antifungals were contraindicated. The patient had recently returned from 4 months in Jamaica with a one month history of progressively increasing pain and inflammation in his left eye. Corneal samples grew a filamentous fungus and internal transcribed spacer sequencing polymerase chain reaction confirmed the presence of *C. truncatum* species complex. Samples showed no microbial growth.

1. Introduction

Fungal endophthalmitis is a vision-threatening infection that is usually seen in immunocompromised individuals with fungemia, intravenous drug users, or immunocompetent individuals following direct inoculation from penetrating ocular trauma [1,2]. Fungal endophthalmitis is generally associated with poor visual outcomes and retinal detachment is a frequent occurrence [2]. However, fungi account for only 2–10% of all endophthalmitis cases making this serious condition quite rare [1].

Yeasts, especially *Candida albicans*, are the most common cause of culture-proven fungal endophthalmitis, followed by molds, usually *Aspergillus* species [2,3]. A limited number of species of *Colletotrichum* have been reported to cause infection in humans. The majority of these cases have been keratitis with a few endophthalmitis cases due to *Colletotrichum dematium* [4] and *Colletotrichum truncatum* [5].

The treatment of fungal endophthalmitis is a serious challenge for ophthalmologists as the outcome is unfavorable in a considerable number of cases. The treatment protocol in fungal endophthalmitis is still not optimized due to the low incidence of this disease at most centers. Various regimens combining oral and topical antifungals have been reported, including triazole and polyene antifungals. Unfortunately triazoles have been responsible for a number of clinically significant drug interactions. Triazoles are inhibitors of lanosterol 14 α-demethylase, which prevents lanosterol production and thereby cell membrane integrity. They also inhibit other cytochrome P450 enzymes, including CYP3A4 and CYP2C9. Therefore a number of CYP3A4 and CYP2C9 substrate drugs, such as alpha-adrenergic antagonists (ex. tamsulosin) are contraindicated, especially when administered in the high doses needed to treat fungal endophthalmitis [6,7].

This case report describes a patient on tamsulosin with *C. truncatum* fungal keratitis and endophthalmitis. Susceptibility data for this species is presented and we review the literature on the treatment and outcomes after ocular infections from *Colletotrichum* species.

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1.1. Case

An 87 year-old man who recently returned to Canada after spending 4 months in Jamaica, presented (day 0) with a 1 month history of progressively increasing pain, redness, excessive tearing, decreased vision, and lid swelling in his left eye. He denied any history of ocular trauma or contact lens wear. The patient had decreased hearing but was otherwise healthy and was taking acetylsalicylic acid 81 mg daily. He reported that his doctor in Jamaica prescribed him an unknown topical ophthalmic solution. Once back in Canada he was seen by an optometrist who treated him with topical moxifloxacin and referred the patient 3 weeks later given the patient's worsening condition.

On examination of the patient's left eye, uncorrected visual acuity was light perception. The left pupil was fixed and mid-dilated. Intraocular pressure (IOP) was 22 mmHg. Slit lamp examination revealed limbal neovascularization; conjunctival injection; inferior keratic precipitates; a 4×5 mm^2, 90% thinned area of corneal stromal haze with no overlying epithelial defect; a dense cataract; and a shallow anterior chamber with temporal iridocorneal touch. Dilated fundoscopy was difficult but the retina appeared flat. A provisional diagnosis of herpes simplex immune stromal keratitis with uveitis was made. The patient was started on oral acyclovir 400 mg 5 times daily, as well as topical prednisolone acetate 1% four times daily, timolol maleate 0.5% twice daily, artificial tears four times daily, and Lacrilube ointment (Allergan, Irvine, CA) before bed.

Two weeks later (day 15), the patient's pain was improved with stable visual acuity, stable IOP, and diminished conjunctival injection. At the 3 week follow-up appointment (day 22), the cornea appeared hazier and had developed an ectatic bulge. A hypopyon measuring 1.6 mm was present and the cataract had become intumescent and white. Retinal consultation was sought and the prednisolone drops were increased to every 2 h, and dexamethasone 0.1% ointment before bed and home atropine 5% three times daily were added. One week later (day 28), the hypopyon had resolved but a 2×2 mm^2 epithelial defect at the 10 o'clock mid-peripheral cornea was noted. Topical moxifloxacin 4 times daily was restarted, prednisolone was decreased to 4 times daily, and the patient continued on oral acyclovir 400 mg 2 times daily as well as timolol/dorzolamide 2 times daily. The patient presented one week later (day 35) with increased redness and eye pain. A geographic ulcer covered the nasal half of the cornea and there was absent corneal sensation. Oral acyclovir was increased to 400 mg 5 times daily, prednisolone was decreased to 2 times daily and antibiotic prophylaxis was started. A week later (day 43), the patient presented with corneal perforation and uveal prolapse.

Urgent pars plana vitrectomy and lensectomy using a temporary keratoprosthesis, and penetrating keratoplasty was performed (day 51). The host cornea was divided into 2 and sent for pathological examination and bacterial and fungal culture. Direct microscopic examination of the specimen for fungi was not performed, as there was a very small amount of tissue received. Intravitreal injections of ceftazidime 2.25 mg/0.1 ml and vancomycin 0.1 mg/0.1 ml were given and post-operatively the patient was prescribed homatropine 5% three times daily, prednisolone 4 times daily, fortified vancomycin 31 mg/ml 4 times daily, fortified tobramycin 13.6 mg/ml 4 times daily, moxifloxacin 4 times daily, and oral acyclovir 400 mg 5 times daily.

On post-operative day (POD) 2 (day 53), the patient was admitted by the urology service for anuria secondary to benign prostatic hyperplasia (BPH). On slit lamp examination, the graft surface had epithelialized, peripheral anterior synechiae had formed 360 degrees, Descemet's membrane folds consistent with early post-operative stromal edema and pigmented precipitates on the endothelium were present. On POD 4 (day 55), the fungal culture became positive for a filamentous fungus, which grew on Sabouraud's agar with gentamicin, brain heart infusion agar with chloramphenicol, cycloheximide and gentamicin, and on Inhibitory Mold Agar. The initial colonial appearance was of a flat white colony with grey speckles and a beige periphery, with a grey reverse (Fig. 1). The culture was referred to the reference mycology laboratory, where it was found to be non-sporulating when examined microscopically. It was sent for ITS2 (internal transcribed spacer) sequencing PCR for identification. By POD 6 (day 57), the preliminary pathology report documented the presence of hyphae in the corneal tissue (Fig. 2). The molecular identification was reported as *Colletotrichum capsici*. After 7 days incubation, identifying features of sporulation were observed on microscopy of the colony, including dark brown, spherical and setose sclerotia, brown, rigid, smooth-walled setae, brown variably shaped appresoria, and one-celled falcate conidia (Fig. 3) with an acute apex. Further molecular testing, based on DNA sequencing using a combination of different primer sets and the MycoBank (CBS-KNAW) reference database indicated that the fungal identification was most consistent with *C. truncatum* species complex. Loci assessed included: D1/D2 (100% *C. truncatum,* accession No. DQ286159), ITS3/ITS4 (100% *C. truncatum*, accession No. AJ301944), beta-tubulin (*C. truncatum* 99.798%, accession No. HM575221.1), and translation elongation factor 1α (*C. truncatum* 96.538). Some entries indicated a high degree of homology with *C. capsici*, which is a synonym of *C. truncatum* and also of *Colletotrichum jasminigenum*, which is part of the *C. truncatum* species complex.

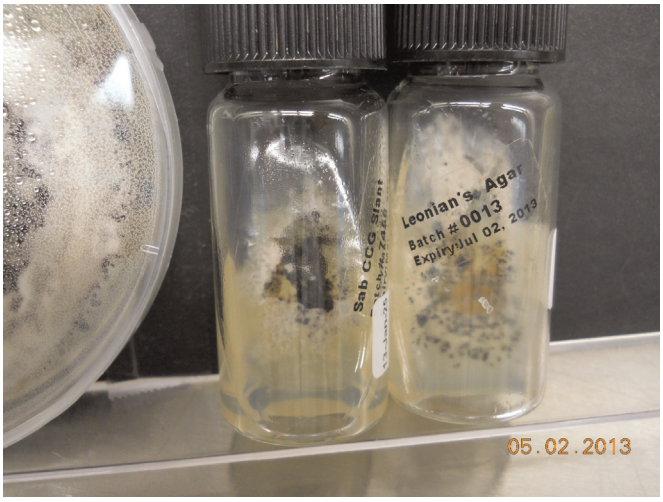

Fig. 1. Initial growth in Sabouraud's agar (left) and brain heart infusion agar (right).

Since the patient was receiving tamsulosin for his advanced BPH, an oral triazole was contraindicated. Infectious diseases was consulted and recommended that 0.15% amphotericin B could be used. Intravitreal injection of amphotericin B 0.01 mg/0.1 ml was attempted but the patient could not tolerate it. A subconjunctival depot was administered (day 78).

The patient once again was lost to follow-up and presented one month later (day 112) with a painful blind eye, mildly injected conjunctiva, clear PK graft with intact epithelium, a large fibrin plaque adherent to the endothelium, and dense vitritis on B-scan ultrasound, consistent with presumed fungal endophthalmitis. At this time, the patient requested and underwent left eye evisceration and reconstruction (day 129). GMS stained section from the evisceration specimen showed fungal elements in the corneal graft and in the anterior chamber (Fig. 4).

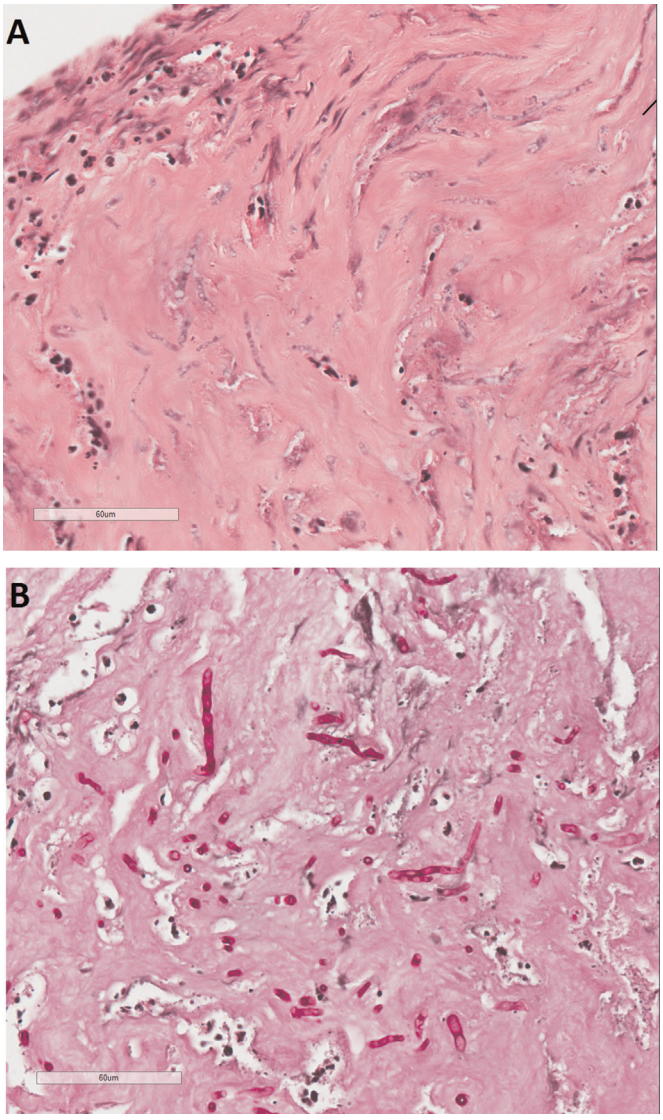

Fig. 2. The presence of hyphae in the corneal tissue of the host was first identified on POD 6 (day 57), H&E stain, X40 (A) and PAS stain, X40 (B).

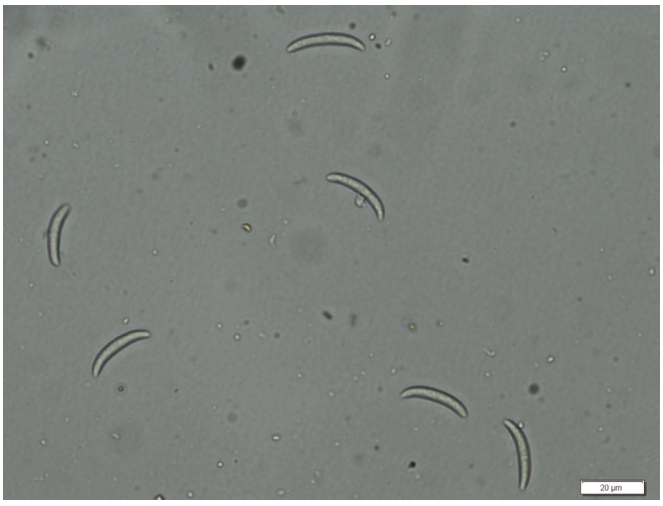

Fig. 3. Identifying sporulating featuring of *C. truncatum*.

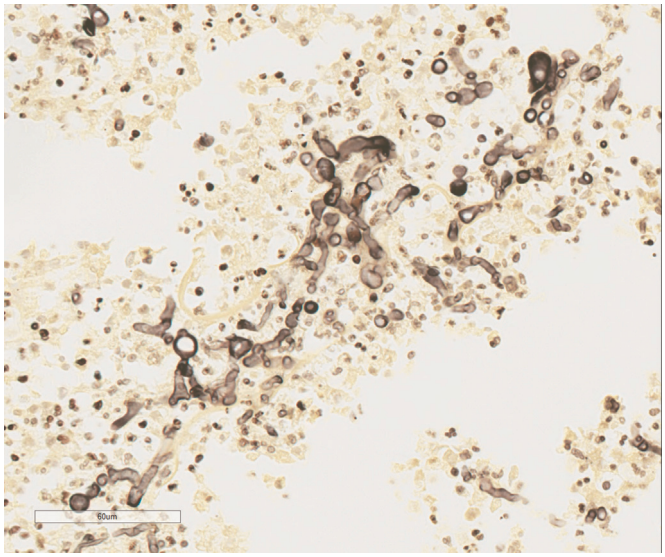

Fig. 4. Septated hyphae with small branching were seen in the anterior chamber, GMS stain, X40.

2. Discussion

Fungal endophthalmitis is an uncommon, but potentially blinding condition requiring early, aggressive therapy. Unfortunately, fungal endophthalmitis is often a diagnostic and treatment challenge for ophthalmologists because it can masquerade as other more common causes of keratitis or uveitis. Some studies have reported rates of misdiagnosis for *Candida endophthalmitis* approaching 50% [1]. Non-candida species have been infrequently documented. This report describes an even less common case of *C. truncatum* keratitis and endophthalmitis identified using molecular methods. The diagnosis was made from the pathological and microbiological analysis of the corneal tissue submitted after PK surgery 3 months after the onset of the patient's symptoms.

Colletotrichum species are coelomycetous soil fungi that are common in tropical and subtropical regions of the world as saprophytes of plants. They usually enter tissue by trauma with organic matter [8]. Traumatic implantation is important for the initiation of infection, as the conidia (spores) are contained in the asexual fruiting body and are not freely released. A small case series from India reported a history of ocular trauma from 5 of 6 patients with ocular infection due to *C. truncatum* and the sixth patient was 70 years old so trivial trauma that went unnoticed could not be excluded [5]. Similarly, no obvious history of trauma could be elicited from our 87-year-old patient so it was possible that he suffered minor trauma that was disregarded due to HSV-related neurotrophic corneal disease. It is probable that our patient acquired the fungus in Jamaica, either through swimming or other contact with environmental fungi, aided by mild trauma or pre-existing disease.

Colletotrichum species may be slow to sporulate and may show subtle morphological features, which makes the conventional microscopic identification difficult. Thus, the molecular approach is very helpful in making a rapid genus and species diagnosis. Phylogenetic analysis based on the nucleic acid sequence of the ITS region of the organism's ribosomal DNA is the most common method for fungal identification, but is unsatisfactory for determining the specific species of *Colletotrichum*, though it reliably identifies the *Colletotrichum* genus and major clades within it. It has been shown that increasing the number of loci that are

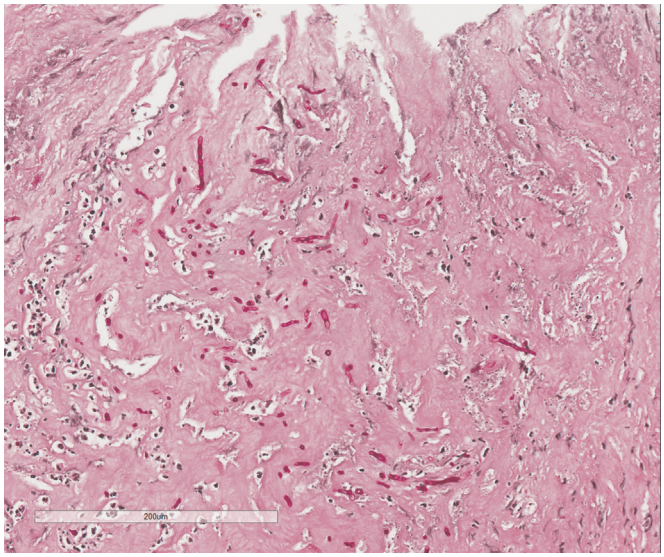

Fig. 5. PAS-stained slide shows septated hyphae X20.

sequenced, increases the reliability of distinguishing individual species in this genus [9]. Thus, when we sequenced 3 other loci (especially beta-tubulin and D1/D2), it became apparent that this isolate fell into the *C. truncatum* species complex. *C. capsici* is an outmoded synonym for *C. truncatum*, which is still present in the GenBank sequence database (National Center of Biotechnology Information). In a small prospective case series of fungal ocular infections from India, Shivaprakash et al. misidentified all 6 strains causing ocular infection as *C. dematium* due to its close morphological resemblance to *C. truncatum* [5]. This evidence emphasizes the need for molecular techniques for species identification.

The final microbiology report stated that the isolated organism, *C. capsici*, was a "probable contaminant," citing its known status as a plant pathogen. Since the original specimen sent for culture was very small, direct microscopy was not performed, which, if positive, would have helped to support the pathogenic role that this fungus was playing in this particular patient, as opposed to considering it a probable contaminant. However, light microscopy of the pathology tissue sample demonstrated the intracellular presence of the organism within the corneal stroma (Fig. 5), thus supporting its pathogenic role. The lab was initially unable to perform susceptibility testing for the isolate because of its poor ability to sporulate, however, by the time it was sent to a reference antifungal susceptibility testing laboratory (Fungus Testing Laboratory, University of Texas), it had sporulated to the extent that susceptibility testing could be carried out.

Other factors complicating the management of this case included the patient's non-compliance with follow-up visits and the issue of a triazole anti-fungal being contraindicated in the patient since he was on tamsulosin, an 1a-selective alpha blocker frequently used to treat BPH. Orally administered triazoles such as fluconazole and voriconazole achieve therapeutic vitreous levels that would have suited this aphakic patient [10]. Unfortunately, we were unable to treat the patient with an oral triazole because he was taking oral tamsulosin for BPH. A theoretical contraindication exists with the concomitant use of tamsulosin and strong CYP3A4 inhibitors including triazoles such as ketoconazole, posaconazole, and voriconazole, because it may increase the serum concentration of tamsulosin. High serum concentrations of tamsulosin could result in adverse cardiorespiratory effects including dyspnea, hypotension, syncope, tachycardia, atrial fibrillation as well as adverse genitourinary effects such as priapism [7]. Bradycardia and hypotonia have been reported in acute tamsulosin intoxication [6]. This is an important consideration since BPH and tamsulosin usage is common in elderly males. The ophthalmologist should be aware of these potential drug interactions when developing a treatment plan for a patient on an alpha-blocker who develops an ocular fungal infection and seek the expertize of infectious disease specialists. In our case, topical amphotericin B was the recommended agent.

Regarding specific treatments for *Colletotrichum* species, there is very little information on drug susceptibility in the literature. The clinical data indicate that ocular infections due to *Colletotrichum* species (*C. dematium, Colletotrichum gloeosporioides*) respond well to natamycin [11–15] although amphotericin B is the treatment of choice in vitro [12,14,16]. MIC results from two studies indicated that *Colletotrichum* species are susceptible to amphotericin, itraconazole, miconazole, micafungin, and voriconazole, but resistant to natamycin, 5-fluorocytosine, and fluconazole [12,15,16]. Unfortunately there are no interpretive guidelines and no in vitro-in vivo correlation studies for *Colletotrichum* species infections. Marangon and colleagues noted that even though voriconazole did very well in their in-vitro susceptibility analysis, it was not effective in clinical use for two of their patients with *Colletotrichum* keratitis [13]. In both of these cases, topical treatment with a 1% solution failed to control the infection, but resolved with topical natamycin [13]. Giaconi and colleagues reported similar results [14].

The results of our in-vitro antifungal susceptibility testing are the first to be published in the literature for *C. truncatum* (Table 1). Like *C. dematium* and *C. gloeosporioides*, *C. truncatum* is also susceptible to amphotericin B in addition to posaconazole. In contrast to the literature, we found that in addition to 5-fluorocytosine, *C. truncatum* showed high and probably resistant MICs to voriconazole and relatively high MICs to ketoconazole, itraconazole, and miconazole. Unfortunately, these data were not available during the course of the patient's care to aid in the management of our patient.

Additional successful treatments specific to fungal endophthalmitis used in various combinations with natamycin include oral and topical voriconazole [12,16,17] as well as topical antibiotics [11,12], intravitreal amphotericin-B [5,10], systemic steroids [18], and vitrectomy [10]. Additional details regarding the treatment and outcomes of reported cases of *Colletotrichum* species ocular infections are summarized in Table 2.

In conclusion, although *Colletotrichum* species infections in humans are rare, this case report highlights the expanding spectrum of infectious agents responsible for fungal keratitis and endophthalmitis and the treatment considerations that may arise in a patient with a contraindication to anti-fungal triazoles. Any uncommon fungus should not be disregarded as a contaminant when isolated from important, especially intraoperative specimens in which the direct microscopic examination of the primary specimen is positive for fungal elements. In addition, it is

Table 1
Minimal inhibitory concentration (MIC) values of different antifungal drugs for *C. truncatum* from analysis of cornea tissue harvested from the patient during his penetrating keratoplasty.

Drug	MIC (μg/mL)
Amphotericin B	0.5
5-Fluorocytosine	>64
Itraconazole	2
Ketoconazole	2
Posaconazole	0.5
Voriconazole	16
Miconazole	2

Table 2
Summary of reported treatment and outcomes of *Colletotrichum* species ocular infections.

Reference	Clinical specimen type	Species (number of cases)	Method of identification	Treatment	Duration of Treatment	Outcome
Fernandez et al. [15][a]	Corneal scrape	Colletotrichum spp. (4)	Direct microscopy, positive culture	Topical natamycin; ± oral amphotericin B	Natamycin: 26–54 days; amphotericin B: 27 days	Final Va = 20/30 – NLP
		C. gloeosporioides (3)	Direct microscopy, positive culture	Topical natamycin; ± amphotericin B and itraconazole; or intravitreal amphotericin B, TPK, oral fluconazole	Natamycin: 25–30 days; amphotericin B: 90 days; itraconazole: 20 days	Final Va = 20/20–20/60
		C. dematium (3)	Direct microscopy, positive culture	Topical natamycin	50–52 days	Final Va = 20/20–20/25
Kaliamurthy et al. [11]	Corneal scrape	*C. dematium* (1)	Direct microscopy	Topical natamycin and ciprofloxacin, hourly (6); Topical ciprofloxacin and tobramycin	10-60 days	2 needed TPK; Final Va = 20/20–20/400
Marangon et al. [13]	Corneal scrape	Colletotrichum spp. (14)	–	Topical voriconazole, hourly	18 days	Failed voriconazole; Resolved with 3 months of topical natamycin
Giaconi et al. [14] [a]	Corneal scrape	*C. dematium* (1)	Direct microscopy	Topical voriconazole	16 days	Failed voriconazole; resolved with 3 months of topical natamycin; Final Va = 20/200
Chakrabarti et al. [4]	Vitreous tap	*C. dematium* (1)	Direct microscopy ± positive culture	PPV; intravitreal amphotericin B; intravitreal dexamethasone; oral fluconazole or itraconazole	6 weeks	Final Va ≥ 20/400; attached retina, preserved globe anatomy, no active inflammation
Mitani et al. [16] [a,b]	Corneal scraping	*C. gloeosporioides* (1)	Direct microscopy, positive culture	Topical voriconazole, topical natamycin, oral voriconazole	3 months	Final Va = 20/25
Takezawa et al. [17]	Corneal scraping	*C. gloeosporioides* (1)	Direct microscopy, positive culture	Topical voriconazole, topical natamycin, topical levofloxacin	Not available	Final Va = 20/25
Shivaprakash et al. [5]	Vitreous tap	*C. truncatum* (2)	DNA sequencing	Intravitreal amphotericin B, PPV; ± itraconazole, dexamethasone	Not available	Clinical improvement; partial improvement (CF at 1.5 m)
	Corneal scrape	C. truncatum (3), Colletotrichum spp. (1)	DNA sequencing	TPK; ± oral and topical fluconazole	Not available	Clinical improvement
Shiraishi et al. [12][a,b]	Corneal scrape	*C. gloeosporioides* (3)	DNA sequencing	Topical voriconazole and natamycin; ± oral voriconazole; ± topical miconazole; ± topical moxifloxacin; ± topical levofloxacin	2–3 weeks	Final Va = 20/16–20/300

NLP, no light perception; TPK, therapeutic penetrating keratoplasty; PPV, pars plana vitrectomy

[a] Based on susceptibility data.

[b] Published minimal inhibitory concentration values.

important to look for microbiologic evidence of all possible etiologies of keratitis/endophthalmitis at the first visit, i.e. bacterial, viral and fungal. This will permit the rapid diagnosis and treatment of these infections, so as to protect sight and ensure the best outcome. A travel history may be helpful in considering unusual agents of infection. It is unclear whether species identification is necessary for the management of this infection, but it is important for the epidemiology of the disease. As the morphological identification of the agent is difficult, molecular techniques can help in its accurate diagnosis. With respect to management, a team approach involving ophthalmology, pathology, microbiology, and infectious diseases, is essential to ensure that the safest and most efficacious treatment is selected. There must be a high level of suspicion to achieve an early diagnosis of fungal keratitis. Once the diagnosis has been made, prompt treatment is necessary. Future studies are required to further understand the epidemiology and optimal management of the *C. truncatum* species complex.

Conflict of interest

CC has previously received honoraria from Allergan, Alcon Labs, and Bausch & Lomb. DW has previously received honoraria from Alcon/Novartis, Bausch & Lomb, Bayer, Labtician, Allergan. SR has previously received research grants from Astellas and Pfizer. YY, AA, NN, and VS have no financial disclosures. No funding was provided for this work.

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References

[1] Shen YC, Wang CY, Tsai HY, Lee HN. Intracameral voriconazole injection in the treatment of fungal endophthalmitis resulting from keratitis. Am. J. Ophthalmol. 2010;149:916–21.
[2] Lingappan A, Wykoff CC, Albini TA, Miller D, Pathengay A, Davis JL, et al. Endogenous fungal endophthalmitis: causative organisms, management strategies, and visual acuity outcomes. Am. J. Ophthalmol. 2012;153:162–6.
[3] Khan FA, Slain D, Khakoo RA. Candida endophthalmitis: focus on current and future antifungal treatment options. Pharmacotherapy 2007;27:1711–21.
[4] Chakrabarti A, Shivaprakash MR, Singh R, Tarai B, George VK, Fomda BA, et al. Fungal endophthalmitis: fourteen years' experience from a center in India. Retina 2008;28:1400–7.
[5] Shivaprakash MR, Appannanavar SB, Dhaliwal M, Gupta A, Gupta S, Gupta A, et al. Colletotrichum truncatum: an unusual pathogen causing mycotic keratitis and endophthalmitis. J. Clin. Microbiol. 2011;49:2894–8.
[6] Anand JS, Chodorowski Z, Wisniewski M, Chodorowski Z. Acute intoxication with tamsulosin hydrochloride. Clin. Toxicol. 2005;43:311.
[7] Michel MC, de la Rosette JJ. Efficacy and safety of tamsulosin in the treatment of urological diseases. Expert Opin. Pharmacother. 2004;5:151–60.
[8] Mendiratta DK, Thamke D, Shukla AK, Narang P. Keratitis due to Colletotrichum dematium–a case report. Indian J. Med. Microbiol. 2005;23:56–8.
[9] Cannon PF, Damm U, Johnston PR, Weir BS. Colletotrichum-current status and future directions. Stud. Mycol. 2012;73:181–213.
[10] Riddell Jt Comer GM, Kauffman CA. Treatment of endogenous fungal endophthalmitis: focus on new antifungal agents. Clin. Infect. Dis. 2011;52:648–53.
[11] Kaliamurthy J, Kalavathy CM, Ramalingam MDK, Prasanth DA, Jesudasan CAN, Thomas PA. Keratitis due to a coelomycetous fungus: case reports and review of the literature. Cornea 2004;23:3–12.
[12] Shiraishi A, Araki-Sasaki K, Mitani A, Miyamoto H, Sunada A, Ueda A, et al. Clinical characteristics of keratitis due to Colletotrichum gloeosporioides. J. Ocul. Pharmacol. Ther. 2011;27:487–91.
[13] Marangon FB, Miller D, Giaconi JA, Alfonso EC. In vitro investigation of voriconazole susceptibility for keratitis and endophthalmitis fungal pathogens. Am. J. Ophthalmol. 2004;137:820–5.
[14] Giaconi JA, Marangon FB, Miller D, Alfonso EC. Voriconazole and fungal keratitis: a report of two treatment failures. J. Ocul. Pharmacol. Ther. 2006;22:437–9.
[15] Fernandez V, Dursun D, Miller D, Alfonso EC. Colletotrichum keratitis. Am. J. Ophthalmol. 2002;134:435–8.
[16] Mitani A, Shiraishi A, Uno T, et al. In vivo and in vitro investigations of fungal keratitis caused by Colletotrichum gloeosporioides. J. Ocul. Pharmacol. Ther. 2009;25:563–5.
[17] Takezawa Y, Shiraishi A, Noda E, et al. Effectiveness of in vivo confocal microscopy in detecting filamentous fungi during clinical course of fungal keratitis. Cornea 2010;29:1346–52.
[18] McGowan G, Lockington D, Imrie F. The firework display of fungal endogenous endophthalmitis. Postgrad. Med. J. 2010;86:509.