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Spectrum and Susceptibilities of Microbial Isolates in Bacterial Keratitis

Bakteriyel Keratitlerin Bakteriyel Spektrumu ve Antimikrobiyal Duyarlılık Profili

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SUMMARY

Introduction: *The aim of this study was to determine the microbial distribution and antibiotic susceptibility patterns of corneal scrapings isolated from patients with bacterial keratitis.*

Materials and Methods: *The study included a survey of all positive corneal scrapings submitted to the microbiology laboratory over a period of five years (2002-2006) at Hadassah University Hospital. Fungal, protozoal, mycoplasma, and mycobacteria isolates were excluded from this survey.*

Results: *During this five-year period, 259 positive corneal scrapings for presumed bacterial keratitis were reported. Gram-positive organisms were the commonest bacterial isolates. The most common pathogens isolated were Staphylococcus species (n= 104, 40.2%), Pseudomonas aeruginosa (n= 44, 17.0%), Streptococcus species (n= 31, 12.0%), and Propionibacterium species (n= 22, 8.5%). There were 218 adults and 41 children. The microbiological survey showed no differences in the main bacterial isolates from corneal scrapings between children and adults. Gram-positive bacteria were sensitive to vancomycin (100%), ceftriaxone (100%), rifampicin (98.2%), teicoplanin (97.6%), and ofloxacin (90.9%), while gram-negative bacteria were sensitive to ceftazidime (100%), ceftriaxone (100%), meropenem (100%), ciprofloxacin (98.6%), piperacillin-tazobactam (98.2%), aztreonam (98.2%), ofloxacin (97.1%), amikacin (97.1%), and gentamicin (94.3%).*

Conclusion: *Staphylococcus species were determined as the most common causative organism for bacterial keratitis. Gram-positive susceptibility was highest for vancomycin, teicoplanin and ofloxacin, while gram-negative bacterial susceptibility was highest for ceftazidime, ceftriaxone and meropenem.*

Key Words: *Antibiotic susceptibility, Microbial isolates, Bacterial keratitis.*

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ÖZET

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Giriş: *Bu çalışmada amaç, bakteriyel keratit sebebiyle alınmış kornea kazıntılarından izole edilen bakteriyel spektrumun ve antibiyotik duyarlılıklarının saptanmasıdır.*

Materyal ve Metod: *Hadassah Üniversitesi Hastanesinde beş yıl süresince (2002 ve 2006 yılları arası) mikrobiyoloji laboratuvarına dahil edilmiş bütün kültür pozitif kornea kazıntılarının sonuçları çalışma kapsamına alındı. Fungus, mikoplazma, protozoa ve mikobakteriler çalışma dışı bırakıldı.*

Bulgular: *Bu beş yıllık süreçte, bakteriyel keratit tanısı düşünülen gözlerden alınan kornea kazıntılarının 259'unda pozitif sonuç bildirilmiştir. Bunlar arasında gram-pozitif mikroorganizmalar çoğunluk teşkil etmiştir. En sık izole edilen bakteriler sırasıyla Staphylococcus türleri (n= 104, %40.2), Pseudomonas aeruginosa (n= 44, %17.0), Streptococcus türleri (n= 31, %12.0) ve Propionibacterium türleri (n= 22, %8.5) olarak bulunmuştur. Örneklerin çoğu 218 göz ile erişkinlerden oluşmuştur. Çocuk ve erişkinler arasında en sık izole edilen bakteriler arasında fark yoktu. Vankomisin (%100) gram-pozitif bakterilere karşı en etkili antibiyotik olarak tespit edilmiş, bunu seftriakson (%100), rifampisin (%98.2), teikoplanin (%97.6) ve ofloksasin (%90.9) izlemiştir. Bu oran gram-negatiflerde ise sırasıyla seftazidim (%100), seftriakson (%100), meropenem (%100), siprofloksasin (%98.6), piperasilin-tazobaktam (%98.2), aztreonam (%98.2), ofloksasin (%97.1), amikasin (%97.1) ve gentamisin (%94.3) olarak bulunmuştur.*

Tartışma: *Staphylococcus suşları en yaygın bakteriyel keratit etkeni olarak bulunmuştur. Gram-pozitifler en yüksek hassasiyeti vankomisin, teikoplanin ve ofloksasine, gram-negatifler ise seftazidim, seftriakson ve meropeneme karşı göstermişlerdir.*

Anahtar Kelimeler: *Antimikrobiyal duyarlılık, Mikrobiyal izolatlar, Bakteriyel keratitler*

INTRODUCTION

Bacterial keratitis is an ocular emergency because progression of this corneal infection may cause visual loss and corneal perforation. The goals of treating bacterial keratitis are to eliminate the causative organisms, suppress the destructive reactions, restore normal ocular structure, and restore vision. When there is sufficient evidence based on clinical examination to raise the suspicion for a possible infectious etiology, laboratory studies are required to establish the identity of the specific causative organism and to determine antimicrobial susceptibility. Initial therapy regimens should include intensive delivery of broad-spectrum antibiotics until the final culture results and sensitivities are available. Initial antimicrobial therapy can be modified based on clinical impression and the results of bacterial susceptibility to antibiotics if needed[1,2].

Antibiotics may be administered in the treatment of bacterial keratitis by topical, subconjunctival, and systemic routes. Topical application is reported to be more effective, especially with concentrated antibiotic eye drops, frequent application, with the corneal epithelium removed, and when treatment is started early[3,4].

The aim of this study was to determine the microbial distribution and antibiotic susceptibility patterns of positive corneal scrapings isolated from patients who presented to the Hadassah University Hospital, Ophthalmology Department, with presumed bacterial keratitis.

MATERIALS and METHODS

We retrospectively reviewed all consecutive positive corneal scrapings submitted to the microbiology laboratory at a tertiary-care teaching hospital, the Hadassah University Hospital in Jerusalem, between 2002 and 2006.

Ulceration was defined as a corneal epithelial defect associated with an underlying acute suppurative infiltrate in the stroma and/or the presence of variable endothelial or anterior chamber reaction, diffuse bulbar and/or limbal injection, chemosis, discharge, lid edema, severe pain, and photophobia[3]. Corneal scrapings of all patients were sent for culture and antibiotic susceptibility. The involved eye was anesthetized with a local anesthetic eye drop (oxybuprocaine hydrochloride) prior to collection of the specimens of corneal scrapings under the slit lamp. Corneal scrapings were taken from the edge and the base of each ulcer. A heat-sterilized platinum Kimura spatula was directly inoculated onto the surface of blood agar, chocolate agar and Sabouraud's dextrose agar and into a thioglycollate broth. Smears were also prepared for Gram and Giemsa stains before treatment was initiated. The media were sent to the Department of Clinical Microbiology and Infectious Diseases, Hadassah University Hospital, Jerusalem, for culture and antibiotic susceptibility. Once the specimens were collected, broad-spectrum topical antibiotic drops were administered. Fungal, protozoal, mycoplasma, and mycobacteria isolates, and cultures yielding mixed growth were excluded from this survey.

Any bacterial growth from corneal scrapings obtained during the study enrollment was considered a positive bacterial culture and was identified using standard bacteriological techniques[5]. Microbial cultures were considered positive only if growth of the same organism was demonstrated on two or more solid media, or there was semi-confluent growth at the site of inoculation on one solid medium associated with the identification of the organism of appropriate morphology and staining characteristics on Gram- or Giemsa-stained corneal smears. In vitro antibiotic susceptibilities were determined by the modified Stokes' comparative disc method[6]. The selection of antibiotics tested in this fashion was determined by the identity of the organism according to local protocols.

RESULTS

Two hundred fifty-nine culture-proven consecutive isolates from the corneal scrapings of bacterial keratitis were included in the study. There were 218 adults (over 16 years of age) and 41 children. Mean (± SD) age was 50.3 ± 22.4 years for adults and 47.6 ± 26.5 months for children.

There were 137 (56.7%) males and 105 (43.3%) females.

The microbiological survey showed no differences in the main bacterial isolates from corneal scrapings between children and adults (Table 1). Overall, gram-positive organisms comprised 71.4% (185 cases) of all bacterial isolates, and gram-negative organisms accounted for 28.6% (74 cases) of the isolates.

The distribution of bacterial species is shown in Table 1. Sixteen different bacterial species were detected among the 259 isolates examined from the 242 people.

The most common isolated microorganisms were *Staphylococcus* species (40.2%) followed by *Pseudomonas aeruginosa* (17.0%), *Streptococcus* species (12.0%), *Propionibacterium* species (8.5%), and undefined gram-positive rods (8.1%), and the least common were *Serratia* species, *Klebsiella* species, *Bacillus* species, *Haemophilus influenzae, Moraxella* species, *Escherichia coli, Morganella morganii, Enterobacter cloacae, Citrobacter koseri, Providencia stuartii, Clostridium perfringens, and Acinetobacter lwoffii*.

Antibiotic susceptibility of all bacterial isolates is shown in Table 2.

Vancomycin (100%), teicoplanin (97.6%), and ofloxacin (90.9%) were the most active agents against the gram-positive isolates. All isolates of *Staphylococcus* and *Streptococcus* were susceptible to vancomycin. Ceftazidime (100%), ceftriaxone (100%), meropenem (100%), ciprofloxacin (98.6%), piperacillin-tazobactam (98.2%), aztreonam (98.2%), ofloxacin (97.1%), amikacin (97.1%), and gentamicin (94.3%) were the most active agents against gram-negative isolates.

Ceftriaxone (100%) and ofloxacin (94.1%) were most effective against gram-positive and gram-negative isolates.

DISCUSSION

Bacterial keratitis is a significant cause of ocular morbidity that can result in severe visual loss. The specific etiologic organisms have been found to vary some what over time and with geographic location, patient population and the health of the cornea itself[4,7]. Microbial cultures help modify the therapy of patients with severe keratitis and aid in the determination of susceptibility to various antimicrobial agents at a time when there is increasing resistance encountered among ocular isolates.

It was reported that the trend of gram-positive bacteria is increasing while that of gram-negative bacteria is decreasing as a cause of bacterial keratitis[8,9]. Gram-positive bacteria, and amongst them *Staphylococcus* species, were the most common corneal surface organisms cultured from patients

Table 1. Bacterial species isolated from corneal scrapings

	Children n (%)	Adult n (%)	Total n (%)
Gram-positive organisms*	29 (70.7)	156 (71.6)	185 (71.4)
Staphylococcus spp.	16 (39.0)	88 (40.4)	104 (40.2)
Streptococcus spp.	7 (17.1)	24 (11.0)	31 (12)
Propionibacterium spp.	3 (7.3)	19 (8.7)	22 (8.5)
Undefined rods	3 (7.3)	18 (8.3)	21 (8.1)
Bacillus spp.	0	6 (2.8)	6 (2.3)
Clostridium perfringens	0	1 (0.5)	1 (0.4)
Gram-negative organisms*	12 (29.3)	62 (28.4)	74 (28.6)
Pseudomonas aeruginosa	9 (22.0)	35 (16.1)	44 (17)
Serratia spp.	0	10 (4.6)	10 (3.9)
Moraxella spp.	0	3 (1.4)	2 (1.2)
Klebsiella spp.	1 (2.4)	5 (2.3)	6 (2.3)
Haemophilus influenzae	1 (2.4)	2 (0.9)	3 (1.2)
Acinetobacter lwoffii	0	1 (0.5)	1 (0.4)
Escherichia coli	1 (2.4)	1 (0.5)	2 (0.8)
Enterobacter cloacae	0	1 (0.5)	1 (0.4)
Citrobacter koseri	0	1 (0.5)	1 (0.4)
Morganella morganii	0	2 (0.9)	2 (0.8)
Providencia stuartii	0	1 (0.5)	1 (0.4)

* Difference between groups: p> 0.5.

with bacterial keratitis examined in the present study, comprising 185 and 104 of 259 isolates, respectively. This finding was consistent with that observed in studies conducted in Northern India, Nigeria, the United States, Israel, and Europe[10-18]. *Staphylococcus* species are indigenous microflora of the skin and mucous membranes in humans and are a common cause of ocular infections.

Pseudomonas was the most common gram-negative bacteria from the gram-negative corneal isolates and the second most common bacteria after *Staphylococcus* from all isolates. *Pseudomonas* is widely distributed in nature, being present in soil and water. *Pseudomonas* has been reported to be the bacteria most commonly isolated from contact lens-associated corneal ulcers. Infection results when a traumatized cornea is exposed to the organism[19,20]. In general, there is an increased prevalence of pseudomonal infections in southern latitudes. Geographical and climatic factors may partially explain the high prevalence of *Pseudomonas* species. Another important factor is the high incidence of myopia and the popularity of wearing contact lenses in Asian countries[21-24].

Only 12% of our isolates were streptococci. This is in contrast with the results reported from developing countries such as Bangladesh, Saudi Arabia, South India, and Eastern Turkey, where *Streptococcus pneumoniae* was the most common organism isolated in bacterial keratitis[25-29].

In investigations conducted in the United Kingdom between 2003 and 2006, and between 1999 and 2009, the spectrum of microbial cultures from bacterial keratitis was similar to that which we report here with *Staphylococcus*, *Pseudomonas*, and *Streptococcus*[17,28].

In this study, gram-positive bacteria were sensitive to vancomycin, teicoplanin, and ofloxacin, while

Table 2. Antibiotic susceptibility of bacterial isolates

	Amikacin	Gentamicin	Ampicillin	Mezlocillin	Cefazolin	Ceftriaxone	Ceftazidime	Aztreonam	Amoxicillin/ clavulanic acid	Piperacillin	Teicoplanin	Fusidic acid	Mupirocin
Gram-positive		43/58	8/8			23/23					83/85	49/57	46/54
Staphylococcus spp.		42/57	1/1								54/56	49/57	46/54
Streptococcus spp.						23/23					28/28		
Undefined rods		1/1									1/1		
Gram-negative	68/70	66/70	7/30	2/2	8/24	30/30	70/70	54/55	15/29	64/68			
Moraxella spp.	2/2	2/2	3/3		1/1	3/3	2/2	1/1	2/2	2/2			
Klebsiella spp.	6/6	6/6	0/6		4/5	6/6	6/6	5/5	5/6	6/6			
Pseudomonas aeruginosa	42/44	40/44					44/44	31/32		42/44			
Serratia spp.	10/10	10/10	0/10	1/1	0/10	10/10	1/1	9/9	0/10	9/9			
Acinetobacter spp.		1/1	1/1		0/1	1/1	1/1	1/1	1/1	0/1			
Escherichia coli		2/2	1/2	1/1	2/2	2/2	2/2	1/1	2/2	0/1			
Enterobacter spp.	1/1	1/1	0/1		1/1	1/1	1/1	1/1	0/1	1/1			
Citrobacter spp.	1/1	1/1	0/1		1/1	1/1	1/1	1/1	1/1				
Haemophilus influenzae			2/3			3/3			3/3				
Morganella spp.	2/2	2/2	0/2		0/2	2/2	2/2	2/2	1/2	2/2			
Providenci spp.	1/1	1/1			0/1	1/1	1/1	1/1	0/1	1/1			
Total	68/70	109/12	15/38	2/2	8/24	53/53	70/70	54/55	15/29	64/68	83/85	49/57	46/54
Sensitive/Total		8											

gram-negative bacteria were sensitive to ceftazidime, ceftriaxone, piperacillin-tazobactam, meropenem, ciprofloxacin, aztreonam, ofloxacin, amikacin, and gentamicin.

Ofloxacin had an extended broad-spectrum activity by covering most gram-positive and gram-negative bacteria. In our study, 60 of 66 (90.9%) gram-positive isolates and 68 of 70 (97.1%) gram-negative isolates were sensitive to ofloxacin. Ciprofloxacin was effective against 97.7% of pseudomonal keratitis isolates and 98.6% of all gram-negative isolates. Fluoroquinolones provide coverage against most gram-negative and gram-positive bacteria, with good ocular penetration, low toxicity, safety, and commercial availability[30,31]. However, there are several reports on the emerging laboratory resistance of both ocular and systemic isolates to the fluoroquinolones[11,32,33].

Vancomycin was 100% effective against *Staphylococcus*, *Streptococcus* and undefined gram-positive rods during all years. Ceftriaxone, teicoplanin and chloramphenicol were effective against all *Streptococcus* isolates. Rifampicin has very high activity against *Staphylococcus* species. All *Pseudomonas aeruginosa* isolates were sensitive to ceftazidime, meropenem, and piperacillin-tazobactam, and most isolates were sensitive to amikacin, gentamicin, aztreonam, piperacillin, ciprofloxacin, imipenem, cefepime, and ofloxacin, but all were resistant to cotrimoxazole. Colistin was effective against *Pseudomonas*, while it was ineffective against *Serratia*.

Table 2. Antibiotic susceptibility of bacterial isolates (continue)

Colistin	Meropenem	Imipenem	Cefepime	Piperacillin-tazobactam	Minocycline	Trimethoprim-sulfamethoxazole	Chloramphenicol	Ofloxacin	Ciprofloxacin	Erythromycin	Tetracycline	Clindamycin	Penicillin	Methicillin	Vancomycin	Rifampicin
						75/89	73/89	60/66		43/71	70/89	51/60	35/89	41/57	89/89	56/57
						50/57	43/57	51/57		18/39	43/57	48/57	17/57	41/57	57/57	56/57
						23/30	30/30	7/7		25/30	26/30	2/2	21/30		30/30	
						2/2	0/2	2/2		0/2	1/2	1/1	2/2		2/2	
50/57	29/29	40/41	54/54	70/70	6/8	27/60	27/30	68/70	69/70	3/4	16/30					
2/2		2/2	2/2	2/2	1/1	2/3	3/3	2/2	2/2	1/1	3/3					
6/6	3/3	3/3	5/5	6/6	1/2	5/6	5/6	6/6	6/6		3/6					
44/44	18/18	25/26	29/30	44/44		0/30		42/44	43/44							
0/10	6/6	4/4	9/9	10/10		10/10	8/10	10/10	10/10		2/10					
1/1		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1		1/1					
2/2	1/1	1/1	2/2	2/2	1/1	1/2	2/2	2/2	2/2		1/2					
1/1		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1		1/1					
1/1	1/1		1/1	1/1		1/1	1/1	1/1	1/1		1/1					
							3/3			2/3	3/3					
0/2		2/2	2/2	2/2	1/1	1/1	2/2	2/2	2/2		1/2					
0/1		1/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1		0/1					
57/70	29/29	40/41	54/54	70/70	6/8	102/149	100/119	128/136	69/70	67/93	86/119	51/60	35/89	41/57	89/89	56/57

Study on microbiological characteristics of bacterial keratitis performed from 2005 to 2007 in Eastern Turkey reported that gram-positive organisms comprised 73%, while gram-negative organisms accounted for 27% of all bacterial isolates. Although this is similar to our results, *Streptococcus pneumoniae* was the most common gram-positive organism isolated in bacterial keratitis in that study, followed by *Staphylococcus*. Similarly, they showed high vancomycin susceptibility for gram-positive isolates[28]. Another study from Western Turkey showed that staphylococci are the most commonly isolated microbial agents in cases of infectious keratitis[34].

A limitation of our study is the period of time, which did not include the newly developed antibiotics such as fourth-generation fluoroquinolones. However, while fluoroquinolones are popular choices for empiric therapy in bacterial keratitis owing to their broad spectrum of activity, emerging resistance to this class of antibiotics has been increasingly reported in a number of studies[9,32,35].

In summary, *Staphylococcus* and *Pseudomonas* species were the most common organisms cultured from bacterial keratitis. Vancomycin was active against all gram-positive isolates tested, and ceftazidime, ceftriaxone, and meropenem had the highest susceptibility rate for gram-negative organisms isolated.

Ceftriaxone and ofloxacin were found to be highly effective against the majority of isolates.

REFERENCES

1. Baum JL. Initial therapy of suspected microbial corneal ulcers. I. Broad antibiotic therapy based on prevalence of organisms. Surv Ophthalmol 1979;24:97-105.
2. Jones DB. Initial therapy of suspected microbial corneal ulcers. II. Specific antibiotic therapy based on corneal smears. Surv Ophthalmol 1979;24:105-16.
3. Leibowitz HM. Bacterial keratitis. In: Leibowitz HM (ed). Corneal Disorders: Clinical Diagnosis and Management. Philadelphia: WB Saunders, 1984:353.
4. Limberg MB. A review of bacterial keratitis and bacterial conjunctivitis. Am J Ophthalmol 1991;112(Suppl):S2-9.
5. Jones DB, Liesegang TJ, Robinson NM. Laboratory Diagnosis of Ocular Infections. Washington DC: American Society for Microbiology, 1981.
6. Brown DF, Kothari D. Antimicrobial-susceptibility testing of rapidly growing pathogenic bacteria. II. A field trial of four disc-diffusion methods. J Antimicrob Chemother 1978;4:27-38.
7. Musch DC, Sugar A, Meyer RF. Demographic and predisposing factors in corneal ulceration. Arch Ophthalmol 1983;101:1545-8.
8. Sun X, Deng S, Li R, Wang Z, Luo S, Jin X, Zhang W. Distribution and shifting trends of bacterial keratitis in north China (1989-98). Br J Ophthalmol 2004;88:165-6.
9. Alexandrakis G, Alfonso EC, Miller D. Shifting trends in bacterial keratitis in south Florida and emerging resistance to fluoroquinolones. Ophthalmology 2000;107:1497-502.
10. Vajpayee RB, Dada T, Saxena R, Vajpayee M, Taylor HR, Vankatesh P, et al. Study of the first contact management profile of cases of infectious keratitis: a hospital-based study. Cornea 2000;19:52-6.
11. Satpathy G, Vishalakshi P. Ulcerative keratitis: microbial profile and sensitivity pattern-a five year study. Ann Ophthalmol 1995;27:301-6.
12. Ubani UA. Bacteriology of external ocular infections in Aba, South Eastern Nigeria. Clin Exp Optom 2009;92:482-9.
13. Gudmundsson OG, Ormerod LD, Kenyon KR, Glynn RJ, Baker AS, Haaf J, et al. Factors influencing predilection and outcome in bacterial keratitis. Cornea 1989;8:115-21.
14. Wahl JC, Katz HR, Abrams DA. Infectious keratitis in Baltimore. Ann Ophthalmol 1991;23:234-7.
15. Mezer E, Gelfand YA, Lotan R, Tamir A, Miller B. Bacteriological profile of ophthalmic infections in an Israeli hospital. Eur J Ophthalmol 1999;9:120-4.
16. Bourcier T, Thomas F, Borderie V, Chaumeil C, Laroche L. Bacterial keratitis: predisposing factors, clinical and microbiological review of 300 cases. Br J Ophthalmol 2003;87:834-8.
17. Schaefer F, Bruttin O, Zografos L, Guex-Crosier Y. Bacterial keratitis: a prospective clinical and microbiological study. Br J Ophthalmol 2001;85:842-7.
18. Orlans HO, Hornby SJ, Bowler IC. In vitro antibiotic susceptibility patterns of bacterial keratitis isolates in Oxford, UK: a 10-year review. Eye (Lond) 2011;25:489-93.
19. Ormerod LD, Smith RE. Contact lens-associated microbial keratitis. Arch Ophthalmol 1986;104:79-83.
20. Mondino BJ, Weissman BA, Farb MD, Pettit TH. Corneal ulcers associated with daily-wear and extended-wear contact lenses. Am J Ophthalmol 1986;102:58-65.
21. Zhang C, Liang Y, Deng S, Wang Z, Li R, Sun X. Distribution of bacterial keratitis and emerging resistance to antibiotics in China from 2001 to 2004. Clin Ophthalmol 2008;2:575-9.
22. Fong CF, Hu FR, Tseng CH, Wang IJ, Chen WL, Hou YC. Antibiotic susceptibility of bacterial isolates from bacterial keratitis cases in a university hospital in Taiwan. Am J Ophthalmol 2007;144:682-9.
23. Lin LL, Shih YF, Tsai CB, Chen CJ, Lee LA, Hung PT, et al. Epidemiologic study of ocular refraction among school children in Taiwan in 1995. Optom Vis Sci 1999;76:275-81.
24. Houang E, Lam D, Fan D, Seal D. Microbial keratitis in Hong Kong: relationship to climate, environment and contact-lens disinfection. Trans R Soc Trop Med Hyg 2001;95:361-7.
25. Williams G, Billson F, Husain R, Howlader SA, Islam N, McClellan K. Microbiological diagnosis of suppurative keratitis in Bangladesh. Br J Ophthalmol 1987;71:315-21.
26. Wagoner MD, Al-Ghamdi AH, Al-Rajhi AA. Bacterial keratitis after primary pediatric penetrating keratoplasty. Am J Ophthalmol 2007;143:1045-7.
27. Srinivasan M, Gonzales CA, George C, Cevallos V, Mascarenhas JM. Epidemiology and aetiological diagnosis of corneal ulceration in Madurai, south India. Br J Ophthalmol 1997;81:965-71.
28. Güler M, Kurt J, Evren Ö, Çeliker Ü. Clinical and microbiological characteristics of bacterial keratitis in our region. Firat Med J 2008;13:235-8.
29. Kaye S, Tuft S, Neal T, Tole D, Leeming J, Figueiredo F, et al. Bacterial susceptibility to topical antimicrobials and clinical outcome in bacterial keratitis. Invest Ophthalmol Vis Sci 2010;51(1):362-8. Epub 2009 Aug 13.
30. Neu HC. Microbiologic aspects of fluoroquinolones. Am J Ophthalmol 1991;112(Suppl):S15-24.
31. Jensen HG, Felix C. In vitro antibiotic susceptibilities of ocular isolates in North and South America. In Vitro Antibiotic Testing Group. Cornea 1998;17:79-87.
32. Goldstein MH, Kowalski RP, Gordon YJ. Emerging fluoroquinolone resistance in bacterial keratitis. A 5-year review. Ophthalmology 1999;106:1313-8.

33. *Bower KS, Kowalski RP, Gordon YJ. Fluoroquinolones in the treatment of bacterial keratitis. Am J Ophthalmol 1996;121:712-5.*

34. *Yilmaz S, Ozturk I, Maden A. Microbial keratitis in West Anatolia, Turkey: a retrospective review. Int Ophthalmol 2007;27:261-8.*

35. *Afshari NA, Ma JJK, Duncan SM, Pineda R, Starr CE, Decroos FC, et al. Trends in resistance to ciprofloxacin, cefazolin, and gentamicin in the treatment of bacterial keratitis. J Ocul Pharmacol Ther 2008;24:217-23.*

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