Therapeutic Class Overview
Ophthalmic Antibiotics

Therapeutic Class

- **Overview/Summary:** Ophthalmic antibiotics are used to treat ocular infections including blepharitis, conjunctivitis, keratitis and several others. There are ophthalmic antibiotics available from a variety of drug classes including aminoglycosides, macrolides, polypeptides, quinolones and sulfonamides.[1] In addition, many are available as combination products with other antibiotics or corticosteroids. A list of available ophthalmic antibiotics is available in Table 1. Blepharitis is a chronic inflammatory condition of the eyelids, often presenting with the symptoms of eye irritation and redness. Overgrowth of normal bacterial flora plays a role in the pathophysiology of blepharitis. The mainstay of blepharitis treatment is patient education regarding eye lid hygiene as well as the use of ophthalmic antibiotics.[2,3] Conjunctivitis occurs worldwide and affects all ages, social strata, and both genders. Mild cases may be self limited as many cases will resolve without treatment in immunocompetent individuals although ophthalmic antibiotics are associated with earlier clinical and microbiological remission compared to placebo. All ophthalmic antibiotics, with the exception of ophthalmic levofloxacin 1.5%, are approved by the Food and Drug Administration to treat bacterial conjunctivitis.[5-37] Severe bacterial conjunctivitis is characterized by purulent discharge, pain and marked eye inflammation. In these cases cultures and slides for gram staining should be obtained and the results of these laboratory tests should guide the choice of the antibiotic.[38] Bacterial keratitis is characterized by an inflammation of the cornea and rarely occurs in the normal eye due to the cornea's natural resistance to infection. Untreated or severe bacterial keratitis can result in corneal perforation and may develop into endophthalmitis and result in the loss of the eye. Ophthalmic antibiotics are the preferred method of treatment in many cases, and antibiotic ointments may be useful at bedtime in less severe cases or as adjunctive therapy. In severe cases, patients should be followed daily until stabilization or clinical improvement is documented.[39]

Table 1. Current Medications Available in Therapeutic Class[1,5-37]

Generic (Trade Name)	Food and Drug Administration Approved Indications	Dosage Form/Strength	Generic Availability
Single Entity Products			
Azithromycin ophthalmic (Azasite®)	Bacterial conjunctivitis	Ophthalmic solution: 1% (2.5 mL)	-
Bacitracin ophthalmic (Bacticin®*)	Acute meibomianitis, bacterial conjunctivitis, bacterial blepharitis, bacterial blepharoconjunctivitis, corneal ulcer, dacryocystitis, keratitis, keratoconjunctivitis	Ophthalmic ointment: 500 units/g (3.5, 3.75 g)	✔
Besifloxacin ophthalmic (Besivance®)	Bacterial conjunctivitis	Ophthalmic suspension: 0.6% (5 mL)	-
Ciprofloxacin ophthalmic (Ciloxan®*)	Bacterial conjunctivitis, corneal ulcer (solution)	Ophthalmic ointment: 0.3% (3.5 g) Ophthalmic solution: 0.3% (2.5, 5, 10 mL)	✔ (solution)
Erythromycin ophthalmic (Ilotycin®*, Romycin®*)	Bacterial conjunctivitis, corneal ulcer†, prophylaxis of ophthalmia neonatorum*	Ophthalmic ointment: 0.5% (3.5 g)	✔
Gatifloxacin ophthalmic (Zymaxid®)	Bacterial conjunctivitis	Ophthalmic solution: 0.5% (2.5 mL)	-
Gentamicin sulfate ophthalmic (Genoptic®*, Gentak®*)	Acute meibomianitis, bacterial blepharitis, bacterial blepharo-conjunctivitis, corneal ulcer,	Ophthalmic ointment: 0.3% (3.5 g)	✔

Generic (Trade Name)	Food and Drug Administration Approved Indications	Dosage Form/Strength	Generic Availability
	dacryocystitis, keratitis, kerato-conjunctivitis	Solution: 0.3% (5, 15 mL)	
Levofloxacin ophthalmic (Iquix®, Quixin®)	Bacterial conjunctivitis (Quixin®), corneal ulcer (Iquix®)	Ophthalmic solution: 0.5% (5 mL) (Quixin®) 1.5% (5 mL) (Iquix®)	-
Moxifloxacin hydrochloride ophthalmic (Moxeza®, Vigamox®)	Bacterial conjunctivitis	Ophthalmic solution: 0.5% (3 mL)	-
Ofloxacin ophthalmic (Ocuflox®)	Bacterial conjunctivitis, corneal ulcer	Ophthalmic solution: 0.3% (1, 5, 10 mL)	✔
Sulfacetamide sodium ophthalmic (AKSulf®*, Bleph-10®*, Ocusulf®*, Sturzsulf®*, Sulster®*)	Bacterial conjunctivitis, bacterial blepharitis‡, bacterial blepharo-conjunctivitis‡, keratitis‡, kerato-conjunctivitis‡, treatment of trachoma (adjunct therapy)‡	Ophthalmic ointment: 10% (3.5 g) Ophthalmic solution: 1% (5, 10 mL) 10% (2, 2.5, 5, 15 mL) 30% (15 mL)	✔
Tobramycin ophthalmic (AKTob®*, Tobrex®)	Bacterial conjunctivitis§, bacterial blepharitis§, bacterial blepharo-conjunctivitis§, keratitis§, kerato-conjunctivitis§	Ophthalmic ointment: 0.3% (3.5 g) Ophthalmic solution: 0.3% (5 mL)	✔
Combination Products			
Bacitracin zinc/polymyxin B sulfate ophthalmic (AK-Poly-Bac®*, Polysporin®*)	Bacterial conjunctivitis, bacterial blepharoconjunctivitis, keratitis, keratoconjunctivitis	Ophthalmic ointment: 500 units/g /10,000 units/g (3.5 g)	✔
Gentamicin sulfate/prednisolone acetate ophthalmic (Pred G®)	Bacterial conjunctivitis‖, corneal ulcer‖	Ophthalmic ointment: 0.3%/0.6% (3.5 g) Ophthalmic suspension: 0.3%/1.0% (5, 10 mL)	-
Polymyxin B sulfate/trimethoprim ophthalmic (Polytrim®*)	Bacterial conjunctivitis, bacterial blepharo-conjunctivitis	Ophthalmic solution: 10,000 units/mL/ 0.1% (10 mL)	✔
Sulfacetamide sodium/prednisolone acetate ophthalmic (Blephamide®*)	Bacterial conjunctivitis‖, corneal ulcer‖	Ophthalmic ointment: 10%/0.2% (3.5 g) Ophthalmic suspension: 10%/0.2% (5, 10 mL)	✔
Sulfacetamide sodium/prednisolone sodium phosphate ophthalmic (Vasocidin®*)	Bacterial conjunctivitis‖, corneal ulcer‖	Ophthalmic solution: 10%/0.23% (5, 10 mL)	✔
Tobramycin/dexametha-sone ophthalmic (Tobradex®*, Tobradex® ST)	Bacterial conjunctivitis‖, corneal ulcer‖	Ophthalmic ointment: 0.3%/0.1% (3.5 g) Ophthalmic	✔ (suspension)

Generic (Trade Name)	Food and Drug Administration Approved Indications	Dosage Form/Strength	Generic Availability
		suspension: 0.3%/0.1% (2.5, 10 mL) 0.3%/0.05% (2.5, 5, 10 mL)	
Tobramycin/loteprednol etabonate ophthalmic (Zylet®)	Bacterial conjunctivitis¶, corneal ulcer	Ophthalmic suspension: 0.3%/0.5% (2.5, 5, 10 mL)	-
Neomycin sulfate/polymyxin B sulfate/bacitracin zinc ophthalmic (Neosporin®*)	Bacterial conjunctivitis, bacterial blepharitis, bacterial blepharo-conjunctivitis, keratitis, kerato-conjunctivitis	Ophthalmic ointment: 0.35%/10,000 units/g /400 units/g (3.5 g)	✔
Neomycin sulfate/polymyxin B sulfate/ dexamethasone ophthalmic (Maxitrol®*)	Bacterial conjunctivitis‖, corneal ulcer‖	Ophthalmic ointment: 0.35%/10,000 units/g /0.1% (3.5 g) Ophthalmic suspension: 3.5mg/mL/10,000 units/mL/0.1% (5 mL)	✔
Neomycin sulfate/polymyxin B sulfate/gramicidin ophthalmic (Neosporin®*)	Bacterial conjunctivitis, bacterial blepharitis, bacterial blepharo-conjunctivitis, keratitis, kerato-conjunctivitis	Ophthalmic solution: 1.75 mg/mL/10,000 units/mL/0.025 mg/mL (10 mL)	✔
Neomycin sulfate/polymyxin B sulfate/ hydrocortisone ophthalmic	Bacterial conjunctivitis‖, corneal ulcer‖	Ophthalmic suspension: 0.35%/10,000 units/mL /1% (7.5 mL)	✔
Neomycin sulfate/polymyxin B sulfate/ prednisolone acetate sulfate ophthalmic (Poly-Pred®)	Bacterial conjunctivitis‖, corneal ulcer‖	Ophthalmic suspension: 0.35%/10,000 units/mL/ 0.5% (5 mL)	-
Neomycin sulfate/polymyxin B sulfate/bacitracin zinc/hydrocortisone ophthalmic	Bacterial conjunctivitis‖, corneal ulcer‖	Ophthalmic ointment: 0.35%/10,000 units/g/ 400 units/g/1% (3.5 g)	✔

* Due to Neisseria gonorrhoeae or Chlamydia trachomatis.
† Indicated for the treatment of superficial ocular infections involving the conjunctiva and/or cornea caused by organisms susceptible to erythromycin.
‡ Indicated for the treatment of conjunctivitis and other superficial ocular infections due to susceptible microorganisms, and as an adjunctive in systemic sulfonamide therapy of trachoma.
§ Indicated in the treatment of external infections of the eye and its adnexa caused by susceptible bacteria.
‖ Indicated for steroid-responsive inflammatory ocular conditions for which a corticosteroid is indicated and where superficial bacterial ocular infection or a risk of bacterial ocular infection exists, *inflammatory conditions of the palpebral and bulbar conjunctiva, cornea, and anterior segment of the globe where the inherent risk of corticosteroid use in certain infective conjunctivitides is accepted to obtain diminution in edema and inflammation as well as use in chronic anterior uveitis and corneal injury from chemical, radiation or thermal burns or penetration of foreign bodies.*
¶Indicated for steroid-responsive inflammatory ocular conditions for which a corticosteroid is indicated and where superficial bacterial ocular infection or a risk of bacterial ocular infection exists, *inflammatory conditions of the palpebral and bulbar conjunctiva, cornea, and anterior segment of the globe such as allergic conjunctivitis, acne rosacea, superficial punctuate keratitis, herpes zoster keratitis, iritis, cyclitis, and where the inherent risk of steroid use in certain infective conjunctivides is accepted to obtain a diminution*

in edema and inflammation, as well as use in chronic anterior uveitis and corneal injury from chemical, radiation or thermal burns or penetration of foreign bodies.

Evidence-based Medicine

- Results from clinical trials have demonstrated that ophthalmic antibiotics are effective in treating and providing relief of conjunctivitis in pediatric and adult patients.[40-62] Several studies comparing ophthalmic antibiotics such as azithromycin, besifloxacin, levofloxacin, moxifloxacin and polymyxin B sulfate/bacitracin zinc to either placebo or vehicle have concluded that these medications resulted in significantly higher clinical resolution rates at days one through five.
- Head-to-head trials evaluating the efficacy of ophthalmic antibiotics for the treatment of bacterial conjunctivitis have found that no one medication was inferior to another. In one trial, significantly more patients treated with ophthalmic moxifloxacin had complete resolution of ocular signs and symptoms at 48 hours compared to treatment with ophthalmic polymyxin B sulfate/trimethoprim.[48] In a small meta-analysis, moxifloxacin was found to be associated with fewer drop-outs for treatment failure (*P*=0.002) compared to ofloxacin.[61] In a seven day trial, a higher percentage of patients receiving levofloxacin had microbial eradication at the final visit compared to patients receiving ofloxacin (*P*=0.034); however, clinical cure rates were similar between the two treatments (*P* value not reported).[63]
- In patients with a diagnosis of corneal ulcer, ophthalmic ciprofloxacin was shown to be an efficacious treatment option.[64-66] Specifically, in one trial of patients with a diagnosis of infectious keratitis ophthalmic ciprofloxacin had a shorter average time to healing as compared to ophthalmic cefazolin sodium fortified with gentamicin sulfate, although this was not found to be significant *(P* value not reported).[65]

Key Points within the Medication Class

- According to Current Clinical Guidelines:
    - There is insufficient evidence to recommend treatment for blepharitis, and due to the self-limiting nature of the condition, a cure is not possible in most cases. An ophthalmic antibiotic ointment may be prescribed and applied on the eyelid margins one or more times daily or at bedtime for one or more weeks. The combination of tobramycin/dexamethasone ophthalmic suspension and azithromycin in a sustained-release system appear to reduce some of the symptoms of blepharitis, but are not approved for this indication.[3]
    - Bacterial conjunctivitis may be self-limiting and resolve spontaneously without treatment in immunocompetent adults. Ophthalmic antibacterial therapy is associated with earlier clinical and microbiological remission compared with placebo at days two to five of treatment. The choice of ophthalmic antibiotic is usually empirical and a five to seven day course of ophthalmic broad-spectrum antibiotic is usually effective. The most convenient or least expensive option can be selected. For severe bacterial conjunctivitis, the choice of ophthalmic antibiotic is guided by the results of laboratory tests.[38]
    - Ophthalmic broad-spectrum antibiotics are used initially for empiric treatment of bacterial keratitis. Therapy with an ophthalmic fluoroquinolones has been shown to be as effective as combination therapy with fortified ophthalmic antibiotics. Ciprofloxacin 0.3%, ofloxacin 0.3% and levofloxacin 1.5% are FDA- approved for this indication. The fourth generation fluoroquinolones have not been approved for the treatment of bacteria keratitis, however, both agents have performed at least as well as standard therapy and potentially better than ciprofloxacin.[39]
    - Some pathogens (e.g., *Streptococci*, anaerobes) reportedly have variable susceptibility to ophthalmic fluoroquinolones and the prevalence of resistance to fluoroquinolones appears to be increasing. The initial therapeutic regimen should be modified (change in type, concentration or frequency of antibiotic) when the eye shows a lack of improvement or stabilization within 48 hours.[39]
- Other Key Facts:
    - There is at least one generic product available for treating each of the conditions outlined in outlined in Table 1.[1]

- With the approval of gatifloxacin 0.5% ophthalmic solution (Zymaxid®) in 2010, Allergan discontinued manufacturing of the 0.3% strength (Zymar®) in January 2011. Both agents have the same indications and administration schedule.[1]
- Both ophthalmic moxifloxacin formulations (Moxeza® and Vigamox®) are 0.5% solutions. Moxeza® may be administered twice daily while Vigamox® is to be administered three times daily for seven days.
- Ciprofloxacin and ofloxacin are considered second-generation fluoroquinolones, with levofloxacin being a third-generation fluoroquinolone. The fourth-generation fluoroquinolones include gatifloxacin, moxifloxacin and the newest fluoroquinolone, besifloxacin.[68,69]
- Ophthalmic suspensions mix with tears less rapidly and remain in the cul-de-sac of the eye longer than solutions. Ophthalmic ointments maintain contact between the drug and ocular tissues by slowing the clearance rate to as little as 0.5% per minute. Ophthalmic ointments provide maximum contact between drug and external ocular tissues.[1]

References

1. Drug Facts and Comparisons 4.0 [database on the Internet]. St. Louis: Wolters Kluwer Health, Inc.; 2011 [cited 2012 Feb 20]. Available from: http://online.factsandcomparisons.com.
2. Shtein RM. Blepharitis. In: Basow D (Ed). UpToDate [database on the internet]. Waltham (MA): UpToDate; 2011 [cited 2012 Feb 20]. Available from: http://www.utdol.com/utd/index.do.
3. American Academy of Ophthalmology Preferred Practice Patterns Committee. Preferred Practice Pattern Guidelines. Blepharitis [guideline on the Internet]. 2011 [cited 2012 Feb 20]. Available from: http://one.aao.org/CE/PracticeGuidelines/PPP_Content.aspx?cid=500cd9ca-173c-4c31-b6ea-a258e3549474
4. Jacobs DS. Conjunctivitis. In: Basow D (Ed). UpToDate [database on the internet]. Waltham (MA): UpToDate; 2010 [cited 2012 Feb 20]. Available from: http://www.utdol.com/utd/index.do.
5. Azasite® [package insert]. Durham, NC: Inspire Pharmaceuticals Inc.; 2010 Nov.
6. Besivance® [package insert]. Tampa, FL: Bausch & Lomb Incorporated; 2009 Apr.
7. Ciprofloxacin solution [package insert]. Tampa, FL: Bausch & Lomb Incorporated; 2006 Mar.
8. Ciprofloxacin ointment [package insert]. Fort Worth, TX: Alcon; 2006 May.
9. Erythromycin ointment [package insert]. Tampa, FL: Bausch & Lomb Incorporated; 2007 Feb.
10. Zymaxid® [package insert]. Irvine, CA; Allergan; 2010 May.
11. Gentak® [package insert]. Lake Forrest, IL; Akorn Inc.; 2008 Oct.
12. Gentamicin ointment [package insert]. Melville, NY; E. Fougera & Co.; 1998 Mar.
13. Quixin® [package insert]. Jacksonville, FL. Vistakon Pharmaceuticals LLC; 2006 Apr.
14. Iquix® [package insert]. Jacksonville, FL. Vistakon Pharmaceuticals LLC; 2007 Apr.
15. Vigamox® [package insert]. Fort Worth, TX. Alcon Laboratories Inc.; 2011 Jul.
16. Moxeza® [package insert]. Fort Worth, TX. Alcon Laboratories Inc.; 2010 Nov.
17. Ofloxacin [package insert]. Tampa, FL: Bausch & Lomb Incorporated; 2007 Aug.
18. Bleph-10® [package insert]. Irvine, CA. Allergan Inc.; 2005 Feb.
19. Tobramycin [package insert]. Tampa, FL: Bausch & Lomb Incorporated; 2007 Aug.
20. Polysporin® [package insert]. Bristol, TN. Monarch Pharmaceuticals Inc. 2006 Oct.
21. Pred G® suspension [package insert]. Irvine, CA. Allergan Inc.; 2005 Dec.
22. Pred G® ointment [package insert]. Irvine, CA. Allergan Inc.; 2004 Jan.
23. Polytrim® [package insert]. Irvine, CA. Allergan Inc.; 2004 Aug.
24. Blephamide suspension® [package insert]. Irvine, CA. Allergan Inc.; 2004 June.
25. Blephamide ointment® [package insert]. Irvine, CA. Allergan Inc.; 2004 Sept.
26. Vasocidin® [package insert]. Duluth, GA; Novartis Ophthalmics; 2001 Feb.
27. Tobradex suspension® [package insert]. Fort Worth, TX. Alcon Laboratories Inc.; 2006 May.
28. Tobradex ointment® [package insert]. Fort Worth, TX. Alcon Laboratories Inc.; 2003 Oct.
29. Tobradex® ST [package insert]. Fort Worth, TX. Alcon Laboratories Inc.; 2009 Feb.
30. Zylet® [package insert]. Tampa, FL. Bausch & Lomb Inc.; 2010 May.
31. Neomycin and polymyxin b sulfates and bacitracin zinc [package insert]. Tampa, FL: Bausch & Lomb Incorporated; 2003 Nov.
32. Maxitrol ointment® [package insert]. Fort Worth, TX: Alcon; 2003 Oct.
33. Maxitrol suspension® [package insert]. Fort Worth, TX: Alcon; 2008 Apr.
34. Neomycin and polymyxin b sulfates and gramicidin [package insert]. Tampa, FL: Bausch & Lomb Incorporated; 2003 Nov.
35. Neomycin and polymyxin b sulfates and hydrocortisone [package insert]. Worth, TX. Alcon Laboratories Inc.; 2006 Sept.
36. Polypred® [package insert]. Irvine, CA. Allergan Inc.; 2006 May.
37. Neomycin and polymyxin b sulfates and bacitracin zinc with hydrocortisone [package insert]. Melville, NY: E. Fougera & Co.; 2004 Aug.
38. American Academy of Ophthalmology Cornea/External Disease Panel. Preferred Practice Pattern Guidelines. Conjunctivitis. [guideline on the Internet]. 2011 [cited 2012 Feb 20]. Available from: http://one.aao.org/CE/PracticeGuidelines/PPP_Content.aspx?cid=79f4327d-6b7d-42e7-bbf3-585e7c3852c7
39. American Academy of Ophthalmology Preferred Practice Patterns Committee. Preferred Practice Pattern Guidelines. Bacterial Keratitis [guideline on the Internet]. 2011 [cited 2012 Feb 20]. Available at: http://one.aao.org/CE/PracticeGuidelines/PPP_Content.aspx?cid=0f20807f-bc61-4f11-b570-01ae26990edb

40. Abelson MB, Heller W, Shapira AM, Erwin SI, HSU P, Bowman LM. Clinical cure of bacterial conjunctivitis with azithromycin 1%: vehicle-controlled, double-masked clinical trial. Am J Ophthalmol. 2008;145:959-6.
41. Karpecki P, Depaolis M, Hunter JA, White EM, Rigel L, Brunner LS, et al. Besifloxacin ophthalmic suspension 0.6% in patients with bacterial conjunctivitis: A multicenter, prospective, randomized, double-masked, vehicle-controlled, 5-day efficacy and safety study. Clin Ther. 2009;31:514-26.
42. Hwang DG, Schanzlin DJ, Rotberg MH, Foulks G, Raizman MB; Levofloxacin Bacterial Conjunctivitis Place-controlled Study Group. A phase III, placebo controlled clinical trial of 0.5% levofloxacin ophthalmic solution for the treatment of bacterial conjunctivitis. Br J Ophthalmol. 2003;87:1004-9.
43. Gigliotti F, Hendley JO, Morgan J, Michaels R, Dickens M, Lohr J. Efficacy of topical antibiotic therapy in acute conjunctivitis in children [abstract]. J Pediatr. 1984 Apr;104(4):623-6.
44. Cochereau I, Meddeb-Ouertani A, Khairallah M, Amraoui A, Zaghloul K, Pop M, et al. 3-day treatment with azithromycin 1.5% eye drops versus 7-day treatment with tobramycin 0.3% for purulent bacterial conjunctivitis: multicentre, randomized and controlled trial in adults and children. Br J Ophthalmol. 2007;91:465-9.
45. Abelson M, Protzko E, Shapiro A, Garces-Soldana A, Bowman L. A randomized trial assessing the clinical efficacy and microbial eradication of 1% azithromycin ophthalmic solution vs tobramycin in adult and pediatric subjects with bacterial conjunctivitis. Clin Ophthalmol. 2007;1:177-82.
46. McDonald MB, Protzko EE, Brunner LS, Morris TW, Haas W, Paterno MR, et al. Efficacy and safety of besifloxacin ophthalmic suspension 0.6% compared with moxifloxacin ophthalmic solution 0.5% for treating bacterial conjunctivitis. Ophthalmology. 2009 Sep;116(9):1615-23.
47. Gross RD, Hoffman RO, Lindsay RN. A comparison of ciprofloxacin and tobramycin in bacterial conjunctivitis in children. Clin Pediatr. (Phil) 1997;36:435-44.
48. Granet B, Dorfman M, Stroman D, Cockrun P. A multicenter comparison of polymyxin B sulfate/trimethoprim ophthalmic solution and moxifloxacin in the speed of clinical efficacy for the treatment of bacterial conjunctivitis [abstract]. J Pediatr Ophthalmol Strabismus 2008;45:340-9.
49. Kernt K, Martinez M, Bertin D, International Tobrex2x group, Cupp S, Martinez C, et al. A clinical comparison of two formulations of tobramycin 0.3% eye drops in the treatment of acute bacterial conjunctivitis. Eur J Ophthalmol. 2005 Sep-Oct;15(5):541-9.
50. Behrens-Baumann W, Quentin CD, Gibson JR, Calthrop JG, Harvey SG, Booth K. Trimethoprim-polymyxin B sulphate ophthalmic ointment in the treatment of bacterial conjunctivitis: a double-blind study versus chloramphenicol ophthalmic ointment. Curr Med Res Opin. 1988;11:227-31.
51. Papa V, Aragona P, Scuderi AC, Blanco AR, Zola P, Di Bella A, et al. Treatment of acute bacterial conjunctivitis with topical netilmicin. Cornea. 2002;21(1):43-7.
52. Leibowitz HM. Antibacterial effectiveness of ciprofloxacin 0.3% ophthalmic solution in the treatment of conjunctivitis [abstract]. Am J Ophthalmol. 1991 Oct; 112(Suppl 4):29S-33S.
53. Lichtenstein S, Rinehart M. Efficacy and safety of 0.5% levofloxacin ophthalmic solution for the treatment of bacterial conjunctivitis in pediatric patients [abstract]. J AAPOS. 2003;7:317-24.
54. Lohr J, Austin R, Grossman M, Hayden GF, Knowlton GM, Dudley. Comparison of three topical antimicrobials for acute bacterial conjunctivitis [abstract]. Pediatr Infect Dis J. 1988;7:626-9.
55. Gibson J. Trimethoprim-polymyxin B ophthalmic solution in the treatment of presumptive bacterial conjunctivitis--a multicentre trial of its efficacy versus neomycin-polymyxin B-gramicidin and chloramphenicol ophthalmic solutions [abstract]. J Antimicrob Chemother. 1983;11:217-21.
56. Silver LH, Woodside AM, Montgomery DB. Clinical safety of moxifloxacin ophthalmic solution 0.5% (Vigamox®) in pediatric and nonpediatric patients with bacterial conjunctivitis. Surv Ophthalmol. 2005;50:S55-S63.
57. Jauch A, Fsadni M, Gamba G. Meta-analysis of six clinical phase III studies comparing lomefloxacin 0.3% eye drops twice daily to five standard antibiotics in patients with acute bacterial conjunctivitis. Arch Clin Exp Ophthalmol. 1999;237:705-13.
58. Sheikh A, Hurwitz B. Antibiotics versus placebo for acute bacterial conjunctivitis. Cochrane Database Syst Rev. 2006 Apr 19;(2):CD001211. Review.
59. Tepedino ME, Heller WH, Usner DW, Brunner LS, Morris TW, Haas W, et al. Phase III efficacy and safety study of besifloxacin ophthalmic suspension 0.6% in the treatment of bacterial conjunctivitis. Curr Med Res Opin. 2009 May;25(5):1159-69.
60. Silverstein BE, Allaire C, Bateman KM, Gearinger LS, Morris TW, Comstock TL. Efficacy and tolerability of besifloxacin ophthalmic suspension 0.6% administered twice daily for 3 days in the treatment of bacterial conjunctivitis: a multicenter, randomized, double-masked, vehicle-controlled, parallel-group study in adults and children. Clin Ther. 2011 Jan;33(1):13-26.
61. Kodjikian L, Lafuma A, Khoshnood B, Laurendeau C, Berdeaux G. Efficacy of moxifloxacin in treating bacterial conjunctivitis: a meta-analysis. J Fr Ophtalmol. 2010 Apr;33(4):227-33.
62. Tauber S, Cupp G, Garber R, Bartell J, Vohra F, Stroman D. Microbiological efficacy of a new ophthalmic formulation of moxifloxacin dosed twice-daily for bacterial conjunctivitis. Adv Ther. 2011 Jul;28(7):566-74.
63. Schwab IR, Friedlaender M, McCulley J, Lichtenstein SJ, Moran CT; Levofloxacin Bacterial Conjunctivitis Active Control Study Group. A phase III clinical trial of 0.5% levofloxacin ophthalmic solution versus 0.3% ofloxacin ophthalmic solution for the treatment of bacterial conjunctivitis. Ophthalmology. 2003 Mar;110(3):457-65.
64. Booranapong W, Kosrirukvongs P, Prabhasawat P, Srivannaboon S, Suttiprakarn P. Comparison of topical lomefloxacin 0.3 per cent versus topical ciprofloxacin 0.3 per cent for the treatment of presumed bacterial corneal ulcers [abstract]. J Med Assoc Thai. 2004 Mar;87(3):246-54.
65. Kosrirukvongs P. Buranapongs W. Topical ciprofloxacin for bacterial corneal ulcer [abstract]. J Med Assoc Thai. 2000 Jul;83(7):776-82.
66. Parks DJ, Abrams DA, Sarfarazi FA, Katz HR. Comparison of topical ciprofloxacin to conventional antibiotic therapy in the treatment of ulcerative keratitis [abstract]. Am J Ophthalmol. 1993 Apr 15;115(4):471-7.
67. Mylan Launches First Generic Version of Xibrom® Ophthalmic Solution [press release on the Internet]. Canonsburgh (PA): 2011 May 16 [cited 2012 Feb 20]. Available from: http://investor.mylan.com/releasedetail.cfm?ReleaseID=577501.

68. Scoper SV. Review of third-and fourth-generation fluoroquinolones in ophthalmology: in-vitro and in-vivo efficacy. Adv Ther. 2008 Oct;25(10):979-94.
69. Yoshida J, Kim A, Pratzer KA, Stark WJ. Aqueous penetration of moxifloxacin 0.5% ophthalmic solution and besifloxacin 0.6% ophthalmic suspension in cataract surgery patients. J Cataract Refract Surg. 2010 Sep;36(9):1499-502.

Therapeutic Class Review
Ophthalmic Antibiotics

Overview/Summary

Ophthalmic antibiotics are used to treat ocular infections including blepharitis, conjunctivitis, keratitis and several others. There are ophthalmic antibiotics available from the many drug classes including aminoglycosides, macrolides, polypeptides, quinolones and sulfonamides.[1] In addition, many are available as combination products with other antibiotics or corticosteroids. A list of available ophthalmic antibiotics is available in Table 1. Moreover, there is at least one generic product available for treating each of the conditions outlined in Table 2.[1]

Blepharitis is a chronic inflammatory condition of the eyelids, often presenting with the symptoms of eye irritation and redness. Overgrowth of normal bacterial flora plays a role in the pathophysiology of blepharitis, with the most common causative organisms including *Staphylococcus* species, *Corynebacterium* species and *Propionibacterium* acnes. The mainstay of the treatment of blepharitis is patient education regarding eye lid hygiene as well as the use of ophthalmic antibiotics. Of note, blepharitis is a chronic condition without definitive cure; therefore, satisfactory results require a long-term commitment to treatment and appropriate expectations. Ophthalmic corticosteroids may also be used acutely to treat blepharitis exacerbations.[2,3]

All ophthalmic antibiotics, with the exception of ophthalmic levofloxacin 1.5%, are approved by the Food and Drug Administration (FDA) to treat bacterial conjunctivitis.[4-37] Conjunctivitis occurs worldwide and affects all ages, social strata, and both genders. This infection rarely causes permanent visual loss or structural damage and mild cases may be self limited as many cases will resolve without treatment in immunocompetent individuals. The most common causative pathogens seen with bacterial conjunctivitis include *Staphylococcus* aureus, *Streptococcus* pneumonia, *Haemophilus* influenza, and *Moraxella* catarrhalis.[38] Use of ophthalmic antibiotics is associated with earlier clinical and microbiological remission when compared to placebo. The selection of an ophthalmic antibiotic is typically empirical, and the most convenient or least expensive ophthalmic antibiotic is typically effective for most cases of conjunctivitis.[39]

Severe bacterial conjunctivitis is characterized by purulent discharge, pain and marked eye inflammation. In these cases cultures and slides for gram staining should be obtained and the results of these laboratory tests should guide the choice of the antibiotic. Methicillin-resistant *Staphylococcus* aureus (MRSA) has been isolated in patients with bacterial conjunctivitis with increasing frequency and may be resistant to many available ophthalmic antibiotics. In patients with conjunctivitis caused by *Neisseria* gonorrhea and *Chlamydia* trachomatis systemic antibiotic therapy is necessary, and while not necessary ophthalmic antibiotics are also typically used.[39]

Bacterial keratitis is characterized by an inflammation of the cornea and rarely occurs in the normal eye due to the cornea's natural resistance to infection. However several predisposing factors such as contact lens wear, trauma, corneal surgery, ocular surface disease, systemic disease and immunosuppression may alter the defense mechanisms of the ocular surface and allow for infection of the cornea.[40] Due to corneal scarring or topographic irregularity, many forms of this infection results in visual loss. Untreated or severe bacterial keratitis can result in corneal perforation and may develop into endophthalmitis and result in the loss of the eye. The most common causative organisms of bacterial keratitis include *Staphylococci* and gram-negative rods, of which the most frequent organisms identified are *Pseudomonas* species. Ophthalmic antibiotics are the preferred method of treatment in many cases, and antibiotic ointments may be useful at bedtime in less severe cases or as adjunctive therapy. In addition, broad-spectrum ophthalmic antibiotics are used initially as empiric treatment. In severe cases, patients should be followed daily until stabilization or clinical improvement is documented.[40]

Medications

Table 1. Medications Included Within Class Review

Generic Name (Trade name)	Medication Class	Generic Availability
Single Entity Products		
Azithromycin ophthalmic (Azasite®)	Macrolide antibiotic	-
Bacitracin ophthalmic (Bacticin®*)	Polypeptide antibiotic	✔
Besifloxacin ophthalmic (Besivance®)	Quinolone antibiotic	-
Ciprofloxacin ophthalmic (Ciloxan®*)	Quinolone antibiotic	✔ (solution)
Erythromycin ophthalmic (Ilotycin®*, Romycin®*)	Macrolide antibiotic	✔
Gatifloxacin ophthalmic (Zymaxid®)	Quinolone antibiotic	-
Gentamicin sulfate ophthalmic (Genoptic®*, Gentak®*)	Aminoglycoside antibiotic	✔
Levofloxacin ophthalmic (Iquix®, Quixin®)	Quinolone antibiotic	-
Moxifloxacin hydrochloride ophthalmic (Moxeza®, Vigamox®)	Quinolone antibiotic	-
Ofloxacin ophthalmic (Ocuflox®)	Quinolone antibiotic	✔
Sulfacetamide sodium ophthalmic (AKSulf®*, Bleph-10®*, Ocusulf®*, Sturzsulf®*, Sulster®*)	Miscellaneous anti-infective	✔
Tobramycin ophthalmic (AKTob®*, Tobrex®)	Aminoglycoside antibiotic	✔
Combination Products		
Bacitracin zinc/polymyxin B sulfate ophthalmic (AK-Poly-Bac®*, Polysporin®*)	Polypeptide antibiotic	✔
Gentamicin sulfate/prednisolone acetate ophthalmic (Pred G®)	Aminoglycoside antibiotic/ corticosteroid	-
Polymyxin B sulfate/trimethoprim ophthalmic (Polytrim®*)	Polypeptide antibiotic	✔
Sulfacetamide sodium/prednisolone acetate ophthalmic (Blephamide®*)	Miscellaneous anti-infective/corticosteroid	✔
Sulfacetamide sodium/prednisolone sodium phosphate ophthalmic (Vasocidin®*)	Miscellaneous anti-infective/corticosteroid	✔
Tobramycin/dexamethasone ophthalmic (Tobradex®*, Tobradex® ST)	Aminoglycoside antibiotic/ corticosteroid	✔ (suspension)
Tobramycin/loteprednol etabonate ophthalmic (Zylet®)	Aminoglycoside antibiotic/ corticosteroid	-
Neomycin sulfate/polymyxin B sulfate/bacitracin zinc ophthalmic (Neosporin®*)	Polypeptide antibiotic	✔
Neomycin sulfate/polymyxin B sulfate/ dexamethasone ophthalmic (Maxitrol®*)	Polypeptide antibiotic/ corticosteroid	✔
Neomycin sulfate/polymyxin B sulfate/gramicidin ophthalmic (Neosporin®*)	Polypeptide antibiotic	✔
Neomycin sulfate/polymyxin B sulfate/ hydrocortisone ophthalmic	Polypeptide antibiotic/ corticosteroid	✔
Neomycin sulfate/polymyxin B sulfate/ prednisolone acetate sulfate ophthalmic (Poly-Pred®)	Polypeptide antibiotic/ corticosteroid	-
Neomycin sulfate/polymyxin B sulfate/bacitracin zinc/hydrocortisone ophthalmic	Polypeptide antibiotic/ corticosteroid	✔

*Generic available in at least one dosage form or strength.

Indications

Table 2. Food and Drug Administration Approved Indications[1,4-37]

Generic Name	Acute Meibo-mianitis	Bacterial Con-junctivitis	Bacterial Blepharitis	Bacterial Blepharo-conjunctivitis	Corneal Ulcer	Dacryo-cystitis	Kera-titis	Kerato-conjunctivitis	Prophylaxis of Ophthalmia Neonatorum*	Treatment of Trachoma (Adjunct Therapy)
Single Entity Products										
Azithromycin		✔								
Bacitracin	✔	✔	✔	✔	✔	✔	✔	✔		
Besifloxacin		✔								
Ciprofloxacin		✔			✔ (solution)					
Erythromycin		✔			✔ †				✔	
Gatifloxacin		✔								
Gentamicin sulfate	✔	✔	✔	✔	✔	✔	✔	✔		
Levofloxacin		✔ (Quixin®)			✔ (Iquix®)					
Moxifloxacin hydrochloride		✔								
Ofloxacin		✔			✔					
Sulfacetamide sodium		✔	✔ ‡	✔ ‡			✔ ‡	✔ ‡		✔ ‡
Tobramycin		✔ §	✔ §	✔ §			✔ §	✔ §		
Combination Products										
Bacitracin zinc/polymyxin B sulfate		✔	✔	✔			✔	✔		
Gentamicin sulfate/ prednisolone acetate		✔ ‖			✔ ‖					
Polymyxin B sulfate/ trimethoprim		✔		✔						
Sulfacetamide sodium/ prednisolone acetate		✔ ‖			✔ ‖					
Sulfacetamide sodium/ prednisolone sodium phosphate		✔ ‖			✔ ‖					
Tobramycin/dexamethasone		✔ ‖			✔ ‖					

Generic Name	Acute Meibo-mianitis	Bacterial Con-junctivitis	Bacterial Blepharitis	Bacterial Blepharo-conjunctivitis	Corneal Ulcer	Dacryo-cystitis	Kera-titis	Kerato-conjunctivitis	Prophylaxis of Ophthalmia Neonatorum*	Treatment of Trachoma (Adjunct Therapy)
Tobramycin/loteprednol etabonate		✔ ¶			✔ ¶					
Neomycin sulfate/polymyxin B sulfate/bacitracin zinc		✔	✔	✔			✔	✔		
Neomycin sulfate/polymyxin B sulfate/dexamethasone		✔ ‖			✔ ‖					
Neomycin sulfate/polymyxin B sulfate/gramicidin		✔	✔	✔			✔	✔		
Neomycin sulfate/polymyxin B sulfate/hydrocortisone		✔ ‖			✔ ‖					
Neomycin sulfate/polymyxin B sulfate/prednisolone acetate sulfate		✔ ‖			✔ ‖					
Neomycin sulfate/polymyxin B sulfate/bacitracin zinc/ hydrocortisone		✔ ‖			✔ ‖					

* Due to Neisseria gonorrhoeae or Chlamydia trachomatis.
† Indicated for the treatment of superficial ocular infections involving the conjunctiva and/or cornea caused by organisms susceptible to erythromycin.
‡ Indicated for the treatment of conjunctivitis and other superficial ocular infections due to susceptible microorganisms, and as an adjunctive in systemic sulfonamide therapy of trachoma.
§ Indicated in the treatment of external infections of the eye and its adnexa caused by susceptible bacteria.
‖ Indicated for steroid-responsive inflammatory ocular conditions for which a corticosteroid is indicated and where superficial bacterial ocular infection or a risk of bacterial ocular infection exists, inflammatory conditions of the palpebral and bulbar conjunctiva, cornea, and anterior segment of the globe where the inherent risk of corticosteroid use in certain infective conjunctivitides is accepted to obtain diminution in edema and inflammation as well as use in chronic anterior uveitis and corneal injury from chemical, radiation or thermal burns or penetration of foreign bodies.
¶Indicated for steroid-responsive inflammatory ocular conditions for which a corticosteroid is indicated and where superficial bacterial ocular infection or a risk of bacterial ocular infection exists, inflammatory conditions of the palpebral and bulbar conjunctiva, cornea, and anterior segment of the globe such as allergic conjunctivitis, acne rosacea, superficial punctuate keratitis, herpes zoster keratitis, iritis, cyclitis, and where the inherent risk of steroid use in certain infective conjunctivides is accepted to obtain a diminution in edema and inflammation, as well as use in chronic anterior uveitis and corneal injury from chemical, radiation or thermal burns or penetration of foreign bodies.

Pharmacokinetics[4-37]

Limited pharmacokinetic data is available for the ophthalmic antibiotics. Although there is the potential for systemic absorption with the administration of these agents, the true clinical significance of this is not known. Specifically, for ophthalmic levofloxacin solution and ophthalmic moxifloxacin hydrochloride solution, post-administration, maximum mean concentrations were reported to be more than 1,000 times lower than those reported after standard oral doses of the respective oral medications.

Clinical Trials

Clinical trials have demonstrated that ophthalmic antibiotics are effective in treating and providing relief of conjunctivitis in pediatric and adult patients.[41-64] Several studies comparing ophthalmic antibiotics such as azithromycin, besifloxacin, levofloxacin, moxifloxacin and polymyxin B sulfate/bacitracin zinc to either placebo or vehicle have concluded that these medications resulted in significantly higher clinical resolution rates at days one through five. However, one trial with ophthalmic polymyxin B sulfate/bacitracin zinc did show that on days eight through ten the difference seen when compared to placebo was not significant.[44]

Head-to-head trials evaluating the efficacy of ophthalmic antibiotics for the treatment of bacterial conjunctivitis have found that no one medication was inferior to another. In one trial, significantly more patients in the ophthalmic moxifloxacin group had complete resolution of ocular signs and symptoms at 48 hours when compared to patients treated with ophthalmic polymyxin B sulfate/trimethoprim (P=0.001).[49] In a small meta-analysis, moxifloxacin was found to be associated with fewer drop-outs for treatment failure (P=0.002) compared to ofloxacin.[62] In a seven day trial, a higher percentage of patients receiving levofloxacin had microbial eradication at the final visit compared to patients receiving ofloxacin (P=0.034);however, clinical cure rates were similar between the two treatments (P value not reported).[64]

Most other studies have shown no significant difference between ophthalmic antibiotic treatments with regard to bacterial eradication, clinical resolution, clinical response, efficacy, microbial eradication, physician's judgment of resolution, severity rating or symptom improvement. While no difference was found between ophthalmic formulations of azithromycin and tobramycin in regard to clinical resolution and bacterial eradication, azithromycin produced the same clinical outcome with 65% fewer drops.[46] In all studies, most adverse events were mild with no significant difference seen with regard to the rate of adverse events. Common adverse events included burning, ocular discomfort, stinging, and tearing.

In patients with a diagnosis of corneal ulcer, ophthalmic ciprofloxacin was shown to be an efficacious treatment option.[65,66] Specifically, in one trial of patients with a diagnosis of infectious keratitis ophthalmic ciprofloxacin had a shorter average time to healing as compared to ophthalmic cefazolin sodium fortified with gentamicin sulfate, although this was not found to be significant (P value not reported).[66]

A number of studies consisted of patients with multiple diagnoses such as blepharitis, blepharoconjunctivitis, bacterial conjunctivitis and blepharitis, keratoconjunctivitis, or symptoms of surface ocular infections. These studies found that the ophthalmic formulations of ciprofloxacin, gentamicin sulfate, ofloxacin, tobramycin solution, and polymyxin B sulfate/trimethoprim were efficacious in resolving or curing multiple ocular infections.[67-78] No significant differences were observed in any study with regard to cure rates, decline in bacterial counts, bacterial eradication or reduction of bacteria, microbial improvement or overall improvement. In one study, ophthalmic ofloxacin was shown to significantly decrease the cumulative summary score on days three through five in patients with conjunctival hyperemia, eyelid crusting or discharge, and positive bacterial culture when compared to ophthalmic gentamicin sulfate (P<0.05); however, there were no significant differences between the two treatments with regard to clinical, microbial and overall improvement rates (P=0.089 for all outcomes).[73] In studies of patients with multiple diagnoses, the most commonly reported adverse events were not significantly different between treatment groups. The most common adverse events included burning, mild discomfort and stinging on instillation.

In one study evaluating the treatment of ophthalmia neonatorum, conjunctivitis in newborn babies principally caused by *Neisseria* gonorrhoeae, prophylaxis with ophthalmic erythromycin ointment was found to be most effective prior to the infant's second week of life. The efficacy of ophthalmic erythromycin prophylaxis from day zero to day 14 was found to be statistically significant when compared to no prophylaxis, however it was not found to be significant when compared from days 15 to 60 (14 vs 9%; *P*=0.05 and 7 vs 8%; *P*=0.92 respectively).[79] In another study, ophthalmic erythromycin prophylaxis resulted in significantly less reports of conjunctival redness and tearing, or serious or purulent discharge during the first 24 hours to two weeks of birth when compared to no prophylaxis (18.4 vs 22.4%; *P*=0.03).[80]

Ophthalmic gentamicin sulfate was compared to ophthalmic neomycin sulfate/polymyxin B sulfate/dexamethasone in patients undergoing cataract and posterior chamber lens implant surgery. It was found that the bacterial colony count was significantly less in the ophthalmic gentamicin sulfate group at day six and eight (*P*=0.033), although there was no significant difference between the two groups with regard to the degree of intra-ocular inflammation or the global assessment of the success of therapy and local tolerance by the study patients and physicians (*P* value not reported).[81] A separate study evaluated ophthalmic preparations of tobramycin/dexamethasone, neomycin sulfate/polymyxin B sulfate/dexamethasone and neomycin sulfate/polymyxin B sulfate/gramicidin in patients undergoing cataract extraction by either manual extraction or phacoemulsification with intraocular lens implantation. Ophthalmic tobramycin/dexamethasone was non-inferior to ophthalmic neomycin sulfate/polymyxin B sulfate/dexamethasone concerning inflammation scores at days three, eight, 14 and 21. Inflammation scores in the ophthalmic tobramycin/dexamethasone group were significantly lower than score seen in the ophthalmic neomycin sulfate/polymyxin B sulfate/gramicidin group at days 8, 14 and 21 (*P*<0.05 for all) and scores in the ophthalmic neomycin sulfate/polymyxin B sulfate/dexamethasone group were significantly lower than those seen in the ophthalmic neomycin sulfate/polymyxin B sulfate/gramicidin group at day 8 (*P*<0.05).[82]

Ophthalmic tobramycin/dexamethasone has also been compared to ophthalmic tobramycin/loteprednol etabonate in patients with moderate blepharokeratoconjunctivitis with results showing significantly greater reductions in symptom scores in the ophthalmic tobramycin/dexamethasone group with regard to signs of blepharitis, conjunctivitis, and ocular discharge (*P*=0.017, *P*=0.013, *P*=0.025 respectively). However the reduction in keratitis score was not found to be statistically significant between the two treatment groups (*P*=0.065).[83]

Table 3. Clinical Trials

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
Conjunctivitis				
Abelson et al[41] Azithromycin 1% 1 drop into the affected eye(s) BID on days 1 and 2 and QD on days 3 through 5 vs vehicle 1 drop into the affected eye(s) BID on days 1 and 2 and QD on days 3 through 5	Phase 3 DB, MC, PC, PG, RCT Male and female patients, ages 1 year and older, with a positive clinical diagnosis of bacterial conjunctivitis with signs and symptoms present for <3 days, and a best-corrected visual acuity score of 20/100 or better in each eye	N=685 5 days	Primary: Clinical resolution at the test-of-cure visit (visit 3 on day 6 or 7) Secondary: Bacterial eradication at visit 3, as indicated by the absence of bacterial growth and incidence of adverse events	Primary: Clinical resolution rates at visit three were significantly higher in the azithromycin group when compared to the vehicle group (63.1 vs 49.7%, respectively; *P*=0.03). Secondary: Bacterial eradication rates measured at visit three were significantly higher in the azithromycin group when compared to the vehicle group (88.5 vs 66.4%; *P*<0.001). The rate of overall adverse events seen in the azithromycin group was 12.3% compared to 12.0% seen in the vehicle group with the most common adverse effects seen including conjunctival chemosis, lid swelling, and other lid events (*P* value not reported).
Karpecki et al[42] Besifloxacin 0.6% 1 drop into the affected eye(s) TID for 5 days vs vehicle 1 drop into the affected eye(s) TID for 5 days	DB, MC, PC, PG, PRO, RCT Patients ages 1 year and older, in good health, with a clinical diagnosis of acute bacterial conjunctivitis as evidenced by a minimum of grade 1 for purulent conjunctival discharge and a minimum of grade 1 for either bulbar or palpebral conjunctival injection in at least 1 eye on	N=269 5 days	Primary: Clinical resolution defined as the absence of conjunctival discharge and bulbar conjunctival injection at visit 3 Secondary: Eradication of baseline bacterial infection, defined as the absence at visit 3 of bacterial species that were present at or above the threshold on day 1, clinical resolution of	Primary: Clinical resolution of baseline conjunctivitis at visit three was significantly higher in the besifloxacin group when compared to the vehicle group (73.3 vs 43.1% respectively; *P*<0.001). Secondary: Clinical resolution of conjunctivitis at visit two did not show significant differences between besifloxacin and vehicle (33.3 vs 17.2% respectively; *P* value not reported), while eradication of bacterial infection at visit two was significantly greater with besifloxacin (90.0 vs 46.6% respectively; *P*<0.0001). Investigators' ratings of individual signs and symptoms were significantly higher in the treatment group when compared to the vehicle group at visit two (ocular discharge; *P*=0.008, bulbar conjunctival injection; *P*=0.004, visit two overall; *P*=0.003) as well as at visit two (*P*=0.013). Ratings of global changes in signs and symptoms were also found to be significantly greater in the treatment group at visit two and visit three (*P*=0.004 and *P*<0.001

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
	ocular examination, with pinhole visual acuity of 20/200 or better in each eye, and females of childbearing potential using a reliable method of contraception		baseline conjunctivitis at visit 2, eradication of the baseline bacterial infection at visit 2, improvements in investigators' ratings of global change in clinical signs and symptoms	respectively).
Tepedino et al[60] Besifloxacin 0.6% 1 drop into the affected eye(s) TID for 5 days vs vehicle 1 drop into the affected eye(s) TID for 5 days	DB, MC, VC Patients ≥1 year of age with clinical manifestations of acute bacterial conjunctivitis in at least one eye	N=957 9 days	Primary: Clinical resolution and microbial eradication of baseline bacterial infection at visit 2 (day 5) Secondary: Clinical resolution and microbial eradication at visit 3 (day 8 or 9), individual clinical outcomes at follow-up visits and safety	Primary: Clinical resolution rates were significantly higher in the besifloxacin treatment group compared to the vehicle group at the second visit (45.2 vs 33.0%; *P*=0.0084). By the second visit, microbial eradication rates were 91.5% and 59.7% for besifloxacin and vehicle, respectively; *P*<0.0001. Secondary: At visit three there was a significantly higher percentage of patients who had clinical resolution compared to the vehicle group (84.4 vs 69.1%; *P*=0.0011). By visit three, the microbial eradication rate continued to be significantly higher with besifloxacin treatment compared to vehicle alone (88.4 vs 71.7%; *P*<0.0001). The percentage of patients treated with besifloxacin who had a resolution of ocular discharge was significantly greater at visit two (73.9 vs 57.6%; *P*=0.0012) and three (93.0 vs 79.1%; *P*=0.0002) compared with those treated with vehicle. A significantly higher percentage of patients treated with besifloxacin had normal bulbar conjunctival injection than those treated with vehicle both at visit two (52.3 vs 36.1%; *P*=0.0007) and visit three (84.9% vs 70.7%; *P*=0.0011). The investigators assessment of cure increased in both the

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				besifloxacin and vehicle groups between visits two and three. At visit two, 39.2% and 29.3% of patients treated with besifloxacin or vehicle, respectively, were considered cured by the investigator (*P*=0.02), while at visit three, the rates were 83.9% and 66.0% (*P*=0.0002). A significantly greater percentage of eyes treated with vehicle experienced at least one ocular adverse event compared with those treated with besifloxacin (13.9 vs 9.2%; *P*=0.0047).
Silverstein et al[61] Besifloxacin 0.6% 1 drop into the affected eye(s) BID for 3 days vs vehicle 1 drop into the affected eye(s) BID for 3 days	DB, MC, PG, PRO, RCT, VC Patients ≥1 year of age with a clinical diagnosis of acute bacterial conjunctivitis with purulent discharge, crusty or sticky eyelids, and ocular surface redness, and a minimum of grade 1 severity for both discharge and bulbar conjunctival injection in at least one eye	N=202 7 days	Primary: Clinical resolution and bacterial eradication of the baseline bacterial infection at visit 2 Secondary: Clinical resolution and bacterial eradication of the baseline bacterial infection at visit 3, individual clinical outcomes at the follow- up visits	Primary: At visit two, clinical resolution of conjunctivitis in the study eye was significantly higher in the besifloxacin group compared to vehicle (69.8 vs 37.5%; respectively; *P*<0.001). The eradication of bacterial infection at visit two occurred in significantly more patients in the besifloxacin group compared with the vehicle group (86.8 vs 57.1%; *P*<0.001). Secondary: Rates of eradication of bacterial infection in the study eye at visit three were significantly greater in the besifloxacin group compared to the vehicle group (86.8 vs 69.6%, respectively; *P*=0.038). Rates of clinical resolution of bacterial conjunctivitis at visit three did not differ significantly between the besifloxacin and vehicle treatment groups (73.6 vs 66.1%; *P*=0.717). At visit two, the percentage of patients treated with besifloxacin who had resolution of ocular discharge was significantly greater compared to those who received vehicle (83.0 vs 55.4%, respectively; *P*=0.002) but not at visit three (86.8 vs 76.8%; *P* value not reported). The proportion of patients treated with besifloxacin who had resolution of bulbar conjunctival injection was significantly greater compared to patients receiving vehicle at visit two (77.4 vs 44.6%;

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				P<0.001), but not at visit three (83.0 vs 73.2%; *P* value not reported).
Hwang et al[43] Levofloxacin 0.5% 1 to 2 drops into the affected eye(s) while awake on days 1 and 2 then every 4 hours while awake on days 3 through 5 vs placebo 1 to 2 drops into the affected eye(s) while awake on days 1 and 2 then every 4 hours while awake on days 3 through 5	Phase 3, DB, MC, PC, RCT Male and female patients, ages 2 years and older, with a clinical diagnosis of bacterial conjunctivitis characterized by purulent ocular discharge and redness in at least one eye	N=249 5 days	Primary: Antimicrobial efficacy, clinical efficacy, resolution of ocular signs and symptoms, safety Secondary: Not reported	Primary: Microbial eradication rates were significantly higher in the levofloxacin group at study visits one, two and three when compared to placebo (95 vs 49%; *P*<0.001, 92 vs 53%; *P*<0.001, and 90 vs 53%; *P*<0.001 respectively). Approximately twice as many patients in the treatment group achieved microbial eradication as those in the placebo group (*P*<0.001). Clinical cure rates were significantly greater in the levofloxacin group when compared to placebo at both the final visit and the last observation made for patients who did not attend all visits (*P*=0.020 and *P*=0.026 respectively). Resolution of ocular signs and symptoms were consistently higher in the treatment group than with placebo at all study visits (*P* value not reported). Statistically significant differences were seen favoring the levofloxacin group with regard to resolution of the ocular signs of conjunctival discharge (*P*=0.027), bulbar conjunctival injection (*P*=0.018), and for the ocular symptoms of burning and stinging (*P*=0.008), itching (*P*=0.037), and photophobia (*P*=0.023) With regard to safety, a total of 91 adverse events were reported by 75 patients, 31% of the safety population. No significant differences were seen between the levofloxacin group and the placebo group with regard to the incidence of overall adverse events or treatment related events (*P* value not reported). Of the most common adverse events, only erythema and swelling was reported in significantly more patients in the levofloxacin group *(P*=0.672), while there was no statistically significant difference in the rate of conjunctival discharge, photophobia, and burning or stinging (*P*=0.027, *P*=0.023 and *P*=0.008 respectively). Secondary:

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				Not reported
Kodjikian et al (abstract)[62] Moxifloxacin vs ofloxacin vs levofloxacin	MA (5 RCT) Patients with a clinical diagnosis of acute bacterial conjunctivitis in one or more eyes	N=not reported Duration not reported	Primary: Clinical efficacy and drop-out rates for all reasons including lack of efficacy Secondary: Not reported	Primary: Patients treated with moxifloxacin were more likely to achieve a clinical cure (OR, 1.59; 95% CI, 1.21 to 2.04; *P*<0.001) and were less likely to experience a treatment failure compared to treatment with placebo (OR, 3.61; 95% CI, 2.30 to 5.65; *P*<0.001). Moxifloxacin treatment was associated with less risk of discontinuing therapy compared to placebo (OR, 2.22; 95% CI, 1.62 to 3.03; *P*<0.001). In comparison to ofloxacin, patients treated with moxifloxacin had fewer drop-outs for reasons other than treatment failure (OR, 1.92; 95% CI, 1.28 to 2.89; *P*=0.02) and fewer drop-outs for treatment failure (OR, 2.53; 95% CI, 1.41 to 4.56; *P*=0.002).
Tauber et al[63] Moxifloxacin 0.5% 1 drop into the affected eye(s) BID for 3 days vs placebo 1 drop into the affected eye(s) BID for 3 days	DB, MC, PG, RCT, VC Patients ≥28 days old with a diagnosis of bacterial conjunctivitis in one or both eyes based on bulbar conjunctival injection and discharge (minimum score of 1 on a 4-point scale for each sign) and matting	N=1,180 6 days	Primary: Clinical cure rate, eradication rates by species Secondary: Not reported	Primary: Patients treated with moxifloxacin twice-daily for three days had a microbiological success rate of 74.5% compared to 56.0% of patients treated with vehicle (*P*<0.0001). Moxifloxacin administered twice-daily was significantly more effective than vehicle in eradicating the three principle conjunctivitis pathogens, *H. influenzae* (98.5 vs 59.6%; *P*<0.001), *S. pneumoniae* (86.4 vs 50.0%; *P*<0.001), and *S. aureus* (94.1 vs 80.0%; *P*<0.001).
Gigliotti et al[44] Polymyxin/bacitracin applied to affected eye(s) QID for 7 days vs	DB, RCT Patients ages 1 month to 18 years, with acute conjunctivitis	N=102 10 days	Primary: Clinical cure rate, bacterial pathogen eradication Secondary: Not reported	Primary: During days three through five significantly more patients in the polymyxin/bacitracin group were clinically cured as compared to the placebo group (62 vs 28% respectively; *P*<0.02). However, on days eight through 10 the difference between the treatment group and placebo group was not significant (91 vs 72%; *P* value not reported). It was found that the bacterial pathogen was eradicated in

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
placebo applied to affected eye(s) QID for 7 days				significantly more patients in the treatment group than the placebo group by day three to five, as well as in days eight to 10 (72 vs 19% and 79 vs 31% respectively; *P*<0.001 for both). Secondary: Not reported
Cochereau et al[45] Azithromycin 1.5% 1 drop into the affected eye(s) BID for 3 days vs tobramycin 0.3% 1 drop into the affected eye(s) every 2 hours up to 8 times a day for 2 days, then QID for 5 days	IB, MC, NI, PG, RCT Patients ages 1 day and older, with a diagnosis of purulent bacterial conjunctivitis defined as bulbar injection and purulent discharge	N=1,043 9 days	Primary: Clinical efficacy, microbiological assessment, safety Secondary: Not reported	Primary: Clinical efficacy, measured as the number of patients cured on day nine, showed that azithromycin was NI to tobramycin (87.8 vs 89.4%, respectively; 95% CI -7.5 to 4.4). Noninferiority was also found for all efficacy criteria at assessment days three and nine (95% CI, -5.3 to 8.3 and -6.6 to 3.0 respectively). Additionally, azithromycin showed a statistically higher cure rate than tobramycin (29.8 vs 18.6% respectively; *P* value not reported). The rate of bacteriological resolution for azithromycin was found to be NI to tobramycin at both day three (85.2 vs 83.8%; 95% CI, not reported) and day nine (92.8 vs 94.6%; 95% CI, not reported). Adverse events reported were mile to moderate. Four patients presented with treatment-related adverse events, three from the azithromycin group, two with burning and one with burning/foreign body sensation, and one from the tobramycin group for discharge. Secondary: Not reported
Abelson et al[46] Azithromycin 1% 1 drop into the affected eye(s) BID on days 1 and 2 and QD on days 3 through 5 vs	Phase 3, AC, DB, MC, PRO, RCT Patients ages 1 year and older, with purulent conjunctival discharge, and conjunctival or	N=743 5 days	Primary: Clinical resolution of signs and symptoms of infective bacterial conjunctivitis Secondary: Bacterial eradication,	Primary: Differences in clinical resolution between azithromycin and tobramycin were not found to be statistically significant (79.9 vs 78.3%, respectively; *P*=0.783). Secondary: Bacterial eradication was not found to be statistically significant between the azithromycin group and the tobramycin group (88.1 vs

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
tobramycin 0.3% 1 drop into the affected eye(s) QID for 5 days	palpebral injection of no more than 3 days duration, with a best corrected visual acuity of 20/100 or better		and investigator ratings of clinical outcomes	94.3%, respectively; *P*=0.073) Clinical outcomes were based on the investigator severity ratings of ocular discharge and injection. At day three there was no significant difference (*P*=0.949), however equivalence with tobramycin was obtained with 65% fewer drops of azithromycin.
McDonald et al[47] Besifloxacin 0.6% 1 drop into the affected eye(s) TID for 5 days vs moxifloxacin 0.5% 1 drop into the affected eye(s) TID for 5 days	DB, MC, NI, PG, RCT Patients ages 1 year and older, in good health, with a clinical diagnosis of bacterial conjunctivitis as evidenced by grade 1 or greater purulent conjunctival discharge and bulbar conjunctival injection in at least 1 eye, pinhole visual acuity of 20/200 or greater in both eyes, willing to discontinue contact lens use during the study, and females of childbearing potential using a reliable method of contraception	N=1,161 8 days	Primary: Clinical resolution on day 5, microbial eradication on day 5 of all accepted ocular bacterial species that were present at or above threshold at baseline Secondary: Clinical resolution on day 8, microbial eradication on day 8 of all accepted ocular bacterial species that were present at or above threshold at baseline, and safety	Primary: Findings on day five showed that there was no statistically significant difference in clinical resolution between the besifloxacin group and the moxifloxacin group (58.0 vs 59.4%, respectively; *P*=0.652). Besifloxacin was found to be NI to moxifloxacin (95% CI, -9.48 to 7.29). Besifloxacin was shown to be NI to moxifloxacin with regard to microbial eradication on day 5 (93.3 vs 91.1%, respectively; *P*=0.124). Secondary: On day eight there was no statistical difference seen with regard to clinical resolution between the besifloxacin and moxifloxacin groups (84.5 vs 84.0%, respectively; *P*=0.501). Besifloxacin was found to be NI to moxifloxacin on day eight (95% CI, -5.67 to 6.75). On day eight besifloxacin was shown to be NI to moxifloxacin with regard to microbial eradication (87.3 vs 84.7% respectively; *P*=0.061). No significant differences were seen with regard to adverse events between the besifloxacin group and the moxifloxacin group (12.0 vs 14.0% respectively; *P*=0.224). One eye irritation was statistically different between the besifloxacin group and the moxifloxacin group (0.3 vs 1.4%, respectively; *P*=0.020).
Gross et al[48]	DB, MC, RCT	N=257	Primary: Treatment efficacy	Primary: Microbiological eradication was shown to be higher in the

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
Ciprofloxacin 3 mg/mL 1 drop into the affected eye(s) every 2 hours on days 1 and 2 and every 4 hours on days 3 through 7 vs tobramycin solution 1 drop into the affected eye(s) every 2 hours on days 1 and 2 and every 4 hours on days 3 through 7	Patients ages 12 years and younger, with bacterial conjunctivitis	7 days	assessed by microbiological culture and physicians' judgment of overall resolution Secondary: Safety	ciprofloxacin group when compared to the tobramycin group, however this difference was not significant (*P*=0.29). Physicians judgment of overall resolution was higher in the tobramycin group than in the ciprofloxacin group, however this difference was not significant (89.9 vs 87.0%; *P*>0.5). Secondary: No serious adverse events were attributed to either treatment.
Schwab et al[64] Levofloxacin 0.5% 1 drop into the affected eye(s) every 2 hours on days 1 and 2 and every 4 hours on days 3 through 5 vs ofloxacin 0.3% 1 drop into the affected eye(s) every 2 hours on days 1 and 2 and every 4 hours on days 3 through 5	AC, DB, MC, RCT Patients ≥1 year of age with a diagnosis of bacterial conjunctivitis, characteristic purulent conjunctival discharge (minimum score of 1 on a 4-point scale), and redness (minimum score of 1 on a 4-point scale for bulbar and/or palpebral injection) in at least one eye	N=423 7 days	Primary: Microbial eradication and clinical cures Secondary: Evaluations of ocular signs and symptoms, safety	Primary: A significantly greater proportion of patients receiving 0.5% levofloxacin experienced microbial eradication compared to patients receiving 0.3% ofloxacin at both the final visit (89 vs 80%; *P*=0.034) and last available evaluation (90 vs 81%; *P*=0.038). Clinical cure rates were similar between the 0.5% levofloxacin and 0.3% ofloxacin treatment groups at all time points assessed. At the last evaluation period, clinical cure rates were 76% in each treatment group (*P* value not reported). Secondary: No significant differences were noted between the two treatment groups in resolution of baseline ocular signs at either the final visit or end point. In each treatment group, there was a trend toward resolution of the ocular signs of conjunctival discharge, bulbar and palpebral conjunctival injection and erythema/swelling, with most subjects (>80%) showing resolution by the completion of the study. There was however, a significantly lower incidence of photophobia associated with ofloxacin compared to levofloxacin (*P*=0.006).

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				There were no significant differences between treatment groups in the overall incidence of adverse events. The most frequently reported nonocular adverse event was headache (3%). The most common ocular adverse events were conjunctivitis in the nonstudy eye or worsening conjunctivitis in the infected eye (8%), burning (2%), eye pain (2%) and decrease in visual acuity (2%).
Granet et al[49] Polymyxin B sulfate/ trimethoprim 1 drop into the affected eye(s) QID for 7 days vs moxifloxacin 0.5% 1 drop into the affected eye(s) TID for 7 days	MC, RCT Patients ages 18 years and younger, with a clinical diagnosis of bacterial conjunctivitis	N=56 7 days	Primary: Relief of all signs and symptoms of bacterial conjunctivitis Secondary: Safety	Primary: At the 48 hour visit complete resolution of ocular signs and symptoms were reported in significantly more patients in the moxifloxacin group when compared to the polymyxin B sulfate/trimethoprim group (81 vs 44%; *P*=0.001). Secondary: No adverse events were reported in either group.
Kernt et al[50] Enhanced viscosity tobramycin 0.3% 1 drop into the affected eye(s) BID for 7 days vs tobramycin 0.3% 1 drop into the affected eye(s) QID for 7 days	IB, MC, PG, RCT Male and female patients with a negative pregnancy test prior to study entry who agreed to use birth control throughout the study, ages 1 year and older, with bacterial conjunctivitis based on clinical observation	N=276 12 days	Primary: Percentage of patients with sustained cure/presumed bacterial eradication based on final clinical judgment at test-of-cure visit Secondary: Lid erythema/swelling, palpebral conjunctiva, bulbar conjunctiva, conjunctival discharge/exudates, tearing, and epithelial disease; microbiology,	Primary: At the test-of-cure visit no statistically significant differences were seen between the enhanced viscosity tobramycin group and the tobramycin group with regard to sustained cure/presumed eradication (98.0 vs 99.0% respectively; *P*=0.604). Secondary: No statistically significant differences were seen between the two groups with regard to lid erythema/swelling, palpebral conjunctiva, bulbar conjunctiva, conjunctival discharge/exudates, and tearing (*P* value not reported). Persistence of the original infecting organism was confirmed in two patients from the enhanced viscosity tobramycin group and in six patients from the tobramycin group (*P* value not reported). Adverse events reported were mild to moderate in severity and were

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
			and safety	reported in 5.8% of the total number of patients in both groups. The most frequent ocular adverse events in the enhanced viscosity tobramycin group were ocular pruritus (1.5%), ocular hyperemia (1.5%), and tearing (1.5%). Only ocular pruritus (0.7%) was reported in the tobramycin group (*P* value not reported).
Behrens-Baumann et al[51] Trimethoprim/polymyxin B sulfate 5 mg/g and 10,000 units/g applied QID to the lower conjunctival sac(s) for 7 days vs chloramphenicol 10 mg/g* applied QID to the lower conjunctival sac(s) for 7 days	DB, PG, RCT Patients with a clinical diagnosis of bacterial conjunctivitis	N=42 10 days	Primary: Reduction in severity rating score Secondary: Safety	Primary: No significant difference was seen between the two groups with regard to reduction in severity rating score (*P*>0.1). Secondary: Three (7%) patients from the trimethoprim/polymyxin B sulfate group experienced adverse events: one patient reported stinging/burning, one reported increases in transient grittiness and conjunctival hyperemia, and one reported periorbital edema (*P* value not reported).
Papa et al[52] Gentamicin 0.3% 1 to 2 drops into the affected eye(s) QID until resolution and up to 10 days with gentamicin ointment applied to affected eye(s) HS vs netilmicin 0.3%* 1 to 2 drops into the affected eye(s) QID until resolution and up to 10 days with netilmicin ointment* applied to affected eye(s) HS	AC, DB, PG, PRO, RCT Male and female patients, ages 3 years and older, with suspected acute bacterial conjunctivitis	N=209 10 days	Primary: Clinical resolution of ocular infection as assessed by either clinical or microbiologic parameters Secondary: Safety	Primary: Netilmicin was shown to be significantly more effective than gentamicin in increasing the percentage of infections eradication over time (*P*=0.001). Netilmicin was shown to be significantly more effective than gentamicin in ameliorating clinical symptoms as assessed by the cumulative score of several signs and symptoms of acute bacterial ocular infection at five and 10 days (*P*=0.001 for both five and 10 days). Secondary: Adverse events were reported in four (3.9%) patients in the gentamicin group and two (1.9%) patients in the netilmicin group (*P* value not reported).Treatment tolerance was rated slightly higher in the netilmicin group as compared to the gentamicin group, however

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				this difference was not statistically significant (96.9 vs 70.9%; *P* value not reported)
Leibowitz et al[53] Ciprofloxacin 0.3% vs tobramycin 0.3% vs placebo	2 MC, PRO, RCT Patients with bacterial conjunctivitis	N=288 Duration not specified	Primary: Antibacterial efficacy, and eradication of bacterial pathogens Secondary: Not reported	Primary: In one study ciprofloxacin was shown to be significantly more effective than placebo (*P*<0.001), and eradicated or reduced the various bacterial pathogens in more patients when compared to placebo (93.6 vs 59.5%; *P* value not reported). In a second study ciprofloxacin and tobramycin were found to be equally effective in antibacterial efficacy (94.5 vs 91.9%; *P* value not reported). Secondary: Not reported
Lichtenstein et al[54] Levofloxacin 0.5% 1 drop into the affected eye(s) every 2 hours on days 1 and 2 and every 4 hours on days 3 through 5 vs ofloxacin 0.3% 1 drop into the affected eye(s) every 2 hours on days 1 and 2 and every 4 hours on days 3 through 5 vs placebo 1 drop into the affected eye(s) every 2 hours on days 1 and 2 and every 4	DB, MC, PG, RCT Patients ages 1 to 16 years, with a diagnosis of bacterial conjunctivitis	N=167 10 days	Primary: Rate of microbial eradication Secondary: Not reported	Primary: At the last observation the levofloxacin 0.5% group showed higher rates of microbial eradication when compared to ofloxacin 0.3% (*P* value not reported). In children ages two to 11 years this finding was statistically significant in favor of the levofloxacin 0.5% group when compared to both ofloxacin 0.3% and placebo (87 vs 62%; *P*<0.032 and 88 vs 24%; *P*<0.001). No statistically significant differences were observed between the three groups in the other age subgroups. Secondary: Not reported

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
hours on days 3 through 5				
Lohr et al[55] Trimethoprim/polymyxin B vs gentamicin sulfate vs sodium sulfacetamide	R Patients with culture-positive conjunctivitis	N=158 17 days	Primary: Patients cured and symptom improvement at days 3 to 6 after the start of treatment, patients cured and symptom improvement at days 2 to 7 after completion of therapy, and bacteriologic response at days 2 to 7 after completion of therapy Secondary: Not reported	Primary: Clinical response at days three to six after the start of treatment was similar for patients cured, as well as symptom improvement between the trimethoprim/polymyxin B, gentamicin sulfate, and sodium sulfacetamide groups (47 vs 49%, 41 and 45% vs 46 vs 48% respectively; *P* value not reported). Clinical response and symptom improvement at days two to seven after completion of therapy were also similar between all groups (84% vs 88% vs 89% and 9% vs 9% vs 4%; *P* value not reported). Bacteriologic response at days two to seven after completion of therapy was similar as well for all groups (83 vs 68%, 72; *P* value not reported). Secondary: Not reported
Gibson[56] Trimethoprim/polymyxin B vs neomycin/polymyxin B/gramicidin vs chloramphenicol*	DB, MC, RCT Patients with a diagnosis of presumptive bacterial conjunctivitis	N=230 Duration not specified	Primary: Treatment efficacy, reduction of signs and symptoms of conjunctivitis Secondary: Not reported	Primary: All groups showed efficacy in the treatment of bacterial conjunctivitis with no statistically significant difference demonstrated between the trimethoprim/polymyxin B group and the neomycin/polymyxin B/gramicidin group (*P* value not reported). However, neomycin/polymyxin B/gramicidin was found to be significantly more efficacious than chloramphenicol in reducing signs and symptoms (*P*=0.03). Secondary: Not reported
Silver et al[57] Moxifloxacin 0.5% 1 drop into the affected eye(s) TID for 4	MA Male and female patients of any race,	N=1,978 7 to 9 days	Primary: Safety Secondary:	Primary: The most frequent adverse events experienced by all patients were ocular discomfort, and transient burning and stinging, which were reported in more patients in the moxifloxacin group than the vehicle

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
days vs ofloxacin 0.3% 1 drop into the affected eye(s) QID for 4 days vs ciprofloxacin 0.3% 1 drop into the affected eye(s) TID for 4 days vs vehicle	with a diagnosis of bacterial conjunctivitis		Not reported	group (2.8 vs 2.1%; *P* value not reported). In pediatric patients similar results were found with ocular discomfort, transient burning and stinging reported as the most frequent adverse events experienced; these adverse events were reported in less patients the moxifloxacin group when compared to the vehicle group (1.9 vs 2.2%; *P* value not reported). The most common systemic adverse event reported in pediatric patients was increased cough which occurred in more patients in the moxifloxacin group than the vehicle group (3.2 vs 2.8%; *P* value not reported). Similar rates of adverse events were reported in a study comparing moxifloxacin to ofloxacin with regard to keratitis, corneal infiltrate, and ocular hyperemia (*P* value not reported). In a study comparing moxifloxacin to ciprofloxacin adverse events were also similar between the two groups with regard to tearing, ocular hyperemia, rash, and rhinitis (*P* value not reported). Secondary: Not reported
Jauch et al[58] Gentamicin 0.3% vs tobramycin 0.3% vs chloramphenicol 0.5%* vs	MA Patients with acute bacterial conjunctivitis, purulent discharge, and at least moderate conjunctival hyperemia	N=582 9 days	Primary: Decrease of cumulative sum score of key signs and symptoms of acute bacterial conjunctivitis Secondary: Safety	Primary: Within group comparisons of the sum score of key signs and symptoms statistically significant improvement in both groups was shown between any two visits (*P* value not reported). The between group comparison showed a statistically significant improvement in the sum score with lomefloxacin by assessment days seven to nine in both the intention to treat population and core population when compared to the other treatments (*P*=0.026 and *P*=0.016 respectively). Secondary: When lomefloxacin was compared to all other medications, poor tolerance for the medication was reported less often in the

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
fusidic acid 1%* vs lomefloxacin 0.3%* vs norfloxacin 0.3%*				lomefloxacin group than with the other medications (1.5 vs 3.9%; *P* value not reported). Duration of any burning sensation was also significantly less in the lomefloxacin group when compared to all other medications (*P*=0.04).
Sheikh et al[59] Bacitracin/polymyxin 500 units/g and 10,000 units/g vs ciprofloxacin 0.3% vs chloramphenicol 0.5%* vs fusidic acid gel 1%* vs norfoloxacin 0.3%* vs vehicle	MA Patients ages one month and older, with acute bacterial conjunctivitis, and symptoms of less than four weeks duration	N=1,034 Duration not specified	Primary: Early clinical remission, early microbiological remission, late clinical remission, and late microbiological remission Secondary: Not reported	Primary: When bacitracin/polymyxin was compared to vehicle with regard to early clinical remission, bacitracin/polymyxin was favored at days three through five (RR, 2.20; 95% CI, 1.19 to 4.06). When bacitracin/polymyxin was compared to vehicle with regard to microbiological remission during days three through five it was found that bacitracin/polymyxin was favored (RR, 3.76; 95% CI, 1.77 to 8.00). Ciprofloxacin was also favored when compared to vehicle with regard to early microbiological remission, at day three (RR, 1.59; 95% CI, 1.21 to 2.08). Bacitracin/polymyxin was favored over vehicle with regard to late clinical remission at days eight to 10 (RR, 1.27; 95% CI, 1.00 to 1.61) as well as for late microbiological remission in days eight through 10 (RR, 2.54; 95% CI, 1.48 to 4.37). Secondary: Not reported

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
Corneal Ulcer				
Booranapong et al[65] Ciprofloxacin 0.3% vs lomefloxacin 0.3%*	DB, PRO, RCT Patients with suspected bacterial corneal ulcers	N=41 Duration not specified	Primary: Time to cure, treatment failure, and resolution of clinical signs and symptoms Secondary: Safety	Primary: No statistically significant differences were found with regard to time to cure, treatment failure, or the resolution of clinical signs and symptoms (*P*>0.05 for all). Secondary: No statistically significant difference was found between the two groups with regard to adverse events (*P*>0.05).
Kosrirukvongs et al[66] Ciprofloxacin 0.3% applied into the affected eye(s) every 15 minutes for the first 6 hours, then every 30 minutes on the first day, then every hour while awake till midnight until complete recovery without staining of fluorescein and no culture growth vs cefazolin 50 mg/mL fortified with gentamicin 14 mg/mL applied into the affected eye(s) every 15 minutes for the first 6 hours, then every 30 minutes on the first day, then every hour while awake till midnight until complete recovery without staining of fluorescein and no culture growth	RCT Patients with suspected corneal ulcers	N=41 16 days	Primary: Rate of therapeutically successful treatment, and mean duration for healing Secondary: Not reported	Primary: A higher number of patients in the ciprofloxacin group had therapeutically successful treatment when compared to the cefazolin fortified with gentamicin group; however this difference was not found to be statistically significant (70.6 vs 62.5%, respectively; *P* value not reported). The mean duration for healing after treatment was found to be less in the ciprofloxacin group but was not found to be statistically significant (14.6 vs 15.6 days, respectively; *P* value not reported). Secondary: Not reported
Keratitis				

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
Parks et al[67] Ciprofloxacin 3 mg/mL vs cefazolin 50 mg/mL fortified with gentamicin sulfate 9.1 mg/mL	RETRO Patients with infectious keratitis	N=44 Duration not specified	Primary: Average time to healing, and duration of antibiotic therapy Secondary: Not reported	Primary: Average time to healing in the ciprofloxacin group was less than that seen in the cefazolin fortified with gentamicin sulfate group, however this was not found to be statistically significant (34±33 vs 45±71 days; *P* value not reported). The duration of antibiotic therapy in the ciprofloxacin group was also less than that seen in the cefazolin fortified with gentamicin sulfate group (27±15 vs 33±50 days; *P* value not reported). Secondary: Not reported
Multiple/Unspecified External Ocular Infection				
Bloom et al[68] Ciprofloxacin treatment to affected eye(s) for 7 days vs tobramycin treatment to affected eye(s) for 7 days	DB, MC, RCT Patients with blepharitis and blepharoconjunctivitis	N=464 7 days	Primary: Eradication or reduction of potentially pathogenic bacteria, improvement or cure rate after 7 days, and adverse events Secondary: Not reported	Primary: Eradication or reduction of potentially pathogenic bacteria after seven days of treatment was reported in more patients in the ciprofloxacin group than in the tobramycin group (93.7 vs 88.9% respectively; *P* value not reported). More than 80% of patients in both groups were cured or improved after seven days. However, no statistically significant differences were seen between the two groups (*P* value not reported). No serious adverse events were reported in either group. Secondary: Not reported
Adenis et al[69] Ciprofloxacin 0.3% vs fusidic acid 1%*	OL, PG, RCT Patients with bacterial conjunctivitis and blepharitis	N=39 7 days	Primary: Eradication of infecting organism, clinical cure rate, and adverse events Secondary:	Primary: The infecting organism was documented to be eradicated in more patients in the ciprofloxacin group than those in the fusidic acid group (81 vs 72%, respectively; *P* value not reported). Clinical cure rates were also found to be higher in the ciprofloxacin group when compared to the fusidic acid group (95 vs 89%,

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
			Not reported	respectively; *P* value not reported). Two patients in the ciprofloxacin group reported adverse events, mild discomfort and stinging on instillation, while one patient in the fusidic acid group reported moderate edema and discomfort (*P* value not reported). Secondary: Not reported
Adenis et al[70] Ciprofloxacin 0.3% vs rifamycin 1%*	DB, PG, RCT Patients with bacterial conjunctivitis and blepharitis	N=41 7 days	Primary: Clinical cure rate on day 7, bacteriological eradication rate, and adverse events Secondary: Not reported	Primary: Clinical cure rates on day seven were shown to be higher in the ciprofloxacin group than the rifamycin group, however this difference was not found to be statistically significant (53 vs 23%, respectively; *P*=0.061). Bacteriological eradication rates were similar in both groups (68 vs 77%, respectively; *P* value not reported). No serious adverse events were reported in either treatment group. Secondary: Not reported
Shulman et al[71] Neomycin/polymyxin B/ dexamethasone 3500 units/mL/6000 units/mL/0.1% vs dexamethasone 0.1%	DB Patients with bacterial blepharitis or conjunctivitis	N=111 Duration not specified	Primary: Bacterial count, bacterial eradication, and reduction in symptoms Secondary: Not reported	Primary: The neomycin/polymyxin B/dexamethasone group showed a significantly greater decrease in bacterial counts and bacterial eradication when compared to dexamethasone (90 vs 50% and 34 vs 17% respectively; *P* values not reported). Neomycin/polymyxin B/dexamethasone was shown to significantly reduce conjunctival discharge when compared to dexamethasone 0.1% (*P* value not reported). Both groups were equally efficacious in alleviating other ocular signs and symptoms (*P* value not reported).

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
				Secondary: Not reported
Bron et al[72] Ofloxacin 0.3% 1 drop into the affected eye(s) every 2 to 4 hours on days 1 and 2 and QID on days 3 through 7 vs chloramphenicol 0.5%* 1 drop into the affected eye(s) every 2 to 4 hours on days 1 and 2 and QID on days 3 through 7	DB, MC, PG, RCT Patients with suspected bacterial ocular infection	N=167 8 days	Primary: Clinical improvement as defined as a decline in symptoms of external ocular infection , microbiological improvement rate, and clinical improvement rate Secondary: Safety	Primary: High rates of improvement were seen in both groups with no statistically or clinically significant differences seen with regard to microbiological, clinical or overall improvement rates of the initial culture-positive group (*P* value not reported). Microbiological improvement rates were similar between the ofloxacin group and the chloramphenicol group (85 vs 88%, respectively; *P* value not reported). Clinical improvement rates were also high for both the ofloxacin group and the chloramphenicol group (100 vs 95%, respectively; *P* value not reported). Secondary: No significant differences were seen between the two groups for any symptom present at visit three or with regard to adverse events (*P* value not reported).
Gwon et al[73] Ofloxacin 0.3% 1 drop into the affected eye(s) every 2 to 4 hours on days 1 and 2 and QID on days 3 through 7 vs gentamicin 0.3% 1 drop into the affected eye(s) every 2 to 4 hours on days 1 and 2 and QID on days 3 through 7	DB, RCT Patients with suspected external ocular bacterial infection including conjunctivitis, blepharitis, and blepharoconjunctivitis	N=194 11 days	Primary: Clinical, microbiological, and overall improvement rates Secondary: Safety	Primary: Ofloxacin was found to have higher rates of clinical (98 vs 92%), microbiological (78 vs 67%), and overall (78 vs 63%) improvement rates when compared to gentamicin however none of these differences were statistically significant (*P*=0.089 for all outcomes). Secondary: Adverse events were reported in 3.2% of the ofloxacin group and in 7.1% of the gentamicin group with the most common reactions including burning, stinging, and photophobia (*P* value not reported).

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
Gwon et al[74] Ofloxacin 0.3% 1 drop into the affected eye(s) every 2 to 4 hours on days 1 and 2 and QID on days 3 through 10 vs tobramycin 0.3% 1 drop into the affected eye(s) every 2 to 4 hours on days 1 and 2 and QID on days 3 through 10	DB, MC, RCT Patients with the presence of conjunctival hyperemia, either eyelid crusting or discharge, and positive bacterial culture	N=345 11 days	Primary: Clinical, microbiological, and overall improvement rates Secondary: Change in cumulative summary score of 10 key biomicroscopic and symptomatologic variables, and safety	Primary: Ofloxacin was found to have higher rates of microbiological (85.2 vs 77.6%), and overall (84.0 vs 77.6%) improvement rates when compared to tobramycin at day 11, while tobramycin was shown to have a higher clinical improvement rate (98.9 vs 100%), however none of these differences were found to be statistically significant (*P*=0.089 for all outcomes). Secondary: The decrease in cumulative summary score was found to be significantly greater in the ofloxacin group when compared to the tobramycin group at visits on days three to five (*P*<0.050) Adverse reactions occurred more frequently in the tobramycin group, however this was not found to be significant (0.6 vs 2.9%, respectively; *P* value not reported).
Laibson et al[75] Tobramycin ointment vs gentamicin sulfate ointment	DB, MC Patients with bacterial infections of the external eye	N=511 Duration not specified	Primary: Efficacy evaluated by resolution of signs and symptoms and follow-up impression made by a physician, and adverse events Secondary: Not reported	Primary: Tobramycin ointment was found to be significantly more effective than gentamicin ointment when compared for resolution of signs and symptoms and follow-up impression made by a physician (*P* value not reported). Tobramycin ointment was associated with significantly less adverse events than gentamicin ointment (*P* value not reported). Secondary: Not reported
Leibowitz et al[76] Tobramycin vs gentamicin	DB, MC, RCT Patients with superficial external eye disease	N=77 10 days	Primary: Clinical cure or improvement, antibacterial effectiveness, and averse events	Primary: A trend favoring the tobramycin group was seen with regard to clinical cure or improvement when compared to the gentamicin group, however this difference was not significant (97 vs 91.3%, respectively; *P*>0.05). Antibacterial effectiveness also favored tobramycin but was not found

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
			Secondary: Not reported	to be statistically significant (87.8 vs 77.4%, respectively; *P*>0.05). Adverse events in the tobramycin and gentamicin groups were also not found to be significantly different (9.3 vs 17.6%; *P*>0.05). Secondary: Not reported
Jacobson et al[77] Tobramycin 0.3% 1 drop into the affected eye(s) every 2 hours while awake on day 1 and then QID on days 2 through 7 vs norfloxacin 0.3%* 1 drop into the affected eye(s) every 2 hours while awake on day 1 and then QID on days 2 through 7	DB, MC, RCT Male and female patients, with a clinical diagnosis of acute bacterial conjunctivitis, keratoconjunctivitis, blepharitis, or blepharoconjunctivitis	N=120 8 days	Primary: Pathogens eliminated after therapy Secondary: Safety	Primary: Almost all patients in both groups were evaluated as cured or improved after treatment (no values reported). Both groups had approximately 80% of all pathogens eliminated after therapy (*P* value not reported). Secondary: None of the side effects reported in either group were regarded as serious. Three patients in the tobramycin group reported having corneal stippling (*P* value not reported).
Foulks et al[78] Trimethoprim/polymyxin B 1 mg/mL/10,000 units/g applied to the affected eye(s) every three hours while awake for 10 days vs trimethoprim/sulfacetamide/ polymyxin B 1 mg/g/5 mg/mL/	DB, RCT Patients with clinical signs and symptoms of surface ocular bacterial infections, ages two months and older	N=57 10 days	Primary: Clinical improvement, and microbiologic improvement Secondary: Safety	Primary: Clinical improvements and cure rates at the final follow up visit were similar in the trimethoprim/polymyxin B and trimethoprim/ sulfacetamide/polymyxin B groups with no statistically significant differences between the two with regard to either outcome (20 vs 29% and 80 vs 71% respectively; *P* value not reported). Differences in microbiologic responses were also not found to be statistically significant between the two groups (87 vs 93%, respectively; *P* value not reported). Secondary:

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
10,000 units/g* applied to affected eye(s) every three hours while awake for 10 days				Patients evaluated for safety showed an identical incidence of adverse events (*P* value not reported).
Prophylaxis of Ophthalmia Neonatorum				
Bell et al[79] Erythromycin 0.5% ointment applied to eyes of child at birth vs silver nitration applied to eyes of child at birth vs no prophylaxis	DB, RCT Women from the University of Washington Medical Center-associated obstetric clinics	N=669 60 days	Primary: Frequency of conjunctivitis, and duration of prophylaxis Secondary: Not reported	Primary: After 2 months of observation it was found that infants who received prophylaxis had lower rates of conjunctivitis with only silver nitrate showing a statistically significant decrease, rates of conjunctivitis were 22% in the no prophylaxis group, 16% in the erythromycin group, and 14% in the silver nitrated group (*P* value not reported). Patients who received silver nitrate at birth had a 39% lower rate of conjunctivitis (HR, 0.61; 95% CI, 0.39 to 0.97), while those who received erythromycin had a 31% lower rate of conjunctivitis (HR, 0.69; 95% CI, 0.44 to 1.07). When cases of conjunctivitis were compared before and after two weeks of age, the protective effect of prophylaxis was found to be most effective prior to two weeks of age. The efficacy of erythromycin from day zero to day 14 was 9.0% as compared to 15.0% with no prophylaxis (*P*=0.050). This was not found to be statistically significant from days 15 to 60 (7.0 vs 8.0% respectively; *P*=0.920). Secondary: Not reported
Ali et al[80] Erythromycin 0.5% ointment applied to eyes during the first few hours of birth vs betadine 2.5% applied to eyes	RCT Healthy newborns, without congenital eye abnormalities, from mother who had not used any form of antibiotics within the last 48 hours prior to	N=330 14 days	Primary: Rate of conjunctival symptoms Secondary: Not reported	Primary: The betadine group and erythromycin group had significantly less reports of conjunctival redness and tearing or serious or purulent discharge during the first 24 hours through two weeks of birth when compared to the group that did not receive prophylaxis (9.0% vs 18.4% vs 22.4%, respectively; *P*=0.030). Secondary: Not reported

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
during the first few hours of birth vs no prophylaxis	delivery, without rupture of membranes for more than 18 hours, and absence of meconium aspiration			
Miscellaneous				
Stewart et al[84] Dexamethasone/ neomycin/polymyxin B instilled 3 days prior to surgery and three weeks following surgery vs placebo instilled 3 days prior to surgery and three weeks following surgery	DB, PRO, RCT Patients undergoing planned extracapsular cataract extraction with intraocular lens implantation	N=23 Duration not known (>3 weeks)	Primary: Postoperative development of iritis/ excessive inflammation Secondary: Not reported	Primary: Five out of 13 patients in the placebo group developed significant iritis compared to none out of 10 patients in the dexamethasone/neomycin/polymyxin B group postoperatively (38 vs 0%; *P*=0.027). Two patients in the dexamethasone/neomycin/polymyxin B group compared to none in the placebo group experienced broken suture followed by iris prolapse postoperatively (*P*>0.10). Secondary: Not reported
Van Endt et al[81] Dexamethasone/ neomycin/polymyxin B vs gentamicin	PG, PRO, RCT Male and female patients undergoing cataract and posterior chamber lens implant surgery	N=112 34 days	Primary: Bacterial colony count, intra-ocular inflammation, and global assessment of success of therapy and local tolerance Secondary: Not reported	Primary: At day six to eight the bacterial colony count was significantly less in the gentamicin group when compared to the dexamethasone/neomycin/ polymyxin B group (*P*=0.033). No statistically significant difference was found between the two groups with regard to the degree of intra-ocular inflammation or the global assessment of the success of therapy and local tolerance by the study patients and doctors (*P* value not reported). Secondary: Not reported
Rhee et al[83] Dexamethasone/tobramycin	DB, PG, RCT Patients with	N=40 5 days	Primary: Reduction in ocular symptom scores	Primary: All scores for ocular symptoms showed greater reductions in symptom scores in the dexamethasone/tobramycin group when

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
0.1%/0.3% 1 drop into the affected eye(s) BID for 3 to 5 days vs loteprednol/tobramycin 0.5%/0.3% 1 drop into the affected eye(s) BID for 3 to 5 days	moderate blepharo-keratoconjunctivitis in at least one eye defined as a total sum of scores >6 derived from grading of blepharitis, conjunctivitis, ocular discharge, and punctuate epithelial keratitis		Secondary: Safety	compared to the loteprednol/tobramycin group. Scores for signs of blepharitis, conjunctivitis, and ocular discharge were significantly reduced (*P*=0.017, *P*=0.013 and *P*=0.025, respectively), while the reduction in the keratitis score was not found to be statistically significant (*P*=0.065). Secondary: No adverse events were reported in any patient in either treatment group.
White et al[85] Loteprednol/tobramycin 0.5%/0.3% 1 drop in the affected eye(s) QID vs dexamethasone/ tobramycin 0.1%/0.3% 1 drop in the affected eye(s) QID	MC, PG, RCT, SB Patients with ocular inflammation associated with blepharokerato-conjunctivitis in at least one eye	N=276 14 days	Primary: Change from baseline in the signs of symptoms composite score of ocular inflammation associated with blepharokerato-conjunctivitis Secondary: Visual acuity, biomicroscopy, intraocular pressure assessments and adverse events	Primary: The mean±SD change from baseline in the signs and symptoms composite score at day 15 was -15.2±7.3 for loteprednol/tobramycin and -15.6±7.7 for dexamethasone/tobramycin (*P* value not reported). Secondary: Patients in the dexamethasone/tobramycin group experienced a significant increase in intraocular pressure compared to patients in the loteprednol/tobramycin group at day seven, day 15, and overall (0.6±2.3 vs -0.1±2.2; *P*=0.03, 1.0±3.0 vs -0.1±2.4; *P*=0.01, and 2.3±2.3 vs 1.6±1.7; *P*=0.02, respectively).
Notivol et al[82] Dexamethasone/tobramycin 1 mg/mL/3 mg/mL 1 drop into the operated eye(s) QID for 21 days	DB, MC, PG, PRO Male and female patients of any race, ages 18 years and older, undergoing cataract extraction by	N=271 21 days	Primary: Intraocular inflammation assessed at days 3, 8, 14 and 21 Secondary: Evaluation of adverse	Primary: Inflammation scores between dexamethasone/tobramycin and dexamethasone/neomycin/polymyxin B were 0.08, 0.13 and 0.09 at days three, eight, 14, and 21 respectively (*P*<0.70 for all) and met the upper 95% CI to show noninferiority of dexamethasone/tobramycin. Inflammation scores were significantly lower in the dexamethasone/

Study and Drug Regimen	Study Design and Demographics	Sample Size and Study Duration	End Points	Results
vs dexamethasone/neomycin/polymyxin B 1 mg/mL/ 3500 units/mL/6000 units/mL 1 drop into the operated eye(s) QID for 21 days vs neomycin/polymyxin B/gramicidin 3500 units/mL/7500 units/mL/20 µg/mL 1 drop into the operated eye(s) QID for 21 days	either manual extraction or phacoemulsification with intraocular lens implantation		events including flare, conjunctival hyperemia, corneal edema, anterior vitreous reaction, ocular pain, physician's impression of inflammation, and presence of ciliary flush	tobramycin group when compared to the dexamethasone/neomycin/ polymyxin B group at days eight, 14, and 21 (0.77, 0.54, 0.39 respectively; *P*<0.050 for all), and scores in the dexamethasone/neomycin/polymyxin B group were significantly lower than those seen in the neomycin/polymyxin B/gramicidin group at day eight (mean score difference, 0.51; *P*<0.050). Secondary: No statistically significant differences were seen in the mean scores of any variable between the dexamethasone/ tobramycin group and the dexamethasone/neomycin/ polymyxin B groups. The neomycin/polymyxin B/gramicidin group reported significantly lower events with regard to flare at day eight, conjunctival hyperemia at days three, eight, 14, and 21, corneal edema at days three, 14, and 21, ocular pain at days eight, 14, and 21, and physician's clinical impression of inflammation at days three, eight, 14, and 21 when compared to the dexamethasone/tobramycin group (*P*<0.05 for all). The percentage of patients with ciliary flush as days eight, 14, and 21 were significantly lower in the dexamethasone/tobramycin group than in the neomycin/polymyxin B/gramicidin group (*P*<0.05 for all). Scores in the dexamethasone/neomycin/polymyxin B group in relation to conjunctival hyperemia at days three, eight, 14, and 21, corneal edema at day 14, ocular pain at days eight, 14, and 21, and physician's impression at days eight, 14, and 21 were significantly lower than those reported in the neomycin/polymyxin B/gramicidin group (*P*<0.05 for all).

*Agent not available in the United States.
Drug regimen abbreviations: BID=twice daily, QD=once daily, QID=four times daily, TID=three times daily,
Study abbreviations: AC=active-controlled, CI=confidence interval, DB=double-blind, HR=hazard ratio, IB=investigator blind, HS=at bedtime, MA=meta-analysis, MC=multicenter, NI=non-inferiority, OL=open-label, PC=placebo-controlled, PG=parallel-group, PRO=prospective, R=randomized, RCT=randomized controlled trial, RETRO=retrospective, RR=risk ratio, SB=single blind, VC=vehicle control

Special Populations

While the ophthalmic agents included in this review are classified as pregnancy category B or C, it is unknown if they are excreted in human breast milk. No overall differences in safety or efficacy were observed in the elderly and no dose adjustments are required in renal or hepatic impairment.

Table 4. Special Populations[1,4-37]

Generic Name	Elderly/ Children	Renal Dysfunction	Hepatic Dysfunction	Pregnancy Category	Excreted in Breast Milk
Single Entity Products					
Azithromycin	No overall differences in safety or efficacy observed in the elderly. Safety and efficacy in pediatric patients <1 year of age have not been established.	Not reported	Not reported	B	Not reported
Bacitracin	No overall differences in safety or efficacy observed in the elderly.	Not reported	Not reported	C	Not reported
Besifloxacin	No overall differences in safety or efficacy observed in the elderly. Safety and efficacy in pediatric patients <1 year of age have not been established.	Not reported	Not reported	C	Not reported
Ciprofloxacin	No overall differences in safety or efficacy observed in the elderly. Ophthalmic ointment: Safety and efficacy in pediatric patients <2 years of age have not been established. Ophthalmic suspension: Safety and efficacy in pediatric patients <1 year of age have not been established.	Not reported	Not reported	C	Not reported
Erythromycin	Safety and efficacy has been established in newborn infants.	Not reported	Not reported	B	Not reported
Gatifloxacin	No overall differences in safety or efficacy observed in the elderly. Safety and efficacy in pediatric patients<1 year of age have not been	Not reported	Not reported	C	Not reported

Generic Name	Elderly/ Children	Renal Dysfunction	Hepatic Dysfunction	Pregnancy Category	Excreted in Breast Milk
	established.				
Gentamicin sulfate	Safety and efficacy in pediatric patients have not been established.	Not reported	Not reported	C	Not reported
Levofloxacin	No overall differences in safety or efficacy observed in the elderly. Iquix®: Safety and efficacy in pediatric patients <6 years of age have not been established. Quixin®: Safety and efficacy in pediatric patients <1 year of age have not been established.	Not reported	Not reported	C	Not reported
Moxifloxacin hydrochloride	No overall differences in safety or efficacy observed in the elderly. Moxeza®: Safety and efficacy in pediatric patients <3 months of age have not been established. Vigamox®: Safety and efficacy in pediatric patients <1 year of age have not been established.	Not reported	Not reported	C	Not reported
Ofloxacin	No overall differences in safety or efficacy observed in the elderly. Safety and efficacy in pediatric patients <1 year of age have not been established.	Not reported	Not reported	C	Not reported
Sulfacetamide sodium	No overall differences in safety or efficacy observed in the elderly. Safety and efficacy in pediatric patients <2 months of age have not been established.	Not reported	Not reported	C	Not reported

Generic Name	Elderly/ Children	Renal Dysfunction	Hepatic Dysfunction	Pregnancy Category	Excreted in Breast Milk
Tobramycin	Not reported.	Not reported	Not reported	B	Not reported
Combination Products					
Bacitracin zinc/ polymyxin B sulfate	Safety and efficacy in pediatric patients have not been established.	Not reported	Not reported	C	Not reported
Gentamicin sulfate/ prednisolone acetate	No overall differences in safety or efficacy observed in the elderly. Safety and efficacy in pediatric patients have not been established.	Not reported	Not reported	C	Not reported
Polymyxin B sulfate/ trimethoprim	No overall differences in safety or efficacy observed in the elderly. Safety and efficacy in pediatric patients <2 months of age have not been established.	Not reported	Not reported	C	Not reported
Sulfacetamide sodium/ prednisolone acetate	Safety and efficacy in pediatric patients <6 years of age have not been established.	Not reported	Not reported	C	Not reported
Sulfacetamide sodium/ prednisolone sodium phosphate	Safety and efficacy in pediatric patients <6 years of age have not been established.	Not reported	Not reported	C	Not reported
Tobramycin/ dexamethasone	No overall differences in safety or efficacy observed in the elderly. Safety and efficacy in pediatric patients <2 years of age have not been established.	Not reported	Not reported	C	Not reported
Tobramycin/ loteprednol etabonate	No overall differences in safety or efficacy observed in the elderly. Safety and efficacy in pediatric patients have not been established.	Not reported	Not reported	C	Unknown
Neomycin sulfate/ polymyxin B sulfate/ bacitracin zinc	Safety and efficacy in pediatric patients have not been established.	Not reported	Not reported	C	Not reported
Neomycin	No overall differences in	Not reported	Not reported	C	Not

Generic Name	Elderly/ Children	Renal Dysfunction	Hepatic Dysfunction	Pregnancy Category	Excreted in Breast Milk
sulfate/ polymyxin B sulfate/ dexamethasone	safety or efficacy observed in the elderly. Ophthalmic ointment: Safety and efficacy in pediatric patients have not been established. Ophthalmic suspension: Safety and efficacy in pediatric patients <2 years of age have not been established.				reported
Neomycin sulfate/ polymyxin B sulfate/ gramicidin	Safety and efficacy in pediatric patients have not been established.	Not reported	Not reported	C	Not reported
Neomycin sulfate/ polymyxin B sulfate/ hydrocortisone	No overall differences in safety or efficacy observed in the elderly. Safety and efficacy in pediatric patients have not been established.	Not reported	Not reported	C	Not reported
Neomycin sulfate/ polymyxin B sulfate/ prednisolone acetate sulfate	No overall differences in safety or efficacy observed in the elderly. Safety and efficacy in pediatric patients have not been established.	Not reported	Not reported	C	Excreted in human milk; use caution.
Neomycin sulfate/ polymyxin B sulfate/ bacitracin zinc/ hydrocortisone	No overall differences in safety or efficacy observed in the elderly. Safety and efficacy in pediatric patients have not been established.	Not reported	Not reported	C	Not reported

Adverse Drug Events

In rare instances sulfonamides have caused fatalities due to adverse reactions including Stevens-Johnson syndrome, toxic epidermal necrolysis, fulminant hepatic necrosis, agranulocytosis, aplastic anemia, and other blood dyscrasias.[18]

Table 5. Adverse Drug Events (%)[1,4-37]

Adverse Event(s)	Single Entity Products													
	Azithromycin	Bacitracin	Besifloxacin	Ciprofloxacin Suspension	Ciprofloxacin Ointment	Erythromycin	Gatifloxacin	Gentamicin Sulfate	Levofloxacin 0.5%	Levofloxacin 1.5%	Moxifloxacin Hydrochloride	Ofloxacin	Sulfacetamide Sodium	Tobramycin
Cardiovascular														
Hyperemia	-	-	-	-	<1	-	-	-	-	<1	-	-	-	-
Central Nervous System														
Dizziness	-	-	-	-	-	-	-	-	-	-	-	✔	-	-
Hallucinations	-	-	-	-	-	-	-	✔	-	-	-	-	-	-
Headache	-	-	1 to 2	-	-	-	1 to 4	-	1 to 3	8 to 10	-	-	-	-
Itching	-	-	-	<10	-	-	-	-	-	-	-	✔	-	-
Itching pain	✔	-	-	-	-	-	-	-	-	-	-	-	-	-
Pruritus	-	-	-	-	<1	-	-	-	-	-	-	-	-	-
Dermatologic														
Contact dermatitis	<1	-	-	-	-	-	-	-	-	-	-	-	-	-
Dermatitis	-	-	-	-	<1	-	-	-	-	-	-	-	-	-
Hives	✔	-	-	-	-	-	-	-	-	-	-	-	-	-
Rash	✔	-	-	-	-	-	-	-	-	-	1 to 4	-	-	-
Endocrine and Metabolic														
Edema	-	-	-	-	<1	-	-	-	-	-	-	✔	-	-
Gastrointestinal														
Diarrhea	-	-	-	-	-	-	-	-	-	1 to 2	-	-	-	-
Dyspepsia	-	-	-	-	-	-	-	-	-	1 to 2	-	-	-	-
Nausea	-	-	-	<1	<1	-	-	-	-	1 to 2	-	✔	-	-
Ocular														
Blurred vision	✔	-	1 to 2	-	<1	-	-	-	-	1 to 2	-	✔	-	-
Burning	<1	-	-	✔	-	-	-	✔	-	-	-	-	✔	-

Adverse Event(s)	Single Entity Products													
	Azithromycin	Bacitracin	Besifloxacin	Ciprofloxacin Suspension	Ciprofloxacin Ointment	Erythromycin	Gatifloxacin	Gentamicin Sulfate	Levofloxacin 0.5%	Levofloxacin 1.5%	Moxifloxacin Hydrochloride	Ofloxacin	Sulfacetamide Sodium	Tobramycin
Chemical conjunctivitis	-	-	-	-	-	-	-	-	-	-	-	✔	-	-
Chemical keratitis	-	-	-	-	-	-	-	-	-	-	-	✔	-	-
Chemosis	-	-	-	-	-	-	1 to 4	-	-	<1	-	-	-	-
Conjunctival epithelial defects	-	-	-	-	-	-	-	✔	-	-	-	-	-	-
Conjunctival erythema	-	-	-	-	-	-	-	-	-	-	-	-	-	<3
Conjunctival hemorrhage	-	-	-	-	-	-	1 to 4	-	-	-	-	-	-	-
Conjunctival hyperemia	-	-	-	<10	-	-	-	✔	-	-	-	-	✔	-
Conjunctival irritation	-	-	-	-	-	-	5 to 10	-	-	-	-	-	-	-
Conjunctival redness	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Conjunctivitis	-	-	-	-	-	-	-	-	-	-	1 to 6	-	-	-
Corneal erosion	<1	-	-	-	-	-	-	-	-	<1	-	-	-	-
Corneal infiltrates	-	-	-	<1	-	-	-	-	-	-	-	-	-	-
Corneal staining	-	-	-	<1	<1	-	-	-	-	-	-	-	-	-
Corneal ulcer	-	-	-	-	-	-	-	✔	-	<1	-	-	✔	-
Crystals/scales	-	-	-	<10	-	-	-	-	-	-	-	-	-	-
Decreased vision	-	-	-	<1	-	-	-	-	1 to 3	1 to 2	-	-	-	-
Decreased visual acuity	-	-	-	-	<1	-	1 to 4	-	-	-	1 to 6	-	-	-
Diplopia	-	-	-	-	-	-	-	-	-	<1	-	-	-	-
Dry eye	<1	-	-	-	<1	-	1 to 4	-	-	-	1 to 6	-	-	-
Dryness	-	-	-	-	-	-	-	-	-	-	-	✔	-	-
Epitheliopathy	-	-	-	-	<1	-	-	-	-	-	-	-	-	-
Eye discharge	-	-	-	-	-	-	1 to 4	-	-	-	-	-	-	-
Eye discomfort	-	-	-	✔	2	-	-	-	-	1 to 2	-	-	-	-
Eye irritation	1 to 2	-	1 to 2	-	<1	✔	1 to 4	-	-	1 to 2	1 to 2	-	✔	-
Eye pain	-	-	1 to 2	-	<1	-	1 to 4	-	-	-	-	✔	-	-
Eye pruritus	-	-	1 to 2	-	-	-	-	-	-	-	-	-	-	-
Eyelid edema	-	-	-	-	-	-	1 to 4	-	-	-	-	-	-	-
Eyelid swelling	✔	-	-	-	-	-	-	-	-	-	-	-	-	-

Adverse Event(s)	Single Entity Products													
	Azithromycin	Bacitracin	Besifloxacin	Ciprofloxacin Suspension	Ciprofloxacin Ointment	Erythromycin	Gatifloxacin	Gentamicin Sulfate	Levofloxacin 0.5%	Levofloxacin 1.5%	Moxifloxacin Hydrochloride	Ofloxacin	Sulfacetamide Sodium	Tobramycin
Floaters	-	-	-	-	-	-	-	-	-	<1	-	-	-	-
Foreign body sensation	-	-	-	<10	<1	-	-	-	1 to 3	-	-	✔	-	-
Irritation upon instillation	<1	-	-	-	-	-	-	✔	-	-	-	-	-	-
Keratoconjunctivitis	-	-	-	-	<1	-	-	-	-	-	-	-	-	-
Keratopathy	-	-	-	<1	2	-	-	-	-	-	-	-	-	-
Keratitis	-	-	-	<1	-	-	5 to 10	-	-	-	1 to 6	-	-	-
Lid edema	-	-	-	<1	-	-	-	-	<1	<1	-	-	-	-
Lid erythema	-	-	-	-	<1	-	-	-	-	<1	-	-	-	-
Lid itching	-	-	-	-	-	-	-	-	-	-	-	-	-	<3
Lid margin crusting	-	-	-	<10	-	-	-	-	-	-	-	-	-	-
Lid margin hyperemia	-	-	-	-	<1	-	-	-	-	-	-	-	-	-
Lid swelling	-	-	-	-	-	-	-	-	-	-	-	-	-	<3
Non-specific conjunctivitis	-	-	-	-	-	-	-	✔	-	-	-	-	✔	-
Ocular discharge	<1	-	-	-	-	-	-	-	-	-	-	-	-	-
Ocular discomfort	-	-	-	-	-	-	-	-	1 to 3	1 to 2	1 to 6	-	-	-
Ocular dryness	-	-	-	-	-	-	-	-	<1	-	-	-	-	-
Ocular hyperemia	-	-	-	-	-	-	-	-	-	-	1 to 6	-	-	-
Ocular infection	-	-	-	-	-	-	-	-	-	1 to 2	-	-	-	-
Ocular itching	-	-	-	-	-	-	-	-	<1	-	-	-	-	-
Ocular pain	-	-	-	-	-	-	-	-	1 to 3	1 to 2	1 to 6	-	-	-
Ocular pruritus	-	-	-	-	-	-	-	-	-	-	1 to 6	-	-	-
Papillary conjunctivitis	-	-	-	-	-	-	5 to 10	-	-	-	-	-	-	-
Periocular swelling	✔	-	-	-	-	-	-	-	-	-	-	-	-	-
Punctate keratitis	<1	-	-	-	-	-	-	-	-	-	-	-	-	-
Redness	-	-	-	-	-	✔	1 to 4	-	-	-	-	✔	-	-
Stinging	-	-	-	-	-	-	-	-	-	-	-	✔	✔	-
Stinging upon instillation	<1	-	-	-	-	-	-	-	-	-	-	-	-	-
Subconjunctival hemorrhage	-	-	-	-	-	-	-	-	-	-	1 to 6	-	-	-

Adverse Event(s)	Single Entity Products													
	Azithromycin	Bacitracin	Besifloxacin	Ciprofloxacin Suspension	Ciprofloxacin Ointment	Erythromycin	Gatifloxacin	Gentamicin Sulfate	Levofloxacin 0.5%	Levofloxacin 1.5%	Moxifloxacin Hydrochloride	Ofloxacin	Sulfacetamide Sodium	Tobramycin
Tearing	-	-	-	<1	<1	-	5 to 10	-	-	-	1 to 6	✔	-	-
Transient ocular burning	-	-	-	-	-	-	-	-	1 to 3	-	-	✔	-	-
Transient ocular discomfort	-	-	-	-	-	-	-	-	-	-	-	✔	-	-
Visual activity reduction	✔	-	-	-	-	-	-	-	-	-	-	-	-	-
White crystalline precipitates	-	-	-	17	-	-	-	-	-	-	-	-	-	-
Respiratory														
Increased cough	-	-	-	-	-	-	-	-	-	-	1 to 4	-	-	-
Nasal congestion	<1	-	-	-	-	-	-	-	-	-	-	-	-	-
Pharyngitis	-	-	-	-	-	-	-	-	1 to 3	-	1 to 4	-	-	-
Rhinitis	-	-	-	-	-	-	-	-	-	-	1 to 4	-	-	-
Other														
Allergic reactions	✔	-	-	<1	<1	-	-	✔	<1	-	-	-	✔	-
Bad taste following instillation	-	-	-	<10	-	-	-	-	-	-	-	-	-	-
Dysgeusia	<1	-	-	-	-	-	-	-	-	-	-	-	-	-
Fever	-	-	-	-	-	-	-	-	1 to 3	1 to 2	1 to 4	-	-	-
Hypersensitivity reactions	-	-	-	-	-	✔	-	-	-	-	-	-	-	-
Infection	-	-	-	-	-	-	-	-	-	1 to 2	1 to 4	-	-	-
Otitis media	-	-	-	-	-	-	-	-	-	-	1 to 4	-	-	-
Photophobia	-	-	-	<1	<1	-	-	-	1 to 3	-	-	✔	-	-
Pyrexia	-	-	-	-	-	-	-	-	-	-	1 to 2	-	-	-
Secondary infections	-	-	-	-	-	-	-	-	-	-	-	-	✔	-
Taste perversion	-	-	-	-	<1	-	1 to 4	-	-	8 to 10	-	-	-	-
Thrombocytopenic purpura	-	-	-	-	-	-	-	✔	-	-	-	-	-	-
Throat irritation	-	-	-	-	-	-	-	-	-	1 to 2	-	-	-	-

✔ Percent not specified.
- Event not reported or incidence <1%.

Table 6. Adverse Drug Events (%)[1,4-37]

Adverse Event(s)	Combination Products														
	Bacitracin Zinc/Polymyxin B Sulfate	Gentamicin Sulfate/ Prednisolone Acetate	Polymyxin B Sulfate/ Trimethoprim	Sulfacetamide Sodium/ Prednisolone Acetate	Sulfacetamide Sodium/ Prednisolone Sodium Phosphate	Tobramycin/Dexamethasone 0.3%/0.1%	Tobramycin/Dexamethasone 0.3%/0.05%	Tobramycin/Loteprednol Etabonate	Neomycin Sulfate/Polymyxin B Sulfate/Bacitracin Zinc	Neomycin Sulfate/Polymyxin B Sulfate/Dexamethasone Ointment	Neomycin Sulfate/Polymyxin B Sulfate/Dexamethasone Solution	Neomycin Sulfate/Polymyxin B Sulfate/Gramicidin	Neomycin Sulfate/Polymyxin B Sulfate/Hydrocortisone	Neomycin Sulfate/Polymyxin B Sulfate/Prednisolone Acetate Sulfate	Neomycin Sulfate/Polymyxin B Sulfate/Bacitracin Zinc/ Hydrocortisone
Cardiovascular															
Increase in blood pressure	-	-	-	-	-	-	0.5 to 1.0	-	-	-	-	-	-	-	-
Central Nervous System															
Headache	-	-	-	-	-	-	0.5 to 1.0	14	-	-	-	-	-	-	-
Itching	✔	-	✔	-	-	<4	-	<4	✔	-	-	✔	✔	-	✔
Dermatologic															
Circumocular rash	-	-	✔	-	-	-	-	-	-	-	-	-	-	-	-
Ocular															
Burning	-	✔	✔	-	-	-	-	9	-	-	-	-	-	-	-
Conjunctival erythema	✔	-	-	-	-	<4	-	-	✔	-	-	✔	✔	✔	✔
Conjunctival hyperemia	-	-	-	-	-	-	<4	-	-	-	✔	-	-	✔	-
Conjunctivitis	-	-	-	-	-	-	-	-	-	-	✔	-	-	✔	-
Corneal deposits	-	-	-	-	-	-	-	<4	-	-	-	-	-	-	-
Corneal ulcer	-	-	-	-	-	-	-	-	-	-	✔	-	-	✔	-
Discharge	-	-	-	-	-	-	-	<4	-	-	-	-	-	-	-
Discomfort	-	-	-	-	-	-	-	<4	-	-	-	-	-	-	-
Elevation in intraocular pressure	-	✔	-	✔	✔	✔	✔	10	-	✔	✔	-	-	✔	-
Eye irritation	-	✔	-	-	✔	-	<4	-	-	-	-	-	-	-	-
Eye pruritus	-	-	-	-	-	-	<4	-	-	-	-	-	-	-	-
Eyelid disorder	-	-	-	-	-	-	-	<4	-	-	-	-	-	-	-
Eyelid edema	-	-	-	-	-	-	<4	-	-	-	-	-	-	-	-
Irritation upon instillation	✔	-	-	-	-	-	-	-	✔	-	-	✔	-	-	-

Adverse Event(s)	Combination Products														
	Bacitracin Zinc/Polymyxin B Sulfate	Gentamicin Sulfate/ Prednisolone Acetate	Polymyxin B Sulfate/ Trimethoprim	Sulfacetamide Sodium/ Prednisolone Acetate	Sulfacetamide Sodium/ Prednisolone Sodium Phosphate	Tobramycin/Dexamethasone 0.3%/0.1%	Tobramycin/Dexamethasone 0.3%/0.05%	Tobramycin/Loteprednol Etabonate	Neomycin Sulfate/Polymyxin B Sulfate/Bacitracin Zinc	Neomycin Sulfate/Polymyxin B Sulfate/Dexamethasone Ointment	Neomycin Sulfate/Polymyxin B Sulfate/Dexamethasone Solution	Neomycin Sulfate/Polymyxin B Sulfate/Gramicidin	Neomycin Sulfate/Polymyxin B Sulfate/Hydrocortisone	Neomycin Sulfate/Polymyxin B Sulfate/Prednisolone Acetate Sulfate	Neomycin Sulfate/Polymyxin B Sulfate/Bacitracin Zinc/ Hydrocortisone
Keratitis	-	-	-	-	-	-	-	-	-	-	✔	-	-	✔	-
Photophobia	-	-	-	-	-	-	-	<4	-	-	-	-	-	-	-
Posterior subcapsular cataract formation	-	✔	-	-	✔	-	-	-	-	✔	✔	-	✔	✔	✔
Stinging	-	✔	✔	-	-	-	-	9	-	-	-	-	-	-	-
Superficial punctuate keratitis	-	✔	-	-	-	-	-	>10	-	-	-	-	-	-	-
Tearing	-	-	✔	-	-	-	-	-	-	-	-	-	-	-	-
Vision disorders	-	-	✔	-	-	-	-	<4	-	-	✔	-	-	-	-
Other															
Allergic reactions	-	-	-	-	-	-	-	-	-	-	-	✔	-	-	-
Allergic sensitizations	-	✔	-	✔	✔	-	-	-	✔	✔	✔	-	✔	✔	✔
Anaphylaxis	✔	-	-	-	-	-	-	-	✔	-	-	✔	✔	✔	✔
Delayed wound healing	-	✔	-	-	✔	-	-	-	-	✔	✔	-	✔	✔	✔
Hypersensitivity reactions	-	-	✔	-	-	<4	<4	-	✔	-	-	✔	✔	✔	✔
Secondary infections	-	✔	-	✔	✔	-	✔	✔	-	✔	-	-	✔	✔	✔
Swelling	✔	-	-	-	-	<4	-	-	✔	-	-	✔	✔	✔	✔

✔ Percent not specified.
- Event not reported or incidence <1%.

Contraindications/Precautions[1,4-37]

Patients with known hypersensitivity to any component of an antibiotic medication should avoid use of the ophthalmic formulation of that medication and the agent should be discontinued at the first sign of skin rash or hypersensitivity. Prolonged use of ophthalmic antibiotics may result in overgrowth of non-susceptible organisms. If super-infection occurs, use of the ophthalmic antibiotic should be discontinued and an alternative therapy should be started. Patients with suspected or confirmed bacterial conjunctivitis should avoid the use of contact lenses.[1,4-37]

Prolonged use of ophthalmic corticosteroids may result in ocular hypertension and/or glaucoma with damage to the optic nerve, defects in visual acuity and fields, and in posterior subcapsular cataract formation. Ophthalmic corticosteroids should be used with caution in patients with glaucoma and intraocular pressure should be monitored routinely when used for10 or more days. The use of topical corticosteroids may delay healing and increase the incidence of bleb formation after cataract surgery. Ophthalmic corticosteroids may also suppress the host response and increase the hazard of secondary ocular infections when used for extended periods of time. Acute purulent eye infections may be masked or enhanced by the use of ophthalmic corticosteroid medications. The use of ophthalmic corticosteroids in the presence of thin corneal or sclera tissue may lead to perforations and perforations have been known to occur with these agents.[20,21,23-29] Ophthalmic ointments may retard corneal healing.

Ophthalmic corticosteroids should be used with caution in the treatment of herpes simplex keratitis since they can exacerbate the severity of viral infections of the eye. They are not effective for the treatment of mustard gas keratitis or Sjogren's keratoconjunctivitis. Fungal infections of the cornea may develop with prolonged use of ophthalmic corticosteroids. If there is any persistent corneal ulceration with ophthalmic corticosteroid use, then fungal invasion should be considered. Concomitant use of ophthalmic corticosteroids and ophthalmic aminoglycosides may result in sensitivity to the topically applied aminoglycosides. If a sensitivity reaction does occur, the ophthalmic corticosteroid medication should be discontinued.[20,21,23-29]

A significant percentage of staphylococcal isolates have been found to be completely resistant to sulfonamides.[23,24]

Drug Interactions[1,4-37]

Since ophthalmic medications have minimal systemic absorption, studies have not been conducted to assess drug interactions associated with these medications.

Dosage and Administration

Table 7. Dosing and Administration[4-37]

Generic Name	Adult Dose	Pediatric Dose	Availability
Single Entity Products			
Azithromycin	Bacterial conjunctivitis: Instill one drop twice-daily for two days then one drop daily for five days	Safety and efficacy in pediatric patients <1 year of age have not been established.	Ophthalmic solution: 1% (2.5 mL)
Bacitracin	Acute infection: Apply a ¼ in to ½ in ribbon every three to four hours into conjunctival sac(s) Mild-to-moderate infection: Apply a ¼ in to ½ in ribbon two to three times daily for seven to 10 days	No specific pediatric information available.	Ophthalmic ointment: 500 units/g (3.5, 3.75 g)

Generic Name	Adult Dose	Pediatric Dose	Availability
Besifloxacin	Bacterial conjunctivitis: Instill one drop three times daily four to 12 hours apart for seven days	Safety and efficacy in pediatric patients <1 year of age have not been established.	Ophthalmic suspension: 0.6% (5 mL)
Ciprofloxacin	Bacterial conjunctivitis: Ophthalmic ointment: apply ½ inch ribbon into conjunctival sac(s) three times daily for one day then a ½ inch ribbon two times daily for five days Ophthalmic solution: instill one to two drops into conjunctival sac(s) every two hours while awake for two days, then one drop every four hours for five days Corneal ulcer: Ophthalmic solution: on day one instill two drops every 15 minutes for the first six hours then two drops every 30 minutes for the remainder of the day, then on day two instill two drops every hour, and then two drops every four hours for days three through 12	Ophthalmic ointment: safety and efficacy in pediatric patients <2 years of age have not been established. Ophthalmic solution: safety and efficacy in pediatric patients <1 year of age have not been established.	Ophthalmic ointment: 0.3% (3.5 g) Ophthalmic solution: 0.3% (2.5, 5, 10 mL)
Erythromycin	Bacterial conjunctivitis and corneal ulcer: Apply 1 cm ribbon directly to eye(s) up to six times daily	Prophylaxis of neonatal ophthalmia: Apply 1 cm ribbon into lower conjunctival sac(s)	Ophthalmic ointment: 0.5% (3.5 g)
Gatifloxacin	Bacterial conjunctivitis: On day one instill one drop every two hours while awake up to eight times daily, then on days two through seven instill one drop up to four times daily while awake (Zymaxid®)	Safety and efficacy in pediatric patients <1 year of age have not been established.	Ophthalmic solution: 0.5% (2.5 mL)
Gentamicin sulfate	Ophthalmic ointment: apply ½ in ribbon to affected eye(s) two to three times daily Ophthalmic solution: Instill one to two drops every four hours, may be increased to two drops once every hour in severe infection	Safety and efficacy in pediatric patients have not been established.	Ophthalmic ointment: 0.3% (3.5 g) Solution: 0.3% (5, 15 mL)
Levofloxacin	Bacterial conjunctivitis: Quixin®: on days one and two instill one to two drops every two	Quixin®: safety and efficacy in pediatric patients <1 year of	Ophthalmic solution: 0.5% (5 mL) (Quixin®)

Generic Name	Adult Dose	Pediatric Dose	Availability
	hours while awake up to eight times per day, then on days three through seven instill one to two drops every four hours while awake up to four times daily Corneal ulcer: Iquix®: on days one through three instill one to two drops every 30 minutes to two hours while awake and approximately four to six hours after retiring, then on days four through completion instill one to two drops every one to four hours while awake	age have not been established. Iquix®: safety and efficacy in pediatric patients <6 years of age have not been established.	1.5% (5 mL) (Iquix®)
Moxifloxacin hydrochloride	Bacterial conjunctivitis: Moxeza: instill one drop three times daily for seven days Vigamox®: instill one drop three times daily for seven days	Moxeza®: Safety and efficacy in pediatric patients <3 months of age have not been established. Vigamox®: Safety and efficacy in pediatric patients <1 year of age have not been established.	Ophthalmic solution: 0.5% (3 mL)
Ofloxacin	Bacterial conjunctivitis: On days one and two instill one to two drops every two to four hours and on days three through seven instill one to two drops four times daily Corneal ulcer: On days one and two instill one to two drops every 30 minutes while awake and awaken four to six hours after retiring to instill one to two drops, then on days three through seven to nine instill one to two drops hourly while awake, then on days seven to nine through treatment completion instill one to two drops four times daily	Safety and efficacy in pediatric patients <1 year of age have not been established.	Ophthalmic solution: 0.3% (1, 5, 10 mL)
Sulfacetamide sodium	Ophthalmic ointment: apply ½ in ribbon into the conjunctival sac(s) every three to four hours and at bedtime	Safety and efficacy in pediatric patients <2 months of age have not been established.	Ophthalmic ointment: 10% (3.5 g) Ophthalmic solution: 1% (5, 10 mL)

Generic Name	Adult Dose	Pediatric Dose	Availability
	Conjunctivitis and other superficial ocular infections: Ophthalmic solution: instill one or two drops into conjunctival sac(s) every two to three hours initially for seven to 10 days Trachoma: Ophthalmic solution: instill two drops into the conjunctival sac(s) every two hours, must be accompanied by systemic administration		10% (2, 2.5, 5, 15 mL) 30% (15 mL)
Tobramycin	Conjunctivitis and other superficial ocular infections: Ophthalmic ointment: apply two to three times daily, for severe infections can apply every three to four hours Mild-to-moderate infections: Ophthalmic solution: instill one or two drops every four hours Severe infections: Ophthalmic solution: instill two drops hourly until improvement, following which treatment should be reduced prior to discontinuation	No specific pediatric information available.	Ophthalmic ointment: 0.3% (3.5 g) Ophthalmic solution: 0.3% (5 mL)
Combination Products			
Bacitracin zinc/ polymyxin B sulfate	Apply every three to four hours for seven to 10 days	Safety and efficacy in pediatric patients have not been established.	Ophthalmic ointment: 500 units/g /10,000 units/g (3.5 g)
Gentamicin sulfate/ prednisolone acetate	Ophthalmic ointment: apply a ½ in ribbon into the conjunctival sac(s) one to three times daily Ophthalmic suspension: instill one drop into the conjunctival sac(s) two to four times daily; during the initial 24 to 48 hours the dosing frequency may be increased up to one drop per hour	Safety and efficacy in pediatric patients have not been established.	Ophthalmic ointment: 0.3%/0.6% (3.5 g) Ophthalmic suspension: 0.3%/1.0% (5, 10 mL)
Polymyxin B sulfate/ trimethoprim	Bacterial conjunctivitis and bacterial blepharoconjunctivitis: Instill one drop every three hours with a maximum of six doses per day, for seven to 10 days	Safety and efficacy in pediatric patients <2 months of age have not been established.	Ophthalmic solution: 10,000 units/mL/ 0.1% (10 mL)
Sulfacetamide sodium/ prednisolone	Bacterial conjunctivitis and corneal ulcer: Ophthalmic ointment: apply a ½ in	Safety and efficacy in pediatric patients <6 years of age	Ophthalmic ointment: 10%/0.2% (3.5 g)

Generic Name	Adult Dose	Pediatric Dose	Availability
acetate	ribbon in the conjunctival sac(s) three to four times daily and one to two times at night Ophthalmic suspension: shake before using, instill 2 drops into the conjunctival sac(s) every 4 hours during the day and at bedtime	have not been established.	Ophthalmic suspension: 10%/0.2% (5, 10 mL)
Sulfacetamide sodium/ prednisolone sodium phosphate	Bacterial conjunctivitis and corneal ulcer: Instill two drops in the eye(s) every four hours	Safety and efficacy in pediatric patients <6 years of age have not been established.	Ophthalmic solution: 10%/0.23% (5, 10 mL)
Tobramycin/ dexamethasone	Bacterial conjunctivitis and corneal ulcer: Ophthalmic ointment: apply a small amount, approximately a ½ in ribbon, into the conjunctival sac(s) up to three or four times daily Ophthalmic suspension, 0.3%/0.1%: instill one to two drops into conjunctival sac(s) every four to six hours, dosage may be increased to one to two drops every two hours during the initial 24 to 28 hours Ophthalmic suspension, 0.3%/0.05%: instill one drop into conjunctival sac(s) every four to six hours, during the initial 24 to 48 hours the dosage may be increased to one drop every two hours	Safety and efficacy in pediatric patients <2 years of age have not been established.	Ophthalmic ointment: 0.3%/0.1% (3.5 g) Ophthalmic suspension: 0.3%/0.1% (2.5, 10 mL) 0.3%/0.05% (2.5, 5, 10 mL)
Tobramycin/ loteprednol etabonate	Bacterial conjunctivitis and corneal ulcer: Instill one to two drops into the conjunctival sac(s) every four to six hours, during the initial 24 to 48 hours the dosing may be increased to every one to two hours, frequency should be decreased gradually as warranted by improvement in clinical signs	Safety and efficacy in pediatric patients have not been established.	Ophthalmic suspension: 0.3%/0.5% (2.5, 5, 10 mL)
Neomycin sulfate/ polymyxin B sulfate/ bacitracin zinc	Apply every three to four hours for seven to 10 days	Safety and efficacy in pediatric patients have not been established.	Ophthalmic ointment: 0.35%/10,000 units/g /400 units/g (3.5 g)
Neomycin	Bacterial conjunctivitis and corneal	Ophthalmic	Ophthalmic ointment:

Generic Name	Adult Dose	Pediatric Dose	Availability
sulfate/ polymyxin B sulfate/ dexamethasone	ulcer: Ophthalmic ointment: apply a small amount, approximately a ½ in ribbon, into the conjunctival sac(s) up to three times daily Ophthalmic suspension: instill one to two drops in the conjunctival sac(s), may be used hourly in severe disease, and up to six times daily in mild disease	ointment: safety and efficacy in pediatric patients have not been established. Ophthalmic suspension: safety and efficacy in pediatric patients <2 years of age have not been established.	0.35%/10,000 units/g /0.1% (3.5 g) Ophthalmic suspension: 3.5mg/mL/10,000 units/mL/0.1% (5 mL)
Neomycin sulfate/ polymyxin B sulfate/ gramicidin	Instill one to two drops every four hours for seven to 10 days, may be increased to as much as two drops ever hour in severe infections	Safety and efficacy in pediatric patients have not been established.	Ophthalmic solution: 1.75 mg/mL/10,000 units/mL/0.025 mg/mL (10 mL)
Neomycin sulfate/ polymyxin B sulfate/ hydrocortisone	Bacterial conjunctivitis and corneal ulcer: Instill one to two drops in affected eye(s) every three to four hours, depending on the severity of the condition	Safety and efficacy in pediatric patients have not been established.	Ophthalmic suspension: 0.35%/10,000 units/mL /1% (7.5 mL)
Neomycin sulfate/ polymyxin B sulfate/ prednisolone acetate sulfate	Bacterial conjunctivitis and corneal ulcer (eye treatment): Instill one to two drops every three to four hours or more frequently as required, may require administration every 30 minutes for acute infections Bacterial conjunctivitis and corneal ulcer (eyelid treatment): Instill one to two drops into the eye every three to four hours, close the eye and rub the excess on the lids and lid margins	Safety and efficacy in pediatric patients have not been established.	Ophthalmic suspension: 0.35%/10,000 units/mL/ 0.5% (5 mL)
Neomycin sulfate/ polymyxin B sulfate/ bacitracin zinc/ hydrocortisone	Bacterial conjunctivitis and corneal ulcer: Apply ointment in affected eye(s) every three to four hours, depending on the severity of the condition	Safety and efficacy in pediatric patients have not been established.	Ophthalmic ointment: 0.35%/10,000 units/g/ 400 units/g/1% (3.5 g)

Clinical Guidelines

Table 8. Clinical Guidelines

Clinical Guideline	Recommendation(s)
American Academy of Ophthalmology: **Preferred**	• There is insufficient evidence to make definitive recommendations for the treatment of blepharitis, and cure is not possible in most cases. • Treatments that are helpful include the following:

Clinical Guideline	Recommendation(s)
Practice Pattern: Blepharitis (2011)[3]	o Warm compresses. o Eyelid hygiene. o Antibiotics (topical and/or systemic). o Ophthalmic anti-inflammatory agents (e.g., corticosteroids, cyclosporine). • These treatment options are often used in combination. • Eyelid hygiene is especially useful for anterior blepharitis, and warm compresses are especially helpful for posterior blepharitis. • Optimal treatment regimens often require a trial and error approach. • An ophthalmic antibiotic ointment such as ophthalmic bacitracin or ophthalmic erythromycin can be prescribed and applied on the eyelid margins one or more times daily or at bedtime for one or more weeks. The frequency and duration of treatment should be guided by the severity of the blepharitis and response to treatment. In severe cases or for patients who do not tolerate ointment, metronidazole gel applied to the eyelid skin is an alternative treatment, although it has not been approved by the Food and Drug Administration (FDA) for this indication. • The combination of tobramycin/dexamethasone ophthalmic suspension and azithromycin in a sustained-release system has been evaluated in and appears to reduce some of the symptoms of blepharitis, but its use for this indication has not been approved by the FDA. • For patients with meibomian gland dysfunction, whose chronic signs and symptoms are not adequately controlled with eyelid hygiene, an oral tetracycline can be prescribed. Macrolide antibiotics also have anti-inflammatory activity. • Treatments can be intermittently discontinued and reinstated, based on the severity of the patient's blepharitis and tolerance for the medication, and to allow re-colonization of normal flora. • Ophthalmic corticosteroid eye drops or ointments are typically applied several times daily to the eyelids or ocular surface. • Once the inflammation is controlled, the ophthalmic corticosteroid can be tapered and discontinued and then used intermittently to maintain patient comfort. • The minimal effective dose of ophthalmic corticosteroid should be utilized, and long-term ophthalmic corticosteroid therapy should be avoided if possible. • Potential adverse effects of ophthalmic corticosteroid use, including the risk for developing increased intraocular pressure and cataracts may be minimized by using a site-specific ophthalmic corticosteroid such as ophthalmic loteprednol etabonate and ophthalmic corticosteroids with limited ocular penetration, such as ophthalmic fluorometholone. • Topical cyclosporine may be helpful in some patients with posterior blepharitis. • Artificial tears may improve symptoms when used as an adjunct to eyelid hygiene and medications. If used more than four times per day, non-preserved tears should be used to avoid preservative toxicity.
American Academy of Ophthalmology: **Preferred Practice Pattern: Conjunctivitis (2011)**[39]	Seasonal allergic conjunctivitis • Treatment of conjunctivitis is ideally directed at the root cause. Indiscriminate use of topical antibiotics or corticosteroids should be avoided, because antibiotics can induce toxicity and corticosteroids can potentially prolong adenoviral infections and worsen herpes simplex virus infections.

Clinical Guideline	Recommendation(s)
	• Treat mild allergic conjunctivitis with an over-the-counter (OTC) antihistamine/vasoconstrictor or second-generation topical histamine H_1-receptor antagonist. The guideline does not give preference to one OTC antihistamine/vasoconstrictor or antihistamine versus another. The guideline does not address the role of prescription vasoconstrictors in the management of allergic conjunctivitis. • If the condition is frequently recurrent or persistent, use mast-cell stabilizers. The guideline does not give preference to one mast-cell stabilizer versus another. • Medications with antihistamine and mast-cell stabilizing properties may be utilized for either acute or chronic disease. The guideline does not give preference to one antihistamine/mast-cell stabilizer versus another. • If the symptoms are not adequately controlled, a brief course (1-2 weeks) of low-potency topical corticosteroid may be added to the regimen. The lowest potency and frequency of corticosteroid administration that relieves the patient's symptoms should be used. • Ketorolac, a NSAID, is also Food and Drug Administration (FDA) approved for the treatment of allergic conjunctivitis. • Additional measures include allergen avoidance and using cool compresses, oral antihistamines, and artificial tears, which dilute allergens and treat coexisting tear deficiency. Frequent clothes washing and bathing before bedtime may also be helpful. • Consultation with an allergist or dermatologist may be helpful for patients with disease that cannot be adequately controlled with topical medications and oral antihistamines. <u>Vernal/atopic conjunctivitis</u> • General treatment measures include modifying the environment to minimize exposure to allergens or irritants, and using cool compresses and ocular lubricants. Topical and oral antihistamines and topical mast-cell stabilizers may beneficial in maintaining comfort. • For acute exacerbations, topical corticosteroids are usually necessary to control severe symptoms. The minimal amount of corticosteroid should be used based on patient response and tolerance. Topical cyclosporine is effective as adjunctive therapy to reduce the amount of topical corticosteroid used to treat severe atopic keratoconjunctivitis. For entities such as vernal keratoconjunctivitis, which may require repeat short-term therapy with topical corticosteroid, patients should be informed about potential complications of corticosteroid therapy and general strategies to minimize corticosteroid use should be discussed. • For severe sight-threatening atopic keratoconjunctivitis that is not responsive to topical therapy, systemic immunosuppression may be warranted. Eyelid involvement may be treated with pimecrolimus or tacrolimus. Patients should be told to keep these medications away from the conjunctival and corneal surface, and from the tear film. Both agents are rarely associated with the development of skin cancer and lymphoma. • Frequency of follow-up visits is based on the severity of disease presentation, etiology, and treatment. Consultation with a dermatologist is often helpful. If corticosteroids are prescribed, baseline and periodic measurement of intraocular pressure and papillary dilation should be

Clinical Guideline	Recommendation(s)
	performed to evaluate for glaucoma and cataract(s). Mild bacterial conjunctivitis • May be self-limited and resolve spontaneously without treatment in immunocompetent adults. • Ophthalmic antibacterial therapy is associated with earlier clinical and microbiological remission compared with placebo at days two to five of treatment. The advantages persist over six to 10 days, but the benefit over placebo lessens over time. • The choice of ophthalmic antibiotic is usually empirical. • A five to seven day course of ophthalmic broad-spectrum antibiotic is usually effective. • The most convenient or least expensive option can be selected. Severe bacterial conjunctivitis • Characterized by copious purulent discharge, pain, and marked inflammation of the eye. • The choice of ophthalmic antibiotic is guided by the results of laboratory tests. • MRSA has been isolated with increasing frequency from patients with bacterial conjunctivitis. Many MRSA organisms are resistant to commercially available ophthalmic antibiotics. • Systemic antibiotic therapy is necessary to treat conjunctivitis due to *Neisseria* gonorrhoeae and *Chlamydia* trachomatis. • If corneal involvement is present, the patient should also be treated topically for bacterial keratitis.
American Academy of Ophthalmology: **Preferred Practice Pattern: Bacterial Keratitis (2011)**[40]	Initial treatment • Ophthalmic antibiotic eye drops are the preferred method of treatment in most cases of bacterial keratitis. • Ophthalmic ointments may be useful at bedtime in less severe cases and also may be useful for adjunctive therapy. • Ophthalmic broad-spectrum antibiotics are used initially in the empiric treatment of bacterial keratitis. • The recommended ophthalmic empiric treatments include: o No organism identified or multiple types of organisms: ophthalmic cefazolin sodium (with gentamicin sulfate or tobramycin) or ophthalmic fluoroquinolones (fewer gram-positive cocci are resistant to gatifloxacin and moxifloxacin hydrochloride than other fluoroquinolones). o Gram-positive cocci: ophthalmic cefazolin sodium, vancomycin (for resistant *Enterococcus* and *Staphylococcus* species and penicillin allergy), ophthalmic bacitracin (for resistant *Enterococcus* and *Staphylococcus* species and penicillin allergy), or ophthalmic fluoroquinolones (fewer gram-positive cocci are resistant to gatifloxacin and moxifloxacin hydrochloride than other fluoroquinolones). o Gram-negative rods: ophthalmic formulations of tobramycin or gentamicin sulfate, ceftazidime, or fluoroquinolones. o Gram-negative cocci: ophthalmic ceftazidime, ceftriaxone sodium, or fluoroquinolones (systemic therapy is necessary for suspected gonococcal infection).

Clinical Guideline	Recommendation(s)
	o Nontuberculous mycobacteria: ophthalmic amikacin sulfate, azithromycin, clarithromycin, or fluoroquinolones. o Nocardia: ophthalmic amikacin sulfate, sulfacetamide sodium, or trimethoprim/sulfamethoxazole. • Single-drug therapy using an ophthalmic fluoroquinolone has been shown to be as effective as combination therapy with ophthalmic antibiotics that are fortified by increasing their concentration over commercially available topical antibiotics. Ciprofloxacin 0.3%, ofloxacin 0.3% and levofloxacin 1.5% are Food and Drug Administration approved for this indication. The fourth generation fluoroquinolones have not been approved for the treatment of bacteria keratitis, however, both agents have performed at least as well as standard therapy, fortified cefazolin/tobramycin combination therapy and potentially better than ciprofloxacin. • Some pathogens (e.g., *Streptococci*, anaerobes) reportedly have variable susceptibility to ophthalmic fluoroquinolones and the prevalence of resistance to fluoroquinolones appears to be increasing. • Combination fortified-antibiotic therapy is an alternative to consider for severe infection and for eyes unresponsive to initial treatment. • Treatment with more than one agent may be necessary for nontuberculous mycobacteria; infection with this pathogen has been reported in association with Laser in Situ Keratomileusis (LASIK). • Methicillin-resistant *Staphylococcus aureus* (MRSA) has been isolated with increasing frequency from patients with bacterial keratitis and has been reported following kerato-refractive surgery. Ophthalmic fluoroquinolones are generally poorly effective against MRSA ocular isolates. MRSA isolates are generally sensitive to ophthalmic vancomycin. • Systemic antibiotics are rarely needed, but they may be considered in severe cases where the infectious process has extended to adjacent tissues (e.g., the sclera) or when there is impending or frank perforation of the cornea. • Systemic therapy is necessary in cases of gonococcal keratitis. <u>Modification of therapy</u> • Efficacy of the regimen is judged primarily by clinical response. The results of cultures and sensitivity testing may have an impact on therapeutic decision making, especially if the patient is not responding to initial therapy. • Dual antibiotic treatment designed to achieve broad-spectrum coverage may become unnecessary once the causative organism has been isolated. • The initial therapeutic regimen should be modified (change in type, concentration or frequency of antibiotic) when the eye shows a lack of improvement or stabilization within 48 hours. • Most antibiotic eye drops should not be tapered below three to four times a day, because low doses are sub-therapeutic and may increase the risk of developing antibiotic resistance. <u>Corticosteroid therapy</u> • Ophthalmic corticosteroid therapy may have a beneficial role in treating some cases of infectious keratitis due to the probable suppression of

Clinical Guideline	Recommendation(s)
	inflammation, which may reduce subsequent corneal scarring and associated visual loss. • Potential disadvantages of ophthalmic corticosteroid use include infection reoccurrence, local immunosuppression, inhibition of collagen synthesis predisposing to corneal melting, and increased intraocular pressure. • There is no conclusive evidence that ophthalmic corticosteroids alter clinical outcome. • Despite risks involved, it is believed that sensible use of ophthalmic corticosteroids can reduce morbidity. • Patients being treated with ophthalmic corticosteroids at the time of presentation of suspected bacterial keratitis should have their ophthalmic corticosteroid regimen reduced or eliminated until the infection has been controlled. • Inflammation may temporarily increase as ophthalmic corticosteroids are reduced. • The minimum amount of ophthalmic corticosteroid required should be used to achieve control of inflammation. • Ophthalmic corticosteroids should not be part of initial treatment of presumed bacterial ulcers, and ideally they should not be used until the organism has been determined by cultures. • The use of ophthalmic corticosteroids in the initial treatment of corneal ulcers has been determined to be a risk factor for requiring a penetrating keratoplasty. • Ophthalmic antibiotics, which are generally administered more frequently than ophthalmic corticosteroids during treatment of active infection, are continued at high levels and tapered gradually. • Patient compliance is essential, intraocular pressure must be monitored frequently, and the patient should be examined within one to two days after initiation of ophthalmic corticosteroid therapy.
American Academy of Ophthalmology: **Preferred Practice Pattern: Refractive Errors and Refractive Surgery (2007)**[86]	<u>Photorefractive keratectomy</u> • Topical antibiotics are administered to minimize the risk of postoperative infection. • Topical corticosteroids are generally started immediately after surgery and tapered over a period of days to weeks, and sometimes months. If corticosteroid treatment is prolonged, the intraocular pressure should be monitored. • Although postoperative pain may be reduced by the use of a bandage, contact lens, and NSAIDs drops, patients may still require prescription oral analgesics. • Since NSAID drops may delay corneal epithelialization, they should be applied judiciously. • Sterile corneal infiltrates associated with the use of NSAID drops without the concomitant use of topical corticosteroids have been described. • Periodic examinations are necessary to monitor ocular status and to check for corticosteroid-related side effects such as elevated intraocular pressure. <u>Laser in situ keratomileusis (LASIK)</u> • Topical antibiotics are administered to minimize the risk of postoperative infection.

Clinical Guideline	Recommendation(s)
	• Corticosteroids are generally used for a short time postoperatively. • Frequent lubrication is recommended in the postoperative period. • Diffuse lamellar keratitis is a noninfectious aggregation of inflammatory cells and treatment is commonly guided by the severity of the inflammation. Increasing frequency of topical corticosteroid administration with a closer follow-up is practiced by most surgeons.
American Academy of Ophthalmology: **Preferred Practice Pattern: Cataract in the Adult Eye (2011)**[87]	Infection prophylaxis • Two emerging concerns are the increasing resistance of *Staphylococcus* species (the most common cause of endophthalmitis) to a broad spectrum of antibiotics, including the latest generation fluoroquinolones, and the increased occurrence of acute endophthalmitis more than a week after surgery. • Prophylactic strategies that have been used include applying topical antibiotic eye drops before surgery, applying 5% povidone iodine to the conjunctival cul de sac, preparing the periocular skin with 10% povidone iodine, careful sterile draping of the eyelid margins and eyelashes, adding antibiotics to the irrigating solution, instilling intracameral antibiotics at the close of surgery, injecting subconjunctival antibiotics, and applying topical antibiotic eye drops after surgery. • Because of the lack of and impracticality of sufficiently large prospective clinical trials, there is insufficient evidence to recommend a specific antibiotic drug or method of delivery for endophthalmitis prophylaxis. • Systemic antibiotics are rarely used; however, it has been shown that certain oral fluoroquinolone antibiotics penetrate the blood/ocular barrier adequately to reach levels above the minimum inhibitory concentrations for many organisms inside the eye, and oral antibiotics that penetrate well into the eye may be beneficial. Postoperative follow-up • Postoperative regimens of topically applied antibiotics, corticosteroids and NSAIDs vary among practitioners. • No controlled investigations establish optimal regimens for the use of topical agents. • The operating surgeon is responsible for making the decision whether to use any or all of the topical products singly or in combination. • Complications of postoperative medications include elevated IOP with corticosteroids and allergic reactions to antibiotics. Significant corneal reactions, including epithelial defects and stromal ulceration and melting, have rarely been reported with topical ocular nonsteroidal anti-inflammatory drugs (NSAIDs). Cystoid macular edema • Topical anti-inflammatory agents are used in an attempt to reduce the inflammatory response to cataract surgery and to treat established cystoid macular edema. • There is evidence that topically applied NSAIDs alone or in combination with corticosteroids is more effective than topical corticosteroids alone in preventing and treating cystoid macular edema.
American Optometric Association: **Care of the Adult Patient with Cataract**	• A combination of topical and oral antiglaucoma, antibiotic and anti-inflammatory medications may be administered to the patient before, during and after an operation. • Topical corticosteroids may be used to suppress inflammation

Clinical Guideline	Recommendation(s)
(2004)[88]	associated with cataract surgery. • To control inflammation associated with anterior uveitis, topical corticosteroids such as prednisolone acetate 1% may be used every two to four hours depending on the degree of inflammation.

Conclusions

Ophthalmic antibiotics are used to treat ophthalmic infections including blepharitis, conjunctivitis, keratitis as well as several others. There are ophthalmic antibiotics available from the aminoglycoside, macrolide, polypeptide, quinolone, sulfonamide and miscellaneous antibiotic drug classes. These agents are available as single agents or in combination with other ophthalmic antibiotics or ophthalmic steroids. All ophthalmic antibiotics, with the exception of ophthalmic levofloxacin 1.5%, are approved for the treatment of bacterial conjunctivitis.[4-37] It should be noted that for all of the all indications listed in Table 2, there is at least one generic option available for treatment.[1]

Head-to-head studies have failed to consistently show that any one ophthalmic antibiotic is significantly more effective than another with regard to bacterial eradication, clinical resolution, clinical response, efficacy, microbial eradication, physician's judgment of resolution, severity rating, or symptom improvement for any indication.[45-52,55,56,65-67,70,72,76,78] In all studies, adverse events were mild with no significant difference seen with regard to the rate of adverse events. Common adverse events reported include burning, ocular discomfort, stinging, and tearing.[41-85]

The majority of ophthalmic antibiotic medications have been studied in pediatric populations greater than one year of age, with ophthalmic sulfacetamide sodium and ophthalmic polymyxin B sulfate/trimethoprim having safety and efficacy data in patients older than two months of age.[1,22-24] Ophthalmic antibiotics are not intended to be used for prolonged periods of time in order to avoid overgrowth of non-susceptible organisms and reduce the risk of resistance. Should super-infection occur, the ophthalmic antibiotic should be discontinued and an alternative therapy should be initiated.[1,4-37]

Guidelines published by the American Academy of Ophthalmology recommend that blepharitis be treated with ophthalmic bacitracin or ophthalmic erythromycin and note that macrolide antibiotics may have anti-inflammatory activity with regard to the treatment of blepharitis.[3] In addition, the guidelines state that keratitis should be treated with a broad-spectrum ophthalmic antibiotic that may be selected based on the isolated organism and if no organism is identified, treatment with ophthalmic fluoroquinolones is recommended. The American Academy of Ophthalmology guideline also notes that fewer gram-positive cocci are resistant to ophthalmic gatifloxacin and moxifloxacin hydrochloride.[40] For the treatment of conjunctivitis, it is recommended that the least expensive or most convenient broad-spectrum antibiotic be selected for a five to seven day course of treatment.[39]

References

1. Drug Facts and Comparisons 4.0 [database on the Internet]. St. Louis: Wolters Kluwer Health, Inc.; 2011 [cited 2012 Feb 20]. Available from: http://online.factsandcomparisons.com.
2. Shtein RM. Blepharitis. In: Basow D (Ed). UpToDate [database on the internet]. Waltham (MA): UpToDate; 2011 [cited 2012 Feb 20]. Available from: http://www.utdol.com/utd/index.do.
3. American Academy of Ophthalmology Preferred Practice Patterns Committee. Preferred Practice Pattern Guidelines. Blepharitis [guideline on the Internet]. 2011 [cited 2012 Feb 20]. Available from: http://one.aao.org/CE/PracticeGuidelines/PPP_Content.aspx?cid=500cd9ca-173c-4c31-b6ea-a258e3549474
4. Azasite® [package insert]. Durham, NC: Inspire Pharmaceuticals Inc.; 2010 Nov.
5. Besivance® [package insert]. Tampa, FL: Bausch & Lomb Incorporated; 2009 Apr.
6. Ciprofloxacin solution [package insert]. Tampa, FL: Bausch & Lomb Incorporated; 2006 Mar.
7. Ciprofloxacin ointment [package insert]. Fort Worth, TX: Alcon; 2006 May.
8. Erythromycin ointment [package insert]. Tampa, FL: Bausch & Lomb Incorporated; 2007 Feb.
9. Zymaxid® [package insert]. Irvine, CA; Allergan; 2010 May.
10. Gentak® [package insert]. Lake Forrest, IL; Akorn Inc.; 2008 Oct.
11. Gentamicin ointment [package insert]. Melville, NY; E. Fougera & Co.; 1998 Mar.
12. Quixin® [package insert]. Jacksonville, FL. Vistakon Pharmaceuticals LLC; 2006 Apr.
13. Iquix® [package insert]. Jacksonville, FL. Vistakon Pharmaceuticals LLC; 2007 Apr.
14. Vigamox® [package insert]. Fort Worth, TX. Alcon Laboratories Inc.; 2011 Jul.
15. Moxeza® [package insert]. Fort Worth, TX. Alcon Laboratories Inc.; 2010 Nov.
16. Ofloxacin [package insert]. Tampa, FL: Bausch & Lomb Incorporated; 2007 Aug.
17. Bleph-10® [package insert]. Irvine, CA. Allergan Inc.; 2005 Feb.
18. Tobramycin [package insert]. Tampa, FL: Bausch & Lomb Incorporated; 2007 Aug.
19. Polysporin® [package insert]. Bristol, TN. Monarch Pharmaceuticals Inc. 2006 Oct.
20. Pred G® suspension [package insert]. Irvine, CA. Allergan Inc.; 2005 Dec.
21. Pred G® ointment [package insert]. Irvine, CA. Allergan Inc.; 2004 Jan.
22. Polytrim® [package insert]. Irvine, CA. Allergan Inc.; 2004 Aug.
23. Blephamide suspension® [package insert]. Irvine, CA. Allergan Inc.; 2004 June.
24. Blephamide ointment® [package insert]. Irvine, CA. Allergan Inc.; 2004 Sept.
25. Vasocidin® [package insert]. Duluth, GA; Novartis Ophthalmics; 2001 Feb.
26. Tobradex suspension® [package insert]. Fort Worth, TX. Alcon Laboratories Inc.; 2006 May.
27. Tobradex ointment® [package insert]. Fort Worth, TX. Alcon Laboratories Inc.; 2003 Oct.
28. Tobradex® ST [package insert]. Fort Worth, TX. Alcon Laboratories Inc.; 2009 Feb.
29. Zylet® [package insert]. Tampa, FL. Bausch & Lomb Inc.; 2010 May.
30. Neomycin and polymyxin b sulfates and bacitracin zinc [package insert]. Tampa, FL: Bausch & Lomb Incorporated; 2003 Nov.
31. Maxitrol ointment® [package insert]. Fort Worth, TX: Alcon; 2003 Oct.
32. Maxitrol suspension® [package insert]. Fort Worth, TX: Alcon; 2008 Apr.
33. Neomycin and polymyxin b sulfates and gramicidin [package insert]. Tampa, FL: Bausch & Lomb Incorporated; 2003 Nov.
34. Neomycin and polymyxin b sulfates and hydrocortisone [package insert]. Worth, TX. Alcon Laboratories Inc.; 2006 Sept.
35. Polypred® [package insert]. Irvine, CA. Allergan Inc.; 2006 May.
36. Neomycin and polymyxin b sulfates and bacitracin zinc with hydrocortisone [package insert]. Melville, NY: E. Fougera & Co.; 2004 Aug.
37. Bacitracin, erythromycin, gentamicin, tobramycin, and trimethoprim and polymyxin b: drug information. In: Rose BD, editor. UpToDate [database on the Internet]. Waltham (MA): UpToDate: 2009 [cited 2012 Feb 20]. Available from: http://www.utdol.com/online/index/do.
38. Jacobs DS. Conjunctivitis. In: Basow D (Ed). UpToDate [database on the internet]. Waltham (MA): UpToDate; 2010 [cited 2012 Feb 20]. Available from: http://www.utdol.com/utd/index.do.
39. American Academy of Ophthalmology Cornea/External Disease Panel. Preferred Practice Pattern Guidelines. Conjunctivitis. [guideline on the Internet]. 2011 [cited 2012 Feb 20]. Available from:

http://one.aao.org/CE/PracticeGuidelines/PPP_Content.aspx?cid=79f4327d-6b7d-42e7-bbf3-585e7c3852c7
40. American Academy of Ophthalmology Preferred Practice Patterns Committee. Preferred Practice Pattern Guidelines. Bacterial Keratitis [guideline on the Internet]. 2011 [cited 2012 Feb 20]. Available at: http://one.aao.org/CE/PracticeGuidelines/PPP_Content.aspx?cid=0f20807f-bc61-4f11-b570-01ae26990edb
41. Abelson MB, Heller W, Shapira AM, Erwin SI, HSU P, Bowman LM. Clinical cure of bacterial conjunctivitis with azithromycin 1%: vehicle-controlled, double-masked clinical trial. Am J Ophthalmol. 2008;145:959-6.
42. Karpecki P, Depaolis M, Hunter JA, White EM, Rigel L, Brunner LS, et al. Besifloxacin ophthalmic suspension 0.6% in patients with bacterial conjunctivitis: A multicenter, prospective, randomized, double-masked, vehicle-controlled, 5-day efficacy and safety study. Clin Ther. 2009;31:514-26.
43. Hwang DG, Schanzlin DJ, Rotberg MH, Foulks G, Raizman MB; Levofloxacin Bacterial Conjunctivitis Place-controlled Study Group. A phase III, placebo controlled clinical trial of 0.5% levofloxacin ophthalmic solution for the treatment of bacterial conjunctivitis. Br J Ophthalmol. 2003;87:1004-9.
44. Gigliotti F, Hendley JO, Morgan J, Michaels R, Dickens M, Lohr J. Efficacy of topical antibiotic therapy in acute conjunctivitis in children [abstract]. J Pediatr. 1984 Apr;104(4):623-6.
45. Cochereau I, Meddeb-Ouertani A, Khairallah M, Amraoui A, Zaghloul K, Pop M, et al. 3-day treatment with azithromycin 1.5% eye drops versus 7-day treatment with tobramycin 0.3% for purulent bacterial conjunctivitis: multicentre, randomized and controlled trial in adults and children. Br J Ophthalmol. 2007;91:465-9.
46. Abelson M, Protzko E, Shapiro A, Garces-Soldana A, Bowman L. A randomized trial assessing the clinical efficacy and microbial eradication of 1% azithromycin ophthalmic solution vs tobramycin in adult and pediatric subjects with bacterial conjunctivitis. Clin Ophthalmol. 2007;1:177-82.
47. McDonald MB, Protzko EE, Brunner LS, Morris TW, Haas W, Paterno MR, et al. Efficacy and safety of besifloxacin ophthalmic suspension 0.6% compared with moxifloxacin ophthalmic solution 0.5% for treating bacterial conjunctivitis. Ophthalmology. 2009 Sep;116(9):1615-23.
48. Gross RD, Hoffman RO, Lindsay RN. A comparison of ciprofloxacin and tobramycin in bacterial conjunctivitis in children. Clin Pediatr. (Phil) 1997;36:435-44.
49. Granet B, Dorfman M, Stroman D, Cockrun P. A multicenter comparison of polymyxin B sulfate/trimethoprim ophthalmic solution and moxifloxacin in the speed of clinical efficacy for the treatment of bacterial conjunctivitis [abstract]. J Pediatr Ophthalmol Strabismus 2008;45:340-9.
50. Kernt K, Martinez M, Bertin D, International Tobrex2x group, Cupp S, Martinez C, et al. A clinical comparison of two formulations of tobramycin 0.3% eye drops in the treatment of acute bacterial conjunctivitis. Eur J Ophthalmol. 2005 Sep-Oct;15(5):541-9.
51. Behrens-Baumann W, Quentin CD, Gibson JR, Calthrop JG, Harvey SG, Booth K. Trimethoprim-polymyxin B sulphate ophthalmic ointment in the treatment of bacterial conjunctivitis: a double-blind study versus chloramphenicol ophthalmic ointment. Curr Med Res Opin. 1988;11:227-31.
52. Papa V, Aragona P, Scuderi AC, Blanco AR, Zola P, Di Bella A, et al. Treatment of acute bacterial conjunctivitis with topical netilmicin. Cornea. 2002;21(1):43-7.
53. Leibowitz HM. Antibacterial effectiveness of ciprofloxacin 0.3% ophthalmic solution in the treatment of conjunctivitis [abstract]. Am J Ophthalmol. 1991 Oct; 112(Suppl 4):29S-33S.
54. Lichtenstein S, Rinehart M. Efficacy and safety of 0.5% levofloxacin ophthalmic solution for the treatment of bacterial conjunctivitis in pediatric patients [abstract]. J AAPOS. 2003;7:317-24.
55. Lohr J, Austin R, Grossman M, Hayden GF, Knowlton GM, Dudley. Comparison of three topical antimicrobials for acute bacterial conjunctivitis [abstract]. Pediatr Infect Dis J. 1988;7:626-9.
56. Gibson J. Trimethoprim-polymyxin B ophthalmic solution in the treatment of presumptive bacterial conjunctivitis--a multicentre trial of its efficacy versus neomycin-polymyxin B-gramicidin and chloramphenicol ophthalmic solutions [abstract]. J Antimicrob Chemother. 1983;11:217-21.
57. Silver LH, Woodside AM, Montgomery DB. Clinical safety of moxifloxacin ophthalmic solution 0.5% (Vigamox®) in pediatric and nonpediatric patients with bacterial conjunctivitis. Surv Ophthalmol. 2005;50:S55-S63.

58. Jauch A, Fsadni M, Gamba G. Meta-analysis of six clinical phase III studies comparing lomefloxacin 0.3% eye drops twice daily to five standard antibiotics in patients with acute bacterial conjunctivitis. Arch Clin Exp Ophthalmol. 1999;237:705-13.
59. Sheikh A, Hurwitz B. Antibiotics versus placebo for acute bacterial conjunctivitis. Cochrane Database Syst Rev. 2006 Apr 19;(2):CD001211. Review.
60. Tepedino ME, Heller WH, Usner DW, Brunner LS, Morris TW, Haas W, et al. Phase III efficacy and safety study of besifloxacin ophthalmic suspension 0.6% in the treatment of bacterial conjunctivitis. Curr Med Res Opin. 2009 May;25(5):1159-69.
61. Silverstein BE, Allaire C, Bateman KM, Gearinger LS, Morris TW, Comstock TL. Efficacy and tolerability of besifloxacin ophthalmic suspension 0.6% administered twice daily for 3 days in the treatment of bacterial conjunctivitis: a multicenter, randomized, double-masked, vehicle-controlled, parallel-group study in adults and children. Clin Ther. 2011 Jan;33(1):13-26.
62. Kodjikian L, Lafuma A, Khoshnood B, Laurendeau C, Berdeaux G. Efficacy of moxifloxacin in treating bacterial conjunctivitis: a meta-analysis. J Fr Ophtalmol. 2010 Apr;33(4):227-33.
63. Tauber S, Cupp G, Garber R, Bartell J, Vohra F, Stroman D. Microbiological efficacy of a new ophthalmic formulation of moxifloxacin dosed twice-daily for bacterial conjunctivitis. Adv Ther. 2011 Jul;28(7):566-74.
64. Schwab IR, Friedlaender M, McCulley J, Lichtenstein SJ, Moran CT; Levofloxacin Bacterial Conjunctivitis Active Control Study Group. A phase III clinical trial of 0.5% levofloxacin ophthalmic solution versus 0.3% ofloxacin ophthalmic solution for the treatment of bacterial conjunctivitis. Ophthalmology. 2003 Mar;110(3):457-65.
65. Booranapong W, Kosrirukvongs P, Prabhasawat P, Srivannaboon S, Suttiprakarn P. Comparison of topical lomefloxacin 0.3 per cent versus topical ciprofloxacin 0.3 per cent for the treatment of presumed bacterial corneal ulcers [abstract]. J Med Assoc Thai. 2004 Mar;87(3):246-54.
66. Kosrirukvongs P. Buranapongs W. Topical ciprofloxacin for bacterial corneal ulcer [abstract]. J Med Assoc Thai. 2000 Jul;83(7):776-82.
67. Parks DJ, Abrams DA, Sarfarazi FA, Katz HR. Comparison of topical ciprofloxacin to conventional antibiotic therapy in the treatment of ulcerative keratitis [abstract]. Am J Ophthalmol. 1993 Apr 15;115(4):471-7.
68. Bloom PA, Leeming JP, Power W, Laidlaw DA, Collum LM, Easty DL. Topical ciprofloxacin in the treatment of blepharitis and blepharoconjunctivitis [abstract]. Eur J Ophthalmol. 1994 Jan-Mar;4(1):6-12.
69. Adenis JP, Colin J, Verin P, Riss I, Saint-Blancat P. Ciprofloxacin ophthalmic solution in the treatment of conjunctivitis and blepharitis: a comparison with fusidic acid [abstract]. Eur J Ophthalmol. 1996 Oct-Dec;6(4):368-74.
70. Adenis JP, Colin J, Verin P, Saint-Blancat P, Malet F. Ciprofloxacin ophthalmic solution versus rifamycin ophthalmic solution for the treatment of conjunctivitis and blepharitis [abstract]. Eur J Ophthalmol. 1995 Apr-Jun;5(2):82-7.
71. Shulman DG, Sargent JB, Stewart RH, Mester U. Comparative evaluation of the short-term bactericidal potential of a steroid-antibiotic combination versus steroid in the treatment of chronic bacterial blepharitis and conjunctivitis [abstract]. Eur J Ophthalmol. 1996;6(4):361-7.
72. Bron AJ, Leber G, Rizk S, Baig H, Elkingont AR, Kirk GR, et al. Ofloxacin compared with chloramphenicol in the management of external ocular infection. Br J Ophthalmol. 1991;75:675-9.
73. Gwon A. Topical ofloxacin compared with gentamicin in the treatment of external ocular infection. Br J Ophthalmol. 1992 Dec;76(12):714-8.
74. Gwon A. Ofloxacin vs tobramycin for the treatment of external ocular infection. Arch Ophthalmol. 1992 Sep;110(9);1234-7.
75. Laibson P, Michaud R, Smolin G, Okumoto M, Rosenthal A, Cagle G. A clinical comparison of tobramycin and gentamicin sulfate in the treatment of ocular infections [abstract]. Am J Ophthalmol. 1981 Dec;92(6):836-41.
76. Leibowitz HM, Hyndiuk RA, Smolin GR, Nozik RA, Hunter GJ, Cagle GD, et al. Tobramycin in external eye disease: a double-masked study vs. gentamicin [abstract]. Curr Eye Res. 1981;1(5):259-66.

77. Jacobson JA, Call NB, Kasworm EM, Dirks MS, Turner RB. Safety and efficacy of topical norfloxacin vs tobramycin in the treatment of external ocular infections. Antimicrob Agents Chemother. 1988 Dec;32(12):1820-4.
78. Foulks GN, Austin R, Knowlton G. Clinical comparison of topical solutions containing trimethoprim in treating ocular surface bacterial infections. J Ocul Pharmacol. 1988 Summer;4(2):111-5.
79. Bell TA, Grayston JT, Krohn MA, Kronmal RA. Randomized trial of silver nitrate, erythromycin, and no eye prophylaxis for the prevention of conjunctivitis among newborns not at risk for gonococcal ophthalmitis. Pediatrics. 1993 Dec;92(6):755-60.
80. Ali Z, Khadije D, Elahe A, Fateme N, Mohammad M, Faateme Z. Prophylaxis of ophthalmia neonatorum comparison of betadine, erythromycin and no prophylaxis. J Trop Pediatr. 2007 Dec;53(6):388-92.
81. Van Endt JJ, Veraart HG, Kramer R, Janssen AG, Sunder Raj P. A comparison of two ophthalmic steroid-antibiotic combinations after cataract surgery [abstract]. Eur J Ophthalmol. 1997 Apr-Jun;7(2):144-8.
82. Notivol R, Bertin D, Amin D, Whitling A, Kennedy M, Cockrum PC, et al. Comparison of topical tobramycin-dexamethasone with dexamethasone-neomycin-polymyxin and neomycin-polymyxin-gramicidin for control of inflammation after cataract surgery: results of a multicenter; prospective, three-arm, randomized, double-masked, controlled ,parallel-group study. Clin Ther. 2004 Aug;26(8):1274-85.
83. Rhee SS, Mah FS. Comparison of tobramycin 03%/dexamethasone 0.1% and tobramycin 0.3%/loteprednol 0.5% in the management of blepharo-keratoconjunctivitis. Adv Ther. 2007 Jan-Feb;24(1):60-7.
84. Stewart RH, Kimbrough RL, Smith JP, deFaller JM. Use of steroid/antibiotic prophylaxis in intraocular lens implantation: a double-masked study v placebo [abstract]. Ann Ophthalmol. 1983;15(1):24-8.
85. White EM, Macy JI, Bateman KM, Comstock TL. Comparison of the safety and efficacy of loteprednol 0.5%/tobramycin 0.3% with dexamethasone 0.1%/tobramycin 0.3% in the treatment of blepharokeratoconjunctivitis. Curr Med Res Opin. 2008;24(1):287-96.
86. American Academy of Ophthalmology Preferred Practice Patterns Committee. Preferred Practice Pattern Guidelines. Refractive errors and refractive surgery [guideline on the Internet]. 2007 [cited 2012 Feb 20]. Available from: http://one.aao.org/ce/practiceguidelines/ppp_content.aspx?cid=e6930284-2c41-48d5-afd2-631dec586286
87. American Academy of Ophthalmology Preferred Practice Patterns Committee. Preferred Practice Pattern Guidelines. Cataract in the adult eye [guideline on the Internet]. 2011 [cited 2012 Feb 20]. Available from: http://one.aao.org/CE/PracticeGuidelines/PPP_Content.aspx?cid=a80a87ce-9042-4677-85d7-4b876deed276.
88. American Optometric Association Consensus Panel on Care of the Adult Patient with Cataract. Care of the Adult Patient with Cataract [guideline on the Internet]. 2004 Mar [cited 2012 Feb 20]. Available from: www.aoa.org/documents/CPG-8.pdf.