CLINICAL AND EXPERIMENTAL OPTOMETRY
2021, VOL. 104, NO. 3, 385–395
https://doi.org/10.1080/08164622.2021.1877533

Optometry AUSTRALIA
Taylor & Francis
Taylor & Francis Group

INVITED REVIEW

Practical use and prescription of ocular medications in children and infants

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ABSTRACT

Optometrists in Australia employ ophthalmic medicines in their paediatric practice to assist clinical diagnosis and to treat ocular conditions. Prior to employing ocular medicines or initiating treatment, it is important to consider the risks versus benefits of ophthalmic medicines and determine the minimum dose required to safely achieve a diagnostic or therapeutic benefit. Instilling drops in infants and young children may require techniques that do not depend on full cooperation, particularly to maintain appropriate dosing and limit the rate of elimination from the eye. Diagnostic cycloplegic agents are highly recommended for the accurate determination of refractive error in infants and young children. Topical atropine is commonly prescribed in paediatric optometry practice in highly variable concentrations. 1% atropine eye drops are used for pharmacological penalisation in management of amblyopia, and, increasingly, low concentration (< 0.1%) atropine is used to manage the progression of childhood myopia. Doses of topical ocular medicines to treat inflammation, infection or glaucoma are generally identical to those use in adults; however, there is potential for increased ocular and systemic side effects with certain medications. It is, therefore, timely to present, summarise and comment on the use of ophthalmic diagnostic and therapeutic agents in children and reference where practitioners can look for more detailed information. The perspective is set in the Australian context of a collaborative approach between paediatric optometry and ophthalmology eye care practitioners for delivery of best practice care in infants and young children. Inclusion of the more complex spectrum of paediatric eye disease in a tertiary ophthalmological setting is provided to build practitioner knowledge of treatment regimens their patients may be using, even though management of these conditions lies outside their scope of practice.

ARTICLE HISTORY
Received 18 June 2020
Revised 17 October 2020
Accepted 1 November 2020

KEYWORDS
Children; infants; ocular medications; ophthalmic medicines; therapeutic agents

Introduction

Optometrists in Australia employ topical medicines to aid diagnosis and to treat ocular conditions. Presently, all Australian optometrists can use drops for ocular examination and in addition nearly two-thirds of optometrists in Australia have their practising registration with an endorsement to prescribe scheduled medicines for therapeutic management of eye conditions.

In Australia, paediatric eye care is provided by optometrists predominantly in private practice, with some optometrists identifying as having a special interest in the provision of paediatric eye care; however, unlike medicine, optometry does not have recognition of sub-specialities such as paediatric optometry. Paediatric ophthalmology is a fellowship endorsed subspeciality of ophthalmology, with care provided either within private practice settings or within ophthalmology departments of speciality children's hospitals.

Hospital ophthalmology departments will generally manage the more complex medical spectrum of paediatric ocular disease. Patient management can then be supported by hospital access drugs, in-patient care if needed, and collaboration with other paediatric medical specialities if required.

The Optometry Board of Australia publishes guidelines for use of scheduled medicines on the Board's website, www.optometryboard.gov.au. The guidelines describe the professional standards expected of registered optometrists when it comes to prescribing ocular therapeutic agents and include the list of medicines in each of the approved classes of scheduled medicines for diagnostic or therapeutic use. Further, as outlined in the *Code of Conduct for Optometrists*, practitioners have responsibility to recognise and work within the limits of their competence and scope of practice, particularly ensuring they have the equipment, expertise and skills necessary to practice safely and effectively. This is particularly important in paediatric care when the visual system is undergoing tremendous development which is vulnerable to visual disruption.

In children and infants, ocular medications are employed to aid ocular examination, are prescribed to treat common bacterial and viral infections, inflammation and allergy, uveitis and glaucoma, and are further used in the management of myopia, amblyopia and strabismus.[1] Before initiating treatment, the practitioner must weigh up the risks of using the medicine against the potential benefits, establish the minimum dose required to achieve the therapeutic benefit, and monitor for local and systemic side effects. These can be highly challenging with the limited evidence for rational use of ocular medicines in the paediatric population.

Determining the risk profile and minimum dose for a paediatric therapeutic regime is challenging in children as many ophthalmic medicines have not had specific study of paediatric safety and efficacy.[2] The cost of clinical paediatric trials and perceived limited paediatric use of drugs has been a barrier to gathering specific evidence. Trials are further challenged by the physiological and metabolic stages that vary from newborns, infants, through stages of childhood to adolescence. Systemic effects, tolerance, kidney function, and metabolism are all different in children when compared to adults.

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The eye of a newborn child is approximately two-thirds of its adult size and reaches adult size by around three to four years of age. While the ocular dimensions of paediatric eye approach that of an adult, body weight is much lower and metabolism immature which makes systemic absorption more concerning.[2] As drugs pass to the systemic circulation they are less diluted by a the circulation of a child compared with an adult, due to the smaller circulating blood volume. The relatively large systemic dose is metabolised at a slower rate, thus an eye drop in a child will achieve a higher plasma level and will last for a longer period of time.[2] Calculating an appropriate paediatric dose should consider body weight, development, metabolism, other medications taken and physiologic function. An approximation in an otherwise healthy child may be to use half the adult dose from birth to two years, and two thirds the adult dose for children between two and four years of age.[3]

Where to look for information

The Australian Medicines Handbook (AMH)[4] is an independent, evidence-based national drug reference, and provides an important clinical resource for health practitioners in hospital and community setting with information supporting quality use of medicines. The AMH Children's Dosing Companion (CDC)[5] provides an independent dosing guide for prescribing and administering medicines to children from birth to 18 years and has inter-product linking to AMH Online and to the Pharmaceutical Benefits Scheme (PBS) website. Most Australian optometry program university libraries will have a subscription to AMH Online and optometrists who are alumni of their qualifying institution should be able to log into the handbook via their institution library.

The AMH lists local and systemic side effects of the medicines referred to in this paper and tabulates pharmacodynamics for classes of drugs. The CDC notes childhood specific information on dosage, administration advice, off-label use, practice points and products, and indicates when an ophthalmologist advice should be sought. The product information section includes a link to PBS and states the concentration and volume of named commercially available products. Paediatric doses for eye drops are usually expressed for age ranges, for oral medications it is by weight and/or age.

Table 1 summarises drug use and product information from the CDC for the drugs commonly employed in management of paediatric eye conditions that are referred to in this viewpoint article. Practical points and local and systemic side effects[6] have been included.

Cost of medicines can be a barrier to compliance with therapeutic regime. Optometrists may need to consider whether the prescribed medicine is subsidised by the PBS, and further consider whether a commercial preparation is available or whether the medication requires preparation by a compounding pharmacist in appropriate sterile facilities. Specialist paediatric pharmacist advice may be sought from in-hospital pharmacy services based within hospitals for children. For any at home therapeutic treatment regime, it is essential to provide clear instructions to parents, including advice regarding safe storage of drops, description of potential systemic side effects and expected local side effects.

Eye drops may be available in multidose bottles or in single minim preparations. While multidose eye drops may be more affordable, they contain preservatives, usually benzalkonium chloride (BAK), which can have a toxic effect on the ocular surface with long-term use.[7] The likelihood of the known side effects occurring with the dose regime prescribed needs to be considered against the benefits of therapeutic management of the ocular condition. A schedule for patient review and steps to mitigate risk of side effects and recommended action should they occur needs to be included in a patient management plan.

Tips for instilling drops in children

Therapeutic outcomes require optimal compliance with instilling drops or ointments which can be particularly challenging in infants and young children. There are a range of difficulties that can arise in instilling drops. The natural instinct that a child will have when lids are forced open and an object brought near is to squeeze the eyelids closed and turn away. In addition, the child may be frightened and in pain, may not understand the need for drops or ointment, may experience unpleasant side effects of stinging, had previous poor experience with eye examination drops, or have general challenges, such as autism or developmental delay, that affect communication, behaviour and cooperation in general.[8]

Parents also need to be fully informed and comfortable with the treatment regime, as any anxiety that they feel about instilling drops may be unwittingly communicated to the child. Planning the tailored therapeutic regime may need to account for practical issues, such as the setting that drops may need to be applied (home, school, day care). Clear written instructions will assist clinical communication and increase likelihood of therapeutic compliance.[8]

Where possible, direct advice to the child about why drops are required and what the experience is likely to be should be given so that child assent can be gained in conjunction with parental consent to drops. Ideal drop instillation technique is for the child to be still and looking up, and while the lower lid is pulled down a drop is placed into the fornix. For infants and young children, it can be easier to instil the drops when the child is lying down on a change table or bed. The child's head and hands may need to be held still, requiring the assistance of a second adult.

To limit hands intervening, a child can be swaddled in a thin blanket or sheet. A good technique is to hold the eyelids open between the index finger and thumb of one hand and put the drops in with the other. If the child will not allow their eye to open, and alternative approach is to put a couple of drops onto the skin at the inner canthal region and part the lids to have the drop slide in.

Three techniques have been described to reduce drug elimination rate: eyelid closure, nasolacrimal occlusion and the application of a smaller volume of drug to the eye. Closing the eyes reduces blinking and the associated pumping action of the lacrimal sac to promote tear drainage and nasolacrimal occlusion physically reduces tears from entering the nasolacrimal system. A smaller volume of drop onto the eye is thought to cause less reflex blinking and tearing, thereby diluting the drop less. 10–20 µl is

suggested to be the ideal drop volume for an ocular medication.[9] There are approximately 20 drops in each mL of an eye drop.

Systemic absorption may be reduced by compressing the lacrimal sac at the medial canthus for a minute during and following the instillation of the drops. This reduces the passage of the drops via the nasolacrimal duct to the wide absorptive area of the nasal and pharyngeal mucosa and is especially advisable in children and parents should be instructed on this technique.

Ointments have a longer duration of effect than drops, as drug dilution and drainage is slower. They are appropriate to use in children and allows sustained drug concentration. While ointment can be difficult to instil, and children may dislike the blur it induces, it is a useful option for night-time use in a sleeping child.

Scheduled medicines for diagnostic use

Summary of topical ocular medications commonly employed in Australia is provided in Table 1. This has been adapted from the Child Dosing Companion and Australian Medical Handbook.[5]

Ocular surface anaesthesia

Local anaesthetics reversibly block nerve conduction and are used for short-term ocular surface anaesthesia that may be required for clinical techniques such as applanation tonometry in an older child or rigid contact lens insertion and removal. The two common anaesthetics employed in paediatric eye care practice are proxymetacaine (alcaine) and oxybuprocaine (benoxinate), both of which will initially sting for about 10 s, have onset of action in 20 s, and duration of action for 10–20 min.[4] While 0.4% oxybuprocaine is available in 0.5 mL single-use minims (benoxinate), 0.5% proxymetacaine (alcaine) that is only available in multidose bottle may be preferred to oxybuprocaine in children as it causes less stinging.

In a child with a sore eye who is reluctant to open the eye, it can be useful to instil an anaesthetic at the commencement of the examination to facilitate eye opening for general inspection, visual acuity assessment, and then slit lamp examination. In a child with dark irides who is likely to require the instillation of multiple cycloplegic drops, topical anaesthetic may reduce the overall discomfort if instilled prior to the cycloplegic. Topical anaesthetics also increase corneal permeability and hence the ocular bioavailability of other drugs so can be a useful adjunct to inducing cycloplegia. Parents and children should be advised that the drops will briefly sting on instillation and of the risks of damage from eye rubbing while the child has topical anaesthetic acting.

Cycloplegia for refraction and mydriasis for fundus examination

Failure to control accommodation during determination of the magnitude of refractive error can result in an overestimation of myopia or an underestimation of hyperopia.[1,10] This is particularly true when assessing refractive error in children when accommodation is most active and attention to a 6-m fixation target difficult to control, or when auto-refractors are used as an adjunct to retinoscopy. Topical anticholinergics (cyclopentolate hydrochloride, tropicamide and atropine sulphate) paralyse ocular accommodation and ensure a more accurate measure of refractive error and cause pupil mydriasis. Phenylephrine (sympathomimetic) may be used to supplement anticholinergic mydriasis.

Common adverse effects of anticholinergics include intolerance to bright light (glare), stinging on instillation, blurred vision (especially near vision), and potential for transient intraocular pressure elevation (especially in pre-existing ocular hypertension). Infrequent effects (0.1–1% occurrence) include contact allergic blepharitis (atropine), persistent ocular irritation, insomnia or drowsiness. Rare effects (< 0.1% occurrence) are systemic anticholinergic toxicity signs that may include dryness of mouth, fever, facial flushing, tachycardia, disorientation, ataxia, visual hallucinations, incoherent speech, delirium, psychosis and seizures.[4]

Cyclopentolate 1% is the most widely accepted cycloplegic agent for refractive error measure in children as it is highly effective at both mydriasis and paralysing accommodation. Peak effect for mydriasis is 30–60 min and for cycloplegia 25–75 min, with approximately 24 h duration of action. While atropine 1% has the greatest efficacy in paralysing accommodation, it has a longer time to peak effect at 30–40 min for mydriasis and 1–3 h for cycloplegia. Atropine 1% action can last up to two weeks and has greatest potential of the anticholinergics for systemic toxicity and prolonged side effects.

Tropicamide has the least side effects and shortest duration of action (six hours); however, 0.5% may not paralyse accommodation to the extent required for childhood refractive error determination. While tropicamide 1% has been suggested to be most appropriate to use in those children who may have increased sensitivity to cycloplegic agents, for example children with Down syndrome, trisomy 12 and 18, cerebral palsy and other central nervous system disorders, there is lack of evidence to preclude the use of atropine in children with Down syndrome.[11]

In healthy children, one drop of 0.5% cyclopentolate is recommended for use in children aged less than 12 months of age, and 1% for older children for routine comprehensive refractive and ocular health examination. Typically, one drop of 1% cyclopentolate is preceded by one drop of topical anaesthetic (0.5% proxymetacine hydrocholoride or oxybuprocaine), with refractive error measure carried out 30 min after drop instillation once cycloplegic. Iris colour and ethnicity are reported to influence the time-course of cycloplegia, with dark irides requiring up to 40 min to reach full loss of accommodation, compared with only 10 min in individuals with light iris colour. While mydriasis accompanies cycloplegia, the increase in pupil size lags behind the loss of accommodation.[9]

Thorough examination of posterior segment ocular structures through dilated pupils is a further advantage of use of cycloplegic agents in children. This is particularly so when a child has presented with reduced vision. While amblyopia (poor vision from abnormal vision development) is a leading cause of reduced vision in children, the diagnosis of amblyopia needs both the presence of an amblyogenic factor and the absence of underlying pathology or structural anomalies.[12] Viewing

through enlarged pupils from cycloplegic agents greatly assists the careful inspection of ocular media and posterior pole.

Scheduled medicines for therapeutic use

Penalisation treatment in amblyopia (1% atropine)

Two to three percent of children have amblyopia, poor vision from abnormal development of the visual system. After correction of the underlying amblyogenic condition, amblyopia may be treated by occlusion or penalisation of the dominant eye. Pharmacologic penalisation using 1% atropine sulphate eye drops is as effective for visual recovery as patching.[13–15] In the eye, the anticholinergic agent atropine blocks the responses of the ciliary muscle and the iris sphincter to cholinergic stimulation, causing cycloplegia and mydriasis. The vision in the dominant eye will be blurred, particularly if there is uncorrected hyperopia.

The established usual dose regime is two days per week instillation of one drop of 1% atropine to the dominant eye. While amblyopia is more responsive to treatment in younger children, many older children have marked improvements in visual acuity comparable to outcomes achieved with two hours per day patching.[16,17]

Clear instructions to parents are important, including safe storage of drops, description of potential systemic side effects and expected local side effects of stinging and light sensitivity, with regular aftercare appointments required for children undergoing treatment to review adherence to the prescribed regime, screening for potential side effects and monitoring of treatment outcomes. Parents should inform the school and other health care providers that the child has a dilated pupil from atropine, and take care to wash their own hands after instilling the child's drop so that they do not accidently rub atropine into their own eye.

Management of myopia progression (< 0.1% low concentration atropine)

Childhood myopia is a key ocular condition that is managed by optometrists. Over the last decade the emphasis in childhood myopia care has turned to measures that limit the continued elongation of axial length that underlies myopic refractive error. Atropine has a concentration-related effect on limiting progression in axial length and subsequent myopia.[18] This drug is a non-selective antagonist of muscarinic acetylcholine receptors; however, the exact mechanism for the beneficial effect on myopia progression is still not entirely known.

Increased pupil diameter with accompanying light sensitivity, and near-vision blur from loss of accommodation are the predominant adverse side-effects when considering atropine as a myopia progression treatment. These side effects and the rebound effects after cessation of treatment are all greater with higher concentration atropine. These adverse effects are substantially reduced with low-concentration atropine (e.g. 0.01, 0.025, 0.05, 0.1%) that are now becoming accepted standard care for management of childhood myopia.[19] The pupil size and accommodation loss side effects are reported to be well tolerated with atropine concentrations between 0.01% and 0.05%, with no impact on visual acuity or vision-related quality of life.[18,20] Drops are instilled daily, typically at night to limit the impact of potential side effects.

The long-term use of low concentration atropine is still not completely understood, and there is lack of consensus regarding when treatment should be ceased. Future results from clinical trials that are investigating low concentration atropine for myopia management are needed to inform more specifically on best concentration dose for treatment efficacy and inform on effects when treatment is ceased.

Standard commercial preparation of atropine is 1.0%. This concentration is highly effective at limiting myopia progression; however, it causes unacceptable photophobia and near blur. While 0.01% atropine is now a licenced therapeutic medicine in some Asian countries, in Australia low concentration (< 0.1%) atropine solution is not yet commercially available so it must be compounded by a pharmacy that has access to a sterile room. It is important that the prescription clearly indicates that the low concentration atropine is to be compounded to prevent the accidental dispensing of commercial 1% atropine.

The compounded low concentration atropine is diluted from a higher concentrated stock solution of atropine sulphate and then combined with BZA 0.1 mg/mL. Non-active excipients include disodium edetate, benzalkonium chloride and hypromellose, boric acid and distilled water. It is important to talk to the compounding pharmacy about any other non-active ingredients that are added to the compound to ensure comprehensive understanding of the solution that is being prescribed.

Atropine sulphate is also susceptible to light degradation, requiring storage in a light limiting container. Compounded sterile low concentration atropine solution will be assigned an expiry date by the compounding pharmacist that can be up to six months, then has a 30-day life after opening. While non-preserved solution is possible for patients sensitive to preservatives, it has a very limited shelf life (28 days unopened, seven days opened).

Treatment of ocular infection

Ocular surface infection including conjunctivitis, keratitis and blepharitis occur commonly in children, and may onset from bacterial, viral or fungal pathogens.[21] In addition to the symptoms of the acute presentation, corneal involvement can result in scars causing vision impairment and potentially amblyopia.

Bacterial infections

Bacterial conjunctivitis

Acute bacterial conjunctivitis is common in young children. It presents with mucopurulent discharge, diffuse bulbar redness, and papillary hypertrophy of the upper tarsal plate conjunctiva, and is bilateral in 70% of cases.[22] While it is often self-limiting (65% will resolve spontaneously in two–five days),[22] antibiotics can hasten recovery, prevent complications and limit the spread of infection to others.[23]

In children, most cases of bacterial conjunctivitis are caused by gram positive organisms, particularly *Haemophilus influenza, Streptococcus pneumoniae* and *Staphylococcus aureus*. Chloramphenicol is an antibiotic that

inhibits protein synthesis in a broad spectrum of gram-positive bacteria. It is effective in treating ocular infections such as conjunctivitis and blepharitis caused by gram positive bacteria Topical chloramphenicol is not in use in the USA due to the concern regarding aplastic anaemia (which has a mortality rate of around 50%) that is a rare but well reported side-effect with the use of intra-venous chloramphenicol.

While there have been isolated case reports of aplastic anaemia in patients who had used ocular chloramphenicol, subsequent larger studies have found no evidence to link the use of topical chloramphenicol to the development of aplastic anaemia.[24] In Australia, Chloramphenicol 0.5% (*Chlorsig)* is PBS listed as a Schedule 3 drug, so is available as both a drop and as an ointment as a Pharmacist provided medicine that does not require a written prescription.

Ophthalmia neonatorum

Conjunctivitis in a neonate less than 30 days old (ophthalmia neonatorum) should be urgently referred to an emergency department for urgent swab, paediatric review and possible admission for intravenous therapy as these babies are at risk of perinatally acquired gonococcal, chlamydia or herpes simplex virus (HSV) infection which in addition to severe ocular morbidity including corneal scarring or perforation, may also lead to pneumonia, meningitis or encephalitis.

Bacterial keratitis

Bacterial keratitis is rare in children unless there is a known precipitant such as contact lens use or trauma.[25] Any suspicion of microbial keratitis should be urgently referred to a hospital emergency department where possible as generally a corneal scrape under general anaesthetic is required. For younger children, the predominant organisms are *Staphylococcus aureus*, and *Streptococcus pneumoniae*. *Pseudomonas* infection is more common in older children and is associated with contact lens wear.[21]

Fluoroquinolone drugs such as ofloxacin (Ocuflox) and ciprofloxacin (Ciloxan) are broad-spectrum antibiotics that are active against both Gram-positive and Gram-negative bacteria and are efficacious for treatment of bacterial keratitis.[26] Due to concern about emerging resistance their use is generally reserved for treatment of bacterial keratitis. Once a gram stain of the organism then subsequent identification and antimicrobial sensitivity information is available then antibiotic therapy can be tailored appropriately.

Aminoglycosides are active mainly against Gram-negative bacterial, with Tobramycin active against *Pseudomonas*, however, Tobramycin is generally fortified to at least 0.9% and combined with cephalosporin by a hospital/compounding pharmacy for use in bacterial keratitis.[22] Commercially available 0.3% tobramycin should not be used as monotherapy for bacterial keratitis as it does not provide adequate cover for *Pneumococcus*, further, the commercial preparation of 0.3% is inadequate to control *Pseudomonas* keratitis.[27]

For contact lens wearers or post-traumatic infections in rural and remote areas where access to a tertiary eye care service will be delayed, commencing a topical fluoroquinolone, plus tobramycin ointment while asleep, will provide good cover for both the common gram positive organisms and gram negative organisms, such as pseudomonas, until the child can be transferred into a hospital with a paediatric eye service.

Infiltrates—sterile versus infective

Immune (sterile) keratitis results from immune-mediated inflammation precipitated by staphylococcus aureus overgrowth. The infiltrates tend to be small and peripheral on the cornea without a large epithelial defect, and these will generally recover quickly with a topical antibiotic and low-dose topical corticosteroid.[22] However, due to the difficulties involved in examining children, it can be hard to confidently differentiate infective versus sterile infiltrates.

Infective infiltrates can cause corneal thinning and scarring and can lead to irregular astigmatism which in a child can present risk for amblyopia.[28] As a result, it is safer to treat even small peripheral infiltrates with intensive topical fluoroquinolone for the first 48 h even if the clinical picture is more in keeping with marginal keratitis. The child can then be switched to 4x day chloramphenicol with a mild topical steroid.[28]

Prescribing topical steroids in children

Optometrists seeking to treat ocular inflammation with topical steroids should have a solid understanding of the pathology and potential complications/sequelae of the disease processes that may require the use of topical steroids as well as an understanding of the potential complications related to topical steroid use.[29] Corticosteroids suppress the immune system and can increase the risk and severity of infections; their anti-inflammatory effects can also mask signs of infection, and their use is contra-indicated in herpes simplex epithelial keratitis and fungal keratitis.

Children are at increased risk of ocular hypertension and cataract,[4] and may experience a rise in within a few weeks of regular use of potent steroids.[30] Intraocular pressure rise to topical 0.1% dexamethasone in children younger than 10 years was found to occur more frequently, more severely and more rapidly than in adults.[30] Even relatively 'mild' steroids such as fluorometholone and hydrocortisone can cause significant rises in intraocular pressure in children, with the risk proportional to dose, potency, penetration and duration of treatment .[31] Delayed corneal healing and rebound inflammation following ceasing treatment must also be considered.[4] The development of steroid-related cataracts and their treatment is also problematic in children.[4]

Optometrists should consider referral for a specialist opinion or co-management for any child requiring potent topical steroids or requiring a low dose less potent steroid for more than a few weeks.

Viral infections

Viral conjunctivitis

Viral conjunctivitis is a common, self-limiting condition that is typically caused by adenovirus, although other viruses that can be responsible for conjunctival infection in children include herpes simplex virus (HSV), varicella-zoster virus (VZV), and poxvirus (molluscum contagiosum, vaccinia).

Adenovirus

Adenovirus is a common cause of membranous conjunctivitis and keratanoconjunctivitis.[32] The infection causes acute lid swelling, follicular conjunctivitis, petechial haemorrhages,

conjunctive membranes, and preauricular lymphadenopathy.[22] Corneal epithelial cell sloughing and anterior uveitis can occur, and sight-threatening immune-mediated sub-epithelial infiltrates can lead to scarring and irregular astigmatism.[22]

Initial treatment is typically based on symptomatic relief with cold compresses or frequent flushing with chilled non-preserved artificial tears, with little evidence for benefit of further therapeutic intervention in the acute phase.[33] Povidone-iodine 0.8% may represent a potential option to reduce contagiousness in cases of adenoviral infections. An in vitro study using adenovirus 8 and A549 human epithelial cell cultures demonstrated that povidone-iodine at a concentration of 1:10 (0.8%) is highly effective against free adenovirus, less effective against intracellular adenoviral particles in already infected cells, and not significantly cytotoxic for healthy cells.[34] However, the use in children is somewhat limited due to significant stinging on instillation.

While most adenoviral conjunctivitis is mild and self-limiting, the formation of pseudo-membranes or corneal infiltrates warrants treatment with a topical steroid such as fluorometholone 0.1% (FML) 3x daily. If this is inadequate, then more potent steroids such as dexamethasone 0.1% (Maxidex) or prednisolone may be required.[29] However, prolonged treatment with prednisolone is not recommended as viral replication and increased duration of viral shedding can occur[35] (see notes on steroid prescribing below). In some patients the corneal infiltrates may have a refractory course requiring a prolonged period of low-dose steroid to prevent vision deterioration and long-term corneal scarring that can be a risk for amblyopia in young children.[36]

Herpes simplex virus (HSV)

In children, HSV may present as the primary infection as an HSV blepharitis with a vesicular rash involving the eyelids or a follicular conjunctivitis. Only around 10% of primary infections are symptomatic. There is limited evidence to support the use of aciclovir ointment in this setting which is self-limiting in 1–2 weeks, however, *Chlorsig* ointment may be useful to prevent secondary bacterial infection.[37]

Children may also get the classic dendritic HSV keratitis which requires treatment with topical aciclovir ointment (*zovirax, acivision*) at the same regimen as adults, with a small amount in the conjunctival sac 5x day for two weeks or for three days after the epithelium is healed.

Topical Ganciclovir (*virgan*) is an alternative anti-viral guanine analogue that is available in a gel for ophthalmic use. It has lower corneal toxicity and dosing involves less frequent applications than acyclovir, and has been temporarily registered for use in Australia during periods of supply shortage of acyclovir. At other times it can be accessed via application to the Therapeutic Goods Administration (TGA) Special Access Scheme.

HSV keratitis is particularly problematic in children who are of amblyopic age, as both the corneal scar and the astigmatism that the scar may induce can result in amblyopia, with residual corneal opacity reported in 50% of paediatric cases.[38] Due to the significant morbidity recurrent HSV keratitis is usually co-managed by a paediatric ophthalmologist in conjunction with infectious disease specialists with systemic antiviral prophylaxis such as oral valaciclovir.

Varicella zoster virus (VZV)

It is possible for primary varicella zoster infection (chicken pox) to cause the significant ocular morbidity that is seen in recurrent zoster infection (shingles), although ocular VZV infection is rare in children unless they are immunosuppressed (e.g., chemotherapy or radiotherapy).[39] A child with a red eye who has chicken pox diagnosis warrants referral for further assessment and consideration of oral antiviral therapy. Oral antivirals reduce the severity of acute herpes zoster infection and the frequency of late onset inflammatory corneal disease 50%, generally prescribed for five days within 72 hours of onset on painful rash over the upper lid and forehead.[39]

Fungal and acanthamoeba infections

Although rare, the possibility of acanthamoeba or fungal infection needs to be considered – particularly in any microbial keratitis not responding rapidly to antibiotics and those with risk factors such as contact lens wear or ocular trauma. Fungal keratitis is characterised by a white stromal infiltrate with feathery borders, satellite lesions, hypopyon, and endothelial plaque formation. *Acanthamoeba* infection in children is rare by may be associated with contact lens wear or trauma. While the epithelial disease may recover, the stromal infection can require months of treatment before the acanthamoeba cysts are eliminated.[40]

Treatment for either of these infections is not started empirically, even if clinically suspected, until appropriate ocular culture and microscopy is obtained. Both conditions require prolonged treatment and usually multidrug therapy that has a high degree of ocular toxicity. The medications to treat these conditions are not registered for routine use and need to be accessed and usually compounded by a tertiary hospital pharmacy.

Treatment of staphylococcal hypersensitivity

Eyelid margin disease with secondary conjunctival and corneal involvement is termed blepharokeratoconjunctivitis (BKC).[41] The keratitis can include punctate epithelial erosions marginal keratitis, phlyctenules, pannus formation and corneal scarring. While lid hygiene forms the backbone of chronic control with all patients with the disease, this can be difficult to carry out effectively in younger children and topical or systemic medications may be required.[28]

Moderate disease may require a short course of combination of chloramphenicol to reduce the levels of staphylococcal carriage and low-dose steroid to reduce inflammation. An easy to administer protocol for children is one drop of fluorometholone 0.1% (*FML)* in the morning, then applying chloramphenicol ointment to the lid margins after lid hygiene at night.

Severe disease with significant inflammation and photophobia may require more frequent chloramphenicol and higher potency steroids and addition of a low dose long course of oral antibiotic to improve the quality of the meibomian gland secretions.[28] Tetracyclines are the most effective class for this but they are contraindicated in children under the age of 12 as they lead to destruction of tooth enamel. Oral erythromycin is an alternative which is safe in children, which is generally well tolerated but may cause gastrointestinal upset. There is little evidence to guide dosing, but common dosages are 400 mg per day in children over 20 kg and 200 mg daily in those under

20 kg, which are around a quarter of the dose used for acute infection.

Treatment of allergic eye disease

Allergic eye disease in children may be seasonal or chronic in nature and ranges from intermittent mild itchy eyes, to severe vernal conjunctivitis and severe chronic atopic eye disease associated with other forms of childhood atopy. Due to the link between allergic eye disease, eye rubbing and keratoconus allergic eye disease must be identified and treated in children to prevent later complications.

Mild intermittent disease may respond to simple conservative measures of ocular lubricants, cool compresses, regular washing of hands and faces to reduce allergen load and allergen avoidance can be enough to control symptoms.[42]

Combined antihistamine and mast cell stabiliser such as Ketotifen (*Zaditen, available as either multidose bottle or unit dose)* or Olopatadine (*Patanol*) tend to be well tolerated and provide relatively rapid symptomatic relief as well as preventing the release of histamine in the longer term.[43] They are most effectively used twice a day over a period of weeks to control symptoms. For acute allergic flares, they can be combined with an over-the-counter oral non-sedating antihistamine such as cetirizine or loratadine which can be used in children over the age of two years. Mast cell stabilisers alone (*Opticrom, Chromofresh)* may be used to prevent the development of seasonal symptoms but takes a few weeks to take effects.

Severe acute flares or recalcitrant chronic disease may require the use of topical steroids. Fluorometholone, e.g. FML or Flarex, provides ocular surface anti-inflammatory action with reduced intraocular penetration so it is less likely to lead to an IOP rise or cataract formation than more potent steroids such as dexamethasone or prednisolone. This is usually commenced at 2–3x day instillation and then weaned over a couple of weeks as symptoms improve. Topical hydrocortisone ointment (*Hycor* 1%) is useful to instil at night-time while asleep in children who are resistant to eye drop instillation or to apply for a short period to the eyelids in children with associated periocular eczema. Although hydrocortisone 1% is a mild steroid, the ointment form has prolonged contact with the eye and more intraocular penetration, thus has a higher risk of intraocular pressure rise.

Children requiring more than infrequent short courses of low potency topical steroids to control their disease should be co-managed with a paediatric ophthalmologist with a view to escalating steroid therapy under close monitoring or consideration of long-term steroid-sparing therapy.

Treatment of intraocular inflammation

Paediatric iritis/uveitis is a rare but potentially blinding condition which is generally co-managed in a tertiary hospital by a paediatric ophthalmologist and paediatric rheumatologist. It is most commonly a chronic uveitis associated with juvenile idiopathic arthritis. It is managed with a combination of long-term topical Maxidex or Prednefrin Forte in combination with systemic immunosuppression. These patients are at high risk of development of cataract and glaucoma and the management of these is very challenging.

Treatment of childhood glaucoma

Childhood glaucoma is due to raised intraocular pressure due to congenital structural anomalies within the eye (primary glaucoma) or as a secondary complication from conditions such as congenital cataract surgery, uveitis or trauma.[44] The onset of primary glaucoma has been reported as 38% congenital (< 3 months of age), 56% infantile (from four months to two years) and 6% juvenile (2–16 years).[44]

While surgery is required in 94% of patients with primary congenital glaucoma and 64% of patients with secondary glaucoma, topical therapy may be used in mild cases as an adjunct to surgical treatment or as a temporising measure prior to surgery.[44] Children are at higher risk of systemic, potentially fatal side-effects from topical administration of anti-glaucoma drugs and parents should be instructed on punctal occlusion.[45]

Table 1 reports the key practice points and side effects that are considered when prescribing intra ocular pressure-lowering medications in children. While it is inevitably managed by an ophthalmologist with subspecialist interest in the area the important points that optometrists should be aware of is that the alpha agonists (Brimonidine and Apraclonidine) are contraindicated in children under the age of 12 years due to the potential for central nervous system depression causing drowsiness and apnoea.[45]

Beta-Blockers are often used as first-line therapy in children but, as in adults, need to be avoided in those with asthma which can manifest with nocturnal cough in children rather than wheezing. Timolol is commercially available as 0.25% solution and as a 0.1% gel forming eye drop; these lower concentration beta-blockers and gel formulations are preferred in children to reduce systemic absorption and side effects.[6] The carbonic anhydrase inhibitors, including Diamox, are safe in children but may be associated with appetite suppression and weight loss which is problematic in children.[6] Prostaglandin analogues, such as Latanoprost 0.005%, tend to be less efficacious in childhood glaucoma than in primary open angle glaucoma as most childhood glaucoma is associated with a congenital or acquired abnormality of the angle.[46]

Conclusion

In general, the dosage of most eye drops is the same in children and adults. The exceptions to this are for medications where children are more likely to experience side effects. This includes reduction in the dose of cyclopentolate to 0.5% in infants under the age of one year and a preference to use the 0.25% timolol instead of 0.5% where IOP lowering is needed. Optometrists can safely manage many paediatric eye conditions, however, do need to co-manage those conditions with significant morbidity associated with them. Bacterial and HSV keratitis, uveitis, and glaucoma are all conditions that require paediatric ophthalmology oversight and may be best managed within tertiary paediatric hospital settings.

Table 1. Topical medications commonly prescribed to manage ocular conditions in children in Australia. Adapted from the Child Dosing Companion, Australian Medical Handbook.5.

	Drug	Products	Practice points and side effects	Dosage
Anaesthetics	**Proxymetacaine**	0.5%, 15 mL, *Alcaine*	Anaesthesia occurs within 20–30 seconds and lasts at least 15 minutes Proxymetacaine may be preferred to tetracaine and oxybuprocaine in children as it causes less stinging Local SE: transient epithelial keratitis, pupil dilation, contact dermatitis Never prescribed for home use	**Ocular surface anaesthesia** Birth – 18 years, 1 eye drop; repeat in 5 minutes if necessary.
	Oxybuprocaine	0.4%, 0.5 mL (single use), 20, *Minims Oxybuprocaine*	Anaesthesia occurs after 1–2 minutes and lasts 20–30 minutes Proxymetacaine may be preferred to oxybuprocaine in children as it causes less stinging	**Ocular surface anaesthesia** Birth – 18 years, 1 eye drop; repeat in 1–2 minutes if necessary.
Mydriatic	**Phenylephrine (Adrenergic agonist Vasoconstrictor)**	2.5%, 0.5 mL (single use), 20, *Minims Phenylephrine* 10%, 0.5 mL (single use), 20, *Minims Phenylephrine*	Do not use 10% drops in children due to risk of systemic adverse effects (e.g., hypertension) Local: Conjunctival blanching Systemic: Hypertension, tachycardia, arrhythmias	**Mydriasis for dilated fundus examination** 1 month – 18 years, 1 eye drop of 2.5% (as adjunct) 15–30 minutes before procedure.
Cycloplegic	**Tropicamide (anticholinergic)**	0.5%, 0.5 mL (single use), 20, *Minims Tropicamide* 0.5%, 15 mL, *Mydriacyl* 1%, 0.5 mL (single use), 20, *Minims Tropicamide* 1%, 15 mL, *Mydriacy*	0.5% concentration is inadequate for cycloplegia. Anti-cholinergic systemic adverse effects may occur, e.g., tachycardia, ataxia, irritability, disorientation, visual hallucinations however are rare with eye drops; Has lower risk of systemic adverse effects than other anticholinergic eye drops	**Mydriasis for examination of fundus** 1–18 years, 1 eye drop of 0.5% 20 minutes before examination. Add phenylephrine if dilation is inadequate. **Cycloplegia for refraction** 1–18 years, 1 eye drop of 1%; repeat after 5 minutes if necessary. If the patient is not examined within 20–30 minutes, instil another drop to prolong the effect.
	Cyclopentolate (anticholinergic)	0.5%, 0.5 mL (single use), 20, *Minims Cyclopentolate* 1%, 15 mL, *Cyclogyl* 1%, 0.5 mL (single use), 20, *Minims Cyclopentolate*	Instil 30–60 minutes before examination. Local: Ocular irritation, follicular conjunctivitis, cutaneous hyperaemia Anti-cholinergic systemic adverse effects may occur, e.g. tachycardia, ataxia, irritability, disorientation, visual hallucinations however are rare with eye drops; observe for pupil dilation for 30–45 minutes after instillation to gauge effect, and monitor for systemic effects Add phenylephrine if mydriasis is inadequate; cyclopentolate-phenylephrine eye drops are prepared by some hospital pharmacies for use in children < 1 year Limited evidence for cyclopentolate in paediatric uveitis	**Cycloplegia for refraction** 1 month – 1 year, 1 eye drop of 0.5%; repeat in 5–15 minutes if necessary. 1–18 years, 1 eye drop of 0.5% or 1%; repeat in 5–15 minutes if necessary.
Cycloplegic/ Amblyopia Penalisation/ Myopia	**Atropine (anticholinergic)**	1%, 15 mL, *Atropt*, PBS 1%, 0.5 mL (single use), 20, *Minims Atropine* Low concentration < 1% requires compounding	Ensure adequate monitoring for adverse effects (systemic effects can occur after use of eye drops), e.g.,dry mouth, tachycardia, fever, delirium, particularly with higher doses than those recommended Atropine is not first choice for uveitis, mydriasis or cycloplegia Full recovery can take up to 14 days after use of eye drops Local SE: Ocular irritation, follicular conjunctivitis, cutaneous hyperaemia Systemic SE: Hyperactivity, restlessness, delirium, somnolence, seizures, hallucinations, psychosis, gastrointestinal disturbances, temperature elevation, hypotension, respiratory depression	**Diagnostic use (mydriasis, cycloplegia)** Use when mydriasis or cycloplegia from other agents is insufficient, e.g., for very dark eyes. Mydriasis takes at least 40 minutes, and cycloplegia 1–3 hours. Once-daily administration is usually sufficient and minimises risk of adverse effects (1 drop of 1% atropine eye drops contains 500 micrograms atropine). For young children, use atropine 0.5% eye drops (may be available from some hospital pharmacies) or consider using an alternative. 1–18 years, usually 1 eye drop once daily for 1–3 days before examination. **Amblyopia** 3–7 years, 1 eye drop (1%) in the unaffected eye once daily each Saturday and Sunday. **Myopia** 5–18 years, 1 eye drop (<0.1%) daily at night **Uveitis** For young children, use atropine 0.5% eye drops (may be available from some hospital pharmacies). 2–18 years, 1 eye drop once daily. If this is inadequate, consider alternative treatment rather than increasing the dose.

(*Continued*)

Table 1. (Continued).

	Drug	Products	Practice points and side effects	Dosage
Anti-viral	**Aciclovir guanine analogue**	Eye ointment, 3%, 4.5 g, *AciVision, Zovirax* PBSR	Start treatment as soon as possible If dosing 5 times daily, give every 4 hours while awake	**Keratitis** 3 months – 18 years, put a small amount of eye ointment into the lower conjunctival sac 5 times daily for 14 days, or for at least 3 days after healing, whichever is shorter.
	Ganciclovir guanine analogue	Eye Gel 0.15% – 5 g, *Virgan*	Not in routine use. Alternative if supply shortage of acyclovir.	**Keratitis** 3 months – 18 years, put a small amount of eye ointment into the lower conjunctival sac 5 times daily for 14 days, or for at least 3 days after healing, whichever is shorter.
Anti-biotic	**Chloramphenicol**	eye drop, 0.5%, 10 mL, *Chlorsig*, PBS-R eye drop, 0.5%, 0.5 mL (single use), 20, *Minims Chloramphenicol* eye oint, 1%, 4 g, *Chlorsig*	Bacterial conjunctivitis usually resolves spontaneously, although antibacterial treatment may hasten recovery and reduce transmissibility Treat chlamydial or gonococcal conjunctivitis with a systemic antibacterial in addition to chloramphenicol Do not supply chloramphenicol over-the-counter if there is blurred vision or severe pain (particularly in a contact lens wearer), as these patients require further investigation; Children < 2 years should be under medical supervision Limited evidence for prevention of eye infection	**Bacterial blepharitis** All ages, massage eye ointment into lid margin once or twice daily for 1–3 weeks. **Bacterial conjunctivitis** Review if symptoms do not improve within 48 hours of starting chloramphenicol. All ages, 1 eye drop every 2 hours for the first day, then gradually decrease to every 6 hours as symptoms improve for 5–7 days. All ages: use eye ointment at night if drops are used during the day, or as a single agent 3 or 4 times daily for 5–7 days. **Prevention of eye infection (after superficial trauma or surgery)** All ages, 1 eye drop 4 times daily until epithelium healed (rarely >4 days)
	Tobramycin aminoglycoside	eye drop, 0.3%, 5 mL, *Tobrex*, PBS-R[3] eye oint, 0.3%, 3.5 g, *Tobrex*, PBS-R[3]	Reserve eye drops for use by ophthalmologists and for serious infections unresponsive to other topical antibacterials (after taking sample for microbiological culture) Commercial 0.3% tobramycin is not an adequate empirical treatment for bacterial keratitis as monotherapy. It may be fortified by a hospital pharmacy to a higher concentration and used in conjunction with a compounded topical cephalosporin to treat bacterial keratitis. Local SE: Epithelial keratopathy, ocular irritation, redness	**Bacterial eye infections** Use on paediatric ophthalmologist advice. 1 eye drop every 2–4 hours (every hour if serious) for the first day, then gradually decrease to every 6 hours as improvement occurs. Apply eye ointment at night if drops are used during the day or as a single agent 2 or 3 times daily (every 3–4 hours in severe infection) for the first day, then gradually decrease frequency as improvement occurs. **Prophylaxis after superficial eye trauma or surgery** Use on paediatric ophthalmologist advice. 1 eye drop 4 times daily until epithelium healed (rarely >4 days).
	Ciprofloxacin, Ofloxacin Quinolone	eye drop, 0.3%, 5 mL, *Ciloquin, Ciloxan*, PBS-A eye drops, 0.3% 5 mL *Ocuflox*, PBS-A	There is very little evidence for use of ciprofloxacin eye drops in children < 1 year Local SE: Ciprofloxacin: White corneal deposits, ocular irritation, pungent taste, nausea Ofloxacin: Ocular burning, redness, photophobia	**Bacterial keratitis** 1 month – 18 years Seek ophthalmologist advice; before starting treatment, obtain sample for microbiological culture. *Day 1*, 1 eye drop every 15 minutes for the first 6 hours, then every 30 minutes. *Day 2*, 1 eye drop every hour. *Subsequent days*, 1 eye drop every 4 hours. Decrease frequency according to clinical response (only under ophthalmologist supervision).
Anti-Allergy	**Olopatadine**	eye drop, 0.1%, 5 mL, *Paladopt, Patanol*[a]	Local SE: Ocular irritation, redness, itching, taste alteration	**Seasonal allergic conjunctivitis** 3–18 years, 1 eye drop twice daily.
	Ketotifen	eye drop, 0.025%, 0.4 mL (single use), 20, *Zaditen* eye drop, 0.025%, 5 mL, *Zaditen*		**Seasonal allergic conjunctivitis** 3–18 years, 1 eye drop twice daily.
	Cromoglycate Mast cell stabiliser	eye drop, 2%, 10 mL, *Cromo-Fresh, opticrom*	It may be several weeks before benefits appear; start nasal spray and eye drops 2–3 weeks before the expected allergy season, and continue for as long as necessary Local SE: Ocular irritation, eyelid oedema	**Allergic conjunctivitis, vernal keratoconjunctivitis** 1 eye drop in each eye 4–6 times daily.
NSAID	**Ketorolac Anti inflammatory**	eye drop, 0.5%, 5 mL, *Acular*	Local SE: Ocular irritation especially in patients wearing soft contact lenses; allergic reactions,; superficial keratitis	**Seasonal allergic conjunctivitis** Use only on specialist advice for severe symptoms. 3–18 years, 1 eye drop 4 times daily

(*Continued*)

Table 1. (Continued).

	Drug	Products	Practice points and side effects	Dosage
Anti-inflammatory	**Fluorometholone Corticosteroid**	Fluorometholone eye drop, 0.1% (suspension), 5 mL, *FML*, PBS Fluorometholone acetate eye drop, 0.1% (suspension), 5 mL, *Flarex*, PBS	Monitor intraocular pressure if used >10 days or in high doses, and for cataract formation if used long term	**Inflammatory eye conditions** 2–18 years, 1 eye drop 1–4 times daily. For severe inflammation, use 1 drop every 1–2 hours for the first 1–2 days.
	Dexamethasone, Prednisolone Corticosteroid	Dexamethasone eye drop, 0.1% (suspension), 5 mL, *Maxidex*, PBS Prednisolone acetate 1%, Phenylephirine Hydrochloride 0.12% (suspension), 10 mL, *Prednefrin Forte*, PBS	Monitor intraocular pressure when eye drops used > 10 days or in high doses Advise parents that steroids may cause mood or sleep disturbances	**Allergic and inflammatory eye conditions** Do not use without close supervision by, or discussion with, an ophthalmologist (serious adverse effects can threaten vision). 2–18 years, 1 eye drop every 30–60 minutes until inflammation controlled, then reduce frequency (eg every 4 hours or less).
Anti-Glaucoma	**Beta-blocker Timolol**	gel forming eye drop 0.1%, *Nyogel PBS* eye drop 0.25%, *Timoptol, Tenopt*, 5 mL, PBS gel forming eye drop, 0.5%, 2.5 mL, *Timoptol-XE*, PBS eye drop, 0.5%, 5 mL, *Timoptol, Tenopt* PBS Gel forming eye drop, 0.5%, 2.5 mL, *Timoptol-XE*, PBS	Beta-blockers are often used first line for glaucoma in children Bradycardia may occur, especially in infants, as use of timolol eye drops in children leads to higher plasma timolol concentrations than in adults. Contra-indicated in patients with asthma Gel forming drop preferred in children to reduce passage into the nasolacrimal system with systemic absorbtion. Local SE: Ocular irritation, visual disturbances Systemic SE: Depression, arrhythmias, bronchospasm, masked hypoglycaemia in diabetics, behavioural changes, dizziness, bradycardia, apnoea, dyspnoea	**Open-angle glaucoma, ocular hypertension** Seek paediatric ophthalmologist advice. Higher initial doses have been used. <1 year 1 eye drop of 0.25% once daily. 1–18 years *Conventional drops*, 1 eye drop of 0.25% twice daily; increase to 1 drop of 0.5% twice daily if necessary. Decrease to 1 drop once daily when controlled. *Gel-forming drops* (Timoptol-XE®), 1 eye drop of 0.5% once daily.
	Beta blocker Betaolol	eye drop, 0.5% (solution), 5 mL, *Betoptic, Betoquin*, PBS	Beta-blockers are often used first line for glaucoma in children Bradycardia may occur, especially in infants 0.25% suspension (which may be available through the SAS) may reduce local stinging compared to 0.5% solution SE as per Timolol	**Open-angle glaucoma, ocular hypertension** Seek paediatric ophthalmologist advice. 1 month – 18 years, 1 eye drop twice daily.
	Brinzolamide Carbonic anhydrase inhibitor	eye drop, 1% (suspension), 5 mL, *Azopt, BrinzoQuin*, PBS	Often used with ophthalmic beta-blockers or when beta-blockers are ineffective or not tolerated Evidence of efficacy and safety in children is limited Local SE: Ocular irritation, punctate keratitis, blurred vision Systemic SE: bitter taste, headache, nausea, fatigue, skin rash	**Open-angle glaucoma, ocular hypertension** Seek paediatric ophthalmologist advice. 1 month – 18 years, 1 eye drop twice daily.
	Dorzolamide	eye drop, 2%, 5 mL, *Trusamide, Trusopt*[a], PBS	Often used with ophthalmic beta-blockers or when beta-blockers are ineffective or not tolerated Evidence of efficacy and safety in children is limited Local SE: ocular irritation, punctate keratitis, blurred vision Systemic SE: Bitter taste, headache, nausea, fatigue, skin rash	**Open-angle glaucoma, ocular hypertension** Seek paediatric ophthalmologist advice. 1 month – 18 years *Single agent*, 1 eye drop 3 times daily. *Adjunct to beta-blocker*, 1 eye drop twice daily.
	Brimonidine Alpha$_2$ agonist	eye drop, 0.15%, 5 mL, *Alphagan P 1.5*, PBS eye drop, 0.2%, 5 mL, *Alphagan, Enidin*, PBS	Serious adverse effects (e.g. somnolence, apnoea, hypotension, bradycardia) are more likely in children than adults, especially if < 6 years or < 20 kg Absolutely contraindicated in children < 2 years of age due to risk of apnoea	**Open-angle glaucoma, ocular hypertension** Paediatric ophthalmologists occasionally use brimonidine for open-angle glaucoma or ocular hypertension in children.
	Prostaglandin analogue Latanoprost Travoprost Bimatoprost	eye drop, 0.005%, 2.5 mL, *Lanpro, Xalaprost, Xalatan*[a], PBS eye drop, 0.004%, 2.5 mL, *Travatan*, PBS eye drop, 0.03%, 3 mL, *Bimtop, Lumigan*[a], PBS eye drop, 0.03%, 0.4 mL (single use), 30, *Lumigan PF*, PBS	Advise carer that irreversible darkening of the iris can occur, particularly if of mixed colour; it may be more obvious if only one eye is treated Local SE: Increased iris pigmentation, excessive eyelash growth, punctate keratitis Systemic SE: Muscle/joint/back pain	**Open-angle glaucoma, ocular hypertension** Seek paediatric ophthalmologist advice. 1 month – 18 years, 1 eye drop once daily, preferably at night.

Disclosure statement

No potential conflict of interest was reported by the authors.

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