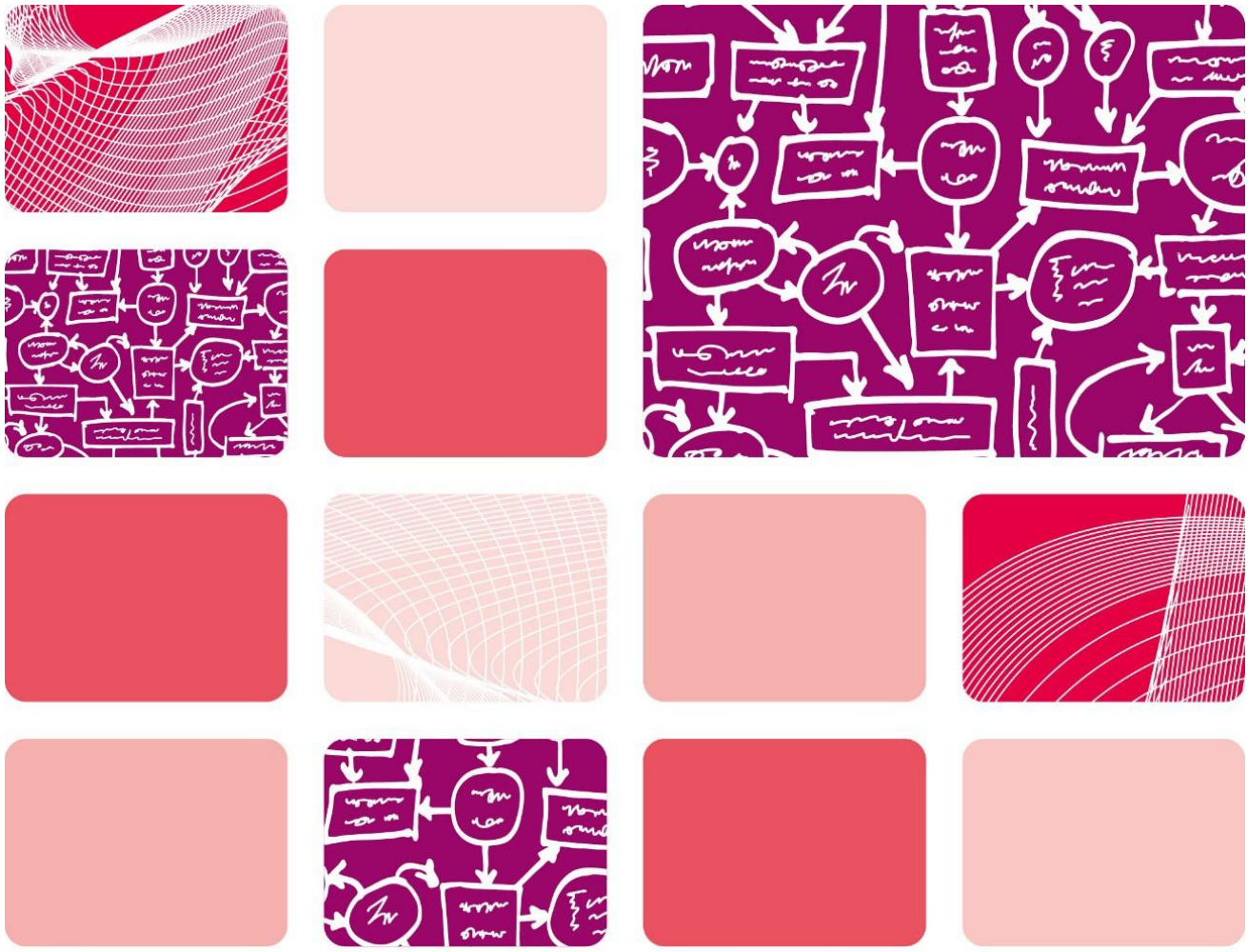
UK Health Security Agency

UK Standards for Microbiology Investigations

Red or painful eye



Acknowledgments

UK Standards for Microbiology Investigations (UK SMIs) are developed under the auspices of UKHSA working in partnership with the partner organisations whose logos are displayed below and listed on the website. UK SMIs are developed, reviewed and revised by various working groups which are overseen by a steering committee.

The contributions of many individuals in clinical, specialist and reference laboratories who have provided information and comments during the development of this document are acknowledged. We are grateful to the medical editors for editing the medical content.

UK SMIs are produced in association with:

Displayed logos correct as of December 2024

Contents

Amendment table

Each UK SMI document has an individual record of amendments. The amendments are listed on this page. The amendment history is available from standards@ukhsa.gov.uk.

Any alterations to this document should be controlled in accordance with the local document control process.

Amendment number/date	1/24.04.25
Issue number discarded	1
Insert issue number	1.1
Section(s) involved	**Amendment**
Whole document.	**This is an administrative point change.** **The content of this UK SMI document has not changed.** **The last scientific and clinical review was conducted on 16.05.23.** Hyperlinks throughout document updated to Royal College of Pathologists website. Public Health England replaced with UK Health Security Agency throughout the document, including the updated Royal Coat of Arms Partner organisation logos updated. Broken links to devolved administrations replaced. References to NICE accreditation removed. Scope and Purpose replaced with General and Scientific information to align with current UK SMI template.
Section 10: Public health responsibilities of diagnostic laboratories	This section has been added to UK SMI templates to highlight the public health responsibilities that diagnostic laboratories have as part of their duties.

Amendment number/date	-/16.05.23
Issue number discarded	-
Insert issue number	1
Anticipated next review date*	16.05.26
Section(s) involved	**Amendment**
Whole document	This new syndromic document red or painful eye is based on UK SMI B 2 infections of the eye. The content has expanded and presented in the new template with the relevant titles and headings. The document focuses on common pathogens associated with red or painful eye. In line with recent updates Candida species are referred to as *Candida* and associated ascomycetous yeasts.
Section 4	Background information updated
Section 5	All the algorithms have been updated
Section 7.4	Table has been restructured including new target organisms

*Reviews can be extended up to 5 years where appropriate

1 General information

View general information related to UK SMIs.

2 Scientific information

View scientific information related to UK SMIs.

3 Scope of document

This UK SMI describes the investigation of patients with red or painful eye caused by infection, focusing on common pathogens. This presentation can occur in otherwise healthy patients of any age, with a normal or impaired immune system function. Characteristic syndromes are often associated with specific underlying conditions.

The document covers common pathogens using molecular, culture and serological techniques. Molecular testing refers to polymerase chain reaction (PCR) tests and nucleic acid amplification tests (NAATs).

This UK SMI should be used in conjunction with other associated UK SMIs.

Please note in accordance with recent updates of fungal taxonomy, Candida species are referred to as Candida and associated ascomycetous yeast (1).

4 Background

Red or painful eye can be caused by bacteria, viruses, fungi and parasites. Common inflammation such as conjunctivitis, blepharitis, canaliculitis and orbital cellulitis affect the external eye. Keratitis, endophthalmitis and uveitis infections affect the globe of the eye and these may be acute or chronic with varying severity. Refer to sections 4.1 to 4.9. Exogenous organisms may be introduced to the eye via hands, fomites (for example contact lenses), traumatic injury or following surgery. Haematogenous spread from a focus elsewhere in the body can also occur. Infections causing red or painful eye can rapidly progress and require urgent investigation and immediate treatment.

Red or painful eye

Red or painful eye can be caused by a variety of infectious and non-infectious conditions. The common diagnoses of red or painful eye are conjunctivitis, dacryoadenitis, blepharitis, canaliculitis, cellulitis, keratitis, retinitis and endophthalmitis. Refer to sections 4.1 to 4.9.

An overarching algorithm of this syndrome covering the common ophthalmic presentations is available in section 5.1 and a brief summary is listed below:

- partial or total visual loss caused by microbial keratitis or uveitis
- painful red eye with no visual loss caused by severe conjunctivitis, orbital cellulitis, microbial keratitis, corneal trauma and corneal ulceration

- painful eye involving the cornea caused by foreign body or topical therapy leading to punctate keratopathy
- painful red eye with mucopurulent conjunctival discharge is caused by chlamydial or bacterial conjunctivitis. Gonococcal conjunctivitis may give rise to hyperpurulent discharge whereas allergic or viral conjunctivitis results in watery discharge or itching
- painful red eye with no visual loss caused by infection and inflammation of the tear sac (dacryocystitis) causing pain and discharge over the medial aspect of the eye and eyelids (2). It is common in infants and middle-aged women and can be classified as either acute, chronic or congenital (3). The most common organisms in acute infection include: *Staphylococcus* and *Streptococcus* species, followed by *Haemophilus influenzae* and *Pseudomonas aeruginosa*. Chronic dacryocystitis is a result of chronic obstruction due to systemic disease, repeated infection, dacryoliths and chronic inflammatory debris of the nasolacrimal system (4)
- red eye with no pain caused by subconjunctival haemorrhage

4.1 Conjunctivitis

Conjunctivitis is inflammation of the conjunctiva (the thin layer of tissue that covers the front of the eye) and is usually due to common viral and bacterial infections. It occurs in people of all ages including neonates. Features such as the clinical appearance of the eye, the age of the patient, and exposure history should be considered in assessing the likely cause of the condition. In most cases of conjunctivitis, the inflammation clears up in a few days and does not require antimicrobial treatment. Signs and symptoms include itching, red eye, foreign body sensation, watery and sticky discharge (5). In England the incidence of conjunctivitis is 13 to 14 in 1000 people per year. The rates are higher in children under one year of age (6).

Viral conjunctivitis

Viral infection of the eye can be contagious and is caused by adenovirus, herpes simplex virus (HSV), varicella zoster virus (VZV) and enterovirus (7). Depending on the cause there maybe additional symptoms or conditions such as respiratory viruses, pharyngoconjunctival fever, acute contagious haemorrhagic conjunctivitis (associated with enterovirus 70 and coxsackievirus A24), herpetic keratoconjunctivitis, measles, rubella, Mpox (Monkeypox virus) and Molluscum contagiosum (8,9) (10). Most viruses spread through hand-to-eye contact following contamination with the infectious virus. Symptoms include watery discharge from the eye (11). Measles, a highly contagious vaccine-preventable illness, remains the single leading cause of blindness amongst children in low income countries (12). In addition to conjunctivitis, it can cause corneal epithelial keratitis, corneal ulceration, blindness and death in young children.

Bacterial conjunctivitis

Bacterial conjunctivitis can occur in adults and in children through poor hygiene, ocular disease or recent ocular surgery (13). Signs and symptoms include red eye, irritation, tearing, discomfort, light sensitivity, the eyelids being stuck together - particularly on waking, with crusting of the eyelids and purulent or mucopurulent discharge. Most cases resolve within 5 to 10 days. The most common organisms that cause bacterial conjunctivitis include: *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Moraxella catarrhalis*, Enterobacterales, *Pseudomonas aeruginosa*, *Neisseria gonorrhoeae* and *Chlamydia trachomatis* (14).

In adults, chlamydial conjunctivitis (also known as inclusion conjunctivitis) is a sexually transmitted disease and commonly occurs in young adults. Chlamydial inclusion conjunctivitis is caused by *Chlamydia trachomatis.* Transmission occurs through hand-to-eye spread of infected genital secretions (15). In very rare cases (for example with use of corticosteroid eye drops) fungal infection may occur.

Ophthalmia neonatorum (ON) also called neonatal conjunctivitis, is an acute, mucopurulent infection occurring in the first 4 weeks of life. It is due to blocked lacrimal duct but may also be caused by bacterial and viral pathogens (16). ON is an acute emergency and requires immediate treatment and referral because of the significant risk of corneal perforation and intraocular infection that can very quickly lead to blindness (17). Most affected neonates have profuse purulent conjunctivitis and oedema of the eyelid, but some may have only a mild inflammatory response (16).

The two major causes of infective neonatal conjunctivitis are *C. trachomatis* and *N. gonorrhoea*, usually transmitted via the maternal genital tract during childbirth. Gonococcal conjunctivitis presents early, often within the first 24 hours of delivery until up to 5 days post-birth. Presentation in the second week suggests postnatal exposure. *C. trachomatis* presents from 5 days to 2 weeks post-birth. Some cases can be as late as 60 days (16).

Allergic (non-infectious) conjunctivitis

Allergic conjunctivitis occurs when the body's immune system attacks allergens, such as pollen. Other causes include foreign bodies such as eye cosmetics that cause inflammation. Most cases of allergic conjunctivitis are seasonal and typically occur in spring and summer causing the eyes to become very itchy (18).

4.2 Dacryoadenitis

Dacryoadenitis is caused by inflammation of the lacrimal gland which results from bacterial or viral infections. In rare cases dacryoadenitis can result from fungal and parasitic infections. Symptoms of dacryoadenitis include pain with eye movements, droopy upper eyelid or difficulty opening the affected eye, redness of the eye, and occasionally double vision (3). The most common viral infection cause is Epstein Barr virus (EBV). Other viruses such as adenovirus, VZV, HSV, rhinovirus, cytomegalovirus (CMV) or mumps are less common. Bacterial causes include *Staphylococcus aureus* and *Streptococcus* species (3).

4.3 Blepharitis

Blepharitis can be an acute or chronic inflammatory process affecting the margin of the eyelids associated with congestion of meibomian glands. It most commonly occurs in middle-aged patients but can occur at any age causing burning, itching, hyperaemia, foreign body sensation, burning and crusted eyelashes affecting both eyes (19). It is estimated that blepharitis causes 5% of all eye problems reported to general practitioners in the UK (20). Organisms which may be implicated include Staphylococcus species, Streptococcus species including S. pneumoniae and S. pyogenes, Moraxella catarrhalis, Corynebacterium species and Cutibacterium acnes. Fungi such as Malassezia species, Trichophyton species, Cryptococcus and Blastomyces can also, rarely cause chronic blepharitis.

4.4 Canaliculitis

Canaliculitis is a rare condition causing chronic inflammation of the canaliculus, a short channel near the inner corner of the eyelid through which tears drain into the tear sac. Infection is most often caused by a bacterial pathogen but can also be caused by a viral or fungal infection. Patients present with epiphora, mucopurulent discharge, eyelid erythema and recurrent conjunctivitis. Primary infection is due to coagulase negative staphylococci, streptococci, *C. acnes*, and *Actinomyces* species. Chronic infections may be due to anaerobic actinomycetes such as *Actinomyces israelii* or by *Cutibacterium propionicum* (21).

4.5 Cellulitis

Preseptal cellulitis

Preseptal cellulitis or periorbital cellulitis is infection of the skin and soft tissue around the eye, anterior to the orbital septum. This condition most commonly occurs in children and may be a result of trauma or contiguous sinusitis. Patients present with unilateral eyelid swelling and oedema. Preseptal cellulitis is commonly caused by bacterial organisms and in rare cases can be viral (22). Most cases resolve after 5 to 7 days of therapy but can progress to orbital cellulitis without appropriate treatment (23). Causative organisms include *H. influenzae, Staphylococcus aureus* and *Streptococcus* species (14).

Orbital cellulitis

Orbital cellulitis is a severe condition that requires urgent medical attention. It affects the orbital tissue and is usually due to underlying bacterial sinusitis. Complications can result in sub-periosteal abscess formation, cavernous sinus thrombosis, intracranial abscess formation, loss of vision and death. Rhino-orbital cellulitis can present similarly to an orbital cellulitis although it has a different pathology (24). The most common pathogens in adults are *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Streptococcus* species and anaerobes.

4.6 Microbial Keratitis

Microbial keratitis is an infection of the cornea that can cause blindness or visual impairment

and may progress to endophthalmitis if not appropriately treated. It may be caused by a range of bacteria, viruses, fungi and parasites. Predisposing factors include contact lens use, pre-existing ocular disease including, ocular trauma, ocular surgery, laser refractive surgery, cataract surgery, corneal transplants, laser-assisted in situ keratomileusis (LASIK), diabetes, immunosuppressive disease and the use of topical steroids (25,26). Gardeners and farmers can also be at risk from trauma to the cornea.

In the first week after laser refractive surgery (early onset), patients typically present with an infection caused by staphylococci or streptococci. In following weeks (late-onset), cases are usually caused by slow-growing organisms like *Mycobacterium* and *Nocardia* species and fungi (27).

Bacterial keratitis

Bacterial keratitis usually presents with corneal ulceration, corneal abscess formation and inflammation of the anterior chamber sometimes manifesting as an hypopyon. Symptoms include severe pain, photophobia and blurred vision. The presence of a red eye in a contact lens user is a warning sign of bacterial or acanthamoeba keratitis (25). Microorganisms include *Staphylococcus* species, *Streptococcus* species, *P. aeruginosa*, Enterobacterales, *Corynebacterium* species (28), *M. catarrhalis*, *H. influenzae*, *N. gonorrhoeae* and *C. acnes.*

Viral keratitis

Herpesvirus keratitis is spread through direct contact (by touching an infected part of the body then touching the eyes) or is an acute reactivation of chronic viral latency. The predominant strain responsible for herpesvirus ocular disease is herpes simplex virus (HSV) type 1 (29). VZV keratitis can also occur associated with ophthalmic shingles (30). Most cases of ocular HSV are recurrent and present classically with unilateral corneal ulceration, often with a dendritic pattern, although the lid and conjunctiva may be involved. The recurrent attacks lead to corneal scarring, decreased corneal sensation and visual loss. The global incidence of HSV keratitis was calculated at approximately 1.5 million with 40 000 new cases of severe monocular visual impairment or blindness per year (25).

Other viral etiologies of keratitis include adenovirus and enteroviruses including Coxsackievirus, often as a complication following conjunctivitis. Worldwide, measles is an important cause of keratitis; whilst most cases are mild, severe cases may lead to corneal ulceration, carrying a risk of scarring and visual loss, with measles being a leading global cause of childhood blindness. Corneal scarring and risk of visual loss are also well described complications of Orthopox virus infections, including Mpox (Monkeypox virus) and cowpox virus.

Acanthamoeba keratitis

Acanthamoeba keratitis is a serious condition associated with poor contact lens hygiene and after ocular trauma (31-33). *Acanthamoeba* keratitis has also been linked to exposure to contaminated water, especially in contact lens users and in individuals who use hot tubs or swimming pools (31). It may be confused with herpesvirus keratitis. All patients with

contact lens associated microbial keratitis require investigation for *Acanthamoeba* keratitis.

Fungal Keratitis

Fungal Keratitis is also known as ‘mycotic keratitis’ or ‘keratomycosis’. It is an infection of the cornea caused by any of the multiple fungi capable of invading the ocular surface (34). Non-specific signs and symptoms include redness, pain, photophobia, impaired vision. Clinical features such as non-yellow infiltrates with feathery edges or raised surface, intact epithelium with deep stromal involvement, satellite lesions, endothelial plaques, lack of improvement with antimicrobials and worsening with steroids are suggestive of fungal keratitis. There are two types: Keratitis caused by yeast like infections and filamentous keratitis.

Keratitis caused by yeast like infections, in particular *Candida sp*ecies usually occurs in patients with chronic ocular surface disease, defective eyelid closure, diabetes, immunosuppression or contaminated contact lenses (35).

Filamentous fungal keratitis usually occurs in agricultural or outdoor workers where there is a risk of accidental eye injury. The risk factors in suspected fungal keratitis are ocular trauma, previous ocular surgery, topical or systemic corticosteroid use, evidence of ocular surface disease and contact lens use. Species of *Fusarium, Aspergillus*, *Curvularia* and other phaeohyphomycetes, *Scedosporium apiospermum*, *Paecilomyces,* ascomycetous yeasts, Dermatophytes*, Cladosporium*, *Curvularia*, and *Mucorales* are the principal causes of filamentous fungal keratitis (26,35).

4.7 Retinitis

Retinitis is inflammation of the retina which can be caused by infection and is vision threatening. Viral retinitis is rare and is usually seen in individuals with a weakened immune system. The most common viruses causing retinitis are HSV, VZV and CMV (36). HSV and VZV retinitis can occur in immunocompetent people. *Treponema pallidum* causes bacterial retinitis. Other organisms associated with retinitis include *Mycobacterium* species, *Toxocara* species, *Toxoplasma gondii*, *Bartonella, Aspergillus species*, ascomycetous yeasts and *Blastomyces* species (37). Toxoplasmosis results from infection with the parasite *Toxoplasma gondii* and is a globally common latent infection which can cause recrudescence of focal intense retinitis.

4.8 Endophthalmitis

Endophthalmitis is a relatively uncommon but potentially sight threatening infection of intraocular fluids and tissue, requiring prompt treatment. Endophthalmitis can be infectious or non-infectious, but most cases are due to infection (26).

Infectious endophthalmitis can develop as a result of haematogenous spread of organisms from an endogenous source or from an exogenous source following trauma, surgery or intraocular injection. Causative organisms include *Staphylococcus* species*, Streptococcus* species, *C. acnes, Aspergillus* species, *Fusarium* species, *Candida* and associated ascomycetous yeasts, dematiaceous fungi and

Scedosporium apiospermum (38).

Post-traumatic endophthalmitis

Post-traumatic endophthalmitis occurs after penetrating or perforating ocular injuries. Risks include metal or blunt trauma injuries, retained intra-ocular foreign bodies, disruption of the lens, and delay in primary repair of greater than 24 hour (39). Poorly treated fungal keratitis can also lead to fungal endophthalmitis. Organisms include *Staphylococcus* species, *Bacillus cereus, Streptococcus* species, *Clostridium perfringens, Microsporidium* species, *Fusarium* species, *Candida* and associated ascomycetous yeasts, *Aspergillus* species, *Acremonium* and *Paecilomyces* species.

Acute post-operative endophthalmitis

Acute post-operative endophthalmitis occurs within 1 to 7 days of intraocular surgery (40), presenting with increasing pain, red eye, ocular discharge and reducing vision. The source of infection is usually the patient's own ocular or eyelid surface flora making diagnosis by culture difficult, although virtually any organism may be introduced and can cause infection. To address these issues molecular testing can now be used to diagnose infection and can help to clarify the causative organisms. Bacterial organisms are more common and include Enterobacterales, *Staphylococcus* species, *Streptococcus* species, *P. aeruginosa and C. acnes*. Fungal postoperative endophthalmitis is less common and usually has a late onset of 1 to 2 months after surgery but in tropical countries it may present acutely within 4 weeks of surgery (41). Organisms include *Aspergillus* species and Ascomycetous yeasts.

Chronic postoperative endophthalmitis

Chronic postoperative endophthalmitis occurs months to years after intraocular surgery. Patients typically present with a persistent low grade uveitis or they may present the same way as acute endophthalmitis which progresses to chronic endophthalmitis. Organisms include *C. acnes, Staphylococcus* species, *Corynebacterium* species, *Mycobacterium* species, *P. aeruginosa, Aspergillus* species, Ascomycetous yeasts and *Fusarium* species (42).

Glaucoma filtering-bleb-associated endophthalmitis

Glaucoma filtering-bleb is a surgically created scleral defect, covered with conjunctiva and tenons, that allows excess aqueous humour to be absorbed into the systemic circulation. The conjunctiva separates the ocular surface flora from the aqueous humour in the bleb. If there is a breakdown of the overlying conjunctiva then endophthalmitis may occur (43). It can occur within weeks or years after the original surgery and is more likely if surgery is augmented with fibroblast inhibitors such as mitomycin-c. Endophthalmitis may also occur with pars plana vitrectomy, penetrating keratoplasty and glaucoma drainage implants. Organisms include Enterobacterales, *Staphylococcus* species, *Streptococcus* species, *P. aeruginosa* and *C. acnes.* In addition to these organisms, *H. influenzae* and *M. catarrhalis* may also be cause glaucoma filtering-bleb (39,43).

Endogenous endophthalmitis

Endogenous endophthalmitis is rare and occurs in patients with bacteremia or fungaemia, associated with immunosuppression, intravenous drug abuse, infective endocarditis, infected indwelling intravenous lines or contamination during surgical procedures, leading to exogenous infection. The patient is often debilitated with acute or chronic systemic medical problems. Intravenous drug users who use lemon juice to dissolve heroin are at risk of fungal endophthalmitis. Patient presentation ranges from asymptomatic to symptoms typical of severe uveitis, including a red, painful eye with photophobia, floaters or reduced vision (44). The patient may be unconscious in the intensive care unit (ICU) and unaware of symptoms until waking. Organisms include *Bacillus cereus*, Enterobacterales, *Staphylococcus* species, *Streptococcus* species, *Candida* and associated ascomycetous yeasts, *Aspergillus*, *Cryptococcus* and *Paecilomyces* species.

4.9 Uveitis

Uveitis is the inflammation of the uveal tract (iris, ciliary body and choroid) and retina. It is an uncommon eye condition which can result in visual impairment. Uveitis can be caused by autoinflammation, autoimmunity, infections, tumours, or trauma. Symptoms of uveitis include aching pain, red eye, watering photophobia, blurred vision, distorted vision, flashes and floaters (45). In low-income countries, it is estimated that uveitis accounts for 25% of blindness, and 5 to 10% of visual impairment cases worldwide. Infectious causes of uveitis include: HSV, VZV, CMV, HIV, toxoplasmosis, tuberculosis, syphilis and rarely Borrelia (Lyme disease) (46,47).

Uveitis can be classified as (48):

- Anterior uveitis which is the most common uveitis occurring at the front of the eye. Infective causes include HSV, VZV, CMV, tuberculosis and syphilis
- Intermediate uveitis manifests as vitritis. A purely intermediate uveitis is rarely infectious but may be a reactive uveitis in response to tuberculosis (TB) infection elsewhere in the body
- Posterior uveitis occurs at the back of the eye and can be caused by toxoplasmosis, *Treponema pallidum*, TB, CMV, HSV, VZV, *Bartonella* and Lyme disease
- Panuveitis is when all parts of the eye are affected by inflammation which can occur in TB, endogenous endophthalmitis and toxoplasmosis (49)

Rates of toxoplasmosis infection are highest in tropical areas (50). Ocular toxoplasmosis is usually unilateral and can cause significant inflammation and subsequent scarring. This may cause temporary or permanent impairment of vision. Ocular toxoplasmosis is usually acquired but can be congenital (transmitted from mother to child during pregnancy from a new primary infection). Infection is through ingestion of undercooked, home-cured or raw meat, contaminated water, or transmission from contaminated soil on hands (51). Ocular toxoplasmosis is due to a rupture of tissue cysts which can occur months or years after the primary infection. Infection is life-long and asymptomatic in most people; however, those with immunosuppression are at risk of cerebral toxoplasmosis and severe bilateral ocular

toxoplasmosis.

Travel associated infections

Ocular infections associated with travel, including travel overseas, may arise from exposure to more unusual pathogens and/or external or environmental factors which, increase the risk of infection. Examples include high temperatures, humidity, sleeping with contact lenses, ocular trauma from vegetation, swimming or bathing in contaminated water or consuming contaminated food. This can increase risk of conjunctivitis, keratitis and uveitis. In some countries where there are less resources available, healthcare may not be easily accessible (52). Infections with some pathogens such as toxoplasmosis, HIV or TB may not cause eye disease until years after the exposure.

Travel history should be explored with patients and pathogens relevant to the location, presenting features and exposure risk considered. Some pathogens have high prevalence in hot climate areas such as Africa. The clinically important infections associated with overseas travel include onchocerciasis, loiasis and dirofilariasis.

Onchocerciasis is also known as ‘African river blindness’. This filarial infection is caused by onchocerca volvulus, transmitted by black fly in tropical climates. It migrates from the skin into the conjunctiva, cornea and anterior chamber of the eye leading to keratitis and uveitis (52) (53).

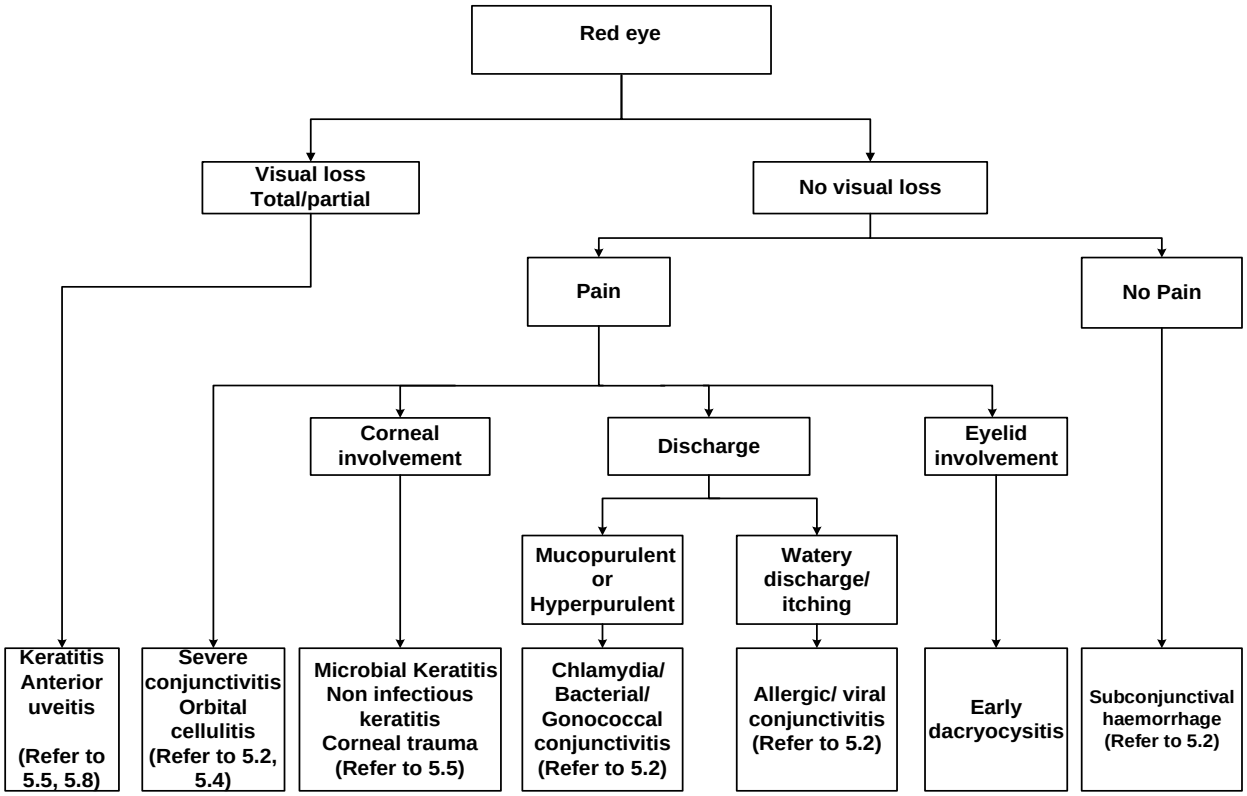
Loiasis (Loa loa) affects millions across West and Central Africa, often causing asymptomatic infection. However, the dramatic migration of an adult worm across the subconjunctiva can lead to conjunctivitis, pain on eye movement and transient visual loss. Adult worms have also been found in other eye compartments including eyelid, anterior chamber and vitreous (54).

Dirofilariasis (also known as dog heartworm) is found worldwide, but in some areas up to half of the canine population may be affected. Human ocular disease is caused by migration of larvae through the periorbital or palpebral tissues, but less commonly through the intraocular structures. Symptoms are dependent on the area affected (55).

5 Clinical presentations of red and painful eye

5.1 Presentation of red or painful eye

Red or painful eye is a common ophthalmic presentation in primary care. Below is an overarching algorithm of this syndrome (2) with further testing shown in algorithms 5.2 to 5.8.



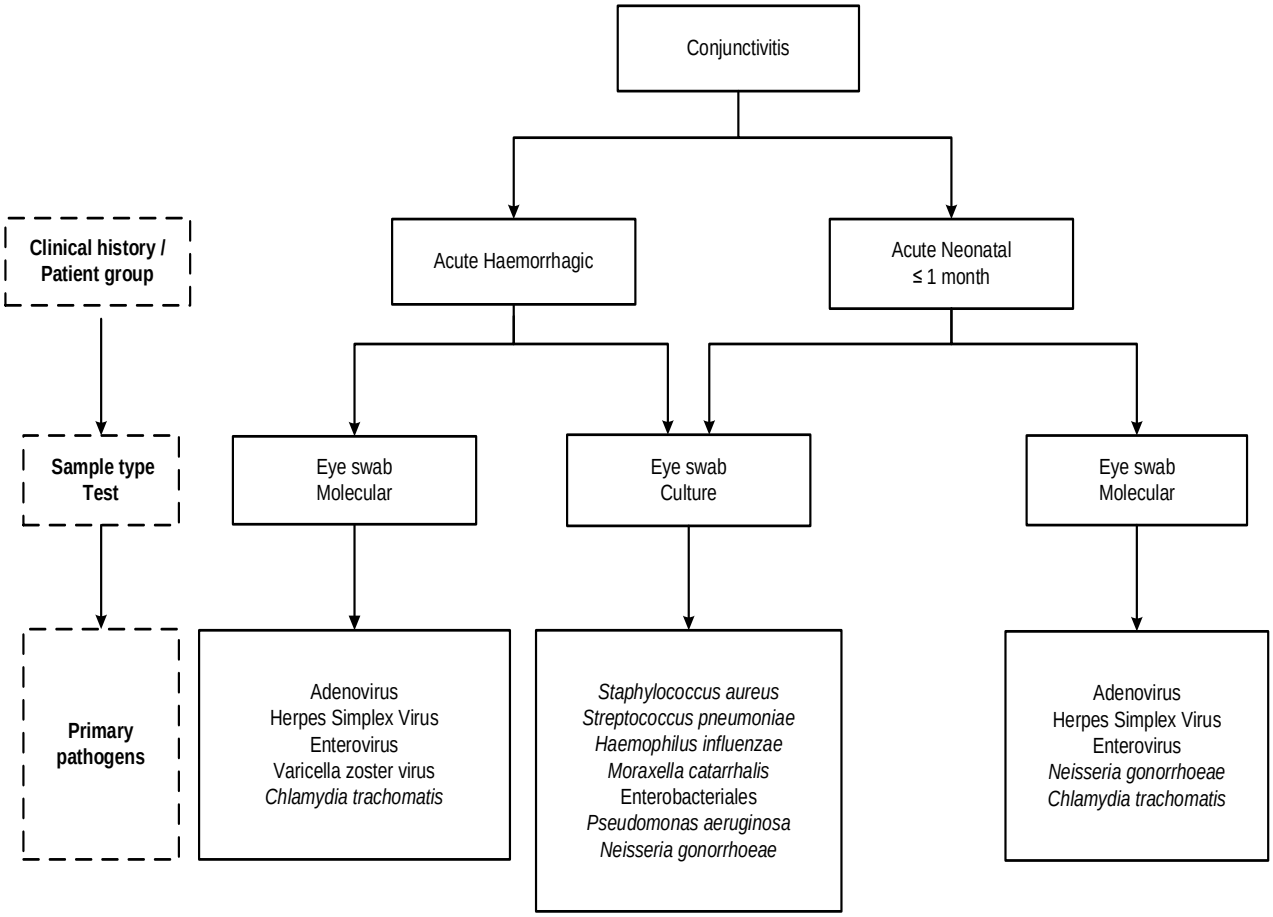
Notes

- Patients with infectious keratitis, anterior uveitis, orbital cellulitis and gonococcal conjunctivitis usually require urgent referral to ophthalmology.
- Patients with severe conjunctivitis, corneal trauma may require referral.
- Patients with non-infectious keratitis, early dacryocystitis, chlamydia, bacterial, allergic or viral conjunctivitis and subconjunctival haemorrhage can be managed in primary care settings (2).
- Patients with endophthalmitis can present with red eye, blurred or visual loss or eye pain after surgery and require emergency referral to ophthalmology (56)

Red or painful eye

5.2 Conjunctivitis

In some cases of uncomplicated conjunctivitis, diagnostic samples are required prior to empirical treatment. Conjunctival swabs should be collected from the following groups: neonatal sticky eye, failure to respond to first-line antibiotics, in sexually active patients suspected of chlamydia, severe disease and in immunocompromised patients.



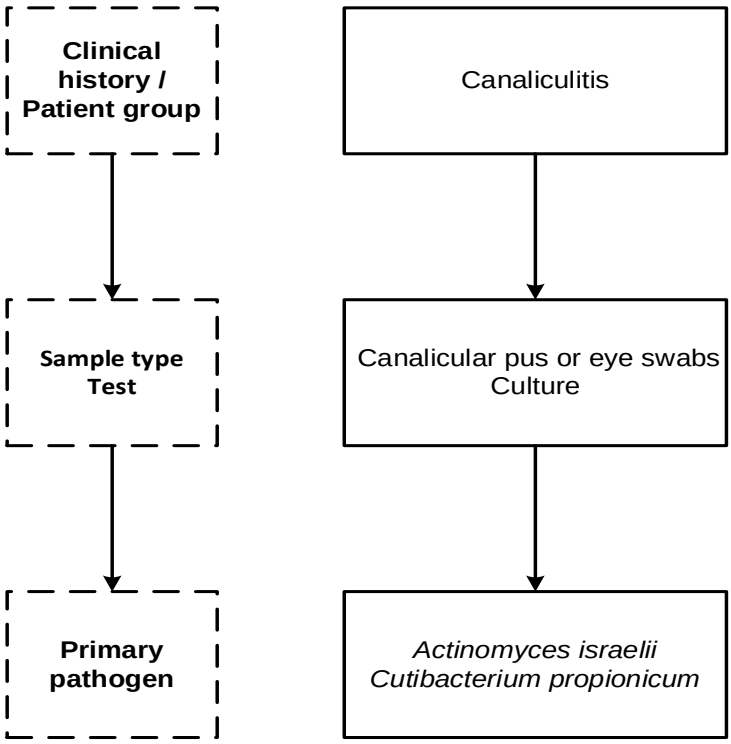
Notes

- Culture or molecular swab maybe required depending on circumstances.
- Haemorrhagic conjunctivitis-enterovirus 70 and coxsackievirus A24 (7).
- Adenovirus 8, 19-associated with keratoconjunctivitis. Notify laboratory if an outbreak is suspected.
- Suspected neonatal HSV should trigger urgent paediatric referral. If *C. trachomatis* or *N. gonorrhoeae* detected, mother and her sexual contacts should be offered testing and the baby will require paediatric referral due to risk of severe local or systemic infection.
- Consider BASHH guidelines on NAAT for non-genital samples.

Please refer to the relevant UK SMI for additional information.

5.3 Canaliculitis

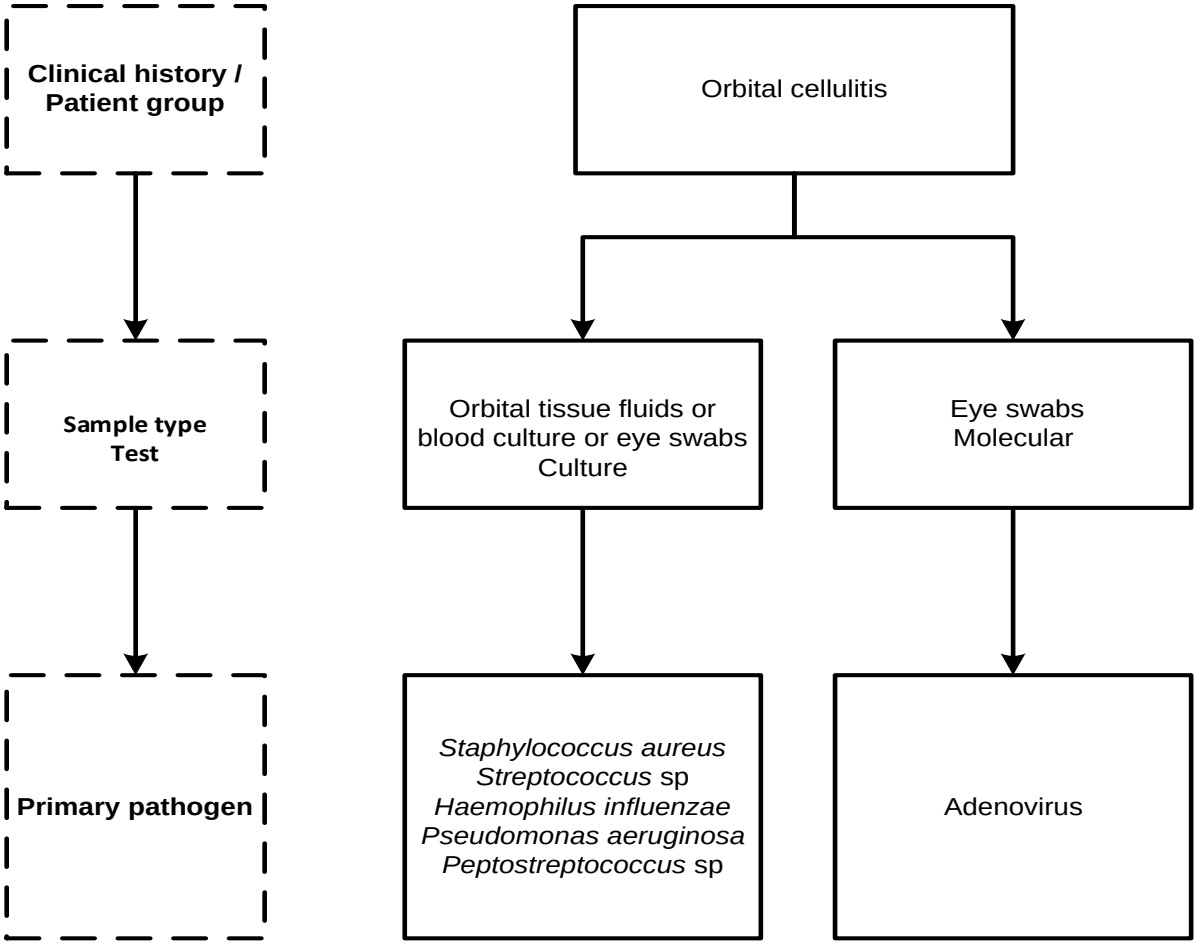
Canalicular pus is preferable to eye swabs for canaliculitis.



Please refer to the relevant UK SMI for additional information

5.4 Orbital Cellulitis

Preseptal cellulitis is commonly caused by bacterial organisms and in rare cases can be viral. Eye swabs and aspirates from the affected orbital tissues should be sampled.

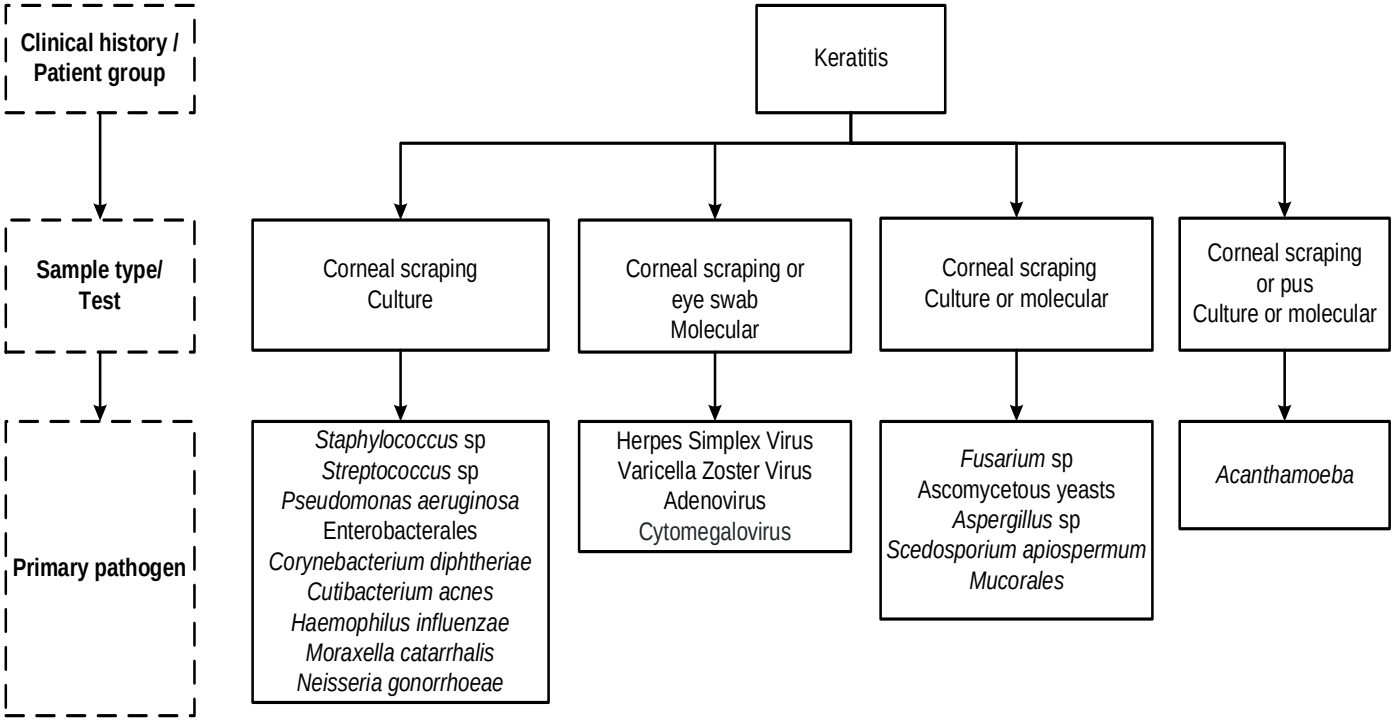


Please refer to the relevant UK SMI for additional information

5.5 Microbial Keratitis

Samples from the corneal ulcer should be collected either by scraping with a sharp instrument such as a needle or blade or using a corneal impression membrane (57-59). Occasionally corneal biopsy or anterior chamber aspirate may also be needed. Microbial keratitis may progress to endophthalmitis if inappropriately treated. *Acanthamoeba* investigation is carried out by a specialist or referral laboratory.

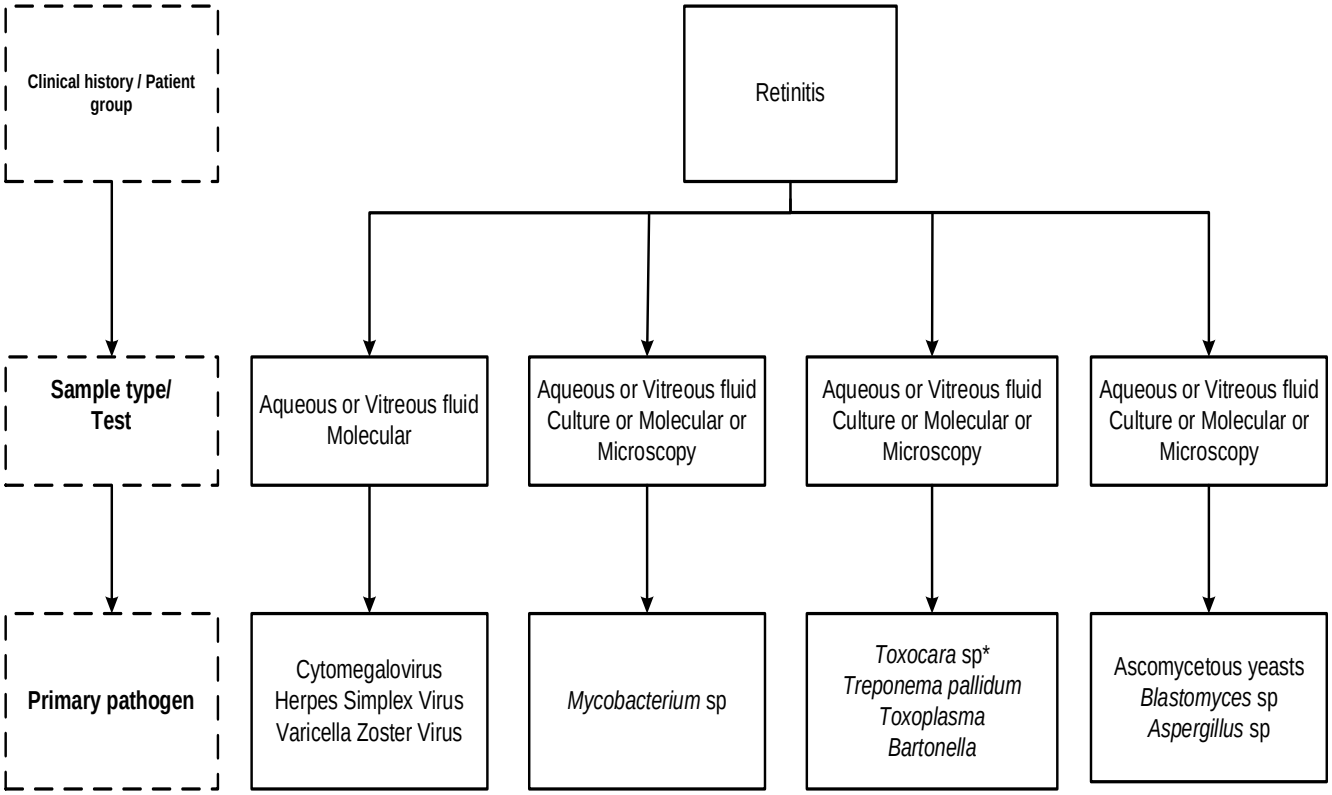
Microscopy is an essential investigation for fungal keratitis. Species identification is critical to treatment, as antifungal susceptibility profiles will vary.



Please refer to the relevant UK SMI for additional information

5.6 Retinitis

Molecular testing of aqueous or vitreous fluid samples are primarily used for the investigation of retinitis.



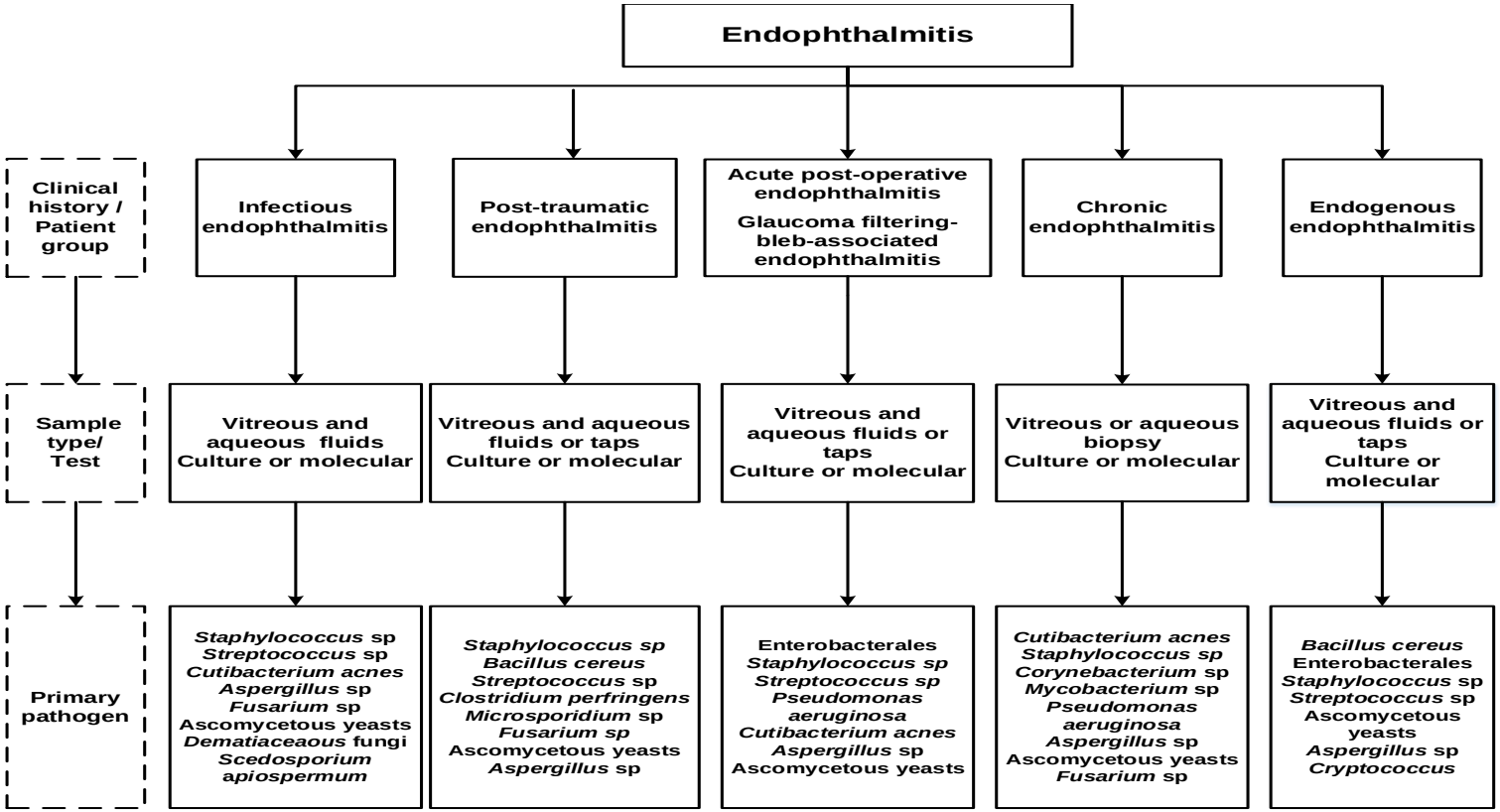
Notes

- *If there is no specimen available from the eye, send a blood specimen for serology testing of Toxocara species if clinical suspicion is high.
- Negative serology for anti Toxocara antibodies in peripheral blood samples cannot exclude ocular Toxocariasis. Testing of vitreous fluid for anti-Toxocara antibodies may be considered if clinical suspicion is high.
- Serology should be performed for Toxoplasma and *Treponema pallidum* organisms. If the results are negative, molecular testing is not required. Serology is a useful adjunct to molecular testing but should not delay treatment in suspected cases.
- In ocular toxoplasmosis, negative serology results are very rare and therefore useful in helping to exclude the disease

Please refer to the relevant UK SMI for additional information

5.7 Endophthalmitis

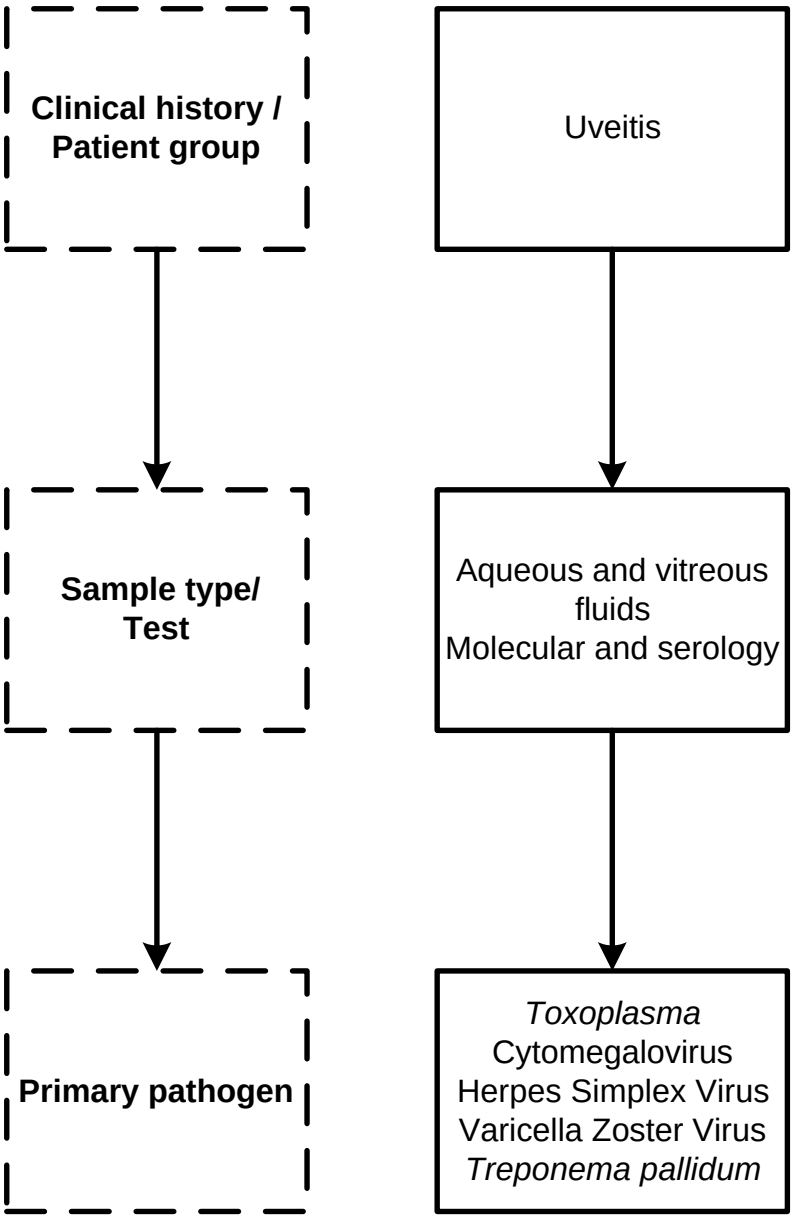
Specimens include intraocular fluids aqueous humour from the anterior chamber and vitreous humour from the vitreous cavity/body. Eye swabs may also be taken for visible pus. For Endogenous Endophthalmitis blood cultures are required.



Please refer to the relevant UK SMI for additional information

5.8 Uveitis

Most cases of uveitis are diagnosed by clinical features, multimodal ocular imaging and ancillary serological tests. If infection is suspected aqueous and vitreous humour fluids can be sampled for molecular and serology testing.



Please refer to the relevant UK SMI for additional information

6 Pre laboratory processes (pre analytical stage)

6.1 Specimen type

Specimen types include:

- Aspirates and tissue for
    - bacterial and fungal culture. These samples may also be processed in blood culture bottles where appropriate (see UK SMI B 26 - Investigation of fluids from normally sterile sites)
    - molecular testing for viruses (PCR), bacteria (16S sequencing) and fungi (pan fungal) and toxoplasmosis as appropriate
- Swabs and scrapings for
    - bacterial and fungal culture
    - microscopy for parasites
    - molecular testing for viruses and parasites (PCR), bacteria (16S sequencing) and fungi (pan fungal) as appropriate
- Blood for
    - blood culture when suspecting disseminated infection (UK SMI S 12 Sepsis and systemic or disseminated infections) and in cases of endogenous endophthalmitis
    - molecular testing for viruses (PCR), bacteria (16S sequencing) and fungi (pan fungal) as appropriate
- Serum for
    - fungal biomarker tests (beta-D-glucan and Aspergillus galactomannan) when suspecting disseminated infection (UK SMI S 12 Sepsis and systemic or disseminated infections). Please note that to avoid false positive results, the BDG test should be taken into a separate tube and only processed at the laboratory performing the test in BDG free environment and equipment. Also, please note that *Aspergillus* galactomannan ELISA testing has poor sensitivity in a non-neutropenic patient setting.
    - infectious diseases serology
- Contact lens cleansing and storage fluid

Note:
On occasions laboratories may wish to test environmental specimens, but this is outside the scope of this document. These environmental specimens may include contact lens cases and cleaning fluids such as contact lens solution, irrigation solution and dye used during eye surgery or corticosteroids injected directly into the eye. Generally, these are tested by culture methods for detection of bacteria, fungi and parasites. Smears are not

recommended.

Gram negative organisms can be isolated from contact lens disinfecting solutions. For example, *P. aeruginosa* and *Serratia marcescens* have been reported to be commonly resistant to contact lens disinfecting solutions (60).

Superficial swabs, although not ideal, may be all that is available. Deep-seated samples such as tissue or aspirates, if available, should be sought as they are superior to swabs depending on clinical syndrome.

6.2 Specimen collection and handling

Collect specimens as soon as possible after onset of symptoms. Specimens should be transported and processed as soon as possible.

Refer to current guidance on the safe handling of all organisms documented in the UK SMI general safety document.

Collect specimens before antimicrobial therapy where possible. If the patient is already on antimicrobial treatment, please provide the details of this to the laboratory. Swabs for bacterial and fungal culture should be placed in the appropriate transport medium (61-63).

When collecting samples using swabs, a conjunctival swab should be taken for culture or molecular testing.

Laboratories should agree a protocol for the collection of specimens, inoculation of media, transport to the laboratory with their local ophthalmologists, and supply kits for this purpose when required.

Corneal samples and intraocular fluids for keratitis are collected by an ophthalmic surgeon. Due to small amounts of material involved, inoculation of transport media for molecular testing, culture plates and preparation of slides may need to be done at the patients' bedside or in clinic. Samples are also collected in brain heart infusion broth and plated in the laboratory (64).

A corneal scrape specimen and confocal microscopy is used for the detection of *Acanthamoeba* keratitis (65). Several molecular based techniques are well established and usually increase sensitivity significantly and are becoming the tool of choice for diagnosis (66).

Sample collection requires anesthetic eye drops, needle, corneal impression membranes (one for culture and the other for molecular tests), cotton or dacron swab, surgical blade, spatula, glass slide and cover slips. Liquid or solid culture media is required.

Separate samples must be collected into appropriate transport media for detection of viruses or chlamydia. Refer to UK SMI V 37: Chlamydia and Gonorrhoea infection: testing by NAATs.

6.3 Specimen transport and storage

This section covers specimen transport and storage consideration related to this UK SMI, and should be read in conjunction with the scientific information.

Bacterial cultures should be submitted in a bacteriological transport media which supports the recovery of the common pathogens identified in this UK SMI including *N. gonorrhoeae.*

Specimens should be transported and processed as soon as possible (51). If processing is delayed, the specimens should be refrigerated (67).

Speed of delivery of specimens to the laboratory is paramount in certain specimens such as postoperative specimens.

If specimens for fungal molecular testing cannot be performed on the same day, they should be frozen and defrosted only on the day of testing.

If specimens for investigation for amoebae cannot be processed immediately, it is preferable to store them at ambient temperature for up to 48 hours. Refer to the UK SMI B 31: Investigation of specimens other than blood for parasites for more information.

6.4 Relevant clinical history details needed on patient request forms when referring samples to the laboratory

Full clinical details and information on patient history should be provided with clinical requests.

These details should include:

- specimen date and time of collection
- where the sample has been taken from, such as the left or right eye
- type of infection suspected
- type of swab/sample sent to the laboratory
- immune status
- trauma
- other relevant information (contact lens wearer, water exposure)

6.5 Safety considerations

The section covers specific safety considerations (61,63,68-86) related to this UK SMI, and should be read in conjunction with the general safety considerations.

All Hazard group 2 organisms must be confirmed at Containment Level 2.

All work on suspected *N. meningitidis* which is likely to generate aerosols must be performed in a microbiological safety cabinet.

If infection with a Hazard group 3 organism, for example *Mycobacterium tuberculosis*, or an agent of endemic mycosis, is suspected, all work must be undertaken in a microbiological safety cabinet under full Containment Level 3 conditions.

7 Laboratory processes (analytical stage)

7.1 Microscopy

Many laboratories utilise molecular methods for the detection of organisms. However, microscopy is still useful in primary identification. Refer to UK SMI TP 39 – Staining procedures.

For safety considerations refer to Section 2.

7.1.1 Sample preparation for eye swabs

Perform a Gram stain on all eye swabs including those from neonates with sticky eyes and canalicular pus. Prepare a thin smear from the swab or pus on a clean microscope slide for Gram staining**.**

7.1.2 Sample preparation for corneal scraping for parasites and fungi

Corneal scrapings and eye fluid or tissue require lactophenol cotton blue stain or potassium hydroxide -Calcofluor wet mount preparation is optimal for visualisation of fungal elements.

Prepare the specimen on a clean slide and then add the stain to slide. Make a thin mount and then examine the prepared slide under low power (×100).

Note:

1. In KOH wet mount*, Acanthamoeba* cysts appear typically as star or hexagonal shaped and double celled wall structures.

2. Fungal species stained with lactophenol stain appear as fungal hyphae or yeast cells (35). Both microscopy and culture should be done whenever possible, as microscopy cannot differentiate between genera and species of fungi (79).

3. Other alternative special stains that could be used include Periodic Acid Schiff reaction (PAS), Giemsa, Ziehl-Neelsen or Gomori methenamine silver stains, when indicated (35).

Other stains include acid fast (detection of mycobacteria and *Nocardia*) and acridine orange (fluorescent stain that interacts with microbial DNA and RNA).

Supplementary

For microscopy of *Mycobacterium* species, refer to
UK SMI B 40: Investigation of specimens for Mycobacterium species.

7.2 Molecular testing

When performing molecular testing, knowledge of the detection range, sensitivity and specificity to a specific assay is required. Any potential pathogens that have been missed or require additional testing should be identified.

Molecular assays for the detection of pathogens directly from ocular samples are now

widely available. Some multiplex molecular testing may give results for organisms not requested. Under these circumstances' laboratories should follow local procedures.

Please refer to UK SMI Q 4: Good practice when performing molecular amplification assays.

7.3 Culture

For safety considerations refer to Section 2 and for culture conditions refer to section 7.4.
For sample preparation of contact lens solution, refer to appendix A.
Culture of Acanthamoeba requires a lawn of *E. coli* or of certain other coliforms on nutrient agar for growth. Refer to appendix A for sample preparation of *Acanthamoeba* species.

Supplementary

For *Mycobacterium* species, refer to UK SMI B 40: Investigation of specimens for Mycobacterium species .

7.4 Culture media, conditions and organisms

Table 1: Culture media, conditions and organisms

Clinical details/ conditions	Specimen type	Standard media	Incubation			Cultures read	Target organism (s)
			Temperature °C	Atmosphere	Time		
Conjunctivitis	Eye swab Culture	Chocolate agar	35 to 37	5 to 10% CO2	40 to 48 hour	Daily	*Staphylococcus aureus* *Streptococcus pneumoniae*
		Blood agar	35 to 37	5 to 10% CO2	40 to 48 hour	Daily	*Haemophilus influenzae* *Moraxella catarrhalis*
							Enterobacteriales
							Pseudomonas aeruginosa
	Eye swab Molecular						Adenovirus Herpes Simplex Virus Enterovirus Varicella Zoster Virus *Chlamydia trachomatis*
Conjunctivitis Neonates	Eye swab Culture or Molecular	GC selective agar	35 to 37	5 to 10% CO2	40 to 48 hour	Greater than or equal to 40 hour	*Neisseria gonorrhoeae*
Blepharitis	Eye swab Culture or molecular	Chocolate agar Blood agar Fastidious anaerobe agar	35 to 37 35 to 37 35 to 37	5 to 10% CO2 5 to 10% CO2 Anaerobic	40 to 48 hour 40 to 48 hour 5 day	Daily Daily	*Staphylococcus* species *Streptococcus* species *Moraxella catarrhalis* *Corynebacterium* species *Cutibacterium acnes* including other anaerobes

		Sabouraud agar (supplement with olive oil for *Malassezia* species)	28 to 30	Air	5 day	Greater than or equal to 40 hour	*Malassezia* species *Trichophyton* species
Canaliculitis	Canalicular pus, eye swab Culture	Fastidious anaerobe agar	35 to 37	Anaerobic	40 to 48h 7 day and 10 day	Greater than or equal to 40 hour	*Actinomyces israelii* *Cutibacterium propionicum*
Orbital cellulitis	Orbital tissue fluids, blood cultures, eye swabs	Blood agar Chocolate agar Sabouraud agar Fastidious anaerobe agar	35 to 37 35 to 37 28 to 30 35 to 37	5 to 10% CO2 5 to 10% CO2 Air Anaerobic	40 to 48 hour 40 to 48 hour 14 day 40 to 48 hour*	Daily Daily Greater than or equal to 40 hour	*Staphylococcus aureus* *Streptococcus* species *Haemophilus influenzae* *Pseudomonas aeruginosa* *Peptostreptococcus* species
	Molecular						Adenovirus
Keratitis	Corneal scrapings and Corneal impression membrane Culture	Blood agar Chocolate agar	35 to 37 35 to 37	5 to 10% CO2 5 to 10% CO2	40 to 48 hour 40 to 48 hour	Daily Daily	*Staphylococcus* species *Streptococcus* species *Pseudomonas aeruginosa* Enterobacterales *Corynebacterium* species *Haemophilus influenzae* *Moraxella catarrhalis*

		GC selective agar	35 to 37	5 to 10% CO2	40 to 48hr	Greater than or equal to 40 hour	*Neisseria gonorrhoeae*
	Corneal scrapings Culture or Molecular	Fastidious anaerobe agar Sabouraud agar	35 to 37 28 to 30	Anaerobic Air	40 to 48hr* 14 day	Greater than or equal to 40 hour	*Cutibacterium acnes* *Fusarium* species Ascomycetous yeasts *Aspergillus* species
	Corneal scrapings, pus Culture or Molecular	Non- nutrient agar with *E.coli***	28 to 30	Air	10 day	24 hour and daily up to 7 day	*Acanthamoeba*
	Eye swab or corneal impression membrane Molecular						Herpes Simplex Virus Varicella Zoster Virus Adenovirus
Retinitis	Vitreous and aqueous humour fluid Microscopy and Culture	Blood agar Sabouraud agar	35 to 37 28 to 30	5 to 10% CO2 Air	40 to 48 hour 14 day	Daily Greater than or equal to 40 hour	*Mycobacterium* species Ascomycetous yeasts *Aspergillus* species

	Vitreous and aqueous humour fluid Molecular						Cytomegalovirus Herpes Simplex Virus Varicella Zoster Virus *Mycobacterium* species *Toxocara* species *Treponema pallidum* *Toxoplasma* Bartonella Ascomycetous yeasts *Blastomyces* species *Aspergillus* species
Endophthalmitis	Vitreous and aqueous humour fluids or taps or biopsy Culture or Molecular	Blood agar Chocolate agar Sabouraud agar Fastidious anaerobe agar	35 to 37 35 to 37 28 to 30 35 to 37	5 to 10% CO2 5 to 10% CO2 Air Anaerobic	40 to 48 hour 40 to 48 hour 14 days 40 to 48hr*	Daily Daily Greater than or equal to 40hr	*Staphylococcus species* *Bacillus cereus* *Streptococcus species* Enterobacterales *Pseudomonas aeruginosa* *Corynebacterium species* *Mycobacterium species* Ascomycetous yeasts *Aspergillus species* *Dematiaceaous fungi* *Scedosporium apiospermum* *Clostridium perfringens* *Cutibacterium acnes* *Fusarium species* *Microsporidium species*
Uveitis	Vitreous and aqueous fluids Molecular and serology						*Toxoplasma* Cytomegalovirus Herpes Simplex Virus Varicella Zoster Virus

*incubation may be extended to 10 to 14 days; in such cases plates should be read at greater than or equal to 48 hour and then daily until day 14.
***Klebsiella* species (*K. pneumoniae*) and *Enterobacter aerogenes* are acceptable alternatives to *E. coli.* Laboratories may wish to use other alternative organisms apart from those mentioned in this document. Laboratories should ensure that these have been validated prior to use.

Red or painful eye

7.5 Identification

Refer to individual UK SMIs for organism identification.

All clinically significant isolates should be identified to species level.

Note: Any organism considered to be a contaminant may not require identification to species level. Organisms may be identified further if clinically or epidemiologically indicated.

All work on suspected *N. meningitidis* and *Acanthamoeba* species and isolates which are likely to generate aerosols must be performed in a microbiological safety cabinet.

8 Post laboratory processes (post analytical stage)

8.1 Reporting microscopy

Report organism or fungal elements seen.
For fungal infection please refer to the British Society for Medical Mycology Best practice guidelines).

Refer to: Microscopy for *Mycobacterium* species UK SMI B 40: Investigation of specimens for *Mycobacterium* species and parasites UK SMI B 31: Investigation of specimens other than blood for parasites.

8.2 Reporting molecular results

Interpretation of the tests requires understanding of the normal flora of the conjunctiva and the eye lids.

Report bacterial, fungal, parasite or viral DNA/RNA as ‘detected’ (state the organism).
Report bacterial, fungal, parasite or viral DNA/RNA as ‘not detected’.

8.3 Reporting culture results

Positive results should be released immediately. Report clinically significant organisms isolated as growth detected. State the species level identified.

Growth not detected report as ‘Absence of growth’.

8.4 Reporting time

Interim or preliminary results should be issued on detection of clinically significant isolates as soon as growth is detected, unless specific alternative arrangements have been made with the requestors. Positive results for microscopy should be released immediately, following

local policy. Many preliminary results require specialist interpretation before they are released.

Final reports should follow as soon as possible.

Results are communicated in accordance with local policy.

9 Antimicrobial susceptibility testing

All isolates from deep/sterile sites should be tested for antimicrobial susceptibility. This should also be considered for superficial isolates.

Laboratories should test and interpret antimicrobial susceptibility using the criteria in The European Committee on Antimicrobial Susceptibility Testing (EUCAST) systemic and topical agents, refer to EUCAST guidelines for breakpoint information, where available.

Antimicrobial susceptibility test result reporting is guided by local epidemiology and stewardship guidelines.

10 Public health responsibilities of diagnostic laboratories

Diagnostic laboratories have public health responsibility as part of their duties. Amongst these are additional local testing, or referral to further characterise the organism as required, primarily for public health purposes e.g. routine cryptosporidium detection; serotyping or microbial subtyping; and a duty to refer appropriate specimens and isolates of public health importance to a reference laboratory.

Diagnostic laboratory outputs inform public health intervention, and surveillance data is required to develop policy and guidance forming an essential component of healthcare. It is recognised that additional testing and referral of samples may entail some costs that has to be borne by the laboratory but in certain jurisdictions these costs are covered centrally.

Diagnostic laboratories should be mindful of the impact of laboratory investigations on public health and consider requests from the reference laboratories for specimen referral or enhanced information.

11 Referral to Reference laboratories

For information on the tests offered, turnaround times, transport procedure and the other requirements of the reference laboratory see user manuals and request forms

Organisms with unusual or unexpected resistance, and whenever there is a laboratory, clinical problem or anomaly that requires elucidation, should be sent to the appropriate reference laboratory.

Adenoviruses can cause outbreaks and when one is suspected, samples should be sent to a specialist laboratory for further identification and confirmation.

Contact the appropriate reference laboratory for information on the tests available, turnaround times, transport procedure and any other requirements for sample submission:

- England
- Wales
- Scotland
- Northern Ireland

Note: In case of sending away to laboratories for processing, ensure that specimen is placed in the appropriate package and transported accordingly.

Appendix A: Sample preparation of contact lens solution

a. Medium for inoculation of specimens

Cultures for *Acanthamoeba* species must be processed in a microbiological safety cabinet.

1. Autoclave a 1.5% concentration (15g/L) of purified non-nutrient agar in quarter-strength Ringer's solution (or preferably Page's saline if available). Allow to cool and pour into small Petri dishes. Dry plates before use
2. Flood the blood agar plate with *Escherichia coli** (NCTC 10418) and incubate at 37°C overnight
3. Recover all the growth with a sterile cotton-tipped swab and suspend in 2mL of the preferred saline (as used in 1) or sterile distilled water
4. Add two drops of the suspension to the surface of the purified agar plates and spread evenly over the surface with a swab. Or add excess suspension, swirl it over the agar surface then pipette off the excess - this prevents marks made by the swab from possibly being mis-interpreted as tracks caused by acanthamoeba. The plates are now ready for inoculation with the specimen. If not used for testing at time of preparation, these plates may be stored at 2 to 8ºC and should be used for testing within a week of inoculation
5. On grounds of patient safety, it is preferred to spread the coliform suspension after receipt of plates by the laboratory after sampling has been performed, in which case, the plates should be flooded on their return to the laboratory and excess fluid removed

Note: An even distribution of the organisms is required on the plate. The bacteria-coated agar plate is used for *acanthamoeba* culture only.

**Klebsiella* species (*K. pneumoniae*) and *Enterobacter aerogenes* are acceptable alternatives to *E. coli.* Laboratories may wish to use other alternative organisms apart from those mentioned in this document. They should however ensure that they have validated these prior to use in their work.

b. Inoculation of specimen

1. Inoculate the specimen to a clean microscope slide (examine with a low-power objective) and to the surface of a bacteria-coated purified agar plate. Ring the inoculated area on the base of the plate with a permanent felt-tipped pen for easy reference. Include a plate with a non-pathogenic *Acanthamoeba* control
2. Place the plate in a sealable bag or moist box
3. Incubate plates at 30°C. Incubation at 37°C is not recommended as some strains grow poorly at this temperature
4. Examine the surface of the plate after 24 hour and then daily for up to 7 days with an inverted microscope with a low-power objective. The plate need not be opened
5. Trophozoite stage amoebae may be seen to have made tracks in the bacterial layer.

Red or painful eye

Characteristic polygonal cysts may also be seen

c. Contact lens solution

1. Transfer fluid from contact lens storage case to a sterile universal container. Rub the inside of the storage case with a sterile cotton—tipped swab moistened with sterile distilled water. Express the liquid from the swab into the fluid in the sterile universal container
2. Centrifuge at 800 × g for 5 mins
3. Using a sterile pipette, discard the supernatant into disinfectant, leaving approximately 0.5mL of centrifuged deposit or pellet
4. Resuspend the centrifuged deposit in the remaining fluid and place 2 drops in the centre of a bacteria-coated purified agar plate

After the fluid has been absorbed, incubate and examine the plate.

Supplementary
Culture for free-living amoebae

1. Cultures for *Acanthamoeba* species must be processed in a microbiological safety cabinet.
2. A non-pathogenic control strain of *Acanthamoeba* species, *A. castellani* (Neff strain), can be obtained from the Culture Collection of Algae and Protozoa (CCAP) on request (CCAP Ref. 1501/1A).
3. Incubate the control culture separately from the test culture to prevent possible migration of the control *acanthamoeba* onto the test plate and causing a false positive culture result

d. Sample processing of swab, pus or corneal scraping

Corneal scrapings should be inoculated to media for culture of *Acanthamoeba* species if indicated by clinical details (for example the use of contact lenses or corneal ulceration).

Inoculate each agar plate with swab or pus (UK SMI Q 5: Inoculation of culture media for bacteriology).

Agar plates for bacterial culture, inoculated directly at the patient's bedside, should be streaked out with a sterile loop for the isolation of individual colonies, and incubated immediately on receipt in the laboratory.

For inoculation methods performed at the patient's bedside, refer to local protocols.

E. coli seeded plates should not be sent to the patient's bedside.

e. Sample processing of aqueous and vitreous humour

If fluids are received, one or two drops of fluid should be inoculated to each of the agar plates and streaked out with a sterile loop for the isolation of individual colonies. Enrichment media should also be inoculated if sufficient specimen is available.

Agar plates maybe inoculated directly at the patient’s side and should be streaked out with a sterile loop for the isolation of individual colonies, and immediately incubated on receipt in the laboratory.

References

An explanation of the reference assessment used is available in the scientific information section on the UK SMI website.

1. Borman AM, Johnson EM. Name Changes for Fungi of Medical Importance, 2018 to 2019 2021: volume 59, issue 2, pages e01811-20.**2++** 10.1128/JCM.01811-20 %J Journal of Clinical Microbiology

2. Ho Cao. '10-MINUTE CONSULTATION Virtual consultation for red eye'. British Medical Journal 2021, pages pages 1 to 6 **++** http://dx.doi.org/10.1136/bmj.n1490

3. The College of Optometrists. ''Clinical Management Guidelines Dacryocystitis''.'last updated' 2021 '(viewed on' 02.03.2022) **++** https://www.college-optometrists.org/clinical-guidance/clinical-management-guidelines/dacryocystitis_acute

4. Taylor. RS AJ 'Dacryocystitis': StarPearls; 2021. **++** https://www.ncbi.nlm.nih.gov/books/NBK470565/

5. Centers for Disease Control and Prevention. 'Conjunctivitis '.'last updated' 2019 '(viewed on' 04.08.2022) **++** https://www.cdc.gov/conjunctivitis/about/symptoms.html

6. Sambursky R. BMJ Best Practice Acute conjunctivitis, straight tio the point of care 2019. **3++**

7. Solano D FL, Czyz CN Viral Conjunctivitis: StatPearls Publishing; 2021. **++**

8. Benatti SV and others. Ophthalmic manifestation of monkeypox infection. Lancet Infect Dis 2022: volume 22, issue 9, pages 1397.**3++** 10.1016/s1473-3099(22)00504-7

9. Ophthalmologists TRCo. Ophthalmic manifestations of monkeypox virus. wwwnaturecom/eye 2022.**3++**

10. The College of Optometrists. Molluscum contagiosum 2021: volume Molluscum contagiosum Version 9.**++**

11. Centers for Disease Control and Prevention. 'Conjunctivitis (for clinicians)'.'last updated' 2021 '(viewed on' 15.07.2022) **++** https://www.cdc.gov/conjunctivitis/clinical.html

12. Semba RD, Bloem MW. Measles blindness. Survey of Ophthalmology 2004: volume 49, issue 2, pages 243-55. **2+** 10.1016/j.survophthal.2003.12.005

13. American Academy of Ophthalmology. 'Bacterial Conjunctivitis'.'last updated' 17.04.2022 2022 '(viewed on' 04.08.2022) **++** https://eyewiki.org/Bacterial_Conjunctivitis

14. Deepthi KG, Prabagaran SR. 'Ocular bacterial infections: Pathogenesis and diagnosis'. Microbial Pathogenesis 2020: volume 145, pages 104206. **++** https://doi.org/10.1016/j.micpath.2020.104206

15. Lee WA, Chen CC. Adult inclusion conjunctivitis diagnosed by polymerase chain reaction and Giemsa stain. IDCases 2022: volume 27, pages e01367. **3++**

10.1016/j.idcr.2021.e01367

16. NHS Greater Glasgow and Clyde. 'Eye infections in the neonate: Ophthalmia Neonatorum and the management of systemic Gonococcal and Chlamydial infections'.'last updated' 2019 '(viewed on' 04.08.2022) **++** https://www.clinicalguidelines.scot.nhs.uk/nhsggc-guidelines/nhsggc-guidelines/neonatology/eye-infections-in-the-neonate-ophthalmia-neonatorum-and-the-management-of-systemic-gonococcal-and-chlamydial-infections/

17. Olusanya B, Baiyeroju A. Emergency management: ophthalmia neonatorum. Community Eye Health 2018: volume 31, issue 103, pages 61.**++**

18. National Institute for Health and Care Excellence. 'Conjunctivitis - allergic: How common is it?'.'last updated' 2022 '(viewed on' 04.08.2022) **++** https://cks.nice.org.uk/topics/conjunctivitis-allergic/background-information/prevalence/

19. National Institute for Health and Care Excellence. Blepharitis 2019. **++**

20. Wu E. 'BMJ Best Practice Blepharitis' 2018. **3++**

21. Feroze KB, Patel BC. Canaliculitis. StatPearls. Treasure Island (FL): StatPearls Publishing Copyright © 2022, StatPearls Publishing LLC.; 2022. **++**

22. Bansal S and others. 'Severe nonbacterial preseptal cellulitis from adenovirus detected via pooled meta-genomic testing'. Clin Case Rep 2020: volume 8, issue 12, pages 3503-6. **3++** 10.1002/ccr3.3468

23. Bae C BD. 'Periorbital Cellulitis'.'last updated' 21.07.2021 2021 '(viewed on' 21.12.2021) **++** https://www.ncbi.nlm.nih.gov/books/NBK470408/

24. H. Jane Kim RK. 'BMJ Best Practice Peri-orbital and orbital cellulitis'.'last updated' 2020 '(viewed on' 26.03.2021) **++** https://bestpractice.bmj.com/topics/en-gb/734

25. Watson S and others. Common eye infections. Australian Prescriber 2018: volume 41, issue 3, pages 67-72. **++** 10.18773/austprescr.2018.016

26. Leal SM, Jr. and others. Practical Guidance for Clinical Microbiology Laboratories: Diagnosis of Ocular Infections. Clin Microbiol Rev 2021: volume 34, issue 3, pages e0007019. **++** 10.1128/cmr.00070-19

27. Das S and others. Keratitis following laser refractive surgery: Clinical spectrum, prevention and management. Indian J Ophthalmol 2020: volume 68, issue 12, pages 2813-8.**++** 10.4103/ijo.IJO_2479_20

28. Aoki T and others. Current Evidence for Corynebacterium on the Ocular Surface. Microorganisms 2021: volume 9, issue 2. **3++** 10.3390/microorganisms9020254

29. National Institute for Health and Care Excellence. 'Herpes simplex-ocular'.'last updated' November 2016 2016 **++** https://cks.nice.org.uk/topics/herpes-simplex-ocular/

30. American Academy of Ophthalmology. 'Herpes Zoster Ophthalmicus'.'last updated' 2022

++ https://www.aao.org/focalpointssnippetdetail.aspx?id=8367b620-245c-4ebf-89e7-eca0c8d35aa3

31. Jain R and others. Clinico-microbiological review of non-contact-lens-associated acanthamoeba keratitis. Seminars in Ophthalmology 2013: volume 30, issue 4, pages 281-8. **2+** 10.3109/08820538.2013.849270

32. Clarke B and others. Advances in the diagnosis and treatment of acanthamoeba keratitis. Journal of Ophthalmology 2012: volume 2012, pages 484892.**+**

33. Holmgaard DB and others. Detection and Identification of Acanthamoeba and Other Nonviral Causes of Infectious Keratitis in Corneal Scrapings by Real-Time PCR and Next-Generation Sequencing-Based 16S-18S Gene Analysis. J Clin Microbiol 2021: volume 59, issue 2. **2++** 10.1128/jcm.02224-20

34. Brown Lao. 'The global incidence and diagnosis of fungal keratitis'. The Lancet Infectious Diseases 2021: volume Volume 21, issue Issue 3 pages pages E49-E57. **++** https://doi.org/10.1016/S1473-3099(20)30448-5

35. Thomas PA, Kaliamurthy J. Mycotic keratitis: epidemiology, diagnosis and management. Clinical Microbiology Infection 2013: volume 19, issue 3, pages 210-20. **++** 10.1111/1469-0691.12126

36. Wu XN and others. Viral retinitis: diagnosis and management in the era of biologic immunosuppression: A review. Clinical & Experimental Ophthalmology 2019: volume 47, issue 3, pages 381-95. **++** https://doi.org/10.1111/ceo.13500

37. Gupta N, Tripathy K. Retinitis. StatPearls. Treasure Island (FL): StatPearls Publishing Copyright © 2022, StatPearls Publishing LLC.; 2022. **++**

38. Keynan Y and others. The microbiology of endophthalmitis: global trends and a local perspective. European Journal of Clinical Microbiology & Infectious Disease 2012: volume 31, issue 11, pages 2879-86. **+**

39. Vinekar A and others. 'Management of recurrent postoperative fungal endophthalmitis'. Indian Journal of Ophthalmology 2014: volume 62, issue 2, pages 136-40. **2+** 10.4103/0301-4738.128588

40. American Acedemy of Ophthalmology. 'Endophthalmitis'.'last updated' 12.05.2022 '(viewed on' 05.09.2022) **++** https://eyewiki.aao.org/Endophthalmitis

41. Agarwal M and others. 'Fusarium Causing Recalcitrant Post-operative endophthalmitis-Report of a Case with Review of Literature'. Ocular Immunology and Inflammation 2021, pages 1-3. **3++** 10.1080/09273948.2020.1830124

42. Tan CL and others. Endophthalmitis: Microbiology and Organism Identification Using Current and Emerging Techniques. Ocular Immunology and Inflammation 2022, pages 1-9. **1++** 10.1080/09273948.2022.2027468

43. Durand ML. Endophthalmitis. Clin Microbiol Infect 2013: volume 19, issue 3, pages 227-34. **+** 10.1111/1469-0691.12118

44. American Academy of Ophthalmology EyeNet magazine Endogenous Endophthalmitis: Diagnosis and Treatment. June 2016 ed.; 2016. **+**

45. National Institute for Health and Care Excellence. Uveitis 2019. **++**

46. Huang J. J EM. British Medical Journal Best Practice Uveitis 2018, pages 56. **++**

47. Minkus CL and others. Real-Time Multiplex PCR Analysis in Infectious Uveitis. Seminars in Ophthalmology 2019: volume 34, issue 4, pages 252-5. **2++** 10.1080/08820538.2019.1620803

48. Burkholder BM, Jabs DA. Uveitis for the non-ophthalmologist. Bmj 2021: volume 372, pages m4979. **++** 10.1136/bmj.m4979

49. Miller JR, Hanumunthadu D. Inflammatory eye disease: An overview of clinical presentation and management. Clinical Medicine 2022: volume 22, issue 2, pages 100-3. **++** 10.7861/clinmed.2022-0046

50. Kalogeropoulos D and others. Ocular toxoplasmosis: a review of the current diagnostic and therapeutic approaches. Int Ophthalmol 2022: volume 42, issue 1, pages 295-321. **2+** 10.1007/s10792-021-01994-9

51. Park YH, Nam HW. Clinical features and treatment of ocular toxoplasmosis. Korean J Parasitol 2013: volume 51, issue 4, pages 393-9. **+** 10.3347/kjp.2013.51.4.393

52. Korzeniewski K. Eye diseases in travelers. International Maritime Health 2020: volume 71, issue 1, pages 78-84. **++** 10.5603/imh.2020.0015

53. Feldman BH PP, Shah VA and others. 'Onchocerciasis (African River Blindness)'.'last updated' 2022 '(viewed on' 01.09.2022) **++** https://eyewiki.aao.org/Onchocerciasis_(African_River_Blindness)

54. Bunya VY AS, Puente, MA. 'Loa Loa Filariasis (African Eye Worm)'.'last updated' '(viewed on' 01.09.2022) **++** https://eyewiki.aao.org/Loa_Loa_Filariasis_(African_Eye_Worm)

55. Kalogeropoulos CD and others. Ocular dirofilariasis: a case series of 8 patients. Middle East African Journal of Ophthalmology 2014: volume 21, issue 4, pages 312-6. **3+** 10.4103/0974-9233.142267

56. R M. 'What is Endophthalmitis?'.'last updated' 2019 '(viewed on' 21.12.2021) **+** https://www.aao.org/eye-health/diseases/what-is-endophthalmitis

57. Centers for Disease Control and Prevention. 'Basics of Bacterial Keratitis'.'last updated' 14.02.2022 2022 '(viewed on' 31.08.2022) https://www.cdc.gov/contactlenses/bacterial-keratitis.html

58. Somerville TF and others. An Evaluation of a Simplified Impression Membrane Sampling Method for the Diagnosis of Microbial Keratitis. Journal of Clinical Medicine 2021: volume 10, issue 23. **2++** 10.3390/jcm10235671

59. Kaye S and others. Impression membrane for the diagnosis of microbial keratitis. British Journal of Ophthalmology 2016: volume 100, issue 5, pages 607-10. **2++** 10.1136/bjophthalmol-2015-307091

60. Zimmerman AB and others. Contact lens associated microbial keratitis: practical considerations for the optometrist. Clin Optom (Auckl) 2016: volume 8, pages 1-12. **+** 10.2147/opto.S66424

61. Gizzie N, Adukwu E. Evaluation of Liquid-Based Swab Transport Systems against the New Approved CLSI M40-A2 Standard. J Clin Microbiol 2016: volume 54, issue 4, pages 1152-6. **2+** 10.1128/JCM.03337-15

62. Tyrrell KL and others. Comparison of the Copan eSwab System with an Agar Swab Transport System for Maintenance of Fastidious Anaerobic Bacterium Viability. J Clin Microbiol 2016: volume 54, issue 5, pages 1364-7. **2+** 10.1128/JCM.03246-15

63. World Health Organization. Guidance on regulations for the transport of infectious substances 2019-2020. WHO. 2019. **++**

64. Kaye SB and others. Simplifying collection of corneal specimens in cases of suspected bacterial keratitis. J Clin Microbiol 2003: volume 41, issue 7, pages 3192-7. **2+** 10.1128/jcm.41.7.3192-3197.2003

65. You JY, Botelho PJ. Corneal In Vivo Confocal Microscopy: Clinical Applications. Rhode Island Medical Journal (2013) 2016: volume 99, issue 6, pages 30-3. **++**

66. Lorenzo-Morales J and others. 'An update on Acanthamoeba keratitis: diagnosis, pathogenesis and treatment'. Parasite 2015: volume 22, pages 10. **++** 10.1051/parasite/2015010

67. Sharma S. Diagnosis of infectious diseases of the eye. Eye The Scientific Journal of the Royal College of Ophthalmologists 2012: volume 26, issue 2, pages 177-84. **++** 10.1038/eye.2011.275

68. Advisory Committee on Dangerous Pathogens. The Approved List of Biological Agents. Health and Safety Executive 2021. pages 1-39. **++**

69. British Standards Institution (BSI). BS 5726:2005 - Microbiological safety cabinets. Information to be supplied by the purchaser and to the vendor and to the installer, and siting and use of cabinets. Recommendations and guidance. 2005. pages 1-14. **++**

70. Centers for Disease Control and Prevention. Guidelines for Safe Work Practices in Human and Animal Medical Diagnostic Laboratories. MMWR Surveill Summ 2012: volume 61, pages 1-102. **+**

71. Department for Transport and others. Transport of infectious substances UN2814, UN2900 and UN3373 Guidance note number 17/2012 (revision 7). 2013. **++**

72. Department of Health. Health Protection Legislation (England) Guidance. pages 1-112. 2010. **++**

73. Health and Safety Executive. Managing risks and risk assessment at work (accessed 28/07/2021). https://www.hse.gov.uk/simple-health-safety/risk/index.htm. **++**

74. Health and Safety Executive. Risk assessment: A brief guide to controlling risks in the workplace. HSE. 2014. **++**

75. Health and Safety Executive. Blood-borne viruses in the workplace. Guidance for employers and employees. HSE. 2001. **++**

76. Health and Safety Executive. Safe use of pneumatic air tube transport systems for pathology specimens. 2009. **++**

77. Health and Safety Executive. Control of Substances Hazardous to Health Regulations. The Control of Substances Hazardous to Health Regulations 2002 (as amended). HSE Books,. 2013. **++**

78. Health and Safety Executive, Advisory Committee on Dangerous Pathogens. Management and operation of microbiological containment laboratories. HSE. 2019. **++**

79. Health Services Advisory Committee. Safe working and the prevention of infection in clinical laboratories and similar facilities. Books. H 2003. **++**

80. Home Office. Public Health Act (Northern Ireland) 1967 Chapter 36. 1967. **++**

81. Home Office. Anti-terrorism, Crime and Security Act. 2001. **++**

82. Official Journal of the European Communities. Directive 98/79/EC of the European Parliament and of the Council of 27 October 1998 on *in vitro* diagnostic medical devices 1998. pages 1-37. **++**

83. Public Health England. Laboratory reporting to Public Health England: a guide for diagnostic laboratories. PHE. 2020. pages 1-31. **++**

84. Scottish Government. Public Health (Scotland) Act. 2008. **++**

85. The Royal College of Pathologists. The retention and storage of pathological records and specimens (5th edition). pages 1-59. 2015. **++**

86. The Welsh Assembly Government. Health Protection Legislation (Wales) Guidance. 2010. **++**