Applied corneal anatomy

Anatomically, the cornea consists of the following five layers: (1) **epithelium**, (2) **Bowman's layer**, (3) **stroma**, (4) **Descemet's membrane** and (5) **endothelium** .

- The epithelium consists of three types of cells:
  1. A single layer of basal columnar cells which is attached by hemidesmosomes to the epithelial basement membrane.
  2. Two to three rows of wing cells which have thin 'wing-like' extensions.
  3. Two layers of long and thin surface cells joined by bridges. The surface area of the outermost cells is increased by microplicae and microvilli which facilitate the adsorption of mucin. After a lifespan of a few days the superficial cells are shed into the tear film. Because of its excellent ability to regenerate, the epithelium does not scar.

- The cornea is richly supplied by sensory nerve endings via the first division of the trigeminal nerve.

- ***Bowman's layer*** is an acellular structure which represents the superficial layer of the stroma. It does not regenerate when damaged.

- ***The stroma*** makes up about 90% of corneal thickness. It is composed of collagen-producing fibroblasts (keratocytes), collagen fibrils and ground substance.

- ***Descemet's membrane*** is composed of a fine latticework of collagen fibrils. It consists of an anterior banded zone which develops *in utero* and a posterior non-banded zone laid down throughout life by the endothelium.

- ***The endothelium*** consists of a single layer of hexagonal cells. It plays a vital role in maintaining the deturgescence of the cornea. With age, the number of endothelial cells gradually decreases but because they cannot regenerate, neighbouring cells have to spread out to fill the space.

CLINICAL SIGNS OF CORNEAL DISEASE

- ***Superficial signs***

- Punctate epitheliopathy or punctate epithelial erosions (FEE) is characterized by tiny, slightly depressed, grey white spots which stain well with fluorescein but not with rose bengal . PEE is a non-specific sign which may be seen during the early stages of a wide variety of keratopathies. The location of PEE may frequently serve as a clue to the aetiology of the keratopathy, for example:

- 1. **Superior PEE** occurs in vernal disease and superior limbic keratoconjunctivitis
  2. **Inferior PEE** may be seen in trichiasis, entropion, staphylococcal blepharitis, primary meibomitis, keratoconjunctivitis sicca, rosacea and corneal exposure.
  3. **Interpalpebral PEE** is associated with seborrhoeic blepharitis, neurotrophic keratopathy and exposure to ultraviolet light.

- ***Epithelial oedema*** is an important sign of endothelial decompensation. It is characterized by loss of normal corneal lustre and in severe cases vesicles and bullae may develop.

- ***Corneal filaments*** are composed of mucous threads attached to abnormal receptor sites. They appear as comma-shaped opacities with the unattached end hanging down over the cornea and moving with each blink. Beneath their attachments to the epithelium, grey subepithelial opacities may be seen. Filaments stain very well with rose bengal but not with fluorescein. This is because fluorescein stays outside the cells, whereas rose bengal has an affinity for mucus in addition to dead and degenerating cells. Causes of corneal filaments include keratoconjunctivitis sicca, superior limbic keratoconjunctivitis, herpes zoster, midbrain strokes and essential blepharospasm.

- ***Punctate epithelial keratitis*** (PEK) is the hallmark of viral infections. The lesions are composed of granular opalescent epithelial cells which stain well with rose bengal, but poorly with fluorescein

- ***A pannus*** consists of an ingrowth of fibrovascular tissue from the limbus into the subepithelial space

- ***Signs involving the stroma and Descemet's membrane***

- ***Stromal infiltrates*** are composed of leucocytes and are indicative of active inflammation. On slitlamp examination they appear as focal granular opacities.

- ***Stromal oedema*** usually coexists with inflammatory infiltration. Clinically, it is characterized by optically empty spaces between stromal lamellae, associated with increased corneal thickness, and variable decrease in transparency as a result of disruption of the regular arrangement of corneal lamellae. Four important causes of central stromal oedema are disciform keratitis, keratoconus, Fuchs' dystrophy and intraoperative damage to the corneal endothelium.

- ***Stromal vascularization*** occurs in a wide variety of corneal disorders. Corneal blood vessels visible at the slitlamp are invariably venous. The arterial feeding vessels are difficult to see without the aid of fluorescein angiography.
- ***Breaks in Descemet's membrane*** may occur as a result of corneal enlargement, birth trauma and keratoconus.
- ***Folds in Descemet's membrane*** are caused by surgical trauma, ocular hypotony and stromal inflammation.
- **Special investigations**
- ***Pachometry*** measures corneal thickness which is an indirect indication of the integrity of the corneal endothelium. The thickness of the cornea increases towards the limbus where it ranges from 0.7 mm to 0.9 mm. The normal central corneal thickness is between 0.49 mm and 0.56 mm and readings of 0.6 mm or more are suggestive of endothelial disease.
- ***Specular microscopy*** photographs the corneal endothelium and delineates various cellular characteristics such as size, shape, density and distribution
- ***Keratometry*** measures corneal curvature.
- ***Keratoscopy*** detects abnormalities of corneal shape. If the corneal surface is regular, the reflected image will consist of uniform concentric rings; if irregular, the reflection will be distorted. The following are the main types of keratoscopes:
- 1. **Hand-held Placido's disc**
- 2. **Photokeratoscopes** are more sophisticated instruments which enable a permanent photographic record to be made
- 3. **Computer-assisted photokeratoscopes** (corneo- scopes) provide a numerical and a colour coded topographical map of the corneal surface; this is very useful in the early diagnosis of keratoconus
- **Microbial keratitis**
- **Bacterial keratitis**
- PREDISPOSING FACTORS
- The pathogens able to produce corneal infection in the presence of an intact epithelium are *Neisseria gonorrhoeae*, *Corynebacterium diphtheriae*, *Listeria* sp. and *Haemophilus* sp. Other bacteria are capable of producing keratitis only after loss of corneal epithelial integrity associated with the following

factors:
1. **Contact lens wear**, particularly extended wear soft lenses, is the most common predisposing factor in patients with previously normal eyes. The infection is often caused by Pseudomonas aeruginosa which requires an epithelial defect for corneal invasion. 2. **Ocular surface disease** which disrupts defence mechanisms such as postherpetic corneal disease, trauma, bullous keratopathy, corneal exposure and dry eye.

- CLINICAL FEATURES

- Although there is no reliable method of identifying the causative organism by slitlamp biomicroscopy, certain bacteria produce characteristic corneal responses:
  1. **Staph. aureus** and **Strep. pneumoniae** tend to produce oval, yellow white, densely opaque stromal suppuration surrounded by relatively clear cornea 2. **Pseudomonas** sp. typically causes irregularly sharp ulceration, thick mucopurulent exudate, diffuse liquefactive necrosis and semi-opaque , ground-glass' appearance of adjacent stroma . The infection may progress rapidly and result in corneal perforation within 48 hours.
  3. **Enterobacteriaceae** usually cause a shallow ulceration, grey-white pleomorphic suppuration and diffuse stromal opalescence. The endotoxins present in Gram- negative bacteria may induce ring shaped corneal infiltrates ('corneal rings').

MANAGEMENT

- A bacterial corneal ulcer is a sight-threatening condition which demands urgent identification and eradication of the causative organism. This is best performed with the patient hospitalized. Scrapings should be taken as already described.

Choice of antibiotics

- ***Gram-negative organisms*** are treated with aminoglycosides. **Gentamicin** and **tobramycin** are effective against a wide range of organisms and are therefore a treatment of first choice in the management of suspected Gram-negative bacterial keratitis. Most strains of *Pseudomonas* are sensitive to gentamicin

- ***Gram-positive organisms*** are treated with **cefuroxime** or **ciprofloxacin**. The latter is active against most Gram-positive and Gram-negative bacteria as well as methicillin-resistant strains of *Staph. aureus* and gentamicin-resistant *Pseudomonas aeruginosa*.

- Unfortunately, there may be poor correlation between the initial Gram stain results and subsequent culture identification of the organism. For this reason, the initial therapy should be with a combination of a fortified aminoglycoside and ciprofloxacin

- ***Subconjunctival injections of antibiotics***

- Subconjunctival injections provide a high but transient peak of antibiotic. The injections are given every 24 hours for about 5 days. The doses are gentamicin 20 mg, tobramycin 20 mg, cefuroxime 125 mg and ciprofloxacin 2 mg.

- ***Systemic antibiotics***

- Ciprofloxacin given systemically (750 mg twice daily) is copiously secreted in the tears and has excellent intraocular penetration. Other systemic antibiotics are not routinely used because they produce low corneal concentrations.

- ***Topical cycloplegics and steroids***

- ***Cycloplegics***, such as atropine, should be used in all eyes with bacterial keratitis to prevent the formation of posterior synechiae from secondary anterior uveitis, and to reduce pain from ciliary spasm.

- ***Steroid therapy*** is controversial. The potential benefits of topical steroids in reducing the extent of stromal necrosis and scarring should be weighed against their effects in decreasing fibroblast activity and inhibiting wound healing, thereby increasing the danger of perforation. Steroids also have the potential for prolonging infection, particularly pseudomonal. For these reasons steroid therapy may be become initiated only when cultures become sterile and there is a clear evidence of improvement. This is usually 7-10 days after initiation of treatment.

- **Fungal keratitis**

- Although rare, fungal corneal infection (keratomycosis) should always be considered if the differential diagnosis of suppurative bacterial keratitis and herpetic stromal necrotic keratitis is suspected.

- CLINICAL FEATURES

- The clinical appearance of fungal keratitis varies with the infectious agent and stage of the disease. Topical steroids enhance fungal replication and corneal invasion by interfering with the host's inflammatory response; they are often in use at the time of diagnosis.

- ***Filamentous fungal keratitis***
- Filamentous fungal keratitis is usually caused by *Aspergillus* or *Fusarium* spp. It is most prevalent in agricultural areas and typically preceded by ocular trauma, most frequently involving organic matter such as wood
- ***Examination*** shows a greyish white ulcer with indistinct margins which may be elevated above the surface of the cornea. The lesion is typically surrounded by delicate, feathery, finger-like infiltrates in adjacent stroma. Less specific associated findings include satellite lesions, ring infiltrate, endothelial plaque and hypopyon
- ***Candida keratitis***
- Candida keratitis usually develops in association with pre-existing chronic corneal disease or in an immunocompromised or debilitated patient.
- ***Examination*** shows a yellow white ulcer associated with dense suppuration similar to that of a bacterial keratitis.
- **Acanthamoeba keratitis**
- Acanthamoebae are ubiquitous free-living protozoans found in air, soil, and fresh or brackish water .Contact lens wearers who use distilled water and salt tablets instead of commercially prepared saline solutions for their lens care are at particular risk
- CLINICAL FEATURES
- ***Presentation*** is with blurred vision and pain which is characteristically severe and disproportionate to the extent of ocular involvement.
- ***Examination*** of early cases shows multifocal, variably sized, patchy, anterior stromal infiltrates. The overlying epithelium may be intact or show mild punctate erosions. The infiltrates gradually enlarge and coalesce to form a partial or complete central or paracentral non-suppurative ring

Viral keratitis **د.زينة محمد حسن**

Herpes simplex keratitis

- Herpes simplex virus (HSV) is a DNA virus with humans as the only host. Infection with HSV is extremely common and about 90% of the population are seropositive for HSV antibodies. In spite of this, most infections are subclinical. According to different clinical and immunological properties, HSV is subdivided into two types.

- ***HSV-1*** predominantly causes infection above the waist (face, lips and eyes) and is usually acquired by kissing or coming into close contact with a person who either has a cold sore (herpes labialis) or is shedding the virus asymptomatically.

- ***HSV-2*** typically causes infection below the waist (genital herpes) and is acquired venereally. Very occasionally, HSV-2 is transmitted to the eye through infected genital secretions, particularly in neonates during passage through the birth canal.

PRIMARY OCULAR INFECTION

Primary ocular infection typically occurs in children between the ages of 6 months and 5 years, and may be associated with generalized symptoms of a viral illness.

Clinical features

- ***Blepharoconjunctivitis*** is usually benign and self-limited and, in children, it may be the only manifestation of primary herpetic infection. The skin lesions typically involve the lids and periorbital area. Initially, they consist of vesicles which rapidly form superficial crusts and then heal without scarring . The conjunctivitis is unilateral, acute, follicular, and associated with a watery discharge and preauricular adenopathy.

- ***Keratitis*** develops within a few days in about 50% of patients with blepharoconjunctivitis. ***Treatment***
- In patients with blepharoconjunctivitis, topical antiviral ointment should be applied prophylactically to the eye five times a day for about 21 days to prevent keratitis
- Dendritic ulceration which may be single or multiple is the hallmark of epithelial disease.
- ***Examination*** of early cases shows opaque cells arranged in a dendritic, coarse, punctate or stellate pattern. **The lesion is associated with diminished corneal sensitivity**. Occasionally, the continued enlargement of a dendritic ulcer leads to a much larger epithelial defect which has a **geographical or 'amoeboid' configuration**. This is particularly likely to occur when the rate of virus replication has been enhanced by injudicious use of topical steroids.
- Following the healing of a dendritic ulcer, the corneal epithelium may continue to show the presence of linear, and sometimes branching, shapes which represent one or more waves of healing epithelium. These **pseudodendrites** will eventually disappear spontaneously and should not be mistaken for persistent active infection. Other causes of non-herpetic dendritic ulceration include:

1. Herpes zoster keratitis

2. A healing corneal abrasion.
3. Soft contact lenses

4. Toxic keratopathies usually caused by excessive drop administration.

Principles of antiviral therapy

Even without treatment, about 50% of active epithelial lesions heal without residua. The cure rate is in the order of 95% with treatment

1. **Acycloguanosine (3% ointment)** (acyclovir, Zovirax) is used five times daily. It is more potent than both idoxuridine and adenine arabinoside and as effective as trifluorothymidine. Acyclovir differs from the other antiviral agents in that it acts preferentially on virus-infected cells disabling viral thymidine kinase. As the drug is relatively non-toxic, even when given for up to **60 days**. Acyclovir is able to penetrate the intact corneal epithelium and stroma, achieving therapeutic levels in the aqueous humour, unlike other currently available antiviral agents

2. **Trifluorothymidine (1% drops)** is used every 2 hours during the day. Like acyclovir, it heals about 95% of dendritic ulcers within 2 weeks.. It is, however, more toxic than

acyclovir to the corneal epithelium and conjunctiva.
3. **Adenine arabinoside (3% ointment, 0.1% drops)** is used mainly in the rare event of resistance to acyclovir and trifluorothymidine.
4. **Idoxuridine (0.5% ointment, 0.1% drops)** is now seldom used because of emergence of resistant strains and toxicity.

Herpes zoster ophthalmicus

Herpes zoster is a common infection caused by human herpes virus 3 ; this is morphologically identical to the herpes simplex virus but different both antigenically and clinically. Varicella (chickenpox) and zoster are different conditions caused by the same virus. There is no evidence, however, that zoster can be acquired by contact with patients with either chickenpox or zoster. Zoster mainly affects elderly patients and is rare in children. The current theory of aetiology is that, after an attack of chickenpox and its attendant viraemia, some virus is retained in the dorsal root ganglion, perhaps arriving by retrograde spread along the sensory nerves from the skin lesions. Later, under the influence of largely unknown trigger factors, it reactivates and migrates back down the sensory nerves to the skin and eye where it causes the characteristic lesions.

Approximately 15% of all cases of herpes zoster affect the ophthalmic division of the trigeminal nerve. The condition is then referred to as herpes zoster ophthalmicus (HZO). **Involvement of the nasociliary nerve (Hutchinson's sign) which supplies the side of the nose occurs in about one-third of patients with HZO** and it correlates significantly with subsequent development of ocular complications. Overall, about 50% of patients with HZO develop ocular lesions. Patients who are HIV positive are at increased risk of HZO .The possibility of AIDS should therefore be considered in patients under 45 years of age who develop HZO. The multiple and diffuse ocular complications of HZO are related to multiple mechanisms, including **presumed viral spread, nerve damage, ischaemic vasculitis and an inflammatory granulomatous reaction**.

Clinically, HZO can be divided into the following three phases:
1. **An acute phase** within the first 4 weeks, which may totally resolve.
2. **A chronic phase**, which may persist for years.
3. **A relapsing phase** where the acute or chronic lesions appear to have been controlled but reappear even years later.

Clinical features of skin lesions

The rash initially it is maculopapular and then becomes pustular. The pustules subsequently burst to form crusting ulcers

Treatment of skin lesions

Treatment is aimed at promoting rapid healing of the skin without the formation of massive crusts which result in scarring of the nerves and postherpetic neuralgia.

1. **Systemic therapy** is with **acyclovir** (Zovirax), 800 mg tablets administered five times daily for 7 days.

2. **Topical therapy** consists of antiviral creams (acyclovir) and a steroid-antibiotic preparation. These should be used three times daily until all crusts have separated.

Clinical features of ocular lesions

1. **Conjunctivitis** is one of the most common complications which is always associated with vesicles on the lid margin. it usually resolves within 1 week.

2. **Episcleritis** occurs in about one-third of cases at the onset of the rash

3. **Scleritis** is much less common. it usually develops after 1 week and also involves the cornea (sclerokeratitis).

Corneal lesions include the following:

1. **Punctate epithelial keratitis** develops in about 50% of patients within 2 days of the onset of the rash.
2. Microdendritic ulcers are also common and appear within 4-6 days

3. **Nummular keratitis**, seen in about one-third of cases, typically appears about 10 days after the onset of the rash. it is characterized by multiple fine granular deposits (just beneath Bowman's membrane), which are surrounded by a halo of stromal haze

4. **Disciform keratitis** develops in about 5% of cases 3 weeks after the onset of the rash.

5-Anterior uveitis results from presumed viral replication, ischaemic vasculitis or lymphocytic infiltration of iris, stromal or intraocular nerves.

Treatment of ocular lesions

- ***Mild involvement***, such as corneal microdendritic ulcers, some cases of nummular keratitis and most cases of episcleritis are self limiting and do not require treatment; although indolent episcleritis and scleritis may require oral **flurbiprofen** (Froben) 100 mg three times daily.
- ***Severe involvement*** is treated with **topical steroids** alone, although long-term therapy is frequently required. Topical acyclovir alone is insufficient in severe ocular inflammation and, although it takes longer than steroids to settle milder cases, it is not inclined to lead to recurrences. Combined treatment with steroids and acyclovir is probably better than steroids alone,

with slightly fewer rebound inflammations. It is imperative that treatment should be very slowly tapered as an abrupt stoppage may precipitate a relapse.

Corneal degenerations

ARCUS SENILIS

- Arcus senilis is the most commonly encountered peripheral corneal opacity. it may be associated with familial and non-familial dyslipoproteinaemias but may also occur without any predisposing factors. Hyperlipoproteinaemia, most notably type II, is frequently associated with bilateral arcus, with less common association in types III, IV and V. The presence of arcus is also age related and is found in virtually all individuals over the age of 80. Unilateral arcus is a rare entity that may be associated with carotid disease or ocular hypotony.
- ***Examination*** shows bilateral lipid deposition which starts in the superior and inferior perilimbal cornea and then progresses circumferentially to form a band about 1 mm wide. Histological studies have shown that the lipid is first deposited in the anterior half of Descemet's membrane and then in the anterior stroma, just beneath Bowman's layer.

Lipid keratopathy is a corneal degeneration which occurs in two settings: (1) **primary lipid keratopathy** is rare and occurs spontaneously in an avascular cornea, and (2) **secondary lipid keratopathy** is much more common and associated with previous ocular injury or disease which results in corneal vascularization.

- ***Examination*** shows white or yellowish corneal stromal deposits consisting of cholesterol, fats and phospholipids.
- ***Treatment*** involves first control of the primary inflammatory disease and then of the lipid deposits..
- **Band keratopathy** is a relatively common disorder characterized by the deposition of calcium salts in the subepithelial space and anterior portion of Bowman's membrane. The four main causes, in order of frequency, are: (1) **chronic iridocyclitis** particularly in children, (2) **idiopathic** in the elderly, (3) **phthisis bulbi** and (4) **increased serum calcium** or **phosphorus levels**.
- ***Treatment*** is indicated for visual or cosmetic reasons by
- the following methods:
  1. **Chelation** is a simple and effective form of treatment for relatively mild cases.

- 2. Excimer laser keratectomy may be used for cases with more extensive and deeper involvement.

- **Corneal dystrophies**

- The corneal dystrophies are a group of spontaneous appearing, usually inherited, bilateral, stationary or slowly progressive corneal alterations that develop in the absence of inflammation. Age of onset, symptoms, mode of progression and inheritance differ in the various dystrophies. Most present by the second decade, but some that have little effect on vision may present in adult life.

Classification

Anterior dystrophies

- microcystic
- Reis-Bücklers'
- Meesmann's

Stromal dystrophies

- lattice
- macular
- granular

Posterior dystrophies

- Fuchs' endothelial
- posterior polymorphous

Ectatic dystrophies

- keratoconus
- posterior keratoconus
- keratoglobus
- pellucid marginal degeneration

Microcystic dystrophy

Microcystic dystrophy, also known as **Cogan's**, **map-dot-fingerprint** or **epithelial basement membrane** is the most common dystrophy seen in clinical practice.

- ***Examination*** shows bilateral, dot-like, cystic or linear, fingerprint-like lesions, involving the corneal epithelium .
- ***Complications*** in the form of recurrent corneal erosions develop in about 10% of patients, usually after the age of 30 years. The remainder are asymptomatic throughout life

Granular dystrophy

There are two types of granular dystrophy. types 1 and 2. The former accounts for about 60% of cases.

Inheritance of both types is autosomal dominant.

GRANULAR DYSTROPHY TYPE 1

- ***Onset*** is during the first decade of life with recurrent corneal erosions.
- ***Examination*** shows very small, discrete, crumb-like, white granules within the anterior stroma of the axial cornea associated with fewer rings or stars .In between the lesions the stroma is clear. By the age of 40 years, visual acuity falls to between 6/12 and 6/60. Some patients may complain of light scattering which is particularly troublesome during night driving.

GRANULAR DYSTROPHY TYPE 2

- ***Onset*** is with blurred vision in the second decade of life.
- ***Examination*** shows large, ring or disc-shaped opacities usually in the superficial stroma with fewer star-shaped deeper opacities . The lesions increase very gradually in size but not in number. Final visual acuity is usually 6/18 or better.

Macular dystrophy

Macular dystrophy is the least common, but the most serious, of the three classic stromal dystrophies.

There are two types of macular dystrophy: **type 1** is associated with lack of keratan sulphate in the serum and cornea. in **type 2** keratan sulphate is normal in both.

- ***Inheritance*** is autosomal recessive.
- ***Onset*** is during the second 5 years of life.
- ***Examination*** shows central, focal, grey white, poorly delineated opacities consisting of glycosaminoglycan. The stroma in between the lesions is diffusely cloudy . Although initially the opacities involve the superficial

stroma, with the passage of time, the entire stromal thickness and extent, including the peripheral cornea, becomes involved.

- ***Penetrating keratoplasty*** is usually required during the third decade to improve visual acuity.
- The main differences between macular and the other two stromal dystrophies are that inheritance is autosomal recessive, the peripheral cornea is involved and significant impairment of vision occurs in early life.
- Keratoconus (conical cornea) is a fairly common, progressive disorder in which the cornea assumes an irregular conical shape. The hallmark of keratoconus is central or paracentral stromal thinning, apical protrusion and irregular astigmatism. The condition starts at around puberty and progresses slowly thereafter, although it may become stationary at any time. Both eyes are affected in about 85% of cases, although the severity of involvement may be markedly asymmetrical. The aetiology of keratoconus is obscure. The role of heredity has not been clearly defined and most patients do not have a positive family history Offspring appear to be affected in only about 10% of cases and an autosomal dominant transmission with incomplete penetrance has been proposed. Keratoconus occurs with increased frequency in the following disorders.
- ***Systemic disorders*** include: Down's syndrome, Turner's syndrome, Ehlers-Danlos syndrome, Marfan's syndrome, atopy, osteogenesis imperfecta and mitral valve prolapse.
- ***Ocular associations*** include: vernal disease, retinitis pigmentosa, blue sclera, aniridia and ectopia lentis. The wearing of hard contact lenses and constant eye rubbing have also been proposed as possible predisposing factors.

Histopathologically, keratoconus shows the following:

- **Fragmentation of Bowman's layer.**
- **Thinning of the stroma and overlying epithelium.**
- **Folds and breaks in Descemet's membrane.**
- **Variable amount of diffuse scarring.**
- <u>CLINICAL FEATURES</u>
- ***Onset*** is typically between the ages of 10 and 20 years, with impaired vision in one eye caused by progressive astigmatism and myopia. The patient may

report the need for frequent changes in spectacle correction or a decreased tolerance to contact lens wear.

- ***Early signs***, can be detected by the following methods of examination:
  1. **Retinoscopy** shows an irregular 'scissor' reflex.
  2. **Keratometry** initially shows irregular astigmatism where the principal meridians are no longer 90 D apart

- 3. **Photokeratoscopy** or Placido's disc shows irregularity of the reflected ring contours.
  4. **Slitlamp biomicroscopy** shows very fine, deep, stromal, oblique striae (Vogt's lines) which disappear with external pressure on the globe. Prominent corneal nerves may also be present.

- ***Late signs*** consist of the following:
  1. Progressive central or paracentral corneal thinning, of as much as one-third of the corneal thickness. This is associated with poor visual acuity resulting from marked irregular astigmatism with steep keratometry (K) readings.
  2. Bulging of the lower lid when the patient looks down (Munson's sign).
  3. Epithelial iron deposits (Fleischer's ring) may surround the base of the cone.
  4. Central and paracentral corneal scarring in severe cases.
  5. Acute hydrops results from ruptures in Descemet's membrane and acute leakage of fluid into the corneal stroma and epithelium . This causes a sudden drop in visual acuity associated with discomfort and watering. Although the break usually heals within 6-10 weeks and the corneal oedema clears, a variable amount of stromal scarring may develop. Acute episodes are initially treated with hypertonic saline and patching or a soft bandage contact lens. In some severe cases keratoplasty may be necessary .

- **MANAGEMENT**

- 1. **Spectacle correction** in very early cases can correct regular astigmatism and very low amounts of irregular astigmatism.

- 2. **Contact lenses** provide a regular refracting surface over the cone..

- **3.cross linking.**
  4. **Penetrating keratoplasty** is indicated in patients with advanced progressive disease, especially with significant corneal scarring.