Classification of Slit Lamp Findings

A Practical Handbook for Contact Lens Fitters and Eye Care Professionals

English translation of the fifth German edition 2022,
with 313 illustrations, 26 tables and additional online material
(video tutorials, case reports, classification exercises, etc.)

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Foreword to the first English edition

I am pleased about the positive response to this book that has led to its translation into Russian, Japanese, Bulgarian and, for its current fifth edition, into English. I am delighted that Lyndon Jones has joined me in writing the foreword.
I first met Lyndon in 1999, at the congress of the German Contact Lens Association (VDC), where he was awarded the "Peter Abel Science Prize". Lyndon has since been and will continue to be a leader and model in contact lens research through his work with the Centre for Ocular Research and Education (CORE), one of the most prominent institutions in the field. I am also proud of my two former students, Alex Müntz and Hendrik Walther, PhD graduates under Lyndon's supervision, who have proofread the manuscript to the current edition. My thanks go out to them.

The present edition has been fully revised and updated. It contains new important classifications, such as meibography, supplemented with example cases and scientific background information for the eye care professional. The interactive DVD contained in editions 3 and 4 has been replaced with new, expanded online content. For example, the practice tools for classifying slit lamp findings have been developed further and adapted to specific target groups. New video tutorials covering the various techniques of examining the anterior eye segment and diagnosing tear film disorders have been created. These can be accessed online via the QR codes given in the relevant chapters of the book. The online content and the material presented in the book thus complement each other perfectly, enhancing the reader's learning experience.

Wolfgang Sickenberger

Foreword of Lyndon Jones to the first English edition

Contact lens technology moves forward at an alarmingly rapid rate, with new lens materials, solutions and designs being released almost every month. So how do eye care practitioners stay up-to-date? They have to keep reading journals for research findings, but everybody needs their "go-to" text book for those times when they need a little refresher, are studying for upcoming exams or have that patient in the exam chair that has them thinking hard about what they are looking at. This text-book is just that – the book that provides practitioners with the knowledge they need to provide their patients with the best care possible.

Wolfgang Sickenberger has put together a gem of a book that is beautifully illustrated, with over 300 illustrations or colour images of anterior segment analysis and contact lens complications, across more than 200 pages. The contents include important aspects of contemporary contact lens practice such as the use of grading scales, how to examine the tear film and lids, and slit lamp analysis of the entire anterior segment. Many examples are given of conditions that present at an initial consultation ahead of fitting contact lenses, as well as the many conditions that may arise during an aftercare or progress check. The association of dry eye disease and how that may impact successful contact lens wear is also covered in great detail. The book contains 26 summary tables that are very helpful as a ready reference and are ideal for studying for exams when a student needs lots of information in one location.

This text-book is suitable for practitioners at every stage of their career and I am delighted to see that it is now available in English. I congratulate Wolfgang on a very worthwhile endeavour to bring to life a text-book that will invaluable to the ongoing education of even the most experienced clinician.

Lyndon Jones
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Contents

A brief overview …

For purposes of clarity, we have adhered to the generally accepted sequence of an examination of the anterior eye segment:

- Tear film
- General overview, surroundings of the eye
- Eyelids and lid margins
- Conjunctiva
- Cornea
- Anterior chamber
- Iris
- Crystalline lens

The subchapter on Deposits, the Appendix with history questionnaire, glossary and case study index, and the online material supplement the contents. The structure and function of those parts of the eye relevant to contact lenses are briefly described and then presented according to the following criteria:

- What are the structure and function of the part of the eye to be examined?
- How should the slit lamp be set up?
- How are possible findings classified?
- What subjective symptoms does the contact lens wearer express?
- What objective symptoms can be expected, and how are they classified?
- How to proceed from there?

In line with our priority concern to enable learning through casework, all relevant findings presented here are illustrated with case descriptions organised according to the SOAPE method. The letters of this acronym stand for:
S: subjective findings
O: objective findings
A: assessment
P: plan
E: educate

How to use this book and the online material

For beginners, this book is a good basis for systematic learning on the subject of slit lamp findings and tear film analysis.

Expert contact lens fitters, optometrists and other eye care providers can use it to answer specific questions and expand their knowledge. For example, the relevant chapter can be found directly through the illustrations in the case description index, or specific findings can be found through the illustration index. The glossary offers a brief explanation of relevant medical terms and abbreviations as well as those relating to contact lenses.

1.3.3. Anterior eye segment findings

This chapter describes test methods that can be used for determining tear volume. This parameter is considered to be almost uninfluenced by other factors.

1.3.3.1 Tear film meniscus height

The purpose of assessing the tear meniscus is to measure the tear volume. Generally, the measurement is performed at the lower eyelid. However, it is also possible to measure at the upper eyelid, which is less prone to confounding influences from light or draught and would lead to more stable values.

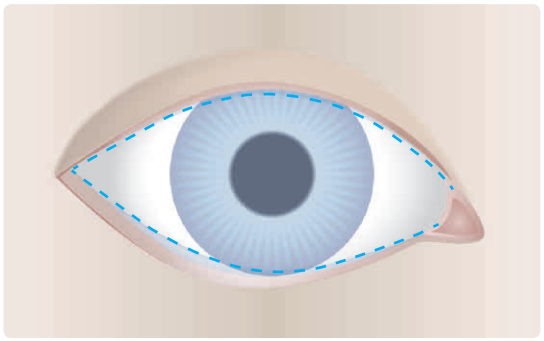


Figure 3:
Tear meniscus (schematic)

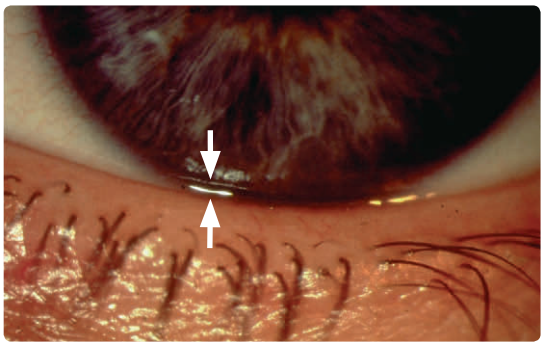


Figure 4:
Determination of tear meniscus height

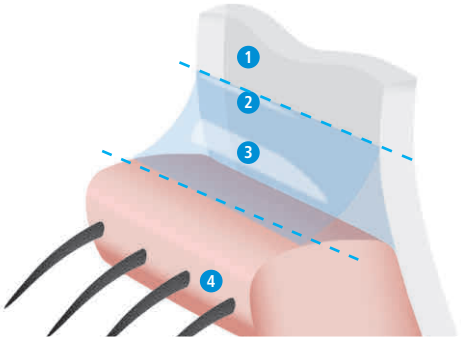


Figure 5:
Tear meniscus cross-section (schematic)

1 Cornea
2 Light reflex for measuring TM height
3 Main light reflex
4 Eyelid margin

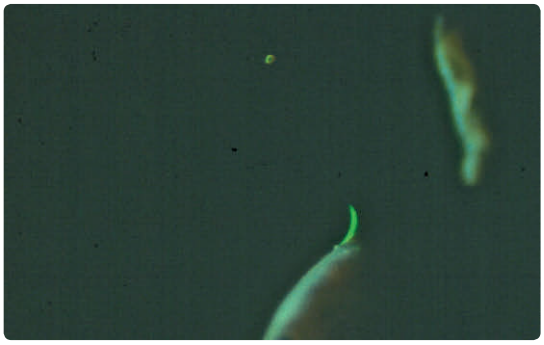


Figure 6:
Concave shape of the tear meniscus highlighted with fluorescein

Method:

Begin the examination of the anterior segment with an estimation or measurement of the tear meniscus height under low illumination. Focus a horizontally oriented slit (0.2 – 0.3 mm in width) on the lower eyelid margin and compare the height of the tear meniscus with the width of the slit (see the width ratio of the gaps between the two yellow and the two black arrows in Figure 7). The chosen slit width is approximately equal to the tear meniscus height of an asymptomatic patient. Definitions of normal tear meniscus height in the literature range between 0.3 and 0.4 mm.

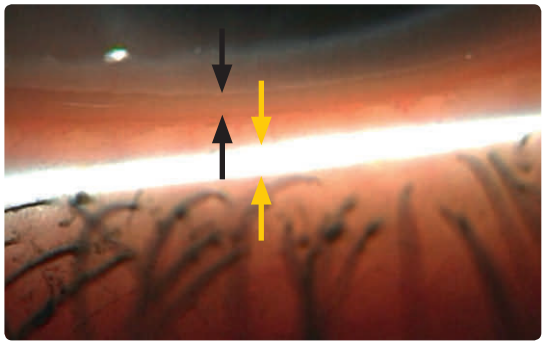


Figure 7:
Assessing the tear meniscus height with minimally invasive illumination equipment via comparison of gap widths

This is a very simple method, but provides meaningful results on tear film quantity. Visibility of the tear meniscus can be significantly improved by application of fluorescein, although this increases fluid quantity, resulting in somewhat higher measurement values.

Note also that the height of the tear meniscus changes under strong illumination. For this reason, it is advisable to assess the tear film at the beginning of an examination using weak illumination or to adopt the minimally invasive procedure (see Figure 7) without application of fluorescein.

Grading of lower tear meniscus height:

Tear meniscus	Assessment: estimation of tear meniscus height
< 0,2 mm	Insufficient quantity
0,2 mm	Threshold value
> 0,2 - 0,4 mm	Normal tear volume, sufficient quantity

Table 2:
Assessment of lower tear meniscus height

The high incidence of dry eye symptoms in recent years has prompted an intensive search for new, improved diagnostic methods. Various hardware has been development for the noninvasive analysis of the tear film.

One of these methods consists in determining tear meniscus height by multifunctional topography (e.g. Keratograph 5M, Oculus). The measurement can be performed in various places around the eyelid margin under a variety of illumination options. Instead of measuring noninvasively with infrared diodes one can also opt for ring illumination. Recent studies [7,8] show that each of these measurement options yields highly reproducible results. They are often referred to in the literature as NIKTMH (non-invasive keratograph tear meniscus height). Figure 8 below, shows a measurement under infrared illumination.

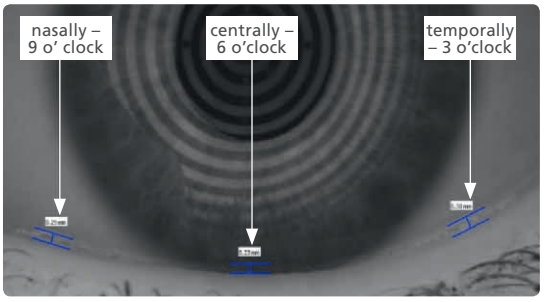
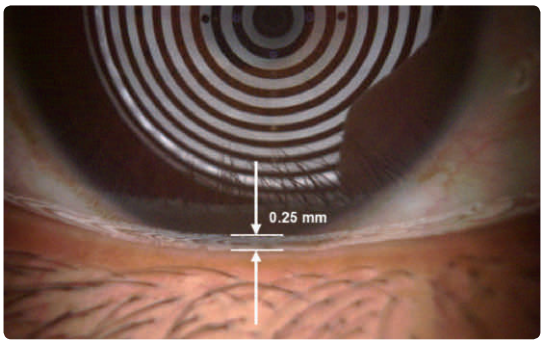


Figure 8:
Noninvasive measurement of tear meniscus height (NIKTMH) under infrared illumination

For reproducible measurements, the location of the measuring points should be in reference to the cornea, as follows. Imagining it to be the face of a clock, the vertical projections from the positions 3, 6 and 9 o'clock downward onto the lower eyelid margin define the points at which tear meniscus height is measured.

Multifunctional topographers are equipped with various illumination options and some also with several magnification options. This permits accurate measurements at different locations along the eyelid margins. The figures below show measurements of tear meniscus height under white light using these options.



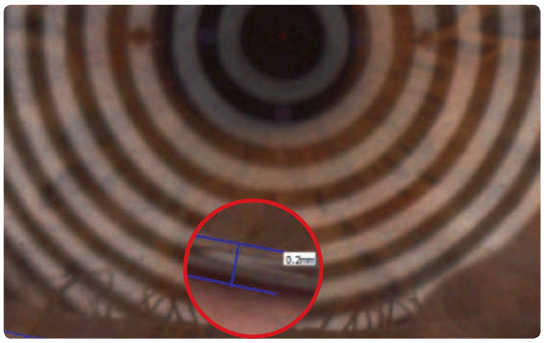
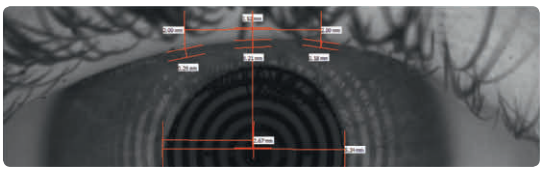


Figure 9:
Determination of tear meniscus height using a multifunctional topographer (Oculus Keratograph 5M)

Figure 10:
Determination of tear meniscus height at different locations along the lower eyelid (recommended when there are irregularities)

Studies have shown that the upper eyelid margin tear meniscus may be less prone to influence by light and wind compared to the lower eyelid. In cases when the patient was exposed to bright light or wind before the measurement, it is advisable to measure the upper tear meniscus in addition to the lower one. Averaging 0.18 mm, the upper tear meniscus is somewhat lower than the widely published mean values for the lower eyelid.



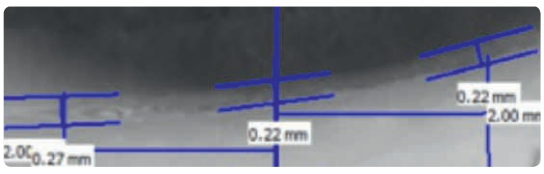


Figure 11:
Measuring the tear meniscus height along the upper eyelid margin

Figure 12:
Measuring the tear meniscus height along the lower eyelid margin

1.6.1 Example case: Dry eye disease

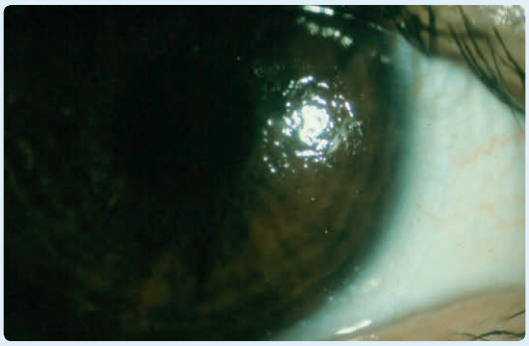


Figure 68:
oft contact lens with a dehydrated area

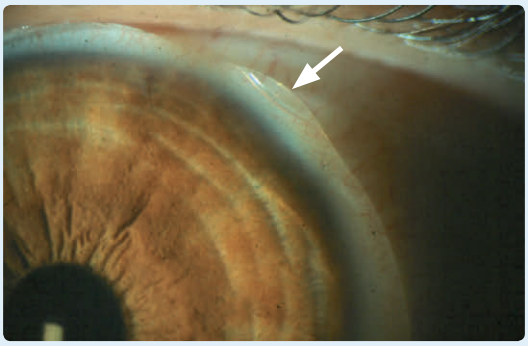


Figure 69:
Edge lift of a contact lens caused by dehydration

Subjective findings:

- Difficulty removing contact lenses
- Comfortable wearing time approx. 6 hours
- Dry sensation
- Fluctuating visual acuity
- "Halo vision" (perception of a light haze around point light sources)

Objective findings:

- Slight bulbar conjunctival redness (grade I)
- Mild superficial corneal punctate keratitis (grade I)
- Tear quantity:
  - ➲ Schirmer I: 14 mm
  - ➲ tear meniscus: 0.1 mm
  - ➲ LIPCOF: grade II
- Tear quality:
  - ➲ oily, viscous rheological behaviour
  - ➲ BUT: 14 s
  - ➲ NIBUT: 18 s, marked interference patterns

Description:

- Subject uses high-water-content conventional contact lenses with a comfortable wearing time of 6 hours.
- Highly gas permeable, rigid contact lenses were worn previously, but only allowed a short comfortable wear time. Bulbar hyperemia and 3/9 o'clock superficial punctate keratitis were also recorded.

Course of action:

- Switching to modern-type rigid contact lenses does not usually lead to success.
- Try switching to soft contact lenses with better hydration properties.
- Preservative-free rewetting solutions can be used if needed.
- Blinking exercises
- Close follow-up

4 Conjunctiva

Anatomy

The three sections of the conjunctiva – the bulbar conjunctiva (conjunctiva bulbi), the tarsal conjunctiva (conjunctiva tarsi) and the fornix – are examined as follows:

The bulbar conjunctiva around the palpebral fissure can be examined using diffuse light. Look for signs of erythema (due to hyperaemia), secretions, and swelling (chemosis) of the conjunctiva. Any degeneration, such as pinguecula or pterygium, but also pigment spots (nevi), should be documented.

The tarsal conjunctiva and the fornix can be examined by pulling down the lower lid and pulling up the upper lid. During the examination, the patient should look up and down, respectively. Often, eversion of the upper eyelid is necessary for a better assessment. Look carefully for any follicles, which can be found especially in the lower fornix, and any papillae, which often appear in the upper tarsal conjunctiva in contact lens wearers. A temporal view allows for assessment of the mucosal fold (plica semilunaris) and the caruncle. A video of a complete slit lamp examination of the conjunctiva can be found in the additional online material that accompanies this book.

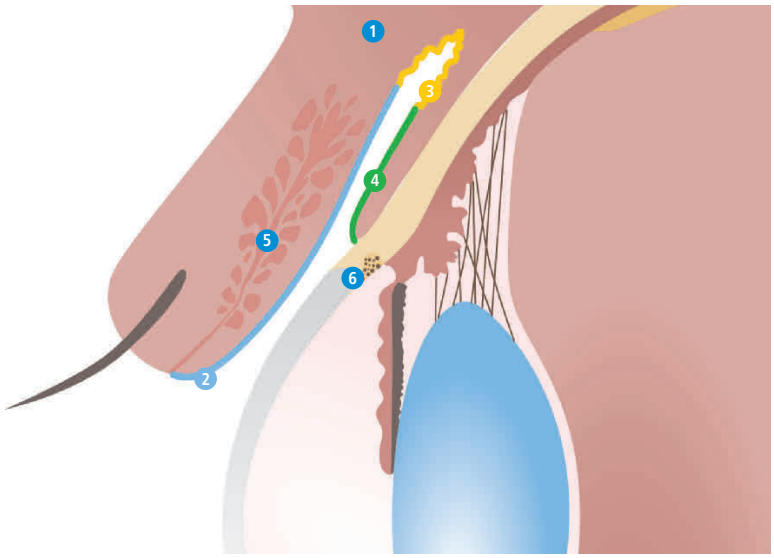


Figure 106:
Anatomy of the conjunctiva (schematic)

1. Upper eyelid
2. Tarsal conjunctiva
3. Fornix
4. Bulbar conjunctiva
5. Meibomian gland
6. Conjunctival-corneal transition (limbus)

Function

- Lubricating surface in conjunction with the tear film
- Protection against infection through secretion of an antimicrobial substance
- Ensures high mobility of the eyeball

4.1 Changes of the conjunctiva

Below we will take a closer look at reactions of the conjunctiva, such as hyperaemia, swelling, follicles, papillae, and secretions. These can offer valuable insights into the cause of possible conjunctival findings.

4.1.1 Hyperaemia of the bulbar conjunctiva

The smaller blood vessels and capillaries of the conjunctiva are often, though not exclusively, responsible for noticeable redness in conjunctivitis. Superficial conjunctival vessels are movable, and can be distinguished from deeper scleral vessels by applying gentle pressure with the finger along the lower eyelid margin. Conjunctival erythema can have many causes, including dry eyes and especially conjunctivitis.

Conjunctivitis can occur in isolation or combined with an inflammation of neighbouring structures (such as a corneal inflammation), or as the result of a systemic illness (flu, hay fever, etc.). It is generally accompanied by swelling and secretions. In more severe cases, pain and light sensitivity (photophobia) are common, which can lead to an eyelid spasm (blepharospasm). Both the amount and the content of conjunctival secretions can be valuable in determining the type of inflammation. Watery secretions often have viral causes, while thicker, purulent secretions often have bacterial causes.

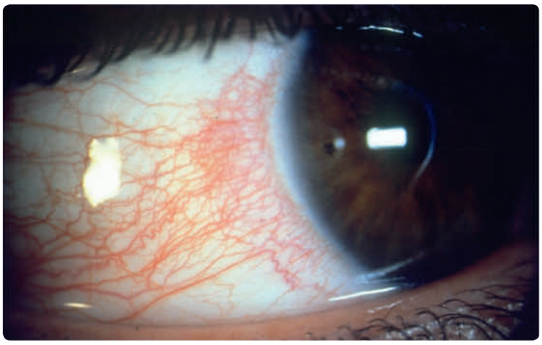


Figure 107:
Limbal and bulbar injection observable when patient looks sideways under diffuse illumination

Observation of the various conjunctival structures can be undertaken using diffuse lighting and medium magnification. Classification can be carried out using the familiar grading scales or objectively, using a multifunctional topographer (Keratograph 5M, Oculus).

Table 13: Grading of bulbar conjunctival injection

Classification of bulbar conjunctival injection				
0	**1**	**2**	**3**	**4**
No injection	Isolated injection	Mild diffuse injection	Severe local injection	Severe diffuse injection

Subjective assessment of the level of ocular redness is not always easy, even for an expert observer. Bulbar redness must be differentiated from limbal redness.
Increased hyperaemia often develops in the conjunctival vessels of the limbus. The type and location of the hyperaemia (injection) can help determine the type of inflammation or irritation.

Differentiation:

1. Conjunctival injection (moveable injection, distributed across the conjunctiva)
2. Ciliary injection (dark-coloured injection that does not move with the conjunctiva, found in cases of inflammation of deeper structures)
3. Mixed injection (conjunctival and ciliary)

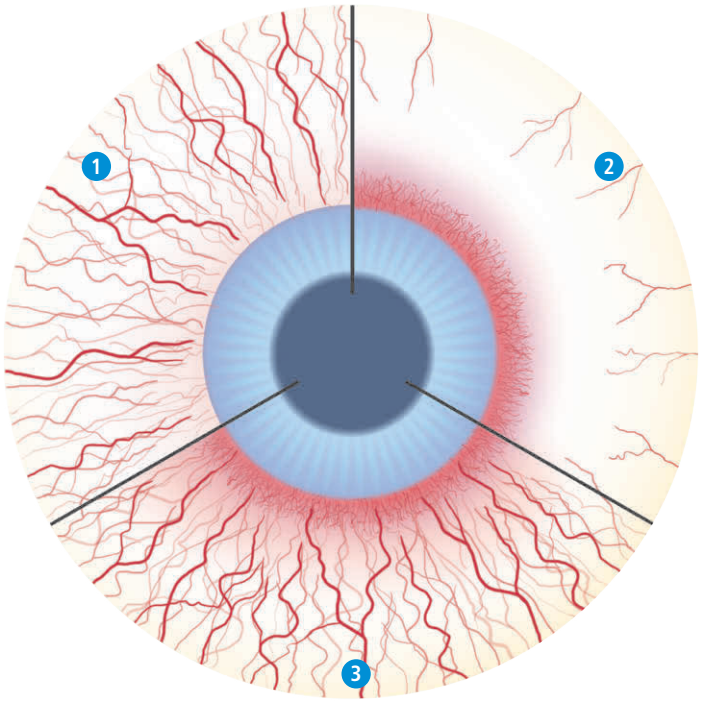
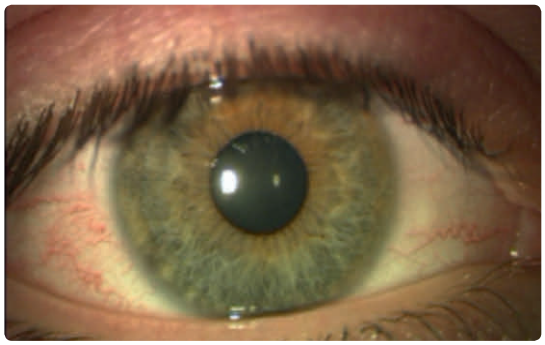


Figure 108: Overview of injection symptoms (schematic)

1. Superficial conjunctival hyperaemia
2. Deep, ciliary hyperaemia
3. Mixed injection (conjunctival and ciliary)

Assessing the four sectors (nasal, temporal, superior, inferior) separately is especially helpful for contact lens wearers. When they have dry eyes, they often exhibit nasal and temporal redness of the bulbar conjunctiva while the other regions appear normal. A first sign of hypoxia in wearers of contact lenses with low gas permeability is increased redness in the limbal conjunctiva.



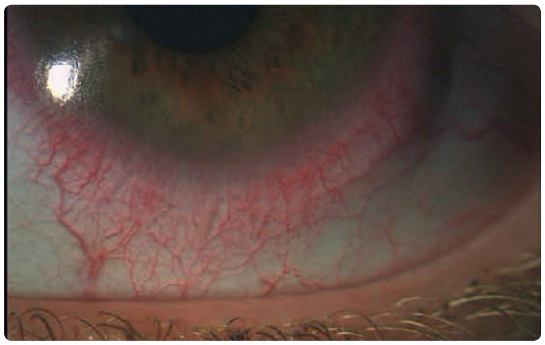


Figure 109:
Conjunctival redness as seen in primary eye position

Figure 110:
Limbal redness and vascularization inferior

It is now possible to objectively measure the level of conjunctival redness. Multifunctional topographers (Keratograph 5M, Oculus) perform this via what is called an R-scan. Using specialized recording technology and image analysis, the level of redness is measured and allocated to the corresponding nasal and temporal bulbar and limbal zones.
The resulting levels of redness have been reconciled with the subjective grading scale (Jenvis) and validated [43].

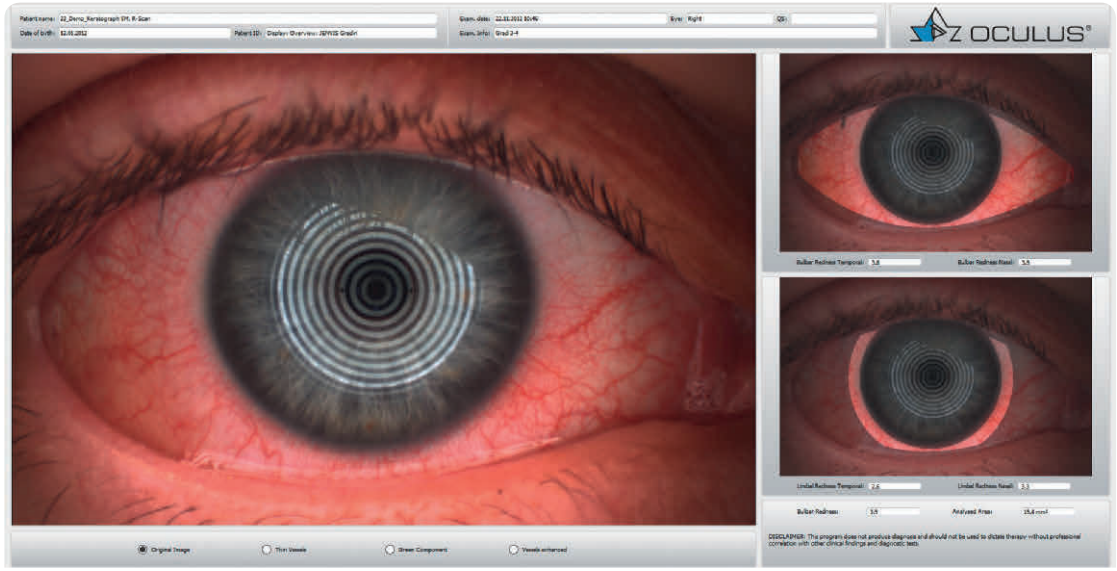
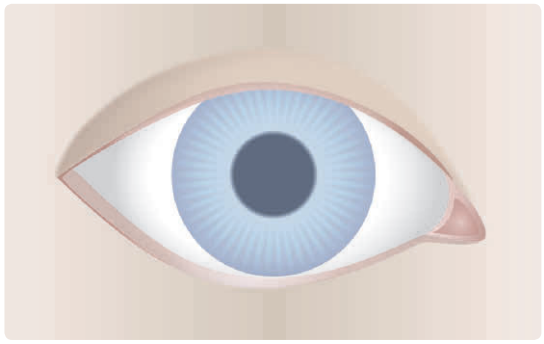


Figure 111:
R-Scan screenshot taken with a multifunctional topographer (Keratograph 5M, Oculus)



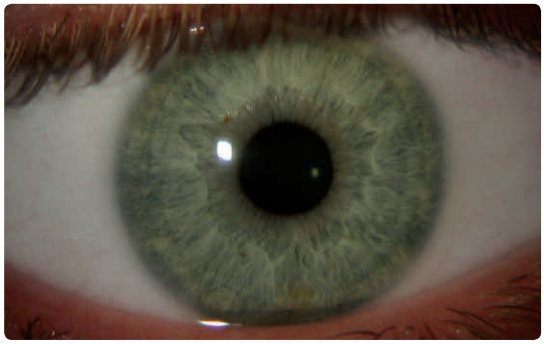
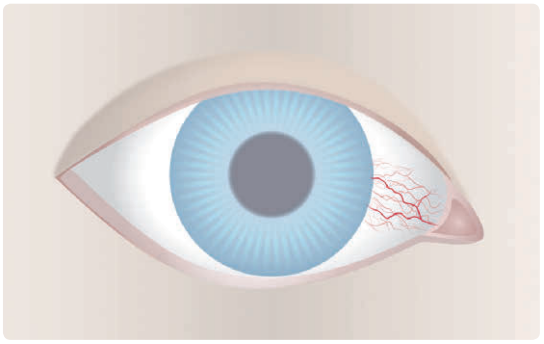


Figure 112:
Grade 0 bulbar conjunctival injection (schematic): isolated injection

Figure 113:
Bulbar conjunctival injection: Isolated injection



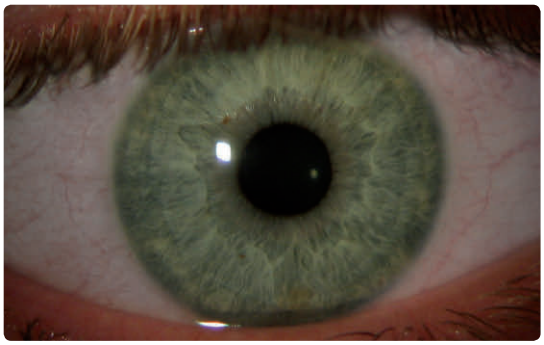
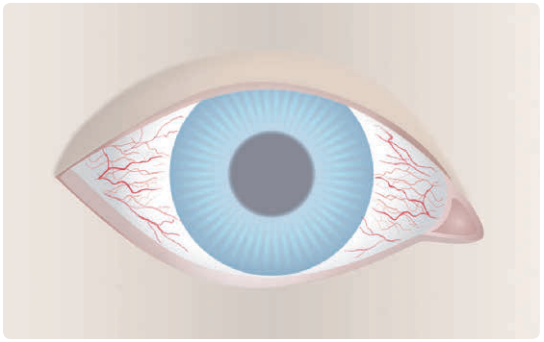


Figure 114:
Grade 1 bulbar conjunctival injection (schematic)

Figure 115:
Bulbar conjunctival injection: Mild diffuse injection



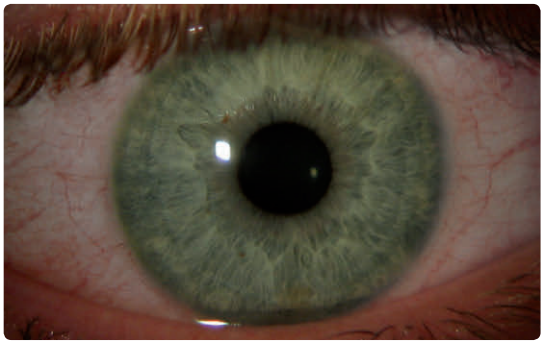
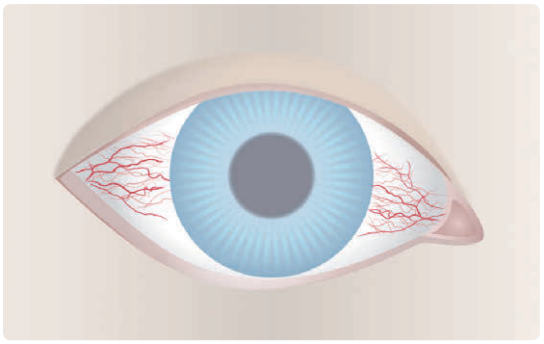


Figure 116:
Grade 2 bulbar conjunctival injection (schematic): 3/9 o'clock redness due to dryness, often associated with 3/9 o'clock superficial punctate keratitis

Figure 117:
Bulbar conjunctival injection: Severe local injection



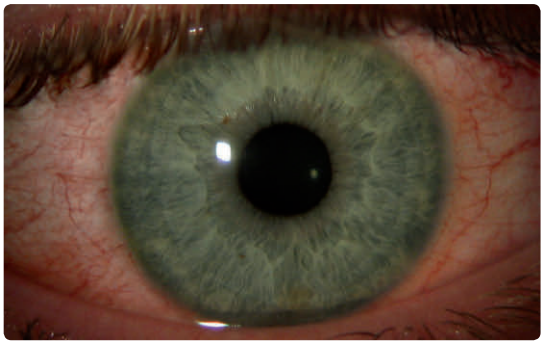
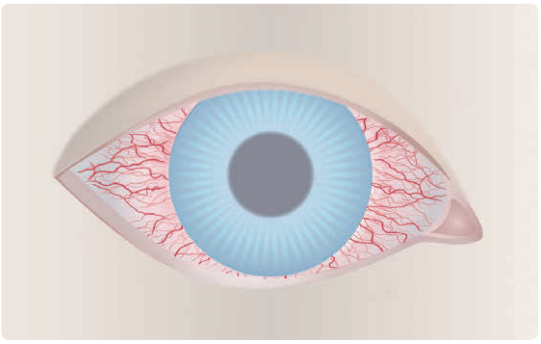


Figure 118:
Grade 3 bulbar conjunctival injection (schematic)

Figure 119:
Bulbar conjunctival injection: Severe diffuse injection



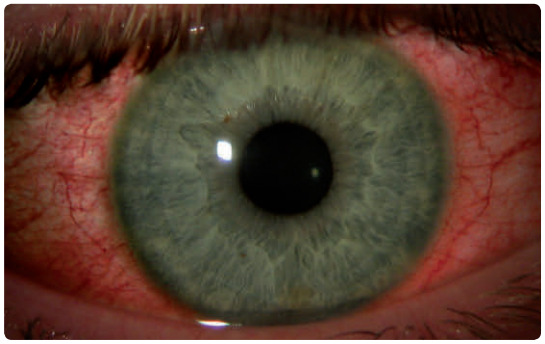


Figure 120:
Grade 4 bulbar conjunctival injection (schematic)

Figure 121:
Grade 4 bulbar conjunctival injection

The objective measurement of the level of redness is conducted using specialized imaging software that only includes thin blood vessels in its calculations. These measurements permit very good documentation of changes in redness over time, as the same area is always measured objectively using the same lighting and magnification.

Besides this objective measurement of the level of redness, you can use modern imaging techniques to assign corresponding grading scales to pathological eye findings. In addition to the automatically calculated values (Figure 111), images can also be compared to commonly used grading scales (Figure 122).

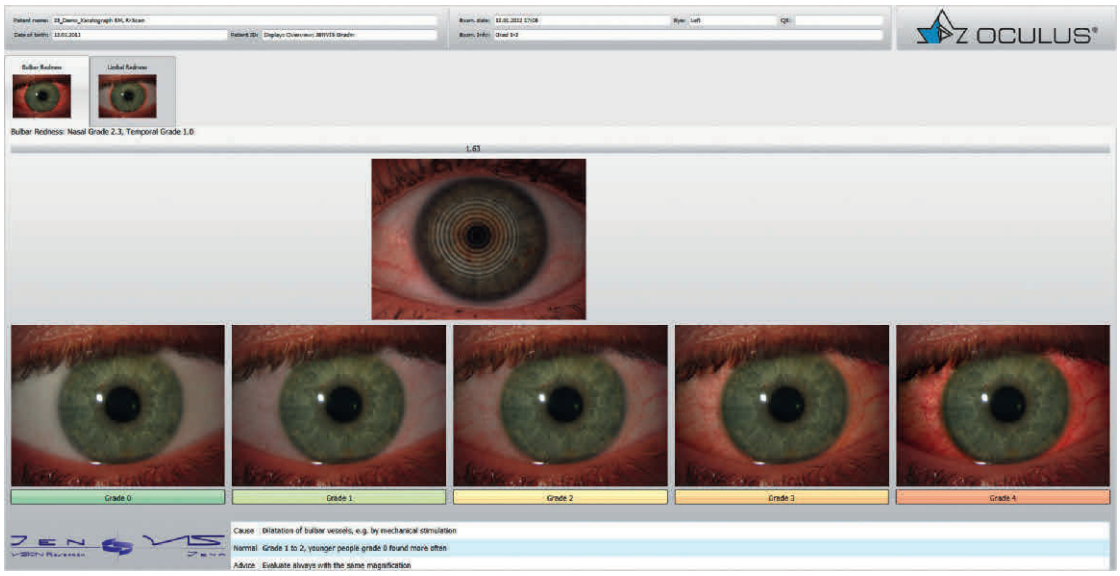


Figure 122:
Grading of redness based on video imaging (KSM, Oculus)

This imaging function also permits comparisons to other findings, such as punctate keratitis (Chapter 4.2). This enhances the communication with the patient and greatly improves documentation of findings. Particularly persons who use traditional multipurpose cleaning solutions for maintaining their contact lenses often present with both mild conjunctival redness and conjunctival punctate keratitis, which can be categorized easily using this imaging technology.

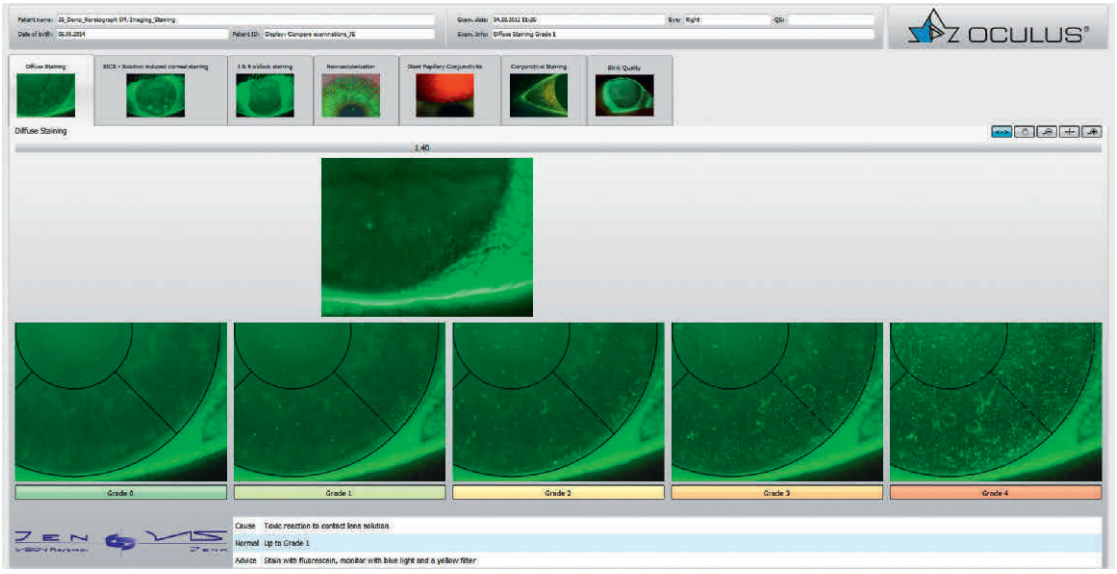


Figure 123:
Grading of corneal and conjunctival punctate keratitis based on video imaging (K5M, Oculus)

4.1.2 Conjunctiva – epithelial defects

The conjunctival epithelium consists of different location-specific types of cells and layers. The tarsal conjunctiva consists of cubic as well as cylindrical cells. Moving from the tarsal conjunctiva towards the fornix there is a further layer of cells between the upper and lower epithelial cell layer which consists of polygonal cells. In the fornix itself the conjunctiva consists of three to six cell layers. Moving from the fornix towards the limbus the number of cell layers that make up the bulbar conjunctiva grows up to twelve.

In addition to redness, the conjunctiva can be assessed using vital stains. Vital stains are used by contact lens fitters mainly in assessing the fit of rigid contact lenses by fluorescein imaging. However, it is also used in a wide variety of diagnostic procedures, where it can supply valuable information in cases of dry eye disease. The three most common dyes are fluorescein, rose bengal and lissamine green, but new ones are also coming into use. One of these is Sudan black, which is used in materials development and quality assurance for purposes such as detecting hydrophobic areas on the surface of contact lenses.

There are different approaches to assess slit lamp findings. Although a number of grading scales have been proposed for assessing epithelial defects (punctate keratitis) (Van Bijsterveld scheme, National Eye Institute/Industry Workshop Scale and the Oxford grading scheme), they are rarely used for assessing the conjunctiva in practice. This fifth edition of the present textbook introduces a classification scheme for conjunctival conditions that supplements the Jenvis grading scales. This scheme is particularly useful for assessing the tolerance of contact lenses and care products (solution-induced corneal or conjunctival punctate keratitis or staining).

Classification of conjunctival epithelial defects				
0	**1**	**2**	**3**	**4**
No defect	Isolated epithelial defects	Mild, diffuse epithelial defects	Severe epithelial defects	Large, severe epithelial defects
				

Table 14:
Classification of conjunctival epithelial defects

4.1.3 Papillae

A papilla is a polygonal protrusion of the conjunctiva with a small vascular tree at its centre. Papillae appear predominantly in the superior tarsal conjunctiva and are typical of allergic conjunctivitis. They sometimes grow together, forming giant papillae. Papillae can also occur because of bacterial conjunctivitis.

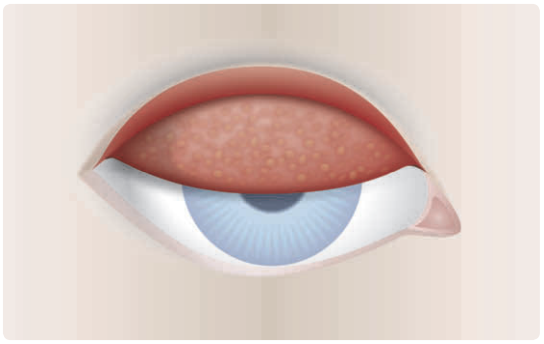


Figure 124:
Everted upper eyelid with papillae (schematic)

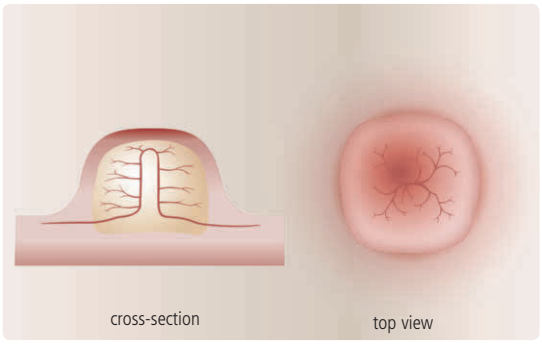


Figure 125:
Papillae with central blood vessel (schematic)

4.1.4 Follicles

Follicles are concentrations of white blood cells in the lower eyelid with no blood vessel at their centre. These tiny lymph nodes most commonly form in the inferior fornix and are often caused by viruses or toxic substances. Contact lenses are contraindicated in such cases.

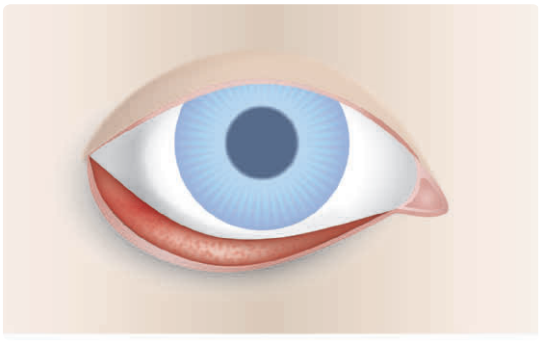


Figure 126:
Everted lower eyelid with follicles (schematic)

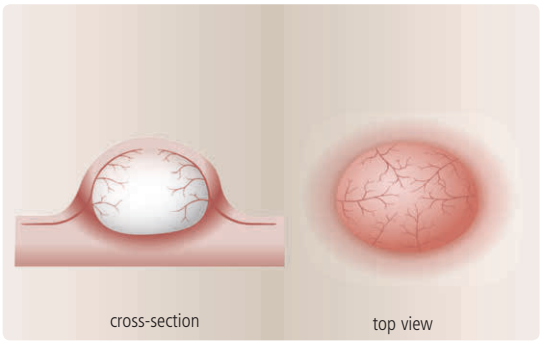


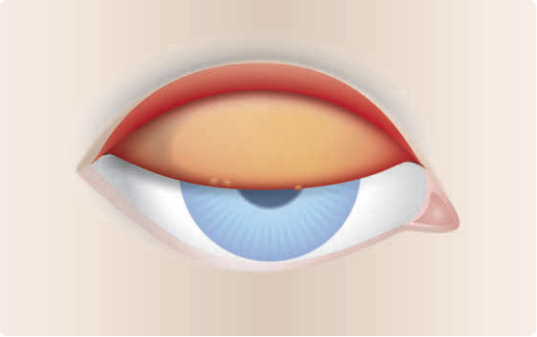
Figure 127:
Follicle with superficial blood vessels (schematic)

Classification of tarsal conjunctival injection				
0	**1**	**2**	**3**	**4**
No injection	Slight redness	Isolated injection / papillae (< 0.3 mm), few follicles	Slight diffuse injection / many papillae (0.3 – 1.0 mm)	Severe injection / distinct papillae (> 1.0 mm)

Table 15:
Classification of tarsal conjunctival injection

Eversion of the eyelid:

Everting or flipping the eyelids inside out to examine the conjunctiva on the inside of the lids and the fornix of the upper and lower lids is an essential part of any thorough examination. While the inferior fornix can easily be made visible through light pressure below the lower eyelid margin, everting the upper eyelid requires practice.
Instruct the patient to look down while grasping the upper lid by the eyelashes with your index finger and thumb. Gently pull the lid forward. With the other hand, place an appropriate object, such as a cotton swab, temporally on the outside of the lid near the fornix and flip the eyelid up over this object. At the same time, lightly press the swab downward.
In grading an upper eyelid disorder, pay attention to the affected zones (see grading scale – division of tarsal conjunctiva).
A video example of this examination technique can be found via the adjoining QR code.



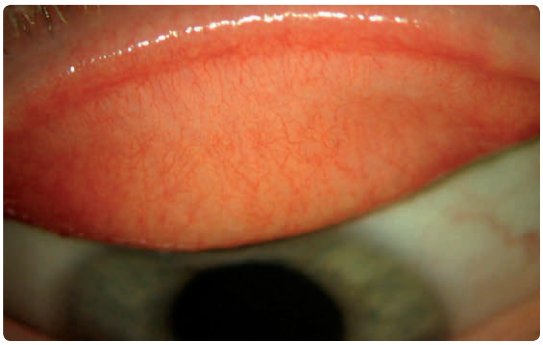
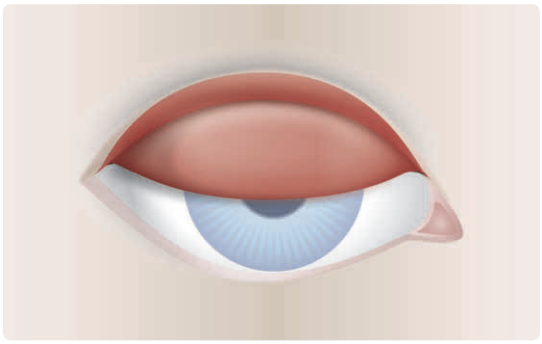


Figure 128:
Grade 0 tarsal conjunctival injection (schematic) - junctional papillae may bepresent

Figure 129:
Normal tarsal conjunctiva



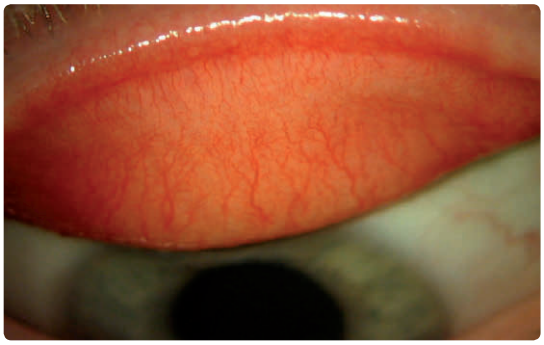


Figure 130:
Grade 1 tarsal conjunctival injection (schematic) – slight redness

Figure 131:
Slightly reddened tarsal conjunctiva

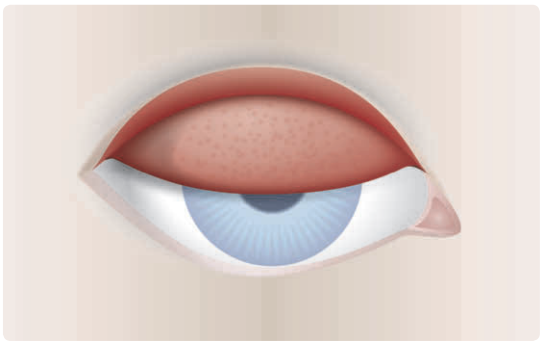
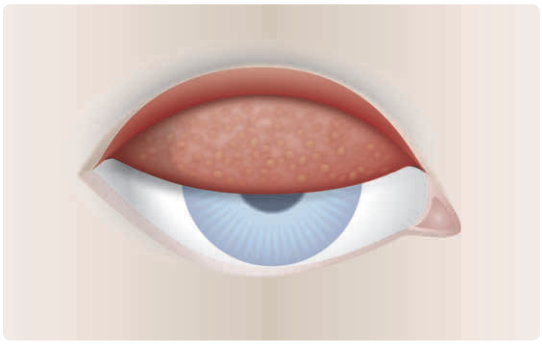


Figure 132:
Grade 2 tarsal conjunctival injection (schematic) – individual micropapillae (< 0.3 mm)

Figure 133:
Isolated tarsal conjunctival injection, many papillae < 0.3 mm, solitary follicles



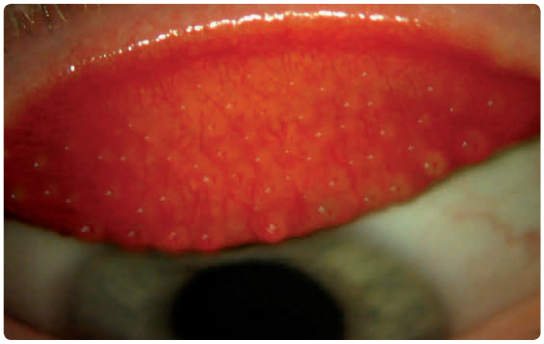


Figure 134:
Grade 3 tarsal conjunctival injection (schematic) – many macropapillae (0.3 – 1.0 mm)

Figure 135:
Mild diffuse tarsal conjunctival injection, many papillae (0.3 – 1.0 mm)

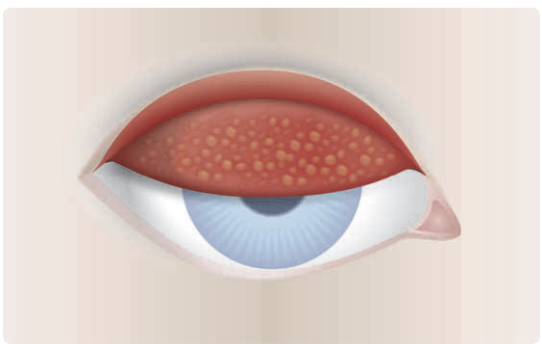


Figure 136:
Grade 4 tarsal conjunctival injection (schematic) – CLIPC, GPC (papillae > 1.0 mm)

Figure 137:
Tarsal conjunctival injection, Papillae > 1.0 mm

4.1.5 Swelling of the conjunctiva (chemosis)

Bacterial, viral or allergic conjunctivitis can lead to an accumulation of fluid under the conjunctiva, causing the conjunctiva to swell and appear translucent and oedematous. The swelling is easily visible using the optical slit in a slit lamp examination.

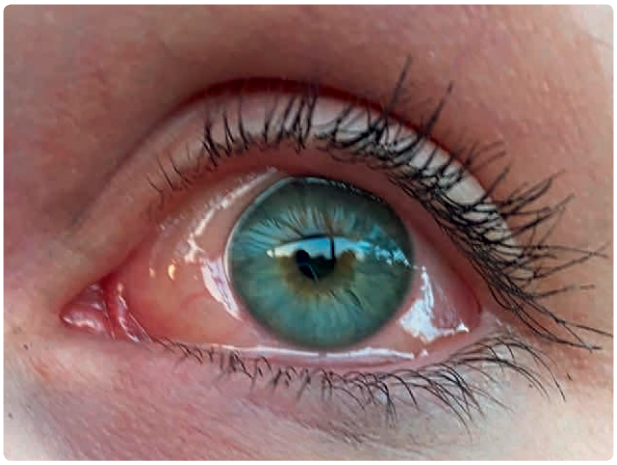
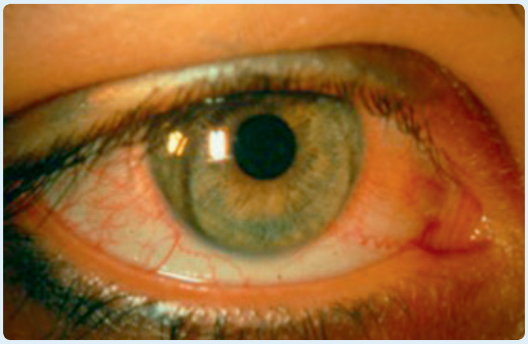


Figure 138:
Chemosis

4.1.6 Secretion

Conjunctival secretions indicate the type of inflammation. Bacterial conjunctivitis tends to be accompanied by mucoid, oedematous secretions, while viral conjunctivitis is accompanied by watery secretions.

4.2.3 Example case: Mechanically caused contact lens-induced conjunctivitis



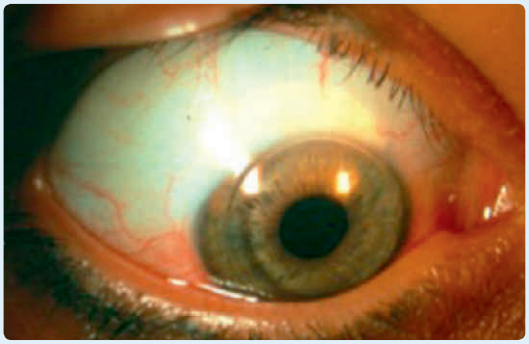


Figure 143: Grade 3 bulbar conjunctival injection

Figure 144: Asymptomatic zone of the superior conjunctiva (same eye)

Subjective findings:

- Hyperopic Patient (+8,0 dpt)
- Reduced wearing comfort
- Reduced wearing time
- Severe dryness sensation after 4 hours wearing time.

Objective findings:

- Severe local redness (nasally/temporally), often associated with 3/9 o'clock punctate keratitis (Figures 171)
- Superior conjunctiva appears normal.
- Decreased, incomplete blinking
- Inferiorly displaced contact lens

Description:

- In this particular case an inferiorly displaced contact lens has resulted in marked redness and punctate keratitis. This condition can be exacerbated by unfavourable ambient conditions as well as by a suboptimal tear film status. It is often found in patients with hyperopia. The inferiorly displaced contact lens acts as a mechanical barrier, impeding blinking and leading to drying phenomena.

Course of action:

- Optimize placement of contact lens (i.e. by using a larger lens diameter or a lens with a minus carrier)
- Blinking exercises
- Lubricating eye drops
- Re-fit with hydrophilic contact lenses with good rewetting properties