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Slit-lamp Examination

KEY POINTS

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A slit-lamp with a good range of magnification and excellent optics is essential for contact lens practice

Establishing a routine aids a thorough and comprehensive examination of all ocular tissue

Use of a fluorescin is essential to examine ocular integrity. An additional barrier filter will enhance observation

Adapting a grading system is essential for accurate and comprehensive records

The slit lamp, or biomicroscope, is probably the single most important objective instrument in contact lens practice, allowing detailed examination of the anterior segment of the eye. Slit-lamp examination is an essential aspect of pre-assessment of the potential contact lens wearer (neophyte) and in the aftercare of the existing wearer.

Guidelines from professional bodies, such as the College of Optometrists (UK), specify the contact lens practitioner must have a slit-lamp microscope.[1] The guidelines further specify that the practitioner must carry out a physical assessment of those tissues which can be affected by contact lens wear – for example, the cornea, the conjunctiva, limbus, lids and tears. The slit-lamp provides the optimum means to carry out this assessment.

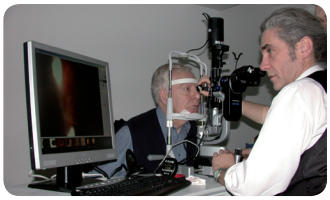

FIGURE 1 Slit-lamp with illumination system above viewing system, with image capture options

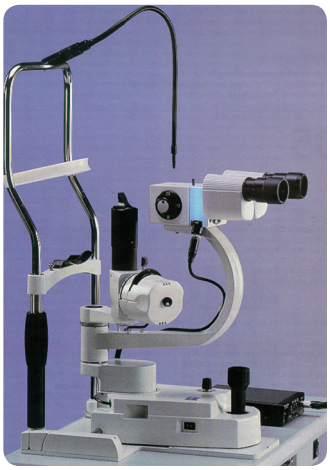

FIGURE 2 Slit lamp with illumination system below the viewing system

Slit-lamp examination of the neophyte has two purposes — to assess the suitability of the eye for contact lenses and to provide baseline data from which any changes during the course of contact lens wear can be measured. Furthermore, in the fitting process, the slit lamp has a role in assessing the physical fit of lenses in situ, rigid as well as soft. In contact lens aftercare, the slit lamp allows the practitioner to make an objective judgement of the interaction between the lens and the eye, as well as a crude assessment of lens spoilation. This instrument, then, has a role to play in all aspects of contact lens practice, and indeed routine practice in general.

Instrumentation

All major instrument manufacturers produce a range of slit lamps. While the basic principle of the biomicroscope is the same whichever model is chosen, there are several aspects to be considered in choosing a new instrument.

Slit lamps can be categorised into two broad groups — those with the illumination system above the viewing system (Figure 1) and those with the illumination below the viewing system (Figure 2). The key points to be considered in choosing a slit lamp are:

Illumination

A bright illumination system is one of the two fundamental requirements for a slit lamp. While halogen lamps are more expensive than tungsten systems, they provide a brighter, clearer light and should be the system of preference. There should also be a means of controlling the intensity of the light.

While neutral density filters allow the investigator to reduce illuminance, they are not as flexible or as fast as a rheostat. A rheostat has the added advantage of allowing instant control for the examination of the photophobic patient.

Viewing system

The second prerequisite for a slit lamp is the viewing system that provides a clear image of the eye and has sufficient magnification for the practitioner to view all structures of the eye.

Binocular viewing permits improved judgement of depth. The slit lamp should be capable of a magnification up to at least 40X. This can be achieved through interchangeable eye pieces and/or variable magnification of the slit-lamp objective.

Ideally, the practitioner should be able to change magnification easily and this gives slit lamps with four or five different objectives an advantage.

TABLE 1

Summary of structures and conditions viewed at each stage of the slit-lamp examination

ILLUMINATION	MAGNIFICATION	FILTERS	SLIT WIDTH	STRUCTURES EXAMINED	CONDITIONS EVALUTATED
Direct	Low	No	Wide	Lashes	Blepharitis
				Bulbar conjunctiva	Hyperaemia Pterygium Pingueculum
				Palpebral conjunctiva	Follicles Papillae Hyperaemia
	Medium/high	No	Wide	Lid margins	Meibomian glands Patency of tear ducts
				Contact lens	Fit
		No	Medium	Cornea Iris Contact lens	Opacities Naevus Surface quality Engravings Wetting
		Red-free		Limbus	Vascularisation
	High	No	Narrow	Cornea	Dellen Striae Folds Depth of lesions Endothelial morphology
				Tear film	Debris
	Medium/high	Blue	Medium	Cornea	Staining
				Conjunctiva	Staining
Indirect	Low	No	Medium	Cornea	Corneal opacities Central corneal clouding
	High	No	Narrow	Corneal epithelium	Microcysts Vacuoles
				Limbus	Vascularisation

Zoom systems have the added advantage of allowing the practitioner to focus on a particular structure without losing sight of it. The importance of choosing a slit lamp with a high-quality optical system cannot be over-stated.

Slit adjustment

The slit in the illumination system must be capable of adjustment. In most slit lamps adjustment is variable, which is desirable.

The practitioner should be able to adjust slit width and height easily without having to fumble for controls. It should also be possible to orient the slit horizontally, as well as vertically. More preferable still is orientation at all angles (Figure 3), especially useful with soft toric fitting and rigid alternating bifocal fitting.

In slit lamps without a graticule, the slit width should be measurable to assist in reviewing the size of any lesions observed.

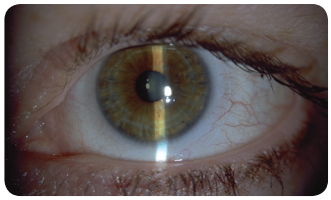

FIGURE 3a Slit beam orientation: vertical

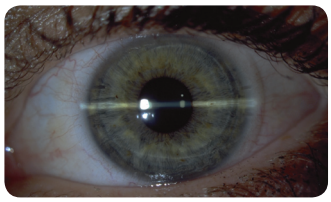

FIGURE 3b Slit beam orientation: horizontal

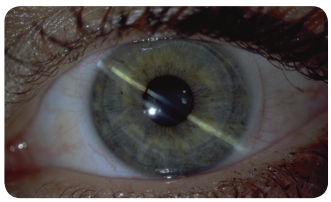

FIGURE 3c Slit beam orientation: oblique

Viewing accessories

The slit lamp must have a cobalt-blue filter for fluorescein excitation. It should also have, or have a means of adding, a barrier filter to facilitate fluorescein viewing. Many slit lamps also have a red-free filter to aid the observation of vascularisation.

Mounting and adjustments

The 'feel' of a slit lamp is personal, it should be easy to use and operate. A single joy-stick assists in this process and leaves a hand free for manipulating the eye during the examination. The slit lamp should have a locking device to hold it in position if required.

The choice of table and stand should also be considered in the selection of a particular instrument. Practitioners will benefit from the slit lamp being mounted on a 'combi' unit which can easily be moved in front of the patient to carry out the examination. Tables are also available which have a common head and chin rest for both keratometer and slit lamp.

These save the practitioner time by maintaining the patient's position between examinations with each instrument.

Additional features

Slit lamps have the facility to add on specialist attachments. These include an applanation tonometer for measurements of intraocular pressure, a 60D, 78D or 90D lens for fundus examination (Figure 1), a gonioscope for examination of the anterior chamber, a pachymeter for measurement of corneal thickness and an anaesthesiometer for corneal sensitivity.

The increased accessibility of digital photography means that, when selecting a new slit lamp, the option to have a digital camera attached should be considered.

Photography and image capture

Slit-lamp observations can be limited by the practitioner's individual memory, consistency of grading and artistic skill during record keeping.

Photography of the eye provides an alternative and accurate means of recording tissue appearance. Traditionally, the most frequently used option for image capture of the anterior segment involved the use of a photographic slit lamp with a beam splitter attached to a 35mm camera back.[2,3]

Conventional 35mm photography requires a certain level of expertise to ensure the correct exposure and unfortunately the results cannot be viewed in 'real' time. Recent advances in video cameras, image-capture boards, digital still cameras

and colour printers has resulted in an affordable alternative to 35mm photography, namely digital image capture.

To create a digital image, four basic components are required:

• A system for recording the image (for example, video camera or digital still camera)

• A system for converting the image data to a digital file (for example, image capture board)

• A system for image storage and retrieval (eg CD-Rom, hard disk)

• A system for viewing the image (SVGA monitor, quality colour printer).

The major advantage of such systems is the ability to generate instantaneous images on the computer monitor following capture. Poor quality images can be deleted with ease and further images recorded until satisfied. Image quality can often be improved by using a separate background illumination source (Figure 4). The instant nature of digital imaging has the additional advantage of supporting patient education; for example, demonstrating the benefits of disposable/frequent replacement contact lenses as well as the importance of regular aftercare.

While digital photography can be a valuable adjunct to normal record keeping, it is important that it should not replace the physical record. The quality of the image obtained is dependent on many variables, the key one of which is the exposure.

Over-exposed images will 'wash out' the eye and light any conjunctival redness, while under-exposed images will accentuate some changes to the eye. The practitioner with a digital camera needs to calibrate the instrument and design a protocol which is dependent on the instrument, as well as any ambient illumination for each type of illumination and magnification that will be used. The image captured with a digital camera is also a one-dimensional image versus the three-dimensional image seen through the viewing system. The practitioner also needs to be aware of which of the two viewing tubes is being used to split the image to the camera, particularly important when looking at high magnification images.

One further consideration in the photography of the eye is that the image plane for the camera may be different from the rest of the viewing system. The practitioner must ensure the image being photographed is in focus. This can be achieved by checking the monitor rather than just relying on the image seen through the eye pieces, again this is very much dependent on the image and the calibration.

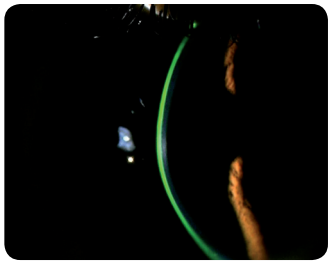

FIGURE 4a Photograph taken without background illumination

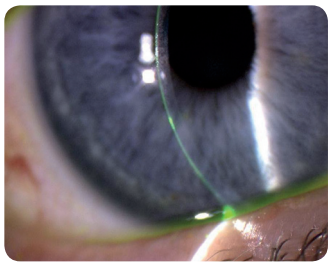

FIGURE 4b Photograph taken with background illumination

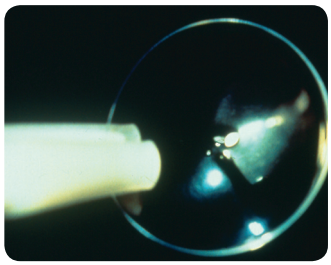

FIGURE 5 Contact lens deposits observed under dark-field illumination

Finally, a digital image is still a record which must be maintained as other records and backed up appropriately. As the image is held digitally, the practitioner needs to take into consideration data privacy laws. Further information on this form of image capture can be obtained from the literature.[4,5]

Technique

Setting up

A correct set-up of the biomicroscope is essential. The illumination and observation systems must be coupled and in focus for the observer, and the patient must be seated comfortably, with his or her chin in the rest, head firmly against the headrest and eye level at the centre of the vertical travel of the instrument. The stages needed to achieve this are:

• **Instrument focusing** – Using the focusing rod provided with the slit lamp ensures a narrow slit beam is clearly in focus through each eyepiece individually, and then binocularly, through adjustment of the interpupillary distance of the instrument. Assuming only one person is using the instrument, this procedure only needs repeating periodically

• **Patient position** – Explain to the patient the nature of the examination and ensure they are seated comfortably. This is critical. If they are uncomfortable, the examination becomes significantly more difficult. Similarly, if the eye level is not in the middle of the instrument's vertical travel, the examiner will have difficulty looking at the inferior and superior parts of the eye. Most slit-lamps have a notch on the headrest which should be lined up with the outer canthus of the eye to ensure the head position is optimal

• **Focusing check** – With the eyelids closed the examiner should focus the light on the lids and check its focus by rotating the illumination system from side to side. As it rotates, the light should remain stationary on the lid. If it is showing relative movement, the instrument is not in focus

• **Patient examination** – The examination can now begin. The

TABLE 2

Structures and lesions requiring measurement or grading

OBJECTIVE MEASUREMENT	SUBJECTIVE GRADING
Microcysts (number)	Staining
Vascularisation (size & position)	Follicles
Folds (number)	Papillae
Striae (number)	Hyperaemia
Pingueculum/pterygium (size)	Deposition
Opacities (size and position)	Tear film

slit beam should never be left shining on the eye when the practitioner is carrying out an examination. If the practitioner is looking away from the eyepieces, the beam should be turned off or directed away from the eye.

Slit-lamp routine

As with many aspects of contact lens and ocular examination, the practitioner should develop a routine which enables them to cover all aspects of the assessments in a logical and consistent manner. Slit-lamp examination of the eye comprises several different illumination techniques. These techniques are described in detail by various authors.[6,7,8,9] This article describes the clinical routine in general terms. Table 1 summarises the illuminations used and the structures and conditions viewed in each sweep of the eye.

The order of the examination will vary from one practitioner to the next. Typically, the examination will start with low magnification and diffuse illumination for general observation, with the magnification increasing and more specific illumination techniques employed to view structures in greater detail. In slit-lamp examination of the contact lens wearer, high magnification and direct illumination must be used to check for striae, folds and microcysts immediately after lens removal, as these may disappear with time.

Beyond this specific request, the practitioner should carry out the examination using the least invasive techniques first. In particular, fluorescein instillation and lid eversion should occur towards the end of the examination, after tear quality has been assessed, to avoid disruption to the tear film.

Overall view – Low magnification, wide diffuse beam

The practitioner should carry out several sweeps across the anterior segment and adnexa with a broad beam and low magnification. Starting with the lids closed, the lid margins

TABLE 3

The CCLRU grading for cornea staining[11]

TYPE	DEPTH	EXTENT OF SURFACE INVOLVEMENT
0 Absent	0 Absent	0 Absent
1 Micropunctate	1 Superficial epithelial involvement	1 1% to 15%
2 Macropunctate	2 Stromal glow present within 30 secs	2 16% to 30%
3 Coalescent macropunctate	3 Immediate localised stromal glow	3 31% to 45%
4 Patch	4 Immediate diffuse stromal glow	4 46% or greater endothelium

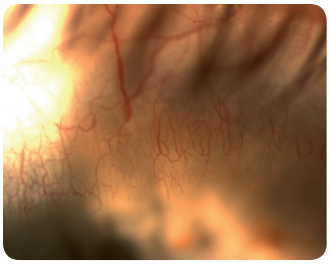

FIGURE 6 Physiological loops combined with some neovascularisation

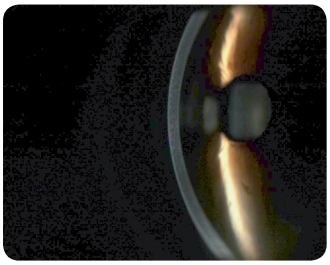

FIGURE 7 Optical section of cornea

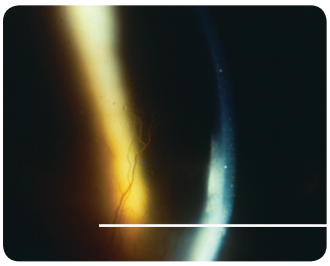

FIGURE 8 Microcysts with neovascularisation

and lashes should be examined for signs of marginal blepharitis or styes. Next, the patient should be asked to open his or her eyes, and the lid margin be examined for patency of the tear ducts and meibomian glands.

Once upper and lower margins have been examined, the practitioner should look at the bulbar conjunctiva to assess hyperaemia and the possible presence of a pingueculum or pterygium. This illumination should also be used to view the superior and inferior palpebral conjunctiva for hyperaemia, follicles and papillae.

This illumination would also be used to give an assessment of soft lens fit in terms of centration, movement and tightness. Diffuse illumination may also be used to assess lens spoilation by dark-field illumination. For this, the lens should be removed from the eye, held in the slit beam in the plane of the headrest, and viewed under magnification through the eyepieces (Figure 5). Lens spoilation cannot be effectively viewed with the lens on the eye.

Corneal and limbus examinations – Medium magnification, 2mm beam

The practitioner typically starts the corneal examination by placing the slit at the limbus and, with room lights off, observing the cornea for gross opacification or central corneal clouding produced by hard lens wear.

The viewing system needs to be uncoupled from the illumination system if the cornea is to be viewed under magnification by this means, although viewing with the naked eye may be sufficient. Once the cornea has been examined by sclerotic scatter, the illumination and viewing system must be recoupled and a series of sweeps carried out across the cornea.

The practitioner should start by moving around the limbus, looking at the limbal vasculature to assess the degree of physiological corneal vascularisation (blood vessels overlaying clear cornea) and differentiate between that and neovascularisation (new blood vessels growing into clear cornea — Figure 6).

Blood vessels are seen in both direct illumination, looking directly over the area of cornea illuminated, or indirect retroillumination, looking to the side of the illuminated cornea. A red-free (green) filter aids in the detection of vascularisation. As well as examining for blood vessels, the practitioner is also looking for peripheral infiltrates or dellen during this part of the examination.

Once the limbus has been assessed, the practitioner sweeps

TABLE 4

US FDA clinical grading

0	Normal
1	Slight or mild changes from normal that are clinically insignificant
2	Moderate changes that may require clinical intervention
3	Severe changes that usually require clinical intervention
4	Very severe changes that require intervention, often medical

across the cornea, looking for any gross abnormalities before narrowing the beam and increasing the magnification to examine the cornea in detail.

Corneal examination – High magnification, narrow beam

It is at this stage of the examination that the slit width is reduced to its minimum, allowing the practitioner to view the cornea in cross-section (Figure 7).

With high magnification, the cornea is swept systematically. A routine is essential to ensure that none of the cornea is missed. As well as looking for opacification and recording depth and location, the practitioner is also looking for microcysts, seen in retroillumination to the side of the direct beam (Figure 8), stromal striae and folds in the endothelium. During the aftercare of a soft lens wearer, this process will be the first part of the slit-lamp examination to be carried out, as signs of oedema disappear shortly after lens removal.

The final aspect of the corneal examination under white light and high magnification is observation of the endothelium. Many practitioners report this to be one of the most difficult corneal structures to examine. Even at 40X magnification, only a gross clinical judgement can be made as it is not possible to view individual cells. Furthermore, only a small area of endothelium will be seen at any one time.

The technique for viewing the endothelium involves using a slightly broadened slit beam and setting up the illumination system and microscope so the angle of incident light is equal to the angle of reflection.

The area of specular reflection is only visible monocularly. Focusing on the back of the corneal section, the endothelium comes into view as a patch with a dull gold appearance (Figure 9).[10]

More detailed assessment of cell count, size, shape and density can be carried out using a specular microscope which are becoming increasingly accessible for the practitioner in routine

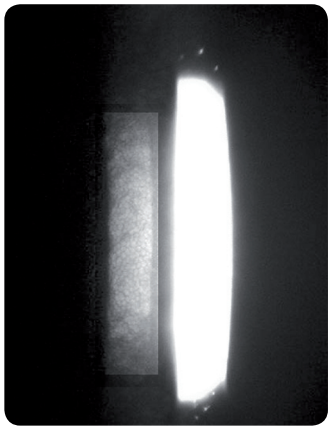

FIGURE 9 Appearance of endothelium observed at medium/high magnification (Courtesy of Haag-Streit)

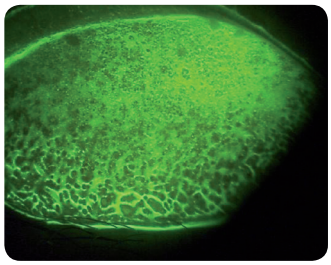

FIGURE 10 Fluorescein helps to highlight papillae

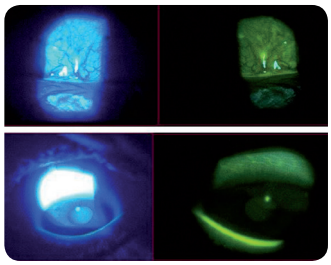

FIGURE 11 Absorption and emission characteristics of fluorescein and slit-lamp photographs taken with (right) and without (left) barrier filtersout.

practice. Modern specular microscopes give the practitioner the opportunity to both view the endothelium and calculate endothelial cell density, polymegathism and pleomorphism. In the absence of such equipment, a clinical grade is best made by comparison with a photographic grading scale, such as that published by the Cornea and Contact Lens Research Unit (CCLRU).[11]

Staining

Fluorescein

The cornea must be examined following fluorescein instillation, both prior to contact lens fitting and at every aftercare appointment. Sodium fluorescein is a vital stain which colours damaged epithelial tissue. It is the best means of judging corneal and conjunctival integrity, and in particular can highlight tissue changes such as CLPC (Figure 10). Practitioners should not shy away from using fluorescein in soft lens wearers as it will reveal changes in corneal integrity which could not otherwise be seen.

Although fluorescein also has the potential to stain hydrogel material, only the minimum amount is needed in the tear film to visualise any disruption to corneal integrity. If a fluorescein-impregnated strip is first wet with sterile saline, shaken clear of excess fluid and dabbed in the lower lid, enough will be introduced into the fornix. This will dissipate quickly to allow insertion of soft lenses within 10 minutes without risk of them being stained.

Fluorescent substances absorb light at specific wavelengths and emit the absorbed energy at longer wavelengths. Fluorescein absorbs blue light in the region of 460nm to 490nm and

TABLE 5

Lens deposit classification[12]

CLASS	HEAVINESS OF DEPOSIT
I	Clean
II	Visible under oblique light when wet using 7X magnification
III	Visible when dry without special light, unaided eye
IV	Visible when wet or dry with the unaided eye
CLASS	**TYPE OF DEPOSIT**
C	Crystalline
G	Granular
F	Filmy
P	Plaque
CLASS	**EXTENT OF DEPOSIT**
a	0-25% of lens
b	25-50% of lens
c	50-75% of lens
d	75-100% of lens

emits at a high wavelength (maximum 520nm). However, the illuminating cobalt-blue light and the emitted green light from the fluorescein must be of roughly equal intensity.

The appearance of fluorescein in the eye may be enhanced by placing a yellow barrier filter over the eyepiece. This filters the blue light to make the fluorescent green stand out more clearly (Figure 11). An assessment of corneal staining with fluorescein is essential and must be carried out at each appointment.

Lissamine green

Lissamine green is increasingly taking over from rose bengal as a the preferred stain for examination of the conjunctiva in dry-eye patients.

It stains damaged conjuctival tissue and is significantly more comfortable to the patient on installation. Staining fades quickly and so requires assessment immediately after installation. While many propose its examination under white light — where the area of staining will apprear green, others recommend the use of a red filter (Wratten No25) to enhance the viewing.[11] Lissamine green staining has higher specificity with symptomatic patients with dry-eye symptoms than fluorescien.[12]

Recording results

Of equal importance to carrying out the examination is recording the results. In law, if an action is not recorded it is deemed not to have taken place. It is not sufficient to say 'cornea clear' — the practitioner must attempt to record and quantify what is seen.

With the graticule in situ some conditions can be measured, while others have to be graded using an established system. Table 2 lists structures and lesions that can be measured and those that need grading. Grading schemes may be quantitative, for example corneal staining (Table 3), or banded according to clinical judgement as used by the US Food and Drug Administration (Table 4). There are several different grading systems available which have been validated for clinical use.

While there are advantages and disadvantages of each it is important that the practitioner sticks to the use of one system. The confidence limits on grading with a 4-5 point published system are ±1.2 grading scale units.[14]

It is not only the appearance of ocular structures that requires grading. Aspects of the contact lens must also be recorded. For example, spoilation may be classified according to Rudko (Table 5).[15]

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Summary

The slit-lamp examination is arguably the most important aspect of contact lens practice, both for judging the potential of a prospective lens wearer and monitoring the established wearer. The examination must be comprehensive and objectively recorded. The practitioner should ensure the slit lamp utilised is capable of viewing the subtle changes that may occur due to contact lens wear. ■

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