

Advice on choosing the right slit lamp

Of all the modern-day instruments available in optometry and ophthalmology, none has had such an impact on clinical practice as the slit lamp. Current slit lamps still have their basic design modelled on the original Gullstrand model, designed in 1911.

With an instrument as fundamentally important as the slit lamp, how do practitioners choose the most appropriate one for their mode of practice? This article describes the design and mechanics of the two fundamental slit lamp designs. Furthermore, basic indicators on judging the quality of the instrument will be discussed.

Design

The slit lamp biomicroscope is by far the most versatile ophthalmic instrument in the practitioner's armoury. Uses of the slit lamp range from contact lens assessment to the detection and diagnosis of ocular disease. The basic construction of a slit lamp comprises of an illumination system and an observation system. These systems are mounted on rotating arms that share a fixed centre of rotation (**Figure 1**). The principal reason they share the same centre of rotation is to allow a clear view of the slit beam with varying angles of illumination.

Over the years, two principal modifications have been made to the design of both the illumination and observation system.



Figure 1
Basic slit lamp design
(picture courtesy of Topcon)

Illumination system

With respect to the illumination system, there are two principal designs commonly referred to after their originators - the Haag-Streit type illumination and the Zeiss type system. Both work on similar optical principles, where the aim is to produce a homogeneous white slit free of any aberration.

The key difference between the two lies in the fact that the Haag-Streit illumination system can be de-coupled in the vertical meridian, whereas the Zeiss type system cannot. (**Figures 2a and 2b**)

Vertical decoupling is primarily used for gonioscopy (to avoid reflections) and during indirect ophthalmoscopy to increase peripheral field of view. However, the key advantage of the



Figure 2a
Haag-Streit type illumination



Figure 2b
Zeiss type illumination

Zeiss system is that it is more compact, lighter and, some practitioners would argue, more user-friendly. Virtually all slit lamps adopt the Vogt (Koeller) illumination principle (**Figure 3**). Using the Vogt optical arrangement, a homogeneous slit beam is produced. Notice that the filament of the halogen lamp is projected on

the projection lens (B) so avoiding disruption to the final slit beam on the ocular surface.

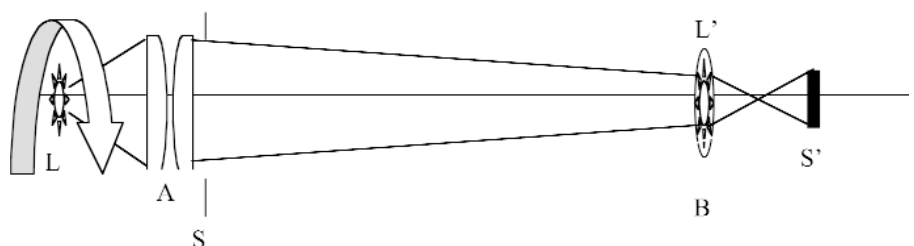
More recently, a convex mirror is placed at the radius of curvature of the light source to enable greater light transmission through the optical system. All illumination systems will comprise of the above with the addition of a series of filters such as neutral density, green and blue filters. The neutral density filters are used to control the intensity of the slit beam, whereas the green filter is used to enhance the view of blood vessels. The blue excitation filter is used to assess fluorescein staining.

The user can control the width of the slit (S) by rotating a knob, usually located at the base of the illuminating column. An intricate mechanism of cogs and levers are used to make this adjustment. Although the user will not be able to inspect these, the 'feel' of the movement and any 'play' in the system are useful indicators of the quality of the internal mechanism. It is desirable for the slit width to range from 0mm to 12mm, although some slit lamp manufacturers will only produce a minimal slit width of 0.3mm. The orientation of the slit width is controlled by rotation of the entire column in the Haag Streit type column (**Figure 3**), for the Zeiss type system rotating the prism changes the orientation of the slit.

For most slit lamps, the column or prism (in the case of the Zeiss type system) will click into place when the slit beam is orientated at 180° or 90°. This feature is useful as little concentration is required by the user and, with practice, the user will not look away from the microscope. The same also applies to the movement of the filters within the illumination column. It is desirable for filters to 'click' into place rather than have the user concentrate on accurately positioning the filter within the illumination column.

Although the intensity of the slit beam may be controlled using the neutral density filters, it

Figure 3 The Vogt (Koeller) optical set-up of slit lamp illumination system. L represents the halogen light bulb, A represents plano convex condensing lenses (to reduce chromatic aberration), B is the projecting lens, L' is the image of the light source L and S' is the slit beam



is far more desirable to have continuously variable beam intensity using a rheostat. The reasons for using a rheostat become apparent when attempting to photograph or even video the anterior ocular surface.

The type of light source is also important. Shorter wavelengths of light provide an easier view of smaller structures. This is the reason why halogen bulbs are used (which produce a bluer light) over tungsten bulbs (which produce a redder light).

Microscopes

All microscopes comprise of an objective and eyepiece, and the same applies to the slit lamp. All slit lamps have a binocular microscope. This is essential in providing a magnified, stereoscopic view of the eye. Magnifications usually range from x5 to x25 on most slit lamps, more advanced slit lamps will provide magnifications of up to x40 and specialist research-based microscope heads can be purchased that provide over x100 magnification. The magnification of a slit lamp may be provided in three ways:

- Flip-type magnification system
- Galilean rotating barrel
- Zoom

The flip-type system provides the most basic level of magnification with only two types of magnification per set of eyepieces (**Figure 4a**). The barrel-type (Galilean) magnification provides multiple steps of magnification (**Figure 4b**). Zoom magnification gives the best choice and a continuous range of magnifications for the user (**Figure 4c**). However, magnification alone is not the only factor to be considered when choosing a slit lamp. By far the most important feature of any microscope is the resolution. Most practitioners would relate this



Figure 4a Flip-type magnification



Figure 4b Galilean, rotating drum magnification

term to the 'quality' of the image. The resolution of the microscope depends on a number of factors:

- The wavelength of light used (shorter wavelengths provide higher resolution)
- The refractive index between the object of interest and the objective (the higher the better)
- The working distance (the shorter the better)
- The diameter of the objective lens (the larger the better)

The first point in the list cannot be practically implemented, as changing the wavelength of light would alter the colour of the eye being examined. Also, a higher refractive index material (such as silicone oil) between the eye (of the patient) and the objective cannot be implemented either. However, laboratory technicians and microbiologists often adopt this principle when examining detail on slide sections.

The working distance of the microscope can be reduced, however, there is a physical restriction limited by the practitioner's need to perform other operations between the microscope and the patient's eye such as lid eversion or indirect ophthalmoscopy, etc. Increasing the diameter of the objective is probably the best way to improve the resolution of the microscope and it is probably this factor (together with the optics of any other lenses within the microscope) that differentiates the different types of slit lamps. Unfortunately, using a large objective will introduce optical aberrations and so reduce the image quality. Fortunately, the use of multi-aspheric design lenses considerably reduces these aberrations. All reputable manufacturers use multi anti-reflection coating lenses within the observation system to reduce light loss.

Another important feature manufacturers often describe is the optimum degree of convergence of their microscope. Owing to the proximity of the ocular structure being viewed, there is a need for the observer's eyes to converge. The optimal convergence setting for the eyepieces range from between 10-15° (depending on the working distance of the microscope). If microscopes are designed without convergence, practitioners may complain of eyestrain. Convergent microscopes also provide greater binocular overlap.



Figure 4c Zoom magnification

Table 1 shows how to evaluate various features and aspects of the slit lamp

Slit lamp illumination system	Evaluation
Homogeneity of light source	Project a fine slit onto the focussing rod, make sure there is no divergence of the beam and illumination along the slit is even
Slit width	Adjust the width of the slit on the focussing rod. Does the width vary smoothly and is there any 'play' in the system? Is the width continuously variable from zero to maximum?
Quality of filter and slit height mechanism	It is preferable for the height and various filters to click into place. Are there green (red-free, see Figure 5), neutral density and cobalt blue filters?
Dissociation mechanism	Does the slit lamp provide vertical and horizontal dissociation?
Illumination	How is illumination varied? Are there pre-set levels of brightness or is brightness controlled using a rheostat for continuous variability?
Microscope	
Binoculars	Even practitioners have refractive errors. If you prefer not to wear spectacles or contact lenses, make sure the eyepiece can be adjusted to correct your refractive error
Convergence	First adjust the eyepiece focus with the focussing rod. View a diffusely illuminated eye and make sure you feel comfortable. Try different types of slit lamps to get an idea
Quality of the optics	Assess the overall quality of the microscope and illumination system. Set the illumination brightness and microscope magnification to maximum and produce a fine, wide slit section. Good optics and a homogeneous quality light source will together render fine details of the corneal section. At least three junctions within the cornea should be clearly defined: the epithelium, the stroma and the fine endothelial layer (see Figure 6).
Magnification	What type of magnification system is there? A x25 maximum magnification is acceptable for general practice. However, for a practitioner using the slit lamp for more intensive contact lens fitting (e.g. continuous wear lenses) higher magnification is almost certainly required to detect subtle clinical signs such as microcysts, etc
Other	
Joystick	Does the joystick provide enough movement in all x, y and z axes? Is the movement smooth or jerky? If the slit lamp is going to receive intense usage then a smooth movement is necessary so as to avoid operator fatigue and more importantly, frustration
Chin rest	Is there enough vertical adjustment? Outer canthus markers are useful for novice users
Filters	Some manufacturers provide yellow filters. Dedicated filters are preferred as they can be easily fixed onto the front of the microscope objective. Yellow filters remove excess blue light enhancing the contrast of any areas of fluorescence (see Figure 7)
Accessories	Can the slit lamp be used with other attachments, i.e. Goldmann? Is there fixation device or occluder

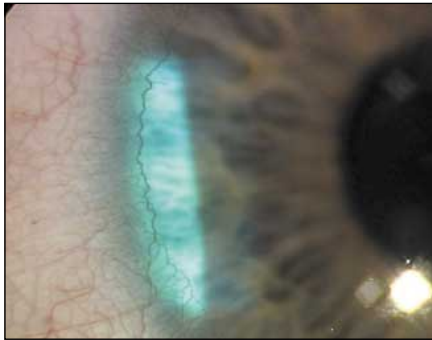


Figure 5
Red-free filters are useful for viewing the blood vessels. The filter increases the contrast of the red vessels against the background (captured using Topcon SL-8Z zoom slit lamp with 3-chip camera)

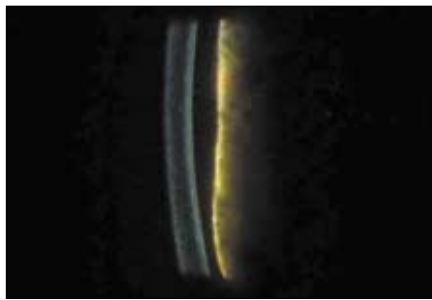
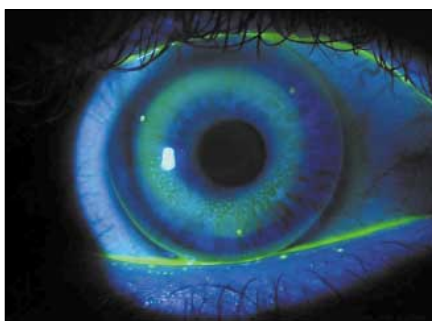


Figure 6
Slit section captured using Topcon SL-8Z zoom slit lamp (x30). The epithelium, stroma and endothelium junctions can easily be seen



Ophthalmic imaging compatibility

All slit lamps can to some degree capture digitised pictures of the anterior eye. Two factors are important in producing a good quality image: one, have as much light as possible being guided towards the camera; and two, have a camera that is capable of imaging an object with minimum levels of light. Combined, these two factors produce a system that is both highly sensitive to light and efficient (as there is little light loss). There are generally two methods of capturing a slit lamp image:

- Insert a camera system in place of the eyepiece. This usually requires a lens system adapter to be made for the camera. A commercial example of such a system is available from most manufacturers
- Have a beam splitter that guides the image to a camera

The advantage of an eyepiece fixed camera system is that it can be used on all slit lamps. Furthermore, all the light entering the eyepiece reaches the camera, i.e. there is little or no light loss. However, the user is restricted to using only a single eyepiece for examination. It also means that setting up the system requires the user to remove the existing eyepiece and attach the camera. Accidental damage to the camera is more likely with this type of set-up. Eyepiece attachment systems are the cheapest and the most cost-effective systems. They are also more suitable for an infrequent user.

Having a beam splitter (usually placed between the microscope and the eyepiece) is a much less cumbersome way of photographing the anterior eye. Beam splitters are effectively semi-silvered mirrors. Beam splitters partially reflect and also partially transmit light reaching its surface. The most common types of beam splitters used are 70/30 or 100% reflectance. This means that for the 70/30 beam splitter, 70% of light is reflected to the camera and 30% transmitted to the observer (via the eyepieces). The key advantage of this type of system is that it requires no setting up and looks far more professional. More recently, manufacturers have introduced small lipstick-sized cameras to further

miniaturise the system.

If a beam splitter type construction is preferred, then the reader is advised to ask the manufacturer if a beam splitter device and camera is compatible with the slit lamp of your choice. Care needs to be taken, as all imaging systems are not the same. The quality of captured images depends not only on the slit lamp optics but the camera and the image grabber board inside the computer. The image grabber board is responsible for converting the analogue camera signal to a digital signal that the computer can recognise. True digital systems are available and with a high resolution camera the results can be quite spectacular, however, such cameras can be very costly.

Table 2:
Desired features of a slit lamp for digital anterior eye imaging

Slit lamp characteristics	Basic capture	High quality imaging
Magnification	Flip-type or barrel-type	Zoom or barrel-type
Illumination	Step change intensity	Rheostat light control. Some manufacturers also provide slit lamp flash system to increase the light intensity momentarily during capture

Summary

The slit lamp remains a very important instrument in optometric practice. Selecting a suitable slit lamp depends on the practitioner's understanding of instrument mechanics and his/her type of usage. For example, a practitioner performing gonioscopy is more likely to choose a vertical illumination column (Figure 2a).

The present article has described the mechanics of the two fundamental designs of slit lamps and has described basic tests practitioners may perform to evaluate the quality and construction. Furthermore, the present article has also informed the practitioner of features required of slit lamps for specific optometric applications.

About the author

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Reading references

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