A Clinical Short Primer

Slit Lamp Imaging & Documentation
The informative power of the recorded image cannot be equaled by even the most ardent description. Unlike words, and their interpretation, the slit lamp image is a neutral constant; a benchmark reference frozen in time. It becomes the quintessentially unbiased witness to the condition at the moment of capture.

As the slit lamp represents one of the single most important tools in eye care, images recorded of observed conditions become equally valuable. Their immediate utility is obvious as a means of closely following the patient’s condition, or immediate transmittal for consultation. For teaching, the captured image is without peer in conveying subtle information in context. The ability to transmit images worldwide serves to enrich the study of the eye and the search for solutions to its problems.

Today’s slit lamp is derived of a host of brilliant minds and boasts a rich history of evolution now verging on the century mark. It is a facile instrument of great ability. On this platform, slit lamp imaging has also attained an unprecedented plateau of relative simplicity. With electronic imaging, slit lamp photography is no longer the daunting task of a few years ago. Immediate review of captured images prompt necessary adjustments in exposure, composition and content. The prospect of failure to record essential information is no longer a concern following the patient’s departure until the film is processed.

Never have more reasons existed for digital slit lamp imaging: High-resolution cameras reproduce the fine detail seen during an examination; Longitudinal studies are much easier to conduct; Identification and storage of images are simple operations, and retrieval is nearly instantaneous over customizable networks; The ability to transmit images worldwide serves to enrich the study of the eye and the search for solutions to its problems; For certain conditions, where progression or regression is measured in small increments (Figures A and B), slit lamp images make possible a definitive comparison, contributing significantly to the enhancement of patient care.

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**Figure A** – Trans-corneal foreign-body track with focal posterior corneal edema.

**Figure B** – Iris transillumination defects in pigment dispersion syndrome.
Slit Lamp Imaging: Getting the Best Picture

By Steve Thomson

Introduction

For almost 100 years the slit lamp has been used clinically primarily as a device that allows the user to observe the transparent structures of the eye. In addition it can provide a magnified, stereoscopic view of almost the entire eye. The recording of the image observed through the slit lamp was first introduced over forty years ago but these analogue photo slit lamps were usually the domain of the professional ophthalmic photographer. The recent digital revolution has seen a switch from conventional film to digital media and has increased the availability and affordability of slit lamp imaging.

As a clinical instrument the slit lamp comprises a biomicroscope and slit illuminator. The biomicroscope produces a three-dimensional image of the eye and the view is aided generally by focused light from the illuminator column. The depth of field observed with the slit lamp is relatively small thus requiring efficient optics that have the ability to transmit low levels of light. In use, and to compensate for this shallow plane of focus, users tend to scan the image where their own visual system compensates. Light efficient optics help to enhance this perception. Further enhancement is perceived due to stereopsis. When an image is acquired it is only a brief moment of this examination that is captured in two dimensions. This is the main reason why slit lamp images can be disappointing when compared to the slit lamp view. Learning to view the image monocularly prior to capture, through the ocular to which the camera is attached will help achieve better focus and improved composition.

If your images seem consistently out of focus check the focus by compensating your refractive error in the eyepiece lens. This ensures that the plane of focus of your retina is at the same level as the camera sensor. This is best achieved by using an eyepiece that contains a reticle but can also be checked by using a focus check rod and a very narrow slit.

One of the important factors that limit the quality of images is the amount of light made available for the sensor to record. This is far more important than the number of individual pixels that comprise the image sensor (cf. Sensitivity vs. Resolution in next section).

Equipment

From the outside, most slit lamps look similar with the only apparent difference being perhaps the upright illumination tower. Many of the more subtle differences are not visible from the outside but can only be appreciated when a greater understanding of the instruments is obtained.

Light is the main factor in imaging and it stands to reason that a slit lamp that has wider, more light efficient optics may be superior to a device with lower aperture optics. This is important as to create the captured image only a portion of the light energy reflected from the eye is available to the camera as this must be shared with the observer. Generally a beam splitter is used for this purpose and for most arrangements a device that sends 70% of light to the camera and 30% to the observer in the best configuration. Ideally, a beam splitter that can be switched in and out combined with an aperture control that can be used to control depth of field and/or image exposure provides best image capture control and quality.

There are many complete slit lamp imaging systems available and all can produce images of reasonable quality. The latest cameras from Haag-Streit, namely the IM 900 and CM 900, have a unique method of controlling the exposure from a convenient remote. Furthermore on capturing an image the previous 30 frames are also recorded and therefore any micro-saccadic eye movements or blinks do not affect the image and the perfect image can be captured each time. This feature is especially helpful when imaging the retina or when attempting higher magnification images.

There are numerous cameras that can be fitted to most current slit lamps and generally they can be a video source that is then digitized via computer or more commonly now, digital video. Digital video cameras are cost effective as no expensive computer hardware is required, however all require some form of driver software and computer hardware.

Camera Integration

The relatively low upfront cost attracts many users to use point-and-shoot consumer cameras with differing levels of success, but choosing the correct camera can be difficult and learning how to use it best on the slit lamp can be time consuming. The introduction of a third optical arrangement, the integrated camera lens system, increases the difficulty of getting good, consistent results.

Most affordable cameras cannot faithfully record the image we observe through the slit lamp as there is a significant difference in the dynamics of recording the information. Clinically we can easily visualize detail in the bright slit and darker surrounding regions with the benefit of our complex visual system. Camera sensors, however, do not yet have the same ability to distinguish areas of wide luminance change that we can observe.

Sensitivity vs. Resolution

The camera sensor plays an important role in the image quality. In recent years great progress has been made in terms of sensitivity and resolution. A common misconception is that the higher the number of pixels, the better the image outcome. This statement may hold some truth if we were imaging low contrast, evenly illuminated subjects in bright conditions using a relatively small aperture lens system. In reality when imaging the eye we have the opposite situation and any digital camera will have problems deciding on the level of exposure. Slit illumination produces a high contrast subject that is partially illuminated and our area of interest can vary between dark or brightly illuminated portions. Furthermore both patient tolerance and international regulations limit the level of light that can be used. This means that a camera with increased sensitivity – an ability to more efficiently record the light photons – is likely to produce a better image than a camera that has lower sensitivity. The efficiency of the camera sensor is generally related to the individual pixel size and therefore it is likely that if two sensors of equal resolution (number of pixels) are compared, the sensor with the larger pixels will reproduce the subject more faithfully. In practice for slit lamp imaging, this means that unless an auxiliary flash system is used, the best solution is a compromise between the individual pixel size and the total number of pixels on the sensor.
Background Illumination

The dynamic range of some cameras is improving, but to help produce a more realistic looking image, and to provide some extra light energy to the sensor, a background, or fill illumination light source can significantly improve image quality. Background illumination is generally delivered to the eye as diffuse light from a small exit source to minimize reflections. This light is normally variable by means of an aperture control and this variation assists in creating the required balance between slit illumination and background detail.

Creating the correct balance between the background illumination and slit illumination is important. Too much background light saturates the slit image, whereas too little will improve the slit image but the user may find it difficult to orientate in the otherwise dim image.

### 3. Illumination Techniques

#### 1. Overview Image

The overview image is generally used to set the scene. In normal practice several images may be required to record faithfully the state of the eye and a simple, low magnification image can be used to orientate the viewers of an image series. Fitting a diffuser to the slit illuminator and opening the slit to the widest beam will produce an image that has balance and shows good detail. If the slit lamp is used close to the optical axis, the image may lack detail as in this position the lighting will flatten some features in the subject.

*Figures 1 and 1a*

**Pearl**

If the angle between the illumination and slit lamp objective is increased to around 45 degrees, detail will be enhanced, however, one side of the image will appear dark. Using a second source at 90 degrees to the primary light source will reduce this effect and improve the image.

Using low magnification ensures that a good depth of field is achieved and that with some slit lamps, cornea, iris and a portion of conjunctiva and sclera will appear in focus.

#### 2. Narrow Slit Image — Optical Section

None of the structures in the eye are absolutely transparent and it is this fact that allows us to view them with the slit lamp. A normal window, much like a cornea, looks clear in diffuse light. However, when a narrow beam of intense illumination is introduced at a wide angle to the viewing angle then detail can be observed in the illuminated section. In slit lamp biomicroscopy this is often referred to as an optical section as in the cornea and lens it can look similar to a thin slice through the semi-transparent media.

Creating an image of an optical section can be a challenge for some imaging systems. This is because only a relatively small amount of light energy is projected into the eye via the slit. The optical effect can only be observed if the slit width is less than 0.2mm and therefore either very large amounts of energy such as a flash from a photo slit lamp or a highly sensitive camera sensor is required. The first step in creating this image is therefore to turn the flash or lamp energy up to maximum and reducing the slit width to around 0.2mm.

In addition to the optical section the narrow slit can also be used to measure the relative thickness of the cornea, demonstrate anterior chamber depth and define surface topography.

*Figures 2 and 2a*

**Pearl**

The optical section cannot be observed unless the angle between the incident light and reflected light is large. In the cornea it is possible to achieve an angle of 90 degrees at which the whole corneal section will appear in focus. The maximum angle in the lens is around 45 – 50 degrees and this can be improved with patent dilatation. The maximum detail will be visualized when no fill light is used. However, in some situations a small amount of diffuse light is required to orientate the viewer.

If the slit lamp has an aperture control it is likely that this will have to be at the widest setting for optical section imaging. The magnification of the slit lamp should also be considered. With each increase in power, the depth of field decreases and the effective aperture of the instrument increases and limits the light further. If low light levels are compromising the quality of the image then using a lower magnification may help.

#### 3. Wide Slit Beam Imaging

Using a moderate slit width of between 1 – 2mm one can demonstrate separation between corneal layers and, much like a spot light, can be used to highlight pathology. A wide beam of 4 – 8mm projected tangentially across the eye can be extremely effective lighting for some very subtle pathology. The wide angle enhances surface texture and the relatively high light levels allow high magnification and reduced apertures in most systems.

*Figures 3 and 3a*

**Pearl**

Generally in tangentially illuminated images no fill light is used, when a moderate slit width is used a small amount of fill can be used to help orientate the image. Be aware that the larger patch of light may introduce larger reflections or artifacts that can be managed by altering the angle of the light tower, microscope or even the eye.

#### 4. Indirect illumination

Indirect illumination can be used to enhance detail in the semi-transparent media of the eye such as the cornea. Very subtle details can be visualized using light reflected from other surfaces within the eye, as it would otherwise be saturated by direct focal illumination.

In normal use the slit and microscope have a common point of focus. When attempting indirect illumination the slit is defocused from this point and directed towards the reflecting tissue. The degree of defocus and the background of the subject can have a large effect on the image that is produced.

*Figures 4 and 4a*

**Pearl**

Many corneal irregularities can be imaged by using a technique of scleral scatter as a form of indirect illumination. When a 3 – 4 mm wide beam is fully decentered and directed towards the corneal limbus, the energy reflected from the sclera is returned into the cornea and by total internal reflection is distributed through the whole cornea.

#### 5. Retro-Illumination

Retro-illumination is a type of indirect lighting that uses the retina to reflect the energy from the slit illuminator. Abnormalities in the media of the eye can then be observed as this reflected light is either refracted or absorbed by the defect. Iris atrophy and similar defects can also be visualized by retro-illumination.

For retro-illumination of the lens and cornea the pupil should be dilated, as the light energy has to...
get in and out of the eye on a different path. With most systems a pupil diameter of at least 4mm will be required but generally the wider the pupil the better the image. The slit lamp should then be arranged so that the slit illumination and the microscope objective to which the camera is attached are aligned coaxially. The red reflex should be visible to the coaxial reflex will compromise the view. Defocusing the slit to the edge of the pupil will move the central reflex and improve the image. Small movements of the slit illuminator can be used to optimize the image brightness and this is best observed monocularly. The three steps to produce good retro images are (i) Set the slit for coaxial illumination to visualize the red reflex (ii) Defocus the slit to remove central reflex (iii) Fine tune the slit (size, width, position) to obtain good reflex with minimal artifact.

**Figures 5 and 5a**

**Pearl**

Ideally the size and shape of the slit should be adjusted so that the white reflex is minimized and the red retro reflex is bright and even. In some pigmented eyes, through small pupils or where a brighter retinal reflex is required, the patient’s fixation can be positioned slightly nasally. This will direct the illumination towards the optic nerve head where the lamina cribrosa will significantly intensify the reflected light. When attempting to retro illuminate the iris the slit need not be defocused as the pupil is used for the incident light. Care should be taken to make the light patch slightly smaller than the pupil and thus avoid causing reflections from the iris that may in turn produce a reduction in image contrast. Again a 3–4mm pupil is required to get sufficient light into the eye and therefore a partially dilated pupil will help.

**6. Fluorescence Imaging**

Sodium Fluorescein has a number of uses in Ophthalmology and it is frequently used with the aid of a slit lamp to visualize regions where the corneal epithelium has become eroded or damaged. A further application of topically applied fluorescein is to mix with the tear film to facilitate tonometry, assess the tear film break up time, and improve the fitting of contact lenses. A small amount of sodium fluorescein is sufficient to temporarily stain damaged epithelial cells and deep epithelialized regions of the corneal surface. The dilute sodium fluorescein (orange) will give off energy at a higher wavelength (yellow – green) when stimulated by an exciter (blue) light source. Thus by using the cobalt blue filter built into most slit lamps, the biomicroscope can be used to observe the stained tissue. It is possible to document the fluorescein stain but it should be considered that the light levels are very low and either flash or a high sensitivity camera sensor is required.

The key to obtaining good quality fluorescein images is to use only a small amount of dye and then, after a few blinks by the patient, rinse the excess from their eye using a sterile solution. Imaging performed quickly after this stage will show good detail without being over saturated by fluorescein pooled in the tears.

**Figures 6 and 6a**

**Pearl**

The slit lamp magnification should be set to 16x magnification with the slit illumination fully open. Using cobalt blue (exciter) filter in place and instrument viewing bulb full intensity will ensure that maximum light is available. Even illumination is desirable and therefore the angle of the illumination should be close to the microscope. Disturbing reflexes can be managed by slight positional changes to this arrangement. The fluorescent stain can be observed against the blue background of the cobalt blue light and this is often sufficient to provide some background or orientation information. If more detail of the stained region is required a yellow – green barrier filter can be used. This filter blocks the blue excitation light and therefore increases contrast in the areas stained with fluorescein but it will also further reduce the light level. A matched filter from the slit lamp manufacturer is best but a Kodak Wratten No. 12 is a good substitute.

**7. Retinal Imaging**

Binocular indirect ophthalmoscopy (BIO) is a routine part of the clinical examination where the slit lamp is used with a hand held condensing lens to provide a stereoscopic view of the fundus. Imaging using a lens designed for BIO is a relatively easy task providing there is knowledge of the slit lamp and an understanding of the principals involved. It should also be remembered that this examination is dynamic and that the image captured can only represent a small portion of this assessment.

When held at its correct working distance from the eye, the condensing lens produces a magnified image of the fundus approximately the same distance in front of the lens. The field size and magnification are dictated by the design of the lens and the image magnification can be further adjusted by the slit lamp magnification control.

**Figures 7 and 7a**

**Pearl**

Some clinical examinations can be carried out on undilated eyes but imaging through a small pupil is extremely difficult. In addition, observing the image binocularly can mask some reflection and artifacts and therefore it is recommended that imaging should be attempted monocularly through dilated pupils whenever possible. The use of a lens that is held in contact with the eye such as the Goldmann 3–mirror can improve image quality as reflexes can be reduced further and stability is increased. The central optical zone of the 3–mirror is used for visualization of the posterior pole and peripheral retinal can be observed via either of the two largest mirrors.

**Preparing Images for Documentation**

Routine documentation as part of the clinical exam is the main use for slit lamp images but increasingly slit lamp images are being used for publication and teaching purposes. Generally routine clinical images need no further manipulation but those images intended for wider audiences could be improved by using image-editing software.

Clinicians are obliged to treat medical images in the same confidential manner that they would with patient medical records. Furthermore significantly altering clinical images using digital manipulation is not recommended. Consequently when preparing images for other uses it is suggested that a copy of the original image is used and that the original remain unaltered.

**Summary**

Producing high quality slit lamp images can be extremely rewarding. By investing some time in practice almost everyone can improve their technique. Attempt to appreciate the different types of illumination, and observe the very subtle patterns produced by small changes in the illumination technique. Attempt to remember the differences between the clinical exam and imaging and procedure.

Finally, learning to understand the abilities or limitations of your slit lamp will tremendously improve outcome in image and diagnostic quality. For more information, please go to http://www.haag-streit-usa.com/prod/Slit-Lamps/BX900-Photo-guide2.pdf

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Digital Stereo Photography with the Photo Slit Lamp Biomicroscope

By Marshall E. Tyler

The modern slit lamp biomicroscope provides a magnified, three dimensional view of the eye. The ophthalmic photographer’s challenge is to record this three dimensional information.

The slit lamp examination produces a single mental composite image that includes height, width, and, of crucial importance – depth. The third dimension is essential to understanding certain structural relationships, without which, the examination would be considerably less informative. Similarly, stereo slit lamp photography is far more effective in describing certain conditions and relationships than the single, two dimensional image. Stereo slit lamp photography produces a permanent record that is the closest possible approximation to the view seen by the clinical examiner. For educating students, the stereo photograph can make the difference between just seeing the pathology and truly understanding the pathology.

Not surprisingly, the significant advantages of stereo photography are commensurate with the disadvantages of instrument complexity and cost, as well as the effort required to view the results.

Stereo Photo Slit Lamp Biomicroscope

Stereo slit lamp biomicrography requires dedicated instrumentation. Unlike ocular fundus photography, where stereo pairs are usually obtained in a sequential manner, the stereo photo slit lamp must capture both images simultaneously. Inadvertent movement of the subject eye amplified by high magnification (and other factors) essentially eliminates the option of sequential recording of stereo images at the slit lamp.

Stereo imaging is accomplished with either a two camera system (see the full text for this system) or a system based on a single camera using a split-frame system. Full frame systems produce larger individual images at higher resolution, as each frame utilizes the full resolving capability of the film or digital sensor used. Split-frame systems (eg: Haag-Streit BX 900®) record both left and right sides of the stereo pair on a single frame of film or digital sensor. These images contain approximately one half the resolution of full frame images. A split-frame system, however, has the advantages of greater simplicity in instrumentation and a permanently fixed, non-variable juxtaposition of its two plus lenses, two mirrors create the effect behind each of the resolution of full frame images. A split-frame system can be accomplished with either a two camera system (see the full text for this system) or a system based on a single camera utilizing a split-frame system.

The Future of Stereo Slit Lamp Imaging

The value of the three dimensional information derived from the two images of a stereo pair is truly greater than the sum of its parts. Its utility to the clinician should not be underestimated. In telemedicine, stereo images increase the diagnostic capabilities of the consulting physician. Simultaneous stereo images, taken with a fixed and reproducible stereo base, permit high-quality computer analysis. Considering the importance of this modality, it is essential for the ophthalmic photographer to master the skills required to produce consistently high quality stereo images. A complete understanding of these theories and practices will ensure the optimum imaging support in the care of the patient.

By Marshall E. Tyler, CRA, FOPS

Resources

Ophthalmic Photography books: Twin Chimney Publishing

www.TwinChimney.com

References


Bennett TJ, Stereo Anaglyph Preparation for Power-Pont, J Ophthalm Photog, Spring/2005 Vol 27:1

Stress split frame image before masking to hide fuzzy image edges which make stereo image viewing easier.
Trigger Happy

By Bill Harvey

Bill Harvey tries out the latest slit-lamp imaging system from Haag-Streit and is impressed by its novel history trigger function.

‘Just stare straight ahead. Hold it! Hold it! And…’ click! The number of times the system captures a blink or a moving eye can be quite frustrating. There is often a delay between pressing the button or foot pedal and the capture of the actual image, meaning several attempts are usually needed before the best image is obtained and selected for storage, analysis, transfer or whatever else is required. This takes up valuable time of both the practitioner and the patient. It also leads to a rapid build-up of images to be sorted through on the hard drive. However, a new imaging system includes features that make this a thing of the past.

The IM 900

The new IM 900 is an integrated camera system (Figure 1) with a 2 megapixel camera integrated into the microscope of the slit lamp. There is also a variable stop adjustment, allowing a reduced stop for higher magnification images when a bigger depth of focus is required. Image capture is either via a foot pedal or – as in the case of the system trialled recently at City University – a large button at the base of the unit to the front of the joystick. On either side of the larger capture button, which I found easier to use than a foot pedal, are two smaller buttons. During capture mode, these may be toggled to change the exposure of the image. Combined with a variable brightness backlighter, the rheostat of the slit lamp itself and the controlled aperture setting for changing depth of focus, this represents the most adaptable imaging setup I have encountered. And with just a few minutes of practice even some of the more difficult images become easily attainable.

History trigger

One push of the button or foot pedal captures the image instantaneously, something that Haag-Streit calls ‘freeze technology’. However, for all those instants where the final image is not the precise one desired, the system includes a useful feature. The previous seconds up to the point of capture are also stored. If the image seen on screen is not adequate or as good as wished, the two buttons at the side of the capture button allow the user to scroll back through preceding presentations, each click showing the image several milliseconds before.

For the blinking eye it was possible to click back three times until a view was selected that was suitable and then a second click of the capture button stored that as the definitive image.

Adaptable and easy

For sheer ease of use and adaptability I have to say that this represents the best slit-lamp image capture system I have used to date. The history trigger function is a great help and the quality of the images produced are excellent.

These include a good optic section of the cornea, either with or without backlighter. As this view requires the thinnest of beams, very often the light levels are too low for capture until the beam is widened – but then the detail of the section is lost. Not so with this system.

Similarly, a good section of the lens is possible and even the capture of the retrolental space and anterior vitreous, as if aiming to view tobacco dust. This is notoriously difficult to achieve because of the reduced light levels reflecting from behind the iris. The image shown has been enhanced by increasing the gamma setting after capture and the anterior vitreous face is just visible. Figure 2 shows another often difficult capture, the endothelium. By adjustment of the incident light it is possible to see some cellular shape detail. Figures 2 to 7 show a variety of images taken during our session.

For sheer use and adaptability I have to say that this represents the best slit-lamp image capture system I have used to date.

I was also able to try image capture when using a fundus viewing lens. The patient shown has significant myopic degeneration and an area of choriretinal scarring may be seen on screen. This was especially useful, not only to show to the patient, but also to show to the students to check that what they had seen with their examination tallied.

Reprinted with permission of Optician and author, Bill Harvey. The original article appeared in Optician April 13, 2007.
Mr. R, a 39-year-old male, presented on June 3, 2006, with a red, painful Left eye. He reported a foreign body sensation following an accident at work. He is employed as a quarryman and had been blasting and cutting rocks. No eye protection was used. He had a past history of similar injury in the Right eye under identical circumstances eight years previously.

On examination the Right eye achieved a best-corrected visual acuity of 6/9 and the Left eye of 6/12. On slit lamp examination multiple foreign bodies were observed embedded in the corneal stromal layer and, in the lens, an old posterior synechiae in an otherwise quite right eye. The Left eye displayed multiple conjunctival and corneal foreign bodies, cells in the aqueous and stromal layer and, in the anterior chamber, a few anterior chamber flare cells. Using a slightly wider slit and, focusing the slit lamp in the anterior chamber, (Figure 2) better illustrates the volume of inflammatory cells present. Retro illumination of the lens in the Right eye (Figure 3) demonstrates the embedded stone fragments and an irido-capsular adhesion. A tear to the iris sphincter is also visible inferiorly. In the Left eye (Figure 4) the cornea is retro illuminated revealing that many of the fragments are semi-transparent. The pupil margin, delineated by the retro illumination, shows evidence that the iris has also suffered multiple tears. Sclerotic scatter illuminates the cornea internally and shows that the cornea has suffered trauma from several hundred stone fragments.

The images were captured using a Haag-Streit BX slit lamp fitted with a Canon EOS 20D camera. Dr. Revathi Rajaraman - Cornea and Refractive Surgery Services, Akwad Eye Hospital and Post Graduate Institute of Ophthalmology, Coimbatore, Tamil Nadu, India.

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Congratulations

to Haag-Streit International, our sister company in Bern, Switzerland, on 150 years of innovation; its impact on medical science, and the lives of patients and doctors around the world.