3- Slit Lamp

Purpose

A slit lamp is an optical device that is used for examination of the ocular structures of both the anterior segment (or frontal structures) and posterior segment of the human eye. When used in conjunction with a bio-microscope, the binocular slit lamp examination allows stereoscopic magnified detailed view of the eye structures, enabling anatomical diagnoses to be made for a variety of eye conditions. Slit lamp is the most commonly used equipment in most eye clinics for diagnostic and surgical procedures. Surgical slit lamps are used mostly in combination with a surgical microscope in intraocular and retinal surgery.

المصباح الشقي هو جهاز بصري يستخدم لفحص الهياكل العينية لكل من الجزء الأمامي (أو الهياكل الأمامية) والجزء الخلفي من عين الإنسان. عند استخدامه مع المجهر الحيوي، يسمح فحص المصباح الشقي الثنائي برؤية مكبرة مجسمة مفصلة لهياكل العين، مما يتيح إجراء تشخيصات تشريحية لمجموعة متنوعة من حالات العين. المصباح الشقي هو الجهاز الأكثر استخدامًا في معظم عيادات العيون للإجراءات التشخيصية والجراحية. تُستخدم المصابيح الشقية الجراحية في الغالب بالاشتراك مع المجهر الجراحي في جراحة العين والشبكية.

Principle

The slit lamp basically consists of a light source that can be focused to shine a thin sheet (slit) of light into the eye. The eye is examined by using the slit lamp with this beam or 'slit' of light whose height and width can be externally adjusted. The slit of light, when directed at an angle, highlights the anatomic structures of the eye, allowing close inspection. The magnification provided by the slit lamp is usually10-25 times. The complete slit lamp system comprises of three basic elements as shown in Figure 1: high intensity light source, stereo-biomicroscope, and mechanical system. The binocular microscope is fixed on a base that moves in an arc, and a frame is provided to rest the head on and hold it steady during the exam. The combination of these elements provides a magnified, three-dimensional (3D) view of the parts of the eye in the anterior segment. The mechanical system connects the microscope to the illumination system and allows for positioning of the instrument. Special lenses are usually placed between the slit lamp and the cornea that help the doctor examine the deeper structures of the eye. A camera may be attached to the slit lamp to take pictures of different parts of the eye under examination. Fluorescein dye is mostly used during a slit lamp examination that makes it easier to see a foreign object, such as a metal fragment, or an infected or injured area on the cornea.

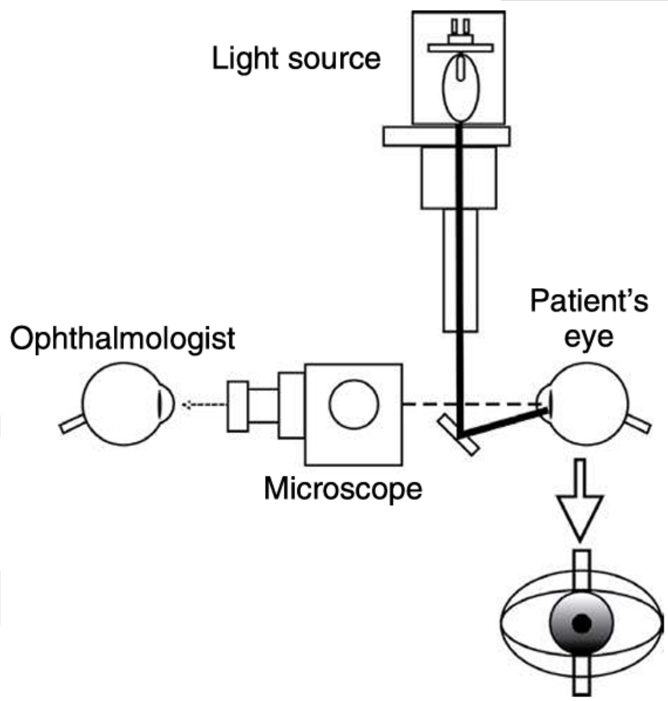

Figure 1 Layout of various components in a slit lamp.

Illumination System

A bright illumination system is one of the fundamental requirements for a slit lamp. The light source usually employed in slit lamps is halogen lamp that gives a bright, clear light. It is necessary to provide a means of controlling the intensity of the light, which can be done by using neutral density filters, but the preferred method is to use a rheostat, which provides an easy and fast method. The other filters used are cobalt blue, red free, and yellow barrier. The lamp housings of the slit lamps are very bulky, because of the halogen lamp light source. In newer instruments, halogen lamp has been replaced with a laser-based fiber optic light supply system. The usable wavelengths of laser radiation are in the near-infrared and visible spectral region. A high intensity diode laser is used in these instruments. Optical zoom systems are used for adjusting the treatment spot sizes. There are two distinct slit lamp types based on the location of their illumination system:

مقارنة مهمة

Zeiss type	Haag Streit type
In this type of slit lamp, the illumination source is located below the microscope.	the illumination source is located above the microscope.

Figure 2 shows the optical diagram of the illumination system. This arrangement produces a slit image that can be varied in terms of its length, width, and position. The method is known as Köhler illumination. The light source L is imaged in the objective O by the collector system K. The objective in turn produces an image at S in the mechanical slit located next to the collector system. The image of the light source at O is the exit pupil of the system. The system provides a very homogeneous slit image even with a structured light source. This is an advantage over illumination systems imaging the light source in the slit and projecting the latter into the eye together with the image of the light source. The brightness of the slit image depends on the luminance of the light source, the transmission of imaging optics, the size of Mechanical Section.

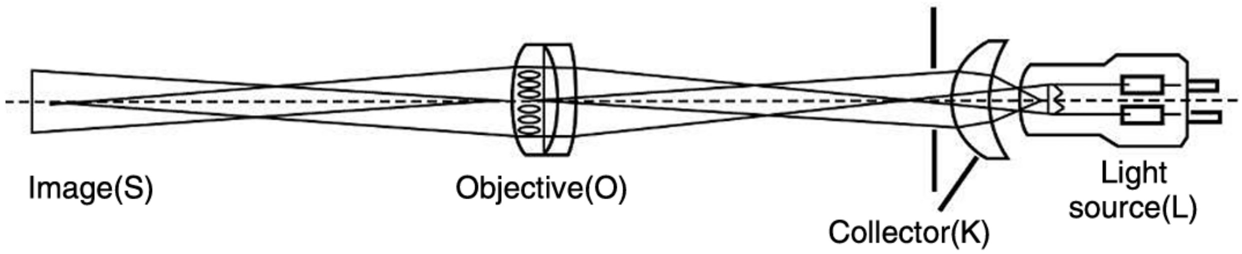

Figure 2 Principle of Köhler illumination for producing a slit image.

The slit lamp mechanical system is highly precise and is so designed that illumination system and the microscope can both be swung independently about a common vertical axis. The visual axis is a virtual extension of the mechanical instrument axis, with the rotational point being located below the patient's eye. The slit is normally focused to the axial plane and can be seen sharply defined at the microscope focal point. During an examination, this axis of rotation is moved to the position of the object to be observed. This is achieved with the aid of a mechanical instrument base containing a cross-slide system and carrying the mechanical support axis of the illumination system and the microscope. The instrument base is moved horizontally with a single control element - the joystick control.

Additionally, the instrument base contains a vertical control mechanism allowing the slit and the viewing axis to be adjusted vertically. This vertical control is typically integrated into the joystick and operated by rotating it. Thus, the operator can adjust the instrument to the object in all three space coordinates with the help of 3D joystick control lever. A single joystick 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 slit image, which is normally in a vertical position, can be rotated continuously through +90º to the horizontal position, and the direction of the slit illumination can be changed by using a tilting prism. This provides a defined angle between the microscope axis and the axis of the slit illumination. The lateral movement of the slit image can be achieved by rotating the prism head from the central position to the right and left.

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Viewing System

The viewing system has sufficient magnification and provides a clear image of the eye to the ophthalmologist to view all structures of the eye. Binocular viewing is usually adopted that allows better judgement of depth. The slit lamp has a magnification up to at least 40x, which can be achieved through interchangeable eye pieces and/or variable magnification of the slit lamp objective. In most of the instruments, it is possible to change magnification easily with four or five different objectives. The zoom system allows to focus on a particular structure without losing sight of it.

Figure .3 Slit lamp in use. *Source:* Mr. PFrankoZeitz, https://commons.wikimedia.org/wiki/File:Slit_lamp_examination.jpg.

Figure.3 shows a typical slit lamp in use. Recording System Traditionally, the most frequently used approach for image capture of the anterior segment involves the use of a photographic slit lamp with a beam splitter attached to a35 mm camera back. Recently, video cameras, image capture boards, digital still cameras, and colour printers have become affordable alternative to 35 mm

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photography. The digital charge coupled device (CCD) camera may have an imaging sensor of 22.3 mm x 14.9 mm, which allows acquiring a maximum resolution of 5184 × 3456 pixels(~17.9 megapixels). The pixel dimension on the camera sensor is 4.3 um × 4.3 um. The digital imaging facility requires a video camera or digital still camera followed by an image capture board for converting the image data to a digital file, which can be displayed on a monitor, printed on a colour printer and stored on CD-ROM and hard disk. In recetions because a 'still' photograph is much less meaningful than a dynamic film record. The photographic biomicroscope is slightly different from the clinical biomicroscope as it has a beam splitter that transmits a percentage of light to the viewing oculars and reflect the remainder of the light to the digital camera. Several useful accessories extend the functioning of the slit lamp for measurement, examination, and documentation. The most widely used accessories include applanation tonometer for measurement of intraocular pressure; micrometre eyepieces for length and angle measurements on the eye, particularly for contact lens fitting; a 60, 78 or 90D lens for fundus examination; a gonioscope for examination of the anterior chamber; a pachymeter for measurement of corneal thickness; an anaesthesiometer for corneal sensitivity; and digital image archiving for the documentation of findings, image processing, and storage.

Specifications

1- Magnifications: 5x, 8x, 12x, 20x, and 32×
2- Field of view: 40-6 mm
3- Eyepiece magnification: 10×
4- Width of slit image: 0-14 mm, continuously adjustable
5- Length of slit image: 0.5, 3.5, 8, and 14 mm, in steps and continuously adjustable
6- Angle of slit image: +90º, continuously adjustable
7- Decentration of slit image: +4º horizontal, click stop at 0º
8- Filters: Blue, green (red-free), and heat-absorbing filter
9- Free working distance: 60 mm exit prism to patient eye

10-Travel of instrument base: Vertical, 30 mm; x-axis, 110 mm; y-axis, 90 mm

11-Vertical travel of headrest: 60 mm

12-Light source: 6 V, 20 W halogen lamp

Applications

The slit lamp is probably the most convenient and essential tool in every ophthalmological clinic.

Fundus Camera

Purpose

A fundus camera, also known as retinal camera, is an instrument designed to take photograph of the interior surface of the eye including the retina, optic disc, macula, and, of course, fundus. These images are useful to study, evaluate, and document ocular conditions such as glaucoma, diabetes, hypertension, etc. With such records, it is possible for the doctor to maintain a database of the progression of the disease such as retinopathy and facilitate its management and control. The camera is often used in retinal angiography. This test is conducted by injecting fluorescein dye into the patient, and a fundus camera is used to take pictures of the retina, which shows retinal circulation. The camera is also used for screening purposes as the photographs can be studied later on.

Principle

Evaluation of the fundus is an important part of an eye examination, which provides valuable diagnostic information. In addition to physical examination, the fundus is often photographed, which allows to document the digital images for evaluating the progression of the disease. These digital images are also useful for sharing them for telemedicine purposes. In the earlier fundus cameras, the pupil was expanded with mydriatic to enhance the amount of incoming light that makes the patient feel vertigo and blurred. Modern fundus cameras are nonmydriatic, which are convenient for both the patient and the medical staff. A typical nonmydriatic camera is shown in Figure 1. Fundus cameras consist of an

intricate low power microscope attached to a flash enabled camera. The optical design of the camera is similar to that of the indirect monocular ophthalmoscope because the observation and illumination systems follow dissimilar paths in both the cases. It is possible to photograph the retina directly as the pupil is used as both an entrance and exit for illumination and imaging light rays of the camera. The patient is asked to place his chin on the chin rest of the camera and the head against a horizontal bar. The camera operator, after focusing and aligning the camera, presses the shutter release, the flash fires, and the photograph of the retinal image is taken in the digital format. These cameras can be conveniently interfaced with a computer for storage of the retinal images as graphic files, which can be archived, edited, printed, or shared with another specialist through a local computer network or over the Internet.

Figure 1 Digital fundus camera. *Source:* Image reproduced with permission M/s Topcon, Japan.

A fundus camera provides an upright, magnified view of the fundus. The camera is usually specified in terms of the angle of view. Angle of view is the optical angle of acceptance of the lens. A typical camera provides a view of 30-50º of retinal area and provides an image that is 2.5 times larger than the actual size of

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the retina. However, the image can be zoomed with the help of auxiliary lenses, and 5x magnification can be achieved. Wide-angle fundus cameras are also available, which can are capable of capturing images between 45º and 140º. The wide-angle camera (even up to 200º) allows for simultaneous evaluation of the peripheral and central retina without causing any patient discomfort. However, the retinal magnification is proportionately much less. The narrow-angle fundus camera has an angle of view that is 20º or even less.

Optical System

Fundus photography is different from conventional photography as the object to be photographed is a virtual image of the retina. Figure 158.2 shows the details of the optics of the camera. The imaging optics of the fundus camera consists of two systems:

(i) The first lens, called the ophthalmoscopic lens, forms a real aerial image of the fundus. In wide-field fundus cameras, this lens is in contact with the cornea and is followed by a field lens that may have multiple elements.

(ii) (ii) The second part is the actual digital camera, which is usually a built-in commercial camera. The illumination system consists of a light source and a series of lenses. Two types of light sources are used in fundus cameras. A 590ºnm source is used for imaging purpose, while 808ºnm light is used for observing the fundus in high resolving power. The stray light is restrained from the cornea centre by using ring lights and a hollow mirror. The light is focused via the lenses through a doughnut-shaped aperture, which then passes it through a central aperture to form an annulus. The light then passes

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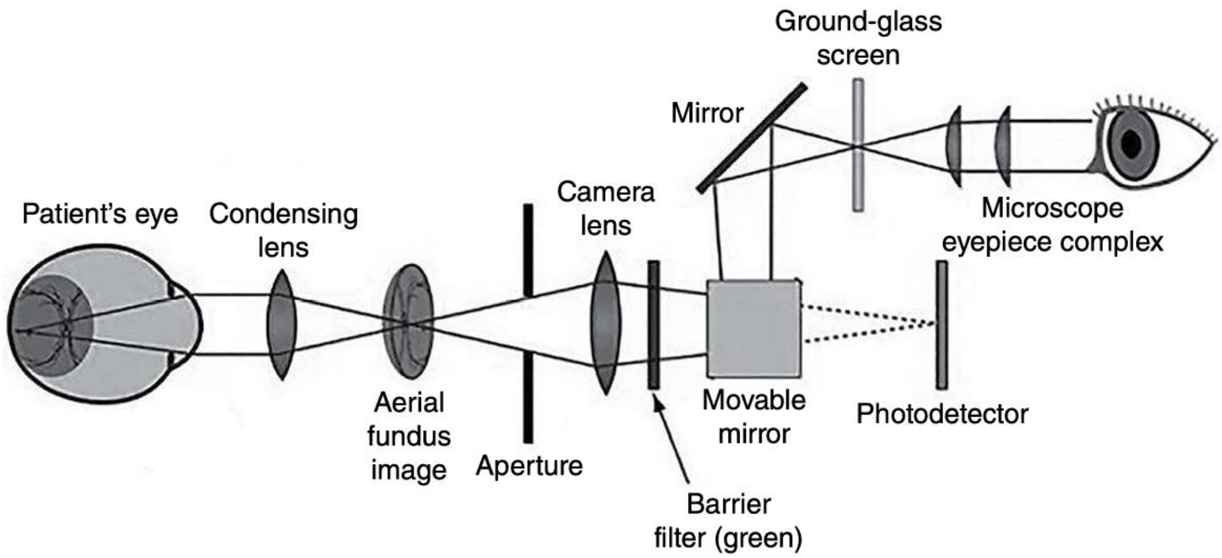

Figure 2 Optical diagram of fundus camera.

through the camera objective lens and through the cornea onto the retina. The focus of the camera is adjustable by repositioning the charge coupled device (CCD) camera along the optical axis. The light that gets reflected from the retina passes through the un-illuminated hole in the doughnut created by the illumination system. The image forming light rays then travel to the low power telescopic eyepiece. When the button is pressed to take a photograph, the path of the illumination system is interrupted to allow the light from the flash bulb to pass into the eye. At the same time, a mirror falls in the path of the observation eyepiece, which redirects the light onto the digital CCD camera. The camera usually provides large image files (uncompressed and with lossless compression) or small image files using lossy compression. The optics being quite complex, only a few manufacturers like Zeiss, Canon, Nidek, and Topcon produce fundus cameras. Figure.3 shows the layout of the various components of the observation system of the Topcon fundus camera.

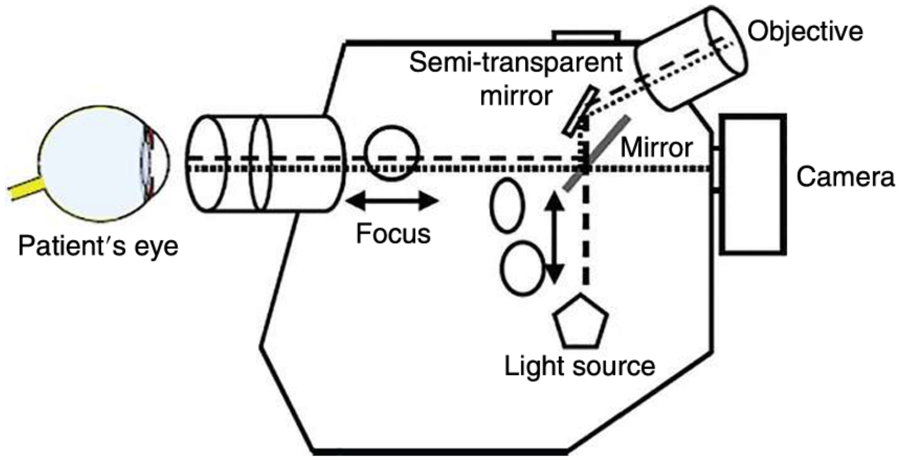

Figure..3 Layout of various components of observation system of a fundus camera. The condensing lens takes light rays from the illuminated fundus and creates an aerial image. A conventional single lens reflex camera body, with its microscope eyepiece and ground glass screen, is then used to focus on the aerial image. When the photograph is taken, a movable mirror flips up, exposing the film, or the image falls on the photodetector.

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