Ophthalmic Equipment, Part 2
Equipment for Treatment

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PART 1 OF THIS SERIES (SEPTEMBER) reviewed equipment for examination and diagnosis of eye problems. Part 2 continues by reviewing some of the equipment used for surgical treatment of eye problems.

Operating Microscope

Eye surgeons use operating microscopes for procedures that require high magnification and variable focusing. The operating microscope has features such as pedal-controlled motorized focusing, motorized zoom magnification, and motorized lateral and longitudinal (x-y) positioning. These features allow the surgeon to concentrate on the surgery rather than on manipulating the microscope.

A set of articulated arms connects the microscope head assembly to a mobile floor stand, wall mount, or ceiling mount. The lens system consists of eyepiece lenses, magnification lenses, and objective lenses. The magnification of operating microscope eyepieces is typically 8X to 20X. Objective lenses are described by their working distance or focal length, which is the focused distance from the objective lens to the viewed object. The typical focal length of objective lenses for eye surgery using a 12.5X eyepiece is 175–200 mm.

Light from a halogen light source is directed into the tube through prisms or fiber-optic cables and shines through the objective lens onto the operating field. The light beam is reflected from the operating field through the objective lens and the magnification changer drum to the eyepieces. The surgeon can then see the image of the operating field. A beam splitter allows the image to be directed through prisms to photographic or video cameras, or to a second eyepiece set for an assistant surgeon.

Phacoemulsification Machine

A cataract is a cloudy eye lens. This condition can be caused by several factors: environment, diseases, drugs, aging, trauma, genetic defects, or birth defects. Age-related cataracts are the most common. Cataracts hinder the transmission of light to the retina, causing blurry vision. If untreated, the patient will experience progressive vision loss leading to blindness.

Phacoemulsification is a technique whereby ultrasonic energy, ranging from about 25 to 80 kHz, is used to break the opaque lens into smaller pieces, which are then aspirated out of the eye. After the entire cataract is removed, an intraocular lens (IOL) is inserted in place of the eye's lens. Many ophthalmic surgeons use this technique since the procedure can be done through one small incision that does not require sutures. This reduces surgically induced astigmatism, decreases surgical complications, such as infection, and accelerates visual rehabilitation. Phacoemulsification is performed with the aid of an operating microscope.

The main components of a phacoemulsification machine are the ultrasonic (US) system and the irrigation/aspiration (I/A) system. The surgeon controls these systems by activating a single pedal. Front-panel controls are used to select ultrasonic power levels, vacuum limits, irrigation rate, and other parameters.

Sterile saline solution is used as an irrigator. The irrigation line runs from the IV bottle through a pinch valve. When this valve opens, fluid flows into the eye through an irrigation sleeve that surrounds the tip of the US handpiece. The surgeon prevents the anterior chamber of the eye from collapsing by adjusting the irrigation flow according to the fluid loss resulting from aspiration.

The aspiration line runs from the handpiece to a vacuum pump through a collection container. Aspiration is used to hold the lens nucleus and larger fragments to the US tip, where they can be emulsified. Smaller fragments of lens and irrigant are then suctioned into a collection canister. Movement of fluid during irrigation and aspiration (I/A) also aids in cooling the US probe tip. I/A systems commonly use peristaltic, diaphragm, or venturi pumps to create suction.

Many phacoemulsification machines contain components for other facets of cataract surgery, such as anterior vitrectomy for removing vitreous and bipolar diathermy for controlling bleeding.

Vitrectomy Machine

Vitreous is a clear, jelly-like substance that fills the inside of the eye. Since vitreous is normally clear, light rays are able to travel through it and reach the retina. Any variation in the consistency, color, or structure of the vitreous can hinder transmission of light to the retina and affect vision. Vitrectomy is a procedure during which the surgeon removes cloudy vitreous from the eye and replaces it with a clear solution. Light can then pass through this clear fluid, restoring normal sight.

A vitrectomy is performed with the aid of an operating microscope and contact lenses that are placed on the patient's cornea. This allows a clear view of the vitreous cavity and retina at various magnifications. Vitrectomy machines have the following main functions: vitreous cutting, irrigation, aspiration, and illumination.

Cutting the vitreous is accomplished with a small handpiece containing a guillotine, oscillating, or rotating cutter. Pulses of compressed air mechanically activate the cutter. Some vitrectomy machines require connection to an external compressed air source, while others have an internal pump. Cutting is performed in the adjustable range of 60 to 2,000 cuts per minute.

The sliced vitreous is aspirated through the handpiece, which is connected to a suction line that carries the fragments to a collection canister. Aspiration systems commonly use peristaltic, diaphragm, or venturi pumps. An irrigation line runs from an IV bottle with sterile saline solution through a pinch valve to the handpiece. When the pinch valve opens, fluid flows into the eye.

A light probe that is inserted through a tiny incision in the eye provides illumination for the procedure. The light probe is coupled via a fiber-optic cable to a high-intensity halogen light source housed inside the machine.

The surgeon controls the vitrectomy machine using a pedal. Front-panel controls are used to select cutting rates, vacuum limits, irrigation rate, light intensity, and other parameters.

It is common to see phacoemulsification and vitrectomy functions integrated into a single machine.

Ophthalmic Lasers

Ophthalmic lasers allow precise treatment of a range of eye problems with little risk of infection. Many laser procedures are relatively pain free and can be performed on an outpatient basis. The combination of safety, accuracy, and relatively low cost make lasers very useful ophthalmic tools.

The word *laser* is an acronym for light amplification by stimulated emission of radiation. Laser light is coherent (wavelengths are in phase in space and time), monochromatic (one color or wavelength), and collimated (light is emitted as a narrow beam in a specific direction). Laser beams are produced by the excitation of atoms to a higher than usual energy state. Laser radiation is emitted as the atoms return to their original energy levels.

The main components of a laser system are the laser tube, the pump or excitation source, the power supply, and a cooling unit. Laser energy is delivered to eye structures using one of several delivery systems: endoprobe (a small fiber-optic probe that is inserted into the eye), slit lamp, operating microscope, or indirect ophthalmoscope.

Different types of lasers emit specific wavelengths of light and are used to treat specific eye problems. Lasers are usually named according to the active material used. For instance, an argon laser contains argon gas as its active material, while the YAG laser contains a solid material made of yttrium, aluminum, and garnet. The effects that lasers have on eye tissues are both a function of the molecular composition of the tissue and the wavelength and power of the laser light.

The argon laser emits blue-green wavelengths, which are absorbed by the cells under the retina and by the red hemoglobin in blood. Blue-green wavelengths can pass through the fluid inside the eye without causing damage. For this reason, the argon laser is used extensively in the treatment of diabetic retinopathy, a severe disorder of the retina that causes blood vessels to leak. The argon laser can burn and seal these blood vessels. Retinal detachment is another serious eye problem that can be treated by the argon laser. The laser is used to weld the detached retina to the underlying choroid layer of the eye. Some forms of glaucoma may also be treated with argon lasers. For instance, angle-closure glaucoma can be treated by using an argon laser to create a tiny hole in the iris, allowing excess fluid inside the eye to drain to reduce pressure. Macular degeneration, a severe condition that affects central vision in older people, is sometimes treated with an argon or krypton laser. In this treatment, the laser is used to destroy abnormal blood vessels so that hemorrhage or scarring will not damage central vision.

The YAG laser generates short-pulsed, high-energy light beams to cut, perforate, or fragment tissue. Many people have the misconception that a YAG laser is used to remove cataracts. This happens because up to two thirds of cataract patients develop a condition known as posterior capsular opacification, a clouding of the lens capsule months after cataract surgery. This gradual loss of vision is similar to the symptoms of a cataract, causing people to believe that their cataract has returned. The YAG laser is commonly used to vaporize a portion of the capsule, allowing light to fully reach the retina.

The diode laser has applications similar to those of both the argon and the YAG lasers. The advantage of diode lasers is that they are more portable, produce less heat, and require much less maintenance than other types of lasers.

The erbium laser has a high absorption rate in water, a main component of the eye's lens. For this reason it is currently being assessed as an alternative to phacoemulsification for the removal of cataracts. The erbium laser is also used in removal of skin wrinkles.

The excimer laser is used in refractive correction surgery

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known as laser-assisted in situ keratomileusis (LASIK). Excimer lasers emit ultraviolet light, vaporizing tissue by breaking down molecular tissue bonds in a minuscule area. It is called a cold laser because it does not produce heat with harmful effects to the surrounding tissue. The excimer laser is precise and each pulse of the laser removes about $^{1}/_{500}$ of the thickness of a hair. This precise control over depth and area of removed tissue is useful for reshaping the cornea for correction of refractive errors.

The holmium laser is used in a refractive surgery procedure known as laser thermal keratoplasty. This procedure uses infrared light to correct mild to moderate cases of farsightedness and some cases of astigmatism. The holmium laser does not reshape the cornea by removing tissue as the excimer laser does. Instead, it reshapes the cornea by causing the tissue to shrink. A pattern of 8 to 16 tiny spots in concentric rings is left around the periphery of the cornea. The heated fluid in these spots creates a series of tiny craters. The shrinking pulls in the periphery of the cornea, causing the center to bulge, resulting in the correction of farsightedness.

Clinical personnel must follow protective measures in order to reduce the possibility of exposure of the eye and skin to hazardous levels of laser radiation. One important measure is to wear the proper laser-safety glasses designed to filter the specific wavelengths and power of the laser being used.

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