A Project Report

On

**Operating Microscope in Neurosurgery**

By

Ramandeep Singh

(2012BMZ8116)



Centre for Biomedical Engineering

Indian Institute of Technology, Delhi

Hauz Khas, New Delhi-110016

### November 2012

**MICROSCOPE**

It is an instrument used to obtain an enlarged image of small objects and reveal details of structure not otherwise distinguishable. Different types of microscopes are as follows:

* **Acoustic microscope** - one using very high frequency ultrasound waves, which are focused on the object; the reflected beam is converted to an image by electronic processing.
* **Binocular microscope** - one with two eyepieces, permitting use of both eyes simultaneously.
* **Compound microscope** - one consisting of two lens systems whereby the image formed by the system near the object is magnified by the one nearer the eye.
* **Darkfield microscope** - one so constructed that illumination is from the side of the field so that details appear light against a dark background.
* **Electron microscope** - one in which an electron beam, instead of light, forms an image for viewing, allowing much greater magnification and resolution. The image may be viewed on a fluorescent screen or may be photographed. Types include scanning and transmission electron microscopes.
* **Fluorescence microscope** - one used for the examination of specimens stained with fluorochromes or fluorochrome complexes, e.g., a fluorescein-labeled antibody, which fluoresces in ultraviolet light.
* **Light microscope** - one in which the specimen is viewed under ordinary illumination.
* **Operating microscope** - one designed for use in performance of delicate surgical procedures, e.g., on the middle ear or small vessels of the heart.
* **Phase microscope (phase-contrast microscope)** - a microscope that alters the phase relationships of the light passing through and that passing around the object, the contrast permitting visualization of the object without the necessity for staining or other special preparation.
* **Scanning electron microscope (SEM)** - an electron microscope that produces a high magnification image of the surface of a metal-coated specimen by scanning an electron beam and building an image from the electrons reflected at each point.
* **Simple microscope -** one that consists of a single lens.
* **Slit lamp microscope** - a corneal microscope with a special attachment that permits examination of the endothelium on the posterior surface of the cornea.
* **Stereoscopic microscope** - a binocular microscope modified to give a three-dimensional view of the specimen.
* **Transmission electron microscope (TEM)** - an electron microscope that produces highly magnified images of ultrathin tissue sections or other specimens. An electron beam passes through the metal-impregnated specimen and is focused by magnetic lenses into an image.
* **X-ray microscope** - one in which x-rays are used instead of light, the image usually being reproduced on film.

**MICROSURGERY**

Microsurgery means, by definition, to perform surgery with the help of a surgical microscope or other tools (e.g., loupes) which can magnify and illuminate the surgical field. Microsurgery does not mean doing non-microsurgical procedures with the help of small or microsurgical instruments.

**SURGICAL PRINCIPLE**

Microsurgery not only means working with the help of a surgical microscope. One of the major advantages lies in the possibility to perform operations through small skin incisions (“keyhole surgery”). This needs meticulous preoperative planning, exact positioning of the patient, and reliable localization of the surgical target area in projection to the entry level on the skin surface. All these factors contribute to the “microsurgical philosophy” which realizes one of the major principles in surgery: to perform the most efficient operation with minimum iatrogenic trauma.

**OPERATING MICROSCOPE**

A Operating microscope is the one that is used in delicate surgical procedures. It is a **stereoscopic microscope** i.e. modified version of binocular microscope to give a three-dimensional view of the specimen. The standing type of operating microscope has a motorized zoom system that quickly changes the magnification. Basic function is to provide clear vision and lighting in addition to magnification. It is also called, **surgical microscope**.

**HISTORY OF DEVELOPMENT OF OPERATING MICROSCOPE**

In 1590, Zacharias and Hans (Dutch opticians) aligned two lenses in a sliding tube and thus invented the compound microscope system. The Italian scientist Galileo also developed the same system in the later decade. Faber a colleague of Galileo coined the term ‘microscope’ from the Greek ‘micro’ (meaning ‘small’) and scope (meaning ‘to aim at’). The Dutchman Anton Von Leeuwenhoek, constructed fine lenses capable of magnifying objects up to 270 times. Robert Hooke, who is well known for describing cell introduced coarse and fine adjustments as well as tube inclination in the microscope. Jackson then used compound lens from more than one element to reduce chromatic aberration. Carl Zeiss in 1848 opened a microscope workshop in Germany, where Ernst Abbe derived a mathematical formula required to standardize the optical qualities of lens. In 1890, the concept of stereopsis utilizing binocular microscope was introduced by Zeiss. In 1921, Carl Nylen, a Swedish otolaryngologist constructed and used the world’s first surgical monocular microscope on humans.

Then in 1957, Theodore Kurze became the first neurosurgeon to use an operating microscope to operate on 8th cranial nerve. In 1958, RMP Donaghy established the world’s first microsurgery research and training laboratory in Burlington. Jacobson and Suarez, working in this neurosurgery training laboratory, performed a successful small vessel anastomose using the microscope in 1960. Then by collaborating with Hans Littman of Zeiss Corporation in 1962 , Jacobson and Suarez designed, stereoscopic microscope utilizing the beam splitter technology to allow second surgeon to assist. In 1966, MG Yasagril attended this training facility of Donaghy and returned to Zurich. Next year, Yasagril also established a training laboratory in Zurich and performed the first superficial temporal artery to middle cerebral artery anastomosis under the microscope.

Since the middle of the 1970s microsurgery pioneers such as Caspar, Yasargil, and Williams performed various microsurgical procedures with the aid of a microscope. Since then, surgical microscopes have become an integral part of neurosurgery.

**OPTICAL PRINCIPLES**

Two optical principles are of importance to the neurosurgeon concerning the operating microscope, namely magnification and stereoscopic perspective.

**MAGNIFICATION**

The enlargement of objects in the operating field is the most widely recognized but actually least important function of the surgical microscope. Optical principles relate the final magnification obtained through any microscope, to the magnification lens and the magnification of the ocular pieces. This relationship varies among different "microscopes, thus changing the quantification of the final magnification. In the neurosurgical operating room at Zurich, an operating microscope is used with a 300 mm objective and 12.5 oculars for all cranio-vertebral surgery except superficial anastomoses when a 200 mm objective and 12.5 ocular lens are more convenient.

**STEREOSCOPIC PERSPECTIVE**

A few neurosurgical procedures such as microvascular anastomoses and nerve repairs are performed on the surface of the operating field, and in these the magnification and depth of field are primary considerations. However, most neurosurgical operations take place in a small space at the base of the brain through a narrow gap and in these cases it is more important to the neurosurgeon that he maintains well-lit binocular vision in the recesses of the field. This stereoscopic perspective is thus the more useful function of the surgical microscope in these situations.

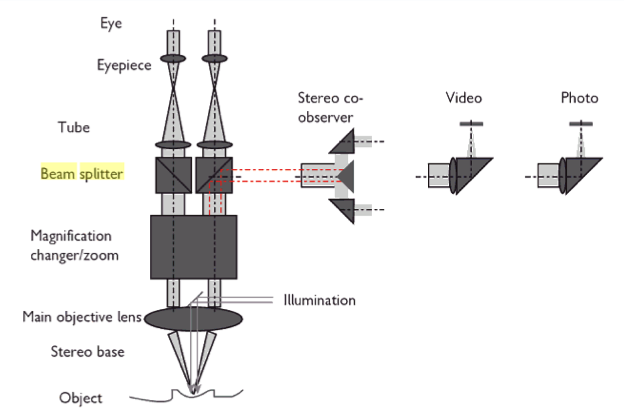


Diagram of the difference in Inter pupillary distance (PD) and interocular operating microscope.

The operating microscope allows stereoscopic vision in small spaces by reducing the necessary interpupillary distance required for binocular vision. The distance between the anterior lenses of the binocular tube of the microscope is only 16 mm, whereas the average interpupillary distance is around 60 mm. This means that light reflected from deep basal structures towards the operating microscope during surgical procedures employing fissure, sulci or transcortical approaches, will result in a stereoscopic image when only a 16 mm image enters the microscope aided eye. Even when assisted with magnification loupes, the eyes are unable to maintain stereoscopic vision in such a narrow space. Thus the real importance of the surgical microscope as it relates to most neurological procedures is not the magnification it supplies, but in the clear visual perspective it provides. With this the surgeon can avoid excessive brain retraction and yet still reach every point in the central nervous system, adequately visualizing deep structures either along the basal cisterns or through a transcerebral tunnel.

**BEAM SPLITTER MECHANISM**

A beam splitter is an optical device for separating incident beam of light into two or more beams. It directs the imaging beam to the eyepiece and to the camera simultaneously. In its most common form, a cube, it is made from two triangular glass prisms which are glued together at their base using polyester, epoxy, or urethane-based adhesives. The following figure shows the beam splitter mechanism of the Zeiss microscope:



Zeiss Beam Splitter Mechanism

**ILLUMINATION SYSTEM**

The light intensity is a fundamental aspect of gaining visual resolutions under the operating microscope. Unfortunately, adequate lighting has been one of the most difficult design problems of the operating microscope and even today remains imperfect. Light intensity is determined by the objective lens and the diameter of the lighted field that is projected through it, i.e. illumination units - lumens or foot candles/units of area. As the magnification is increased, less of the illuminated field is used, resulting in a proportionally diminished intensity of illuminated object as viewed through the microscope. Beam splitters to allow for observer tubes and televisions or camera equipment further decrease the amount of light actually reaching the eyes of the surgeon. A system of lighting has been developed in this department of attempting to maximize light intensity. The primary light source is focused through the objective lens onto the field of vision, as in all Zeiss microscopes. This primary light is a 50 watt tungsten bulb, powered at 10 volts. This bulb is manufactured to accept only 6 volts and overloading the bulb significantly reduces its life, so it is changed after each operation. The system must be ventilated by a suction apparatus placed within the microscope drape to prevent its overheating. This primary light system is supplemented by a fiber optic light source with a 150 watt, 15 halogen lamp. The actual light delivered through this system is about 90,000 lux. With this system it is important to keep the microscope properly centered on the illuminated field so as to maximize the available light.

**MICROSCOPE STAND**

One of the primary impediments to the widespread use of the operating microscope by neurosurgeons has been the need to manually change the position of the microscope. This often forced the surgeon to accept uncomfortable positions of his head or body during delicate procedures because he could not release instruments to repeatedly move the microscope. It was estimated that about 40% of the surgeon's time while using the microscope was spent merely adjusting and moving it around (Fig 190B-C). For over 5 years (1967-1972), the department of neurosurgery in Zurich worked on a solution to this problem. A variety of methods providing a freely mobile yet stable microscope were evaluated. Finally the counterbalance idea of Malis proved most practical, and in 1972 working with the Contraves Company a microscope stand was developed in which the microscope and its accessories were completely balanced by adjustable counterweights mounted on the microscope stand. Then by incorporating a system of electromagnetic brakes into the various joints of the stand, absolute stability of the instrument could be maintained when the microscope was in any desired position. The final addition of a mouth switch allowed all movements.

**ACCESSORIES TO THE MICROSCOPE**

The freely mobile operating microscope has diminished the effectiveness of additional surgeons attempting to assist during the microsurgical part of an operation. Similarly the scrub nurses and anesthetists have not been able to adequately follow the operation process through an observer tube that is constantly moving. Fortunately the optical characteristics of the operating microscope permit its easy adaptation to include the use of closed circuit television monitoring, thereby allowing these members of the surgical team (and others) to more actively participate in the operation itself. Also this allows an operation to be simultaneously taped and still camera photographs taken for later documentation of the pathology and for educational purposes. In fact these photographic facilities have proved to be an exceptionally helpful way for the surgeon to disseminate operative information to his colleagues at meetings and to educate medical students, residents, and visitors. In (1980) a vidicon tube (RGB-Hitachi mod. SSOO) color TV camera was installed in Zurich, which has markedly increased the resolution and true color rendition of microsurgical procedures.

**VIDEO SYSTEMS AND DOCUMENTATION**

Video systems for presentations and documentation are also very necessary (Fig. 2.3). In general, high-resolution 3CCD cameras are used. They are usually integrated into the microscope system. The entire team can follow the procedure on a video monitor, which generally has a very positive effect on the surgical workflow. Digital video sequences or still shots can be created for presentations or documentation. When photographs are needed, 35 mm or digital SLR cameras can also be connected to the microscope. The cameras are triggered via a programmable handgrip on the microscope. High-resolution pictures from the sterile field can be easily captured.

**ADVANTAGES**

The advantages of surgical microscopes in neuro surgery are obvious and follow a basic tenet of surgery: “The more you can see, the better you are able to treat.” Surgeons have a high degree of safety and control thanks to perfect visualization during the entire procedure. Good illumination and variable magnification enable improved recognition of anatomical structures. Additional highlights when working with microscopes are:

1. Three-dimensional magnification.

2. Coaxial illumination.

3. Easier differentiation of tissue types.

4. A comfortable working position.

5. A particularly short learning curve. Surgeons become familiar with the microscope after only a few procedures.

6. Almost no interference with other surgical devices in the OR.

7. Particularly suitable for training purposes.

8. No additional microsurgical instruments are needed.

9. Autofocus systems simplify work. Surgeons can concentrate more on the operation.

10. Reduction of the interpupillary distance from 65 mm to 22–28 mm enables smaller entrances. 11. Smaller surgical incisions reduce trauma. Faster operations and shorter rehabilitation times lead to shorter hospital stays.

12. Microscopes contribute to the reduction of overall costs.

**DISADVANTAGES**

Experienced surgeons have proved on a daily basis that microscopes have no real disadvantages in minimally invasive neurosurgery. Surgeons can quickly learn how to operate a microscope under expert supervision within the framework of fellowship programs, or other special training courses. However, there are a few points to consider:

1. Detailed planning of the surgical procedure is required as the visible field can be reduced to as little as 1 cm2 depending on the magnification. Good recognition of anatomical landmarks is required.

2. At the beginning of using a microscope inexperienced surgeons often have difficulty with hand–eye coordination.

3. As the visual area is limited, the microscope must often be repositioned to eliminate the problem of blind spots and concealed areas.

4. Personnel may have some difficulty with the sterile draping in the beginning, but after only a few procedures this process becomes routine.

On closer examination it becomes clear that most of the disadvantages of a surgical microscope can be directly traced to the experience of the surgeon. As a rule, these disadvantages can be quickly and easily overcome by learning microsurgical techniques in training or hands on courses headed by experienced instructors.

**MICROSURGICAL INSTRUMENTATION**

The application of microsurgical techniques to neurosurgery has necessitated the development of instrumentation which properly exploits the advantages offered by the operating microscope. As instrumentation is basically an extension of human physical abilities, principles of instrument design must account for the surgeon's physical requirements as well as the job to be undertaken. Just as the body requires stabilization of the larger parts in order that small parts may carry out fine movements, instrumentation was developed to provide stability as well as to enhance mobility.