OPERATING MICROSCOPE - PHYSICS, OPTICS AND USES IN NEUROSURGERY

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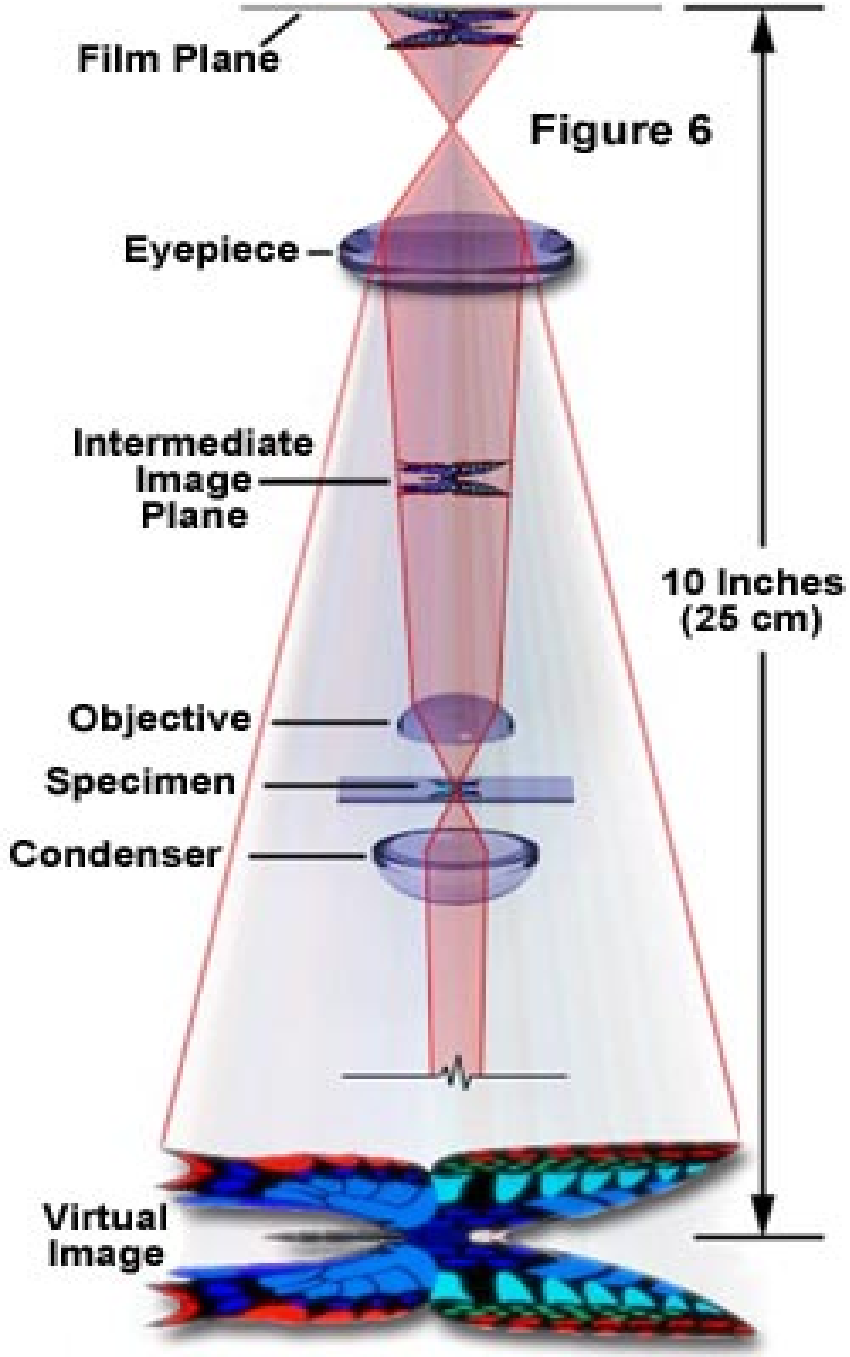
Basic Optics

- Basic function of a microscope is to provide a magnified view of the object being studied
- Magnification is essentially an increase in viewing angle or the angle subtended by the object at the eye.
- Two essentials of the operating microscope
  - Magnification
  - Stereoscopic vision

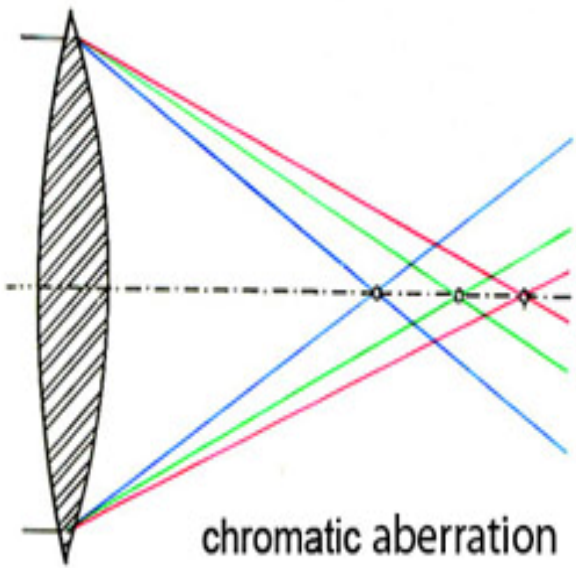
Simple microscope

- Consists of an illumination source and two lens system
  - Objective lens
  - Eyepiece
- The objective lens focuses the light rays from the object under study to form a real inverted image
- The eyepiece forms a virtual magnified image at a distance which is seen by the observer.
- The image undergoes a two step magnification.

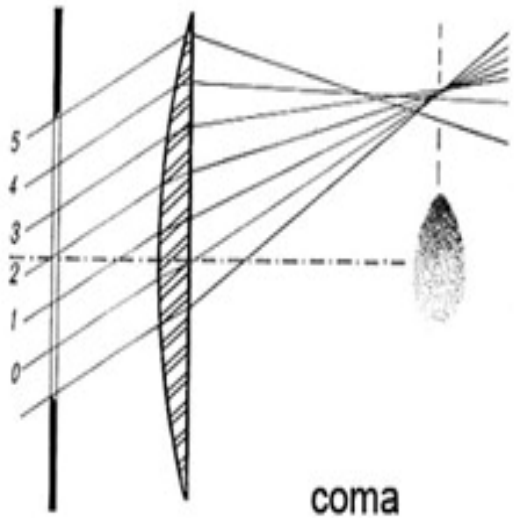

Film Plane
Figure 6
Eyepiece
Intermediate Image Plane
10 Inches (25 cm)
Objective
Specimen
Condenser
Virtual Image

- Magnifying power of a microscope is calculated by multiplying the individual magnification produced by the objective lens and eyepiece individually.
- Simple lens systems suffer from several defects such as chromatic aberration, Spherical aberration, diffraction
- Compound lens systems diminish these deficiencies

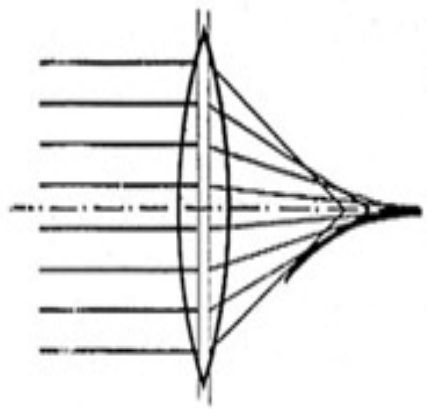
Optical defects of simple lenses



chromatic aberration



coma



spherical aberration

The operating microscope

- History of its development
  - magnification loupes have been used in surgery from mid part of 19th century.
  - Surgical binocular microscope first used by Carl Nylen in 1929 for middle ear surgery.
  - Popularised for otological surgery by William House
  - In 1957, Theodore Kurze became the first neurosurgeon to use the microscope in removal of a neurilemmoma of the seventh nerve.

- History (contd..)
  - In 1958, R.M.P. Donaghy established the first microneurosurgical training laboratory where several neurosurgeons like M Gazi Yasargil also trained
  - Yasargil made several revolutionary improvements in the design of the operating microscope and is regarded as the “Father Of Microneurosurgery” for his contributions.

The operating microscope

- Optical principles
  - Magnification :

    dependent on the magnification of the objective and eyepiece

    a zoom system of lenses is interposed between these two principal lenses allowing continuous change in magnification.
  - The field of view changes with the magnification according to the formula-

    Diameter of field = 200/total magnification

- Depth of field is also an important parameter which is a measure of field of vision in a stereoscopic system.

  The depth of field
  - increases with the square of the focal length of the objective lens
  - decreases linearly with the magnification of the microscope.

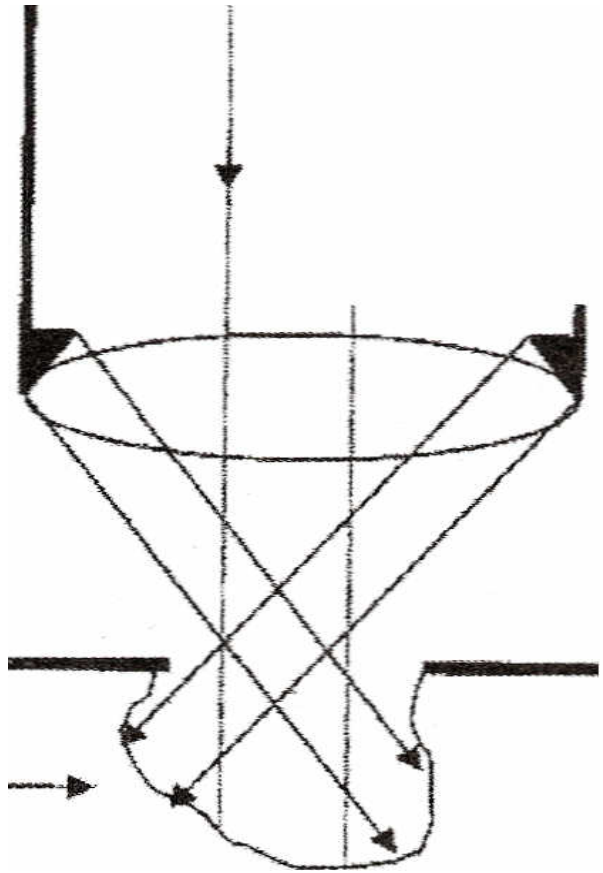
Components Of An Operating Microscope

- **Main Objective Lens**
  - variable focal length ranging from 200-500 mm depending upon the depth of operative field allowing the microscope to be adjusted at different distances from the op cavity.
  - Greater focal length required for operating in depth.
- **Magnification Changer**
  - It is a lens system placed between the objective and the binocular system comprising microprocessor controlled lenses which allow continuous adjustment of magnification
  - Together with the objective lenses they form the double barrel system.

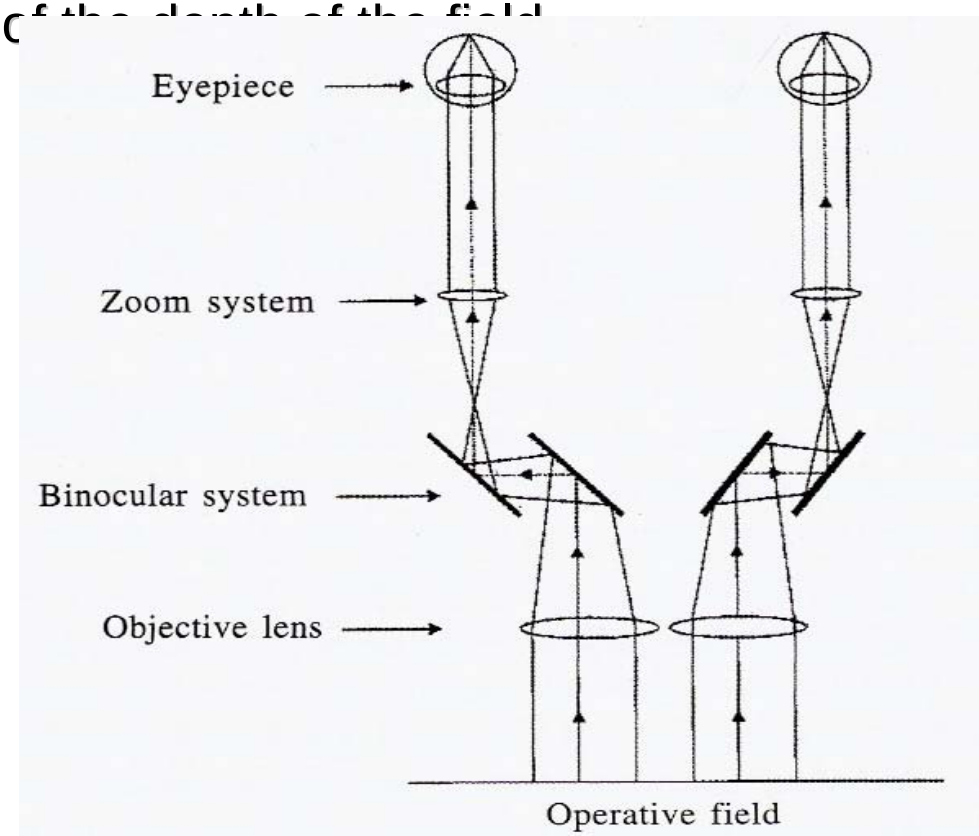
- Illumination
  - Earlier microscopes used integrated light sources such as tungsten or halogen bulbs which generated a lot of heat. Prolonged surgery cumbersome.
  - Development of fibreoptics enabled the use of a remote illumination source .
  - Automatic adjustment of light collimation in modern microscopes allows appropriate illumination as the magnification is varied.

- Auxiliary illumination

  In some advanced models auxiliary illumination is being used to decrease shadowing when changing the viewing angle.



- Stereoscopic perspective
  - Each of the binocular eyepieces project a slightly different image of the field which is fused to form the resultant 3D image.
  - The binocular system ensures that the two images are always separated by the interpupillary distance of the observer irrespective of the depth of the field



- Operative Microscope-based Neuronavigational Systems
  - Neuronavigation provides a precise surgical guidance by referencing the coordinate system of the brain with a parallel coordinate system of the three-dimensional data of the patient .
  - Picture in picture facility : the simultaneous display of the image data into the eyepiece of the microscope from either the neuronavigational system or during the use of an intraoperative endoscope is possible.

- Microscope mounts

  Essentially two types

  - Floor mounted

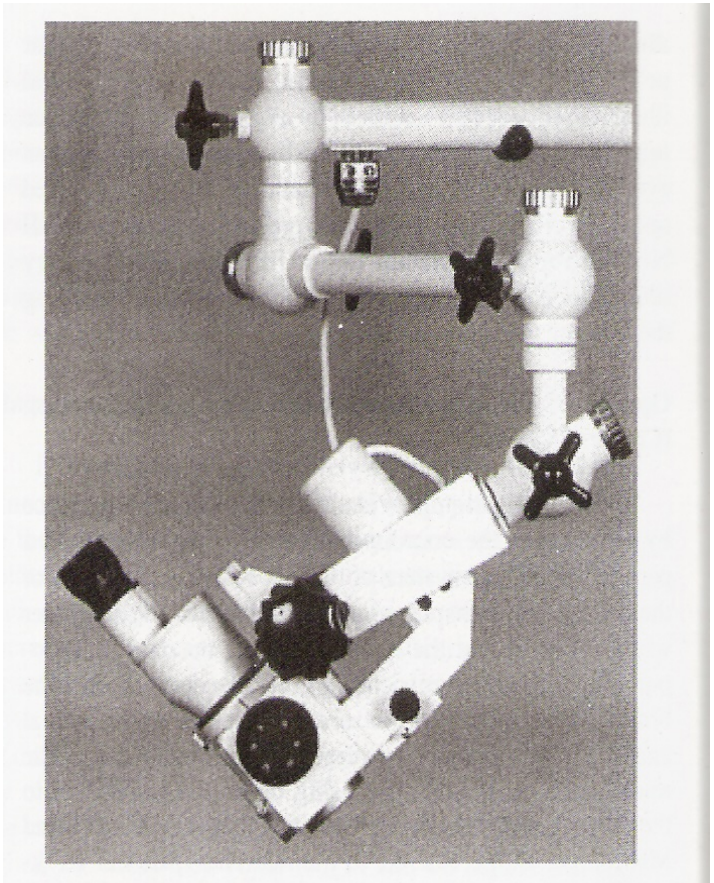
    transportable, occupies floor space

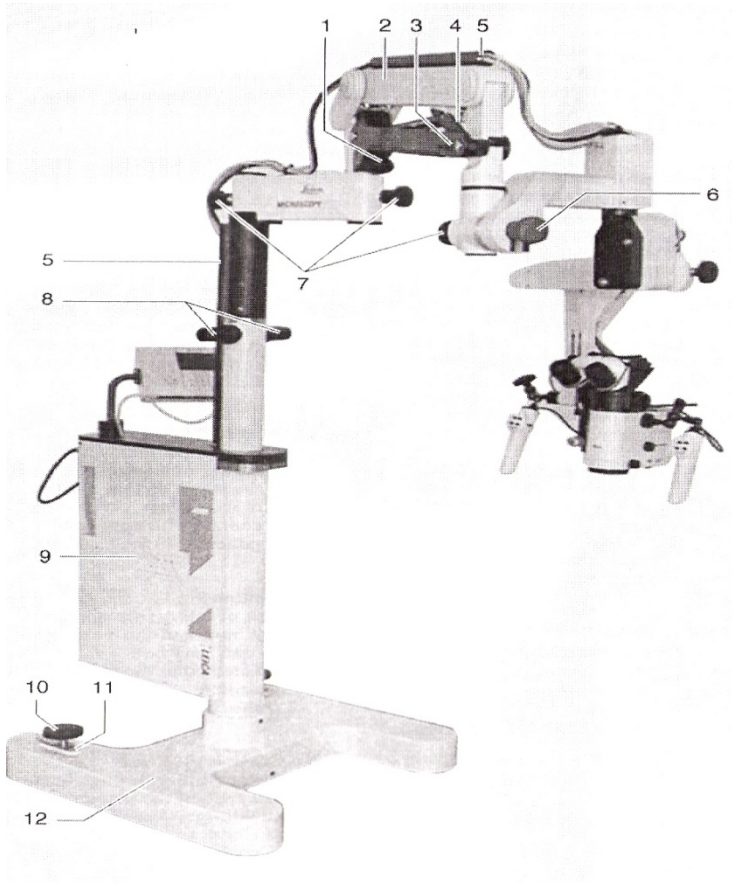
  - Ceiling mounted

    More expensive, saves floor space.

  Unnecessary movements while adjusting the microscope are minimised by a system of counterbalances and electromagnetic locks which secure the microscope in the desirable position.

- “Point lock” system and “focus lock” system available in advanced models
- The use of the point lock mechanism allows the surgeon to position the microscope without any chance of losing the observation point or the focus of that point.
- focus lock allows the surgeon to position the microscope in an *x-y* plane without affecting the *z* axis

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Extent and scope of application of microscope in neurosurgery.

- Role of microscope in improving surgical outcomes first demonstrated in Acoustic Neuromas.
- Now routinely used in almost all intradural operative procedures whether in the brain or spine.
- Its use has resulted in smaller wounds, less postoperative neural and vascular damage, better hemostasis, more accurate nerve and vessel repairs, and surgical treatment of some previously inoperable

  lesions.

- It has improved operative results by
  - permitting neural and vascular structures to be delineated with greater visual accuracy
  - deep areas to be reached with less brain retraction and smaller cortical incisions
  - bleeding points to be coagulated with less damage to adjacent neural structures,
  - nerves distorted by tumor to be preserved with greater frequency
  - and enabling anastomosis and suturing of small vessels and nerves not previously possible to be performed.

Emerging technologies

- Intraoperative flourescence
  - It is an upcoming technique available in several advanced micrscopes.
  - applicable in aneurysm and tumour surgery where it allows the visualisation of sub millimeter vessels by the use of Indo-cyanin green dye used as fluorescing agent