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.
• 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
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 microscopes.
  ➢ 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