A NEW OPERATING MICROSCOPE FOR OCULAR SURGERY

BY

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The delicate structures of the eyeball require special attention and careful, precise surgical manipulations to avoid interference with the transparency of the optical components of the visual system, making this organ especially suited for microsurgery.

Constant advances in surgical technique and instrumentation allow performance of more delicate surgical procedures which require perfect visual control. This can only be achieved using proper magnification and illumination to facilitate the execution of the different surgical maneuvers and reduce the operative risk and the surgical trauma.

Ophthalmology has been the first specialty to introduce a stereoscopic microscope and a slitlamp for routine clinical examination, but so far no special operating microscope has been developed exclusively for ophthalmic surgery. The models currently in use have been passed on from other specialties or have been assembled from components of other instruments. This means that these devices are not optimally adapted to the requirements of ocular microsurgery and that they are provided with accessories which are unnecessary in this type of surgery. It seems logical that the first instruments of this type had these faults since their multiple uses (otology, ophthalmology, vascular surgery, etc) facilitated their introduction in the operating theatres of many establishments.

When a microscope which has not been specially designed for ocular microsurgery is used, certain manipulations become difficult. Moreover, many of the properties and advantages of the instrument, developed primarily for examination purposes, are of no use during surgery.

Ocular surgery, being really a kind of microsurgery in itself, imposes special conditions on the surgeon, especially when the procedure concerns structures or details of structures which cannot be visualized optimally with the usual means of magnification (spectacles, loupes, etc). Although the sitting position had been recommended for many years by famous eye surgeons, it was Prof. Ignacio Barraquer who promoted and developed a real technique, designing for this purpose a stretcher-operating table, an armchair for the surgeon, separate stools for the assistants and instrument nurses, etc, in order to perform surgical interventions on the anterior segment of the eye with minimal fatigue of the surgeon and maximal security for the patient (figs. 1, 2 and 3).

Taking into account the necessity for the
surgeon to adopt a sitting position, the operating microscope for eye surgery must be designed to be used in this position. This is important since it conditions the measurements of the instrument and its optical features, as well as the position of both surgeon and patient. Further, it is imperative that the distance between the eyes of the surgeon and the operative field be comfortable while, at the same time, there must be enough free space between the microscope and the eye of the patient to allow easy unimpeded manipulation and movements of the instruments. For these reasons, the body of the microscope should be of reduced size, even though this may require elimination of one or more traditional accessories (change of magnification, manual focusing device, filters, etc).

The illumination, which is almost as im-

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Fig. 2 (Barraquer, Barraquer and Littmann). Stretcher-operating table.

Fig. 3 (Barraquer, Barraquer and Littmann). Arrangement in the operating room: (1) container for sterile trays with instruments, (2) central suspension column, (3) surgical microscope, (4) motion picture equipment, (5) container for used instrument trays.
important as the magnification for good visualization, should be focal, intense, with an adequate angle of incidence and capable of orientation in the desired direction. To provide the additional benefit of an optical section, the equipment should be supplied with a slitlamp to be orientated as required and allowing rotation around its own axis to make the slit coincide with any meridian in relation to the sclerocorneal limbus. A second light source should be provided to avoid shadows produced by the instruments during certain surgical maneuvers.

On the basis of these principles and our experience with the use of the Zeiss microscope since 1953, we have come to the conclusion, after numerous trials with different experimental prototypes, that the ideal microscope for ocular surgery should comply with the following conditions:

1. It should allow the surgeon to adopt a comfortable sitting position similar to the one he uses when operating with teleloupes.

2. The microscope and the front lenses of the light sources should be kept at a suitable distance in order to avoid interfering with the surgeon's movements; a distance of 150 mm seems adequate since it allows unhampered manipulations in the operative field without separating the microscope excessively from the patient's eye.

3. The field of observation should include the entire anterior segment of the eye. We have found that a magnification of X10 is most suitable for our purposes.

4. The slitlamp attachment should have an angle of incidence of 40 degrees and allow rotation of the instrument all around the axis of the microscope. At the same time it should be possible to orient the slit toward any meridian of the eyeball.

5. An accessory light source should be provided, which could be equally rotated around the principal axis of the instrument, in the same way as the slitlamp. Its angle of incidence should be smaller in order to reduce possible shadows that may be produced during surgery.

6. The focus should be regulated with a foot control.

7. Any parts of the instrument which the surgeon may possibly have to touch should be provided with suitable protectors to maintain absolute asepsis.

8. The instrument should be entirely sterilizable with gases or ultraviolet irradiation, which means that the device must be lightweight and easily separated from its support.

9. The size of the entire set-up should be reduced as much as the mechanical and optical conditions permit.

Taking into account these principles a special surgical microscope for ocular microsurgery has been designed (figs. 4 and 5).

This instrument has three arms which may be rotated around the same axis, supporting the body of the microscope and the two light sources, respectively. The prolongation of the axis of rotation passes through the optical axis of the microscope in such a way that the object, once it has been focused, will always remain in the center of the field of observation and the centering of the light sources will always be maintained.

Fig. 4 (Barraquer, Barraquer and Littmann). Operating microscope with slitlamp attachment (left) and homogeneous light source (right).
during any rotation of the arms of the instrument.

The microscope is composed of an objective and binocular tubes only. To reduce the length of the instrument, no devices for changing the magnification have been provided. This can only be achieved by exchanging the tubes and/or the oculars for others with a different focal distance. There is no device for focusing either. The instrument is focused with the help of the column to which the microscope is attached and which may be hanging from the ceiling of the operating room or may be supported by a special stand on the floor. The vertical movements of the microscope, necessary to focus the instrument, are controlled by an electric or mechanical device which moves the column up or down and is regulated by a foot control. Thus both hands of the surgeon are left free and the focus may be adjusted to different planes, if necessary, without interrupting the surgical manipulations and without losing the continuity of a clear image of the maneuver.

Optically, the microscope is constructed in such a way (fig. 6) that between the principal objective with the focal distance $f_1$ and the lenses of the tube $f_2$, the incidence of the beams is parallel. Thus, an object (G) which is situated in the focal plane anterior to the objective is reproduced in the two focal planes on the image side $G'$ of the lenses of the tube, magnified by the factor $f_2$. On the other hand the intermediate images $G'$ are seen with the two eyepieces

Fig. 5 (Barraquer, Barraquer and Littmann). Operating microscope with homogeneous light source and microlamp.

Fig. 6 (Barraquer, Barraquer and Littmann). Diagram of the optics.
with a magnification of \( V = \frac{f_2}{f_1} \cdot V_{ok} \). The instrument is focused permanently for a distance of \( f_1 = 150 \text{ mm} \). The corresponding binocular tubes have lenses with a focal distance of \( f_2 = 125 \text{ mm} \) (short tube) or \( f_2 = 160 \text{ mm} \) (long tube).

At present eyepieces of \( V_{ok} = \times 12.5 \) and \( \times 20 \) are available. Eyepieces of \( V_{ok} = \times 10 \) and \( \times 16 \) are being prepared and the magnifications shown in Table 1 may be obtained using the corresponding tubes and oculars:

### TABLE 1

<table>
<thead>
<tr>
<th>Tube</th>
<th>( V_{ok} )</th>
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<tbody>
<tr>
<td>Short ( F_2 = 125 )</td>
<td>( \times 10 )</td>
</tr>
<tr>
<td>8.3</td>
<td>10.4</td>
</tr>
<tr>
<td>Long ( F_2 = 160 )</td>
<td>10.7</td>
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With the lowest magnification, the observer sees a circular field of 24 mm and with the highest magnification a field of 9-mm diameter. The selection of the tube not only depends upon the magnification which can be achieved but also upon the posture which is preferred by the surgeon. According to recent experience, the optimal combination would be a long tube with \( \times 10 \) eyepieces. This produces a total magnification of \( \times 10.7 \) and a field with a diameter of 18.7 mm, which permits adequate observation of the whole area of the cornea even if a certain decentration should occur during the operation.

For illumination of the eye during surgery, three light sources are supplied. Two of them may be used simultaneously. The lamps can be exchanged and combined freely. Thus we see in Figure 4 the combination of a slitlamp with a homogeneous light and in Figure 5 the combination of a homogeneous light with a so-called microlamp. Of course, the combination of two homogeneous light sources or of two microlamps or of a slitlamp with a microlamp are equally possible. On the other hand, one of the arms may be removed in which case the instrument would only have one of the three lamps, as shown in Figure 7 which illustrates the microscope with the slitlamp only.

All light sources are directed, logically, toward the center of the field and focused there.

The homogeneous lamp produces an illumination with acute limits of the luminosity on a field with a diameter of 38 mm. The slitlamp gives a similar field of about 17 mm; if the slit aperture is used, the slit will be 17-mm long. The microlamp produces, according to its adjustment, a more or less extensive not very uniform field of illumination of approximately \( 15 \times 25 \text{ mm}^2 \). The proportion of luminosity which can be achieved with the homogeneous lamp, the slitlamp and the microlamp is 1:2.6:4.

The two arms which support the light sources have different inclinations and the incidence of the light occurs at angles of 27 and 40 degrees, respectively, with regard to the optic axis of the microscope. Preferably, the 40-degree arm is used to accommodate...
the slit lamp, since this ensures sufficient inclination of the optic section in the anterior segment of the eye, while the 27-degree arm should be reserved for general illumination to reduce the shadows produced by the hand of the surgeon.

Moreover, the slit may be rotated 360 degrees around its own axis independently of the position of the lamp. When the slit is placed perpendicularly to its arm an optic section of 40 degrees is obtained (fig. 8-a). With the slit following the same direction as the arm, the optic section finally would be 0 degree (fig. 8-c). Combining the rotation of the slit around its proper axis and the position of the arm, the optic section which is obtained may vary between 0 and 40 degrees (fig. 8-b). In these intermediate positions, however, only the central part of the slit will be in perfect focus.

In figure 9 the new operating microscope (right) is compared with the old instrument (left). The important reduction of the distance between the surgeon’s eyes and the object is clearly seen; this has become possible by eliminating the device for changing the magnification and shortening the focal distance.

**Use of Operating Microscope**

As experience with this instrument increases, the indications for its use will gradually be extended. At present it is considered particularly useful in the following procedures:

A. **Surgery of the cornea**

1. **Penetrating keratoplasty**
   a. To check the centering of the trephination. A small error is more easily detected with the microscope than with the naked eye.
   b. To complete the section with scissors. Microscopic control allows the surgeon to follow exactly the groove prepared with the trephine and to avoid irregularities in the deeper layers.
   c. To preform peripheral iridectomies.

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**Fig. 8** (Barraquer, Barraquer and Littmann). (M) Microscope. (LH) Slitlamp. (B) Arm of slitlamp attachment. Adjusting the rotation of the slit and the position of the arm, and optical section varies from 40 to 0 degrees: (a) slit at 40 degrees, (b) slit at 20 degrees, (c) slit at 0 degree.
Fig. 9 (Barraquer, Barraquer and Littmann). The new operating microscope and the old instrument. The working distance has been considerably reduced.

d. To place the edge-to-edge sutures: (1) the exact depth of insertion can be determined accurately, (2) the slitbeam may be adjusted to the different corneal diameters to locate two points exactly apposed to each other for correct application of the sutures.  
e. Once the anterior chamber has been reformed, it is easy to determine with the slitlamp whether the iris is adherent to the wound margins and, if necessary, these adherences can be immediately separated under microscopic control. In large penetrating keratoplasties this is a very important advantage since without a slitlamp the detection and observation is rather difficult.  
f. To remove the sutures postoperatively.

2. Lamellar keratoplasty
   a. Microscopic control allows exact dissection in the desired plane.  
   b. The dissection may be carried very deep into the corneal thickness by doing successive resections; controlling the residual thickness to avoid inadvertent perforation of the cornea.  
c. In certain cases it is impossible to determine preoperatively the transparency of the deeper layers; once the resection has been completed it will be possible to check this and, if the transparency is not satisfactory, an immediate penetrating keratoplasty may be considered.

3. Keratomileusis
   a. To check the coaptation and orientation of the lenticulus.  
   b. For accurate placing of the sutures without any traction.  
   c. To check the absence of foreign bodies in the graft interface. Should any foreign material be found it may be removed under microscopic control.

4. Keratoprosthesis
   The dissection of the plane to fixate the acrylic prosthesis may be performed with maximum precision at a suitable depth to avoid protrusion of the optic cylinder above the epithelial layer of the cornea and to maintain the intralamellar support at an adequate level, which is of utmost importance to ensure tolerance of the prosthesis.

5. Corneal trauma
   a. Microscopic control allows very meticulous examination of the lesion to decide the treatment to be applied.  
   b. The wound can be sutured with maximum precision.  
   c. Corneal foreign bodies, especially deeply imbedded particles, may be removed adequately.

6. Pterygium surgery
   a. Verification of the absence of vessels, especially near the superior and inferior margin of the pterygium head.  
   b. To check the uniformity of the corneal thickness underneath the pterygium head and for levelling the cornea if irregularities are found (to prevent recurrence).
B. SURGERY OF THE LENS

1. Extracapsular extraction
   a. The opening of the capsular sac can be achieved with precision and all details can be visualized to determine whether it would be convenient to incise in certain areas.
   b. The aspiration of the lens material may be carried out more precisely and more completely since the position of the posterior capsule can be determined and residual material can easily be seen in all areas.
   c. If a posterior capsulotomy is indicated, the microscope allows determination of whether the vitreous remains well behind the iris or whether there is vitreous incarceration, which should be reduced.

2. Intracapsular extraction
   a. The insertion of the corneoscleral sutures is the stage which benefits most from the use of the microscope.
   b. The other surgical maneuvers may also be performed under microscopic control but, because of the multiplicity of different manipulations, the technique may become rather tedious and the operation prolonged unnecessarily.
   c. In cases of accidents, such as rupture of the capsule or vitreous loss, greater precision can be achieved to complete the extraction or to reduce the incarceration.

C. GLAUCOMA SURGERY

The projection of the slit upon the iris and the limbus gives a very good idea of the limits of the anterior chamber, which in turn allows the surgeon to evaluate the extension of the surgical limbus and the incision can be placed with great accuracy.

D. EXAMINATION OF PATIENTS IN THE SUPINE POSITION

1. Children under general anesthesia
   a. The microscope allows one to examine all meridians with the slitlamp, setting the slit at different angles from 0 to 40 degrees, which is not possible at present with any other apparatus.

2. Catheterization of the lacrimal passageways
   a. In difficult cases (atresia of the punctum, for example), the procedure can be expedited.

E. SURGERY OF THE ANTERIOR CHAMBER

1. Liberation of small synechiae
2. Reposition of Descemet's membrane in cases of partial postoperative detachment
3. Removal of foreign bodies from the anterior chamber

CONCLUSIONS

In this brief discussion we have only mentioned some of the principal applications of the microscope and the slitlamp in ocular surgery. Its utility grows from day to day with increased experience in its use. The instrument has certain characteristics which make it especially valuable in surgery of the anterior segment of the eye.

The mechanical or electrical focusing device ensures complete freedom of the surgeon's hands during the operative procedure.

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