Transparent optical neurosurgical instruments

Technical note

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Neurosurgical instrumentation over the last two decades has improved with the increasing use of the operating microscope and has provided much better visualization and lighting of the surgical field. During this time, dissecting instruments have become smaller, but they sacrifice some of the microscopic gains because they are made of opaque metal. This has the disadvantage of hiding from the surgeon the area of the surgical field being worked on. This paper reports the development of transparent instruments that are strong enough to be used in dissection and yet do not sacrifice part of the improved visualization and lighting gained with the operating microscope. Made of a high-strength plastic, these instruments can be used for dissection in surgical procedures and allow the surgeon to look through them and observe the tissues underneath. He can watch the condition of blood vessels and nervous tissues with an improved visibility that can help to avoid damage to delicate structures. Furthermore, as hidden structures such as small vessels come into view they are identified earlier. These instruments can also incorporate jeweled cutting edges and use their optical properties to improve further visualization of the surgical field.

KEY WORDS • microsurgery • instrumentation • transparent surgical instruments

The principal aims of the introduction of the operating microscope in neurosurgery have been to improve visualization and lighting of the surgical field. These have been accomplished with the magnification and co-axial lighting provided by the microscope. However, the instruments currently used, although small and refined, sacrifice part of the gain. Being of opaque metal they block the area being operated on. Given the small size of crucial areas such as delicate vessels supplying the brain, the use of one or two instruments in a surgical field can prevent the surgeon from seeing these structures while working on them. The surgeon’s instinct, experience, and feel can often overcome this problem. However, it would still be advantageous to be able to observe these structures while working.

This paper reports the development of transparent microsurgical instruments that allow the surgeon to continue to observe the operative field while he is working. He can see small blood vessels, the effects of manipulation upon them and upon neural structures. Unexpected small branches of vessels or nerves are detectable earlier, whereas they are seen only after removal of an opaque instrument.

Description of the Instruments

These instruments are made of a strong high-density polycarbonate transparent plastic. After casting, they are hand machined to give the final configuration. They have in common the property of transmitting a high-quality visual image through them. They are made in a variety of shapes as are traditional microsurgical instruments, and are disposable, inexpensive items for one-time use. They are available pre-sterilized. A set of 12 microsurgical instruments and six regular instruments is available (Fig. 1).* The degree of rigidity of the shaft can be controlled by a combination of the choice of plastics, the diameter and length of the shaft, and the amount of machining done. This allows the instruments to have optimal flexibility, sufficient to dissect delicate nervous structures but able to bend slightly. This minimizes the consequences of any sudden movement of neural structures.

Over a period of 1 year these instruments have been used on approximately 40 neurosurgical cases. They

* Instruments available from PMT, Inc., Hopkins, Minnesota.
definitely improve visualization of the operative field (Figs. 2 and 3). Often one is able to observe under magnification blood flow in the small vessels that are intrinsically part of the nervous tissue, as well as to observe the condition of small vessels branching off major cerebral arteries. Thus, during dissection one can better appreciate whether sufficient stress is being placed on a vessel to kink, tear, or otherwise injure it. One can appreciate the condition of the cranial nerves and other delicate structures so as to better judge the minimum force necessary to accomplish the dissection and avoid injury. There is an improved feedback of information to the surgeon about the consequences of his actions on tissue.

At some angles the instruments can reflect light from the operating field which can partially obscure visualization through them. However, it is rarely the case that one cannot see adequately through the instruments while working in a particular angle on a given structure. In fact, one usually has an excellent view of the area, and at times the instruments provide a slight additional magnification. There have been no adverse effects seen and no instances of breakage, scratching, or opacification during use.

Discussion

These instruments can preserve the advantages for the surgeon of lighting and visualization given by the operating microscope. Since the surgeon’s abilities are built on experience, the fact that he can continue to observe the tissue as he works should improve his response to the effects of his manipulations. The relationship of the instrument to structures along its entire length is better appreciated because one can see through the entire length, whereas, during dissection with an opaque instrument, the tip can be hidden by a more proximal part. The ability to observe small vessels and other delicate structures during the actual dissection provides an additional valuable dimension in control of the surgical field.
Certain features of these instruments can lead to further useful developments. Prototypes are being tested that incorporate jeweled cutting edges; these allow the surgeon to observe the field during sharp dissections as well as blunt. The optical properties of these instruments, with refraction and reflection of light, allow for the design of prototypes that provide additional magnification where needed. More importantly they can refract light so that it is possible to observe at least partially behind a structure being worked on, such as an aneurysm. Furthermore, illumination can be built into the instruments using the optical properties of the instrument itself with fiber-optics. Finally, the ability to make the shaft flexible to a controlled degree allows the instrument to be designed so that it will permit dissection and yet flex to adjust to sudden pressure. This can help to protect delicate structures against abrupt movement. These instruments are intended to give the surgeon the best visualization of his operating field during a microsurgical dissection.

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