REPRODUCTIVE INFERTILITY MICROSURGERY IN THE MALE AND FEMALE

Sherman J. Silber

Reproductive Infertility Microsurgery in the Male and Female

Sherman J. Silber, M.D.

St Luke's West Medical Center
St. Louis, Missouri

and

Microsurgery Laboratory
St John's Mercy Medical Center
St Louis, Missouri

Illustrations by
Scott Barrows

WILLIAMS & WILKINS
Baltimore/London

Editor: Toni M. Tracy
Associate Editor: Victoria M. Vaughn
Copy Editor: Caral Shields Nolley
Design: Bert Smith
Illustration Planning: Reginald R. Stanley
Production: Raymond E. Reter

Accurate indications, adverse reactions, and dosage schedules for drugs are provided in this book, but it is possible that they may change. The reader is urged to review the package information data of the manufacturers of the medications mentioned.

Made in the United States of America

Library of Congress Cataloging in Publication Data

Silber, Sherman J.
Reproductive infertility microsurgery in the male and female.

Bibliography: p.
Includes index.
1. Generative organs—Surgery. 2. Microsurgery. I. Title. [DNLM: 1. Genitalia, Male—Surgery. 2. Genitalia, Female—Surgery. 3. Microsurgery. 4. Sterilization, Sexual. WJ 700 S582r]
RD584.S54 1984 617'.463 83-16780
ISBN 0-683-07754-6

Composed and printed at the
Waverly Press, Inc.

Reproductive Infertility Microsurgery in the Male and Female

Preface

Microsurgery is basically a technique for expanding the visual horizon of the surgeon so that he can deal with smaller structures successfully. The only limit to our manipulative skill is what the eye can see, providing that the hand is willing to practice. There should be no mystery to microsurgery. The microscope simply opens up an exciting new universe in which the urologist, gynecologist and reproductive biologist can deal with small structures that were previously unmanageable. To the clinical surgeon there is a vast expansion of what he can offer his patients. To the academic surgeon there is a new array of animal models for studying physiological processes that never seemed possible before the days of transplantation in isogeneic inbred animals. To the basic researcher, not necessarily interested in surgery, microsurgical expertise will provide new avenues for experimentation. Most surgeons and biologists will have to develop some microsurgical expertise to remain in the 20th century.

Not only have new operations been made possible that were never before dreamed of, but the older operations are being performed better by use of microscopic techniques. Pregnancy rates after tubal reconstruction and vas deferens reconstruction have tripled. Autotransplantation of the testicle to the scrotum for intra-abdominal cryptorchidism (which was once considered a pure dream) is now being performed routinely.

The premise upon which this book is written is that practice in basic microsurgical techniques will allow each of us to more seriously and more effectively utilize this surgical discipline, both in our research and in our clinical practice. The urologist who is wrestling with some of the difficult microsurgical problems of his male infertility patients will find striking similarities as well as differences to the microsurgical problems with which his gynecological consultant is dealing in the patient's wife.

All surgical disciplines have a common interest in developing microsurgical expertise. The microsurgical problems in gynecology, urology and reproductive biology are sufficiently related that a book such as this is now necessary.

SHERMAN J. SILBER, M.D.

Contributors

Brian Cohen, M.D.
Fertility Center of North Texas
Gynecological Microsurgical Institute
8220 Walnut Hill Lane
Dallas, Texas 75231

Robert Cohen, M.D.
Department of Obstetrics & Gynecology
St. Lukes Medical Center and
St. John's Mercy Medical Center
St. Louis, Missouri

Julius Jacobson II, M.D.
Division of Vascular Surgery
Mt. Sinai Hospital
New York, New York

Sherman J. Silber, M.D.
St. Luke's Medical Center and
Microsurgery Laboratory
St. John's Mercy Medical Center
St. Louis, Missouri

Early History of Microsurgery

Julius H. Jacobson II, M.D.

Division of Vascular Surgery
Mount Sinai Hospital
New York, New York

It is indeed an honor to be asked to contribute the introduction to this outstanding book. To comment on the contents of the book would serve no purpose, because the author is an expert in this particular area. Of greater interest would be to give a brief history of microsurgery and some perspective on its current use and future horizons.

The microscope for use in surgery was initially developed for surgery of the eye and ear. Its use along with finer suture materials and instruments dramatically allowed many of the blind to see and the deaf to hear.

While people in the basic science laboratories were using binocular microscopes to aid in their dissection, its use had never been applied in the field of vascular surgery. In 1958, while a resident at Presbyterian Hospital in New York City, I was waiting between operations one day and wandered into a room where a stapes mobilization procedure was going on. I was allowed to look through the microscope and was intrigued by the tiny anatomical details that were made visible—but no gong sounded in regard to its implications in other surgical fields.

Fresh out of a seven-year residency I was appointed Associate Professor of Surgery and Director of Surgical Research at The University of Vermont. Its superbly equipped laboratories, loads of animal space, and a National Institutes of Health which then had money for any project considered worthwhile, made it a grand milieu for new ideas.

I was asked, shortly after my arrival, to help the Department of Pharmacology with a project in which they were trying to denervate the canine carotid artery. No matter how well the artery was skeletonized, there was still evidence of sympathetic activity in its wall. It appeared that the only way to effectively denervate the artery was to divide and reanastomose it, although the general teaching in the newly developing field of vascular surgery was that one should not attempt anastomoses on vessels that small. We became intrigued with the reason for the failures, inasmuch as the technique was the same as that used for canine aortic anastomoses in which patency is consistently achieved.

In assessing the reasons for poor results in small vessel anastomoses, it was reasoned that the technique was at fault. Thus a 1-mm error in placement in a 1-cm artery is of no practical significance, whereas it would cause failure in a 2- or 3-mm vessel. One has only to examine the relationship expressed in Poiseuille's law, which states: other factors aside, the flow through a vessel is a function of the fourth power of its radius. In an exponential function of this type, minute changes in diameter have a profound effect on flow.

In analyzing the situation further, it became apparent that the major defect in technique was the inability of the eye to see, rather than the hand to do. After attempts with the use of magnifying spectacles and a magnifying glass placed over the operative field, the ear operation I had observed years earlier was finally remembered. A microscope was borrowed from the ENT operating room.

The first experience using the microscope for vascular anastomosis can be compared to the first time the moon was seen through a powerful telescope; a welter of previously unrecognized detail was seen. What was considered innocuous—holding the intima with a forceps—was seen as the cause of a major trauma. A tag of intima intruding into the lumen could be seen as the nidus formation for clot and the reason for failure.

Once the problem of adequate vision was solved, the existing surgical instruments and suture materials proved to be unsatisfactory. At a local jewelry store, forceps were found which were superior to anything in the surgical armamentarium. The jeweler's forceps are still satisfactory for most applications, and much cheaper than those which can be bought from a surgical supply house. Quite incidentally, a test of forceps adequacy that we have come to rely upon is the ability to pick a single hair from the back of a hand without slippage or cutting the hair.

The assistants were unable to hold the clamp steadily enough so various adjustable arm devices were developed to circumvent the problem. The vascular clamps themselves slipped and were not hemostatic when used on small thin-walled arteries and veins. The problem was easily solved by slipping lengths of shoelace around the clamp jaws to increase their thickness. Thus new microvascular clamps were first produced.

Fine finger motion was an essential to properly manipulate needle holders and scissors; however, the ordinary ring-handled instruments available were predominantly controlled by the wrist. The Castro-Viejo handle design, which has been developed for doing precision eye surgery, proved to be the answer. Ethicon, Inc. developed a needle with a diameter of 0.005 inches with a 0.001-inch monofilament nylon suture swaged to it. Although slightly finer suture products are now made, there remains a greater need for still finer ones for working on very small vessels. The fundamental problem is that the ratio of needle diameter to suture diameter cannot be made smaller than 3 to 1 and still give a strong enough swage joint. Some attempts have been made at metalizing the end of a suture and then sharpening the point. It is in this direction that future advances lie.

The next problem encountered was that the surgical assistant could not be a proper help because he was unable to see the surgical field in magnified form. The two largest American manufacturers of surgical microscopes were contacted in regard to producing a double binocular microscope. As so often happens when contacting large corporations, the middle management people were enthusiastic and said it could be done, but top management did not see any future potential and the projects were scrapped. Finally, Carl Zeiss, Inc. of West Germany was asked to help and they sent over the engineer who designed the original microscope for eye work. The Zeiss approach was in sharp contrast to that of the American firms. They agreed to build one double binocular microscope (to be named the Diploscope) at no cost. Their firm had an immediate success and they elected to put 50% of all profits into the foundation to support research and development.

For the next year and a half our laboratory spent its time dividing virtually every small tubular structure in the body and rejoining it. Success was achieved in arteries down to 0.8 mm and veins as small as 1 mm in diameter. Coronary arteries were divided and reanastomosed but we were told by our medical cardiologist friends that the utility of this procedure was essentially nonexistent.

The first paper on anastomosis of small vessels was presented at the surgical forum of The American College of Surgeons, 1961. It was not practical according to the critics. It is gratifying to see, although many years later, the profession has widely accepted the value of microsurgery, and this book serves as a confirmation of their ability to make it useful.

Contents

CHAPTER 1

Microsurgical Technique

SHERMAN J. SILBER, M.D.

Microsurgery should be learned in the laboratory and not on patients. The techniques are very exacting and at first may seem extraordinarily difficult. However, with a reasonable amount of practice one can develop a great deal of facility with the basic techniques. Then when approaching the more involved problems of clinical microsurgery, confidence, which comes from a good laboratory background, will allow the operation to proceed much more smoothly. A clinical microvascular case should not be attempted until the surgeon feels quite confident from his laboratory practice that he will have no difficulty anastomosing almost any vessel down to 0.5 mm in diameter. If one does not have access to a small animal laboratory in his hospital or medical center, and is only interested in doing nonvascular microsurgery such as tuboplasty or vasovasostomy, he can at least practice on segments of vas deferens or fallopian tube removed from patients at the time of hysterectomy, tubal ligation, or vasectomy. The fact that this tissue is not living and there is no bleeding to contend with or seepage of seminal fluid to cloud one's view of the lumen makes such practice unrealistically easy; but at least the basic manipulations can be practiced before a live patient is subjected to a procedure whose success depends upon the precision of the surgeon. For microvascular work no clinical undertaking should be considered until adequate practice in the small animal laboratory has been obtained.

The basic finding upon which all microsurgery is based is the observation that the hand can perform remarkably intricate micromanipulations as long as the eye can see a magnified field and guide it properly. A simple experiment with a micron gauge for measuring finger movement demonstrates unbelievably fine control is possible if the movements can be visualized precisely. One can move such a gauge almost 1 μm at a time as long as his eye is viewing it and feeding the information back to the brain. In a similar vein, studies on basketball players who have demonstrated great shooting accuracy have revealed that part of their prowess lies in an extraordinary degree of visual acuity and distance perception. (Tupper J.W., and Jako, G.J., each: personal communication, Ethicon International Microsurgical Seminar. December 16, 1977.) Optical magnification expands the horizon of what the hands can do simply because we can see better.

The principle of this chapter is that as long as one can see the structure well, he can manipulate it adequately to perform a reliable operation, no matter how tiny and delicate the tissue.

OPTICAL LOUPES AND THE OPERATING MICROSCOPE

The most convenient operating loupes provide 2.5 × magnification. Loupes can be obtained at considerable expense that go all the way up to 6 × magnification, but they tend to be very awkward to use. Since they are worn on the head, they move with the head, and cannot be held stationary. With magnification greater than 2.5 ×, these movements become very distracting and irritating. In addition, loupes simply do not have the ability to obtain the same depth of focus at 6 × magnification that can be achieved with a microscope. The field of view is extremely narrow with 6 × magnification and such loupes are totally useless unless they are worn in conjunction with a headlight. Despite the first impression that 6 × loupes with a headlight might have some convenience over a fixed microscope, they usually become rather cumbersome to deal with. Therefore loupe magnification is generally most useful when minor degrees of magnification are all that is needed. One can obtain loupes from Keeler, or Designs For Vision, which have relatively long focal lengths and therefore give one a comfortable working distance. For anastomosis of tubular structures greater than 3 mm in internal diameter, loupes can be used advantageously, but for structures smaller than that a microscope is necessary for a reliable anasto-

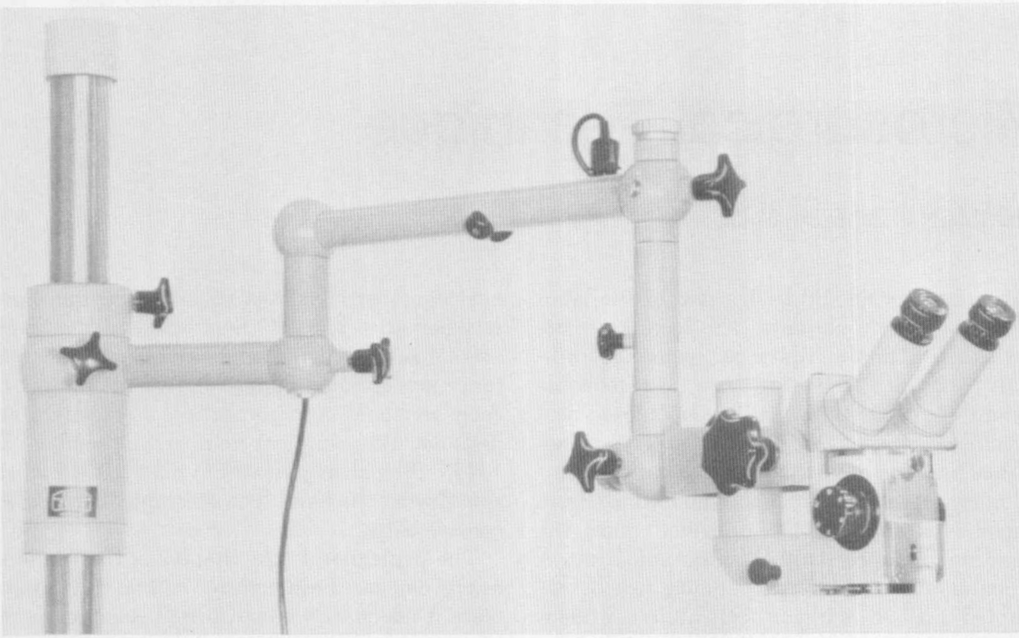


Figure 1.1. A typical Opmi-One Zeiss microscope with a floor stand available for use clinically in the operating room.

mosis. Loupes find their greatest use in microsurgery during the process of freeing up and dissecting the specimen prior to the actual anastomosis. Most microanastomoses are better performed under the microscope.

There are a variety of microscopes available. The Zeiss Opmi-One provides magnification settings of 6 ×, 10 ×, 16 ×, 25 ×, and 40 ×. Focusing and magnification settings are controlled by hand with this model (Figs. 1.1, 1.2). This is the classical Zeiss operating microscope and still is my favorite. The only difficulty with it previously had been the inability of one's assistant to look down his own set of binoculars and observe exactly what the surgeon observes. However, an Urban quadroscope (Burbank, California) can be attached to the Opmi-One to solve this problem (Fig. 1.3). This is a beam splitter which fits onto the Zeiss Opmi-One microscope and allows an ideal arrangement for the surgeon and the assistant to look down binoculars seeing the exact same operative field at a 180° position from each other (Fig. 1.4). In addition, there are two ports on either side of the quadroscope to which movie cameras, still cameras, or TV cameras can be attached for photography or video monitoring. The view one obtains is, of course, three-dimensional (the importance of this becomes readily apparent when one takes his first photograph). A photograph records a two-dimensional account of what the operator originally saw in three dimensions, and for that reason never quite lives up to the surgeon's expectations. An observer tube frequently available on these microscopes provides an inverted image in only two dimensions (it is a monocular

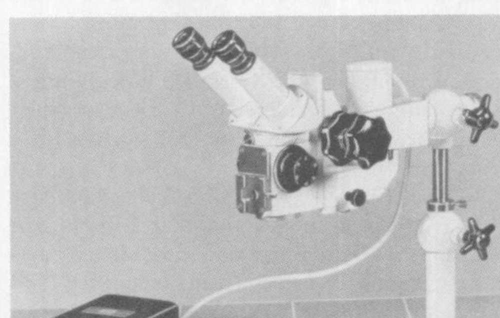


Figure 1.2. The same Opmi-One microscope on a desk stand is less expensive than on a floor stand, and quite handy for laboratory usage.

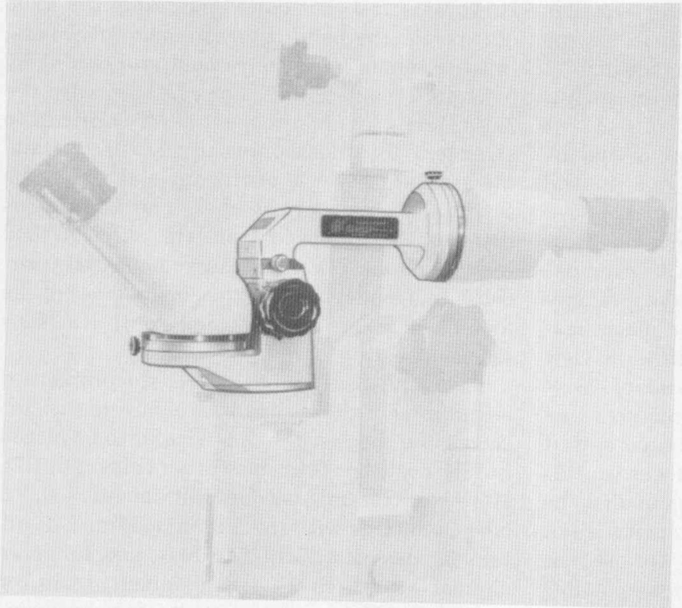


Figure 1.3. This is an illustration of the Urban quadroscope which converts an Opmi-One into a modern microscopic unit whereby both surgeon and assistant can see the same view in three dimensions.

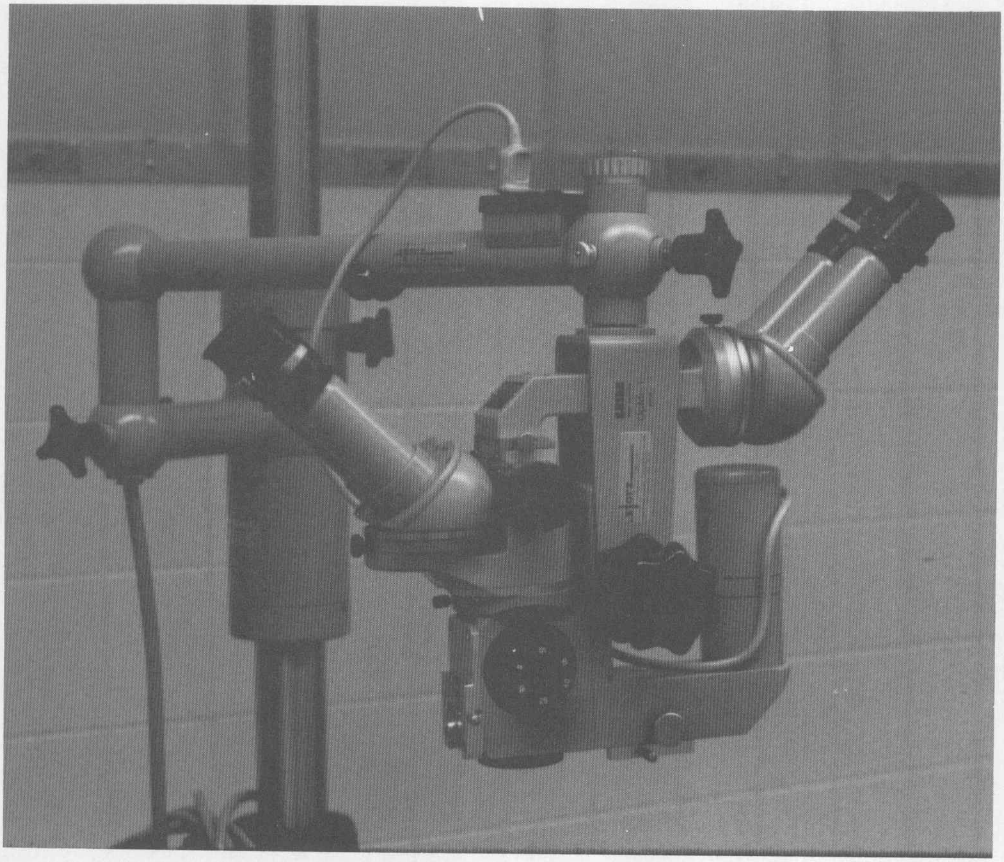


Figure 1.4. This is a photograph of the microscopic arrangement which I find most convenient. All of the controls are manual, and the Urban quadroscope allows 180° positioning for the assistant.

tube) and this tube is worthless for surgical assistance. It is only what it says it is, i.e. an observer tube. It is impossible to adequately assist in microsurgery by looking down such a monocular observer tube.

Equally as important as the degree of magnification afforded by the microscope is the amount of light one can get into the operative field (Fig. 1.5). Magnification will give no effective gain in visual acuity unless it is accompanied by increased light intensity. If the intensity of light can be improved at higher magnifications without any change in the optics, the view becomes much sharper. For the use of 25 × magnification with very small structures one needs an extremely strong light source and, if the optics give a somewhat soft focus at this high magnification, the real problem may be that a light source of sufficient intensity is not being used. We generally prefer to use the strongest available bulb at the highest possible voltage, or an extremely bright fiber-optic light source. Zeiss now has a halogen light source for the Opmi-One which is much brighter than fiberoptic systems. I personally prefer this model (Opmi-One-H).

For more than double the cost of a simple Zeiss Opmi-One microscope, Urban quadroscope equipped, one can purchase an electronically operated zoom and focusing foot pedal mechanism which obviates the need for hand controls. Some microsurgeons prefer this foot-operated remote control focusing and zoom device to reduce hand movement and subsequent fatigue. However, I feel that quite apart from the issue of expense, the hand-operated microscopes are, in truth, much more convenient and less likely to require maintenance. For example, with the Zeiss Opmi-Six microscope it is very difficult to arrange a 180° positioning of the surgeon and the assistant because of the angle at which the assistant's binocular attaches. The assistant is therefore far removed from the surgical field with the Opmi-Six. Many surgeons hastily purchase this model because the convenience of the foot pedal zoom and focusing control at first seems appealing.

The Opmi-Seven model solves the problem of positioning of the assistant by allowing the surgeon's and the assistant's binocular to be placed in 180° positions from each other (Figs. 1.6, 1.7). However, this microscope costs about $30,000 (the Opmi-One with the Urban quadroscope arrangement costs about $14,000), and for most clinical operations in the abdomen, groin, or scrotal area, foot pedal controls are very inconvenient. If one is operating in the abdomen or in the groin he would prefer to stand, not only for ease of exposure, but also because with most operating room tables there is no place to put one's knees when sitting (Fig. 1.8). With these foot-operated microscopes, there is a pedal on the left for fine focusing upward and on the right for fine focusing downward. In addition there are pedals on the left and on the right just in front of the latter pedals for coarse focusing upward and coarse focusing downward. Finally, there are two more pedals, one on the left and

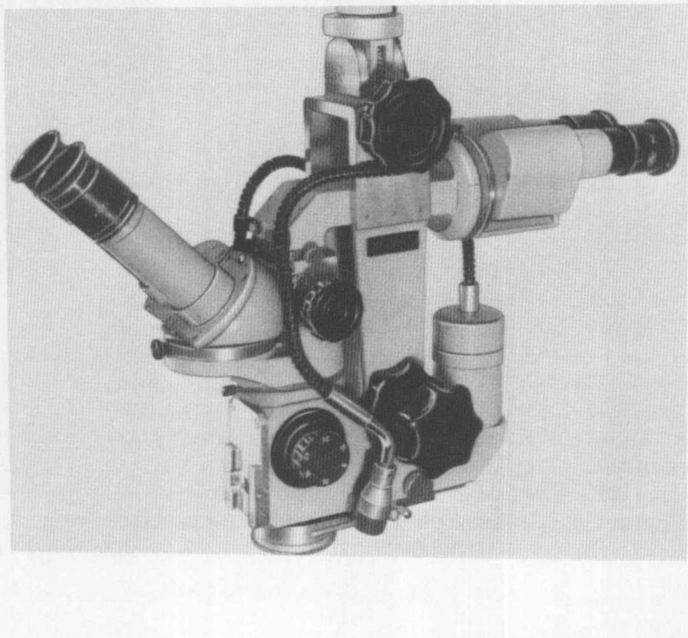
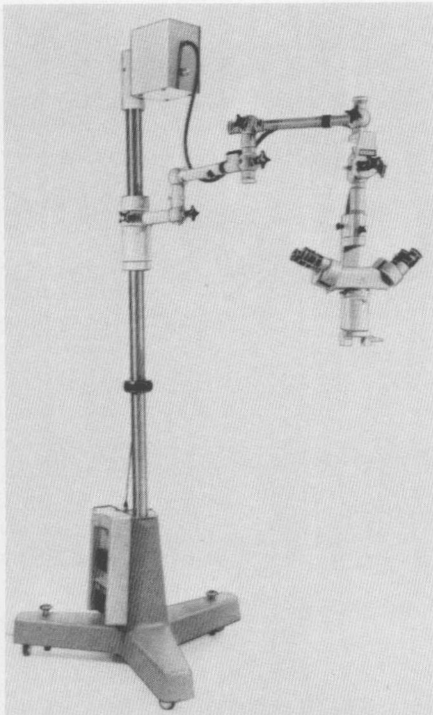


Figure 1.5. This is another view of an Opmi-One with an Urban quadroscope with a fiber-optic light source added for extra brilliant illumination.



Figures 1.6 and 1.7. These are illustrations of Zeiss Opmi-Seven microscopes operated with a zoom foot pedal switch for magnification and focusing. These are good microscopes but they are extremely expensive and can be very clumsy when one is performing his surgery in the standing position.

one on the right, in a different position, which control zooming in and zooming out respectively. The only way that one can easily keep track of where the different pedals are is to be sitting and have both feet planted properly on the foot pedal control board. For one who is performing microsurgery in the standing position, this is just about impossible. Therefore, for overall versatility we find the standard manual model, i.e., the Opmi-One fitted with an Urban quadroscope, not only to be the best buy from an economic point of view, but also the most convenient.

Although Zeiss (West Germany) has had a monopoly on good operating microscopes for many years, Wild (Switzerland) has now come out with an operating scope that is superior in many regards. It has a superior depth of focus, which means very little adjustment of the focusing knob is necessary during an operation. It also has a better light source and a wider field of view. The only problems are that it is more expensive and has a clumsy floor stand.

For both the microscope and loupes, one must set the interpupillary distance properly for the individual surgeon. When you first look through the loupes or through the microscope, everything may appear to be blurred and disconnected simply because the ocular lenses are farther apart from each other than your pupils are. With the microscope, one's interpupillary distance can be very quickly adjusted without any aggravation. However, with loupes this interpupillary distance is a little more difficult to establish. Once one has adjusted his loupes so that he has good convergence of the images, he should tighten this adjustment carefully and then keep them for his own use. It is very uncomfortable to pass loupes around from one surgeon to another because we all have a slightly different interpupillary distance and, unlike the microscope, loupes are not quite that easy to adjust.

Figure 1.8. With a manually operated scope almost all surgery can be performed very comfortably in the standing position. For intra-abdominal surgery, or surgery in the groin, this is essential. One simply cannot sit down to perform clinical surgery in this area.

SUTURE AND NEEDLES

Monofilament nylon is preferred for all microsurgical procedures. For tuboplasty procedures, some surgeons prefer the new monofilament Vicryl, although we do not. Other sutures, although apparently fine to the naked eye, are braided and appear like cable under the microscope. They tear through the delicate tissue of the small vessels or tubes being sutured. In addition, a great deal of reaction is associated with braided sutures which, in itself, can be a cause of occlusion of the anastomosis. Monofilament nylon is essentially nonreactive, and slips through the tissue with virtually no friction or tearing. 10-0 nylon (22-μm diameter) is ideal for most microvascular anastomoses. For somewhat larger structures of 2- or 3-mm diameter, 9-0 monofilament nylon (35 μm) is quite good. Some microsurgeons prefer 11-0 nylon (18-μm diameter), but in my very large experience I have not found that there is significant benefit to such thin suture, even with vessels as tiny as ⅓ mm in diameter.

Until relatively recently the best needles available on these microsutures were 140 μm in diameter (BV-2) and although many fine microvascular procedures were performed with this needle, it certainly leaves a large hole (considerably larger than the suture) and, at least theoretically, the BV-6 needle (75-μm diameter) is preferable and less traumatic. However, for anastomosis of the vas deferens the BV-6 and BV-2 microvascular needles are really quite inadequate. Since the vas has such a tough muscular wall and inner elastic lining, a cutting needle is necessary to perform both the inner mucosal and the outer muscularis anastomosis without tearing or tugging. The finest cutting needle available is necessary for this type of suturing since the standard cutting needles generally used for corneal work in the eye are too large and create a big hole (Fig. 1.9).

However the Ethicon GS-16 needle has been quite admirable for this purpose. It is a superbly sharp cutting needle which is moderately fine and leaves only a modest hole. If one tries to use a microvascular needle such as the BV-2 or BV-6 on the vas deferens, he will have a hopeless time pulling and tugging and tearing at tissue that is amazingly tough for its very tiny size. The GS-16 needle, however, is still not quite ideal, in that some tissue tearing still can occur. Newer cutting needles are coming out that are even finer than this and will probably be preferable for vasoepididymostomy.

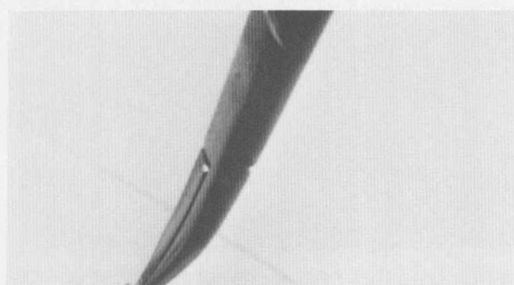


Figure 1.9. Very delicate needles with swedged on 9-0 or 10-0 monofilament nylon are used for all microsurgical anastomoses. The needle holders must have very delicate tips.

These new Ethicon needles will be the "Silber" V-100, with a 140° curvature, and an extremely fine "taper-cut" point. It represents a great improvement in that it cuts with ease into tough tissue, but causes no tearing.

INSTRUMENTS

When one goes to microsurgery conferences he is often confronted by instrument companies sporting an almost infinite variety of very expensive "microsurgical" instruments, which he is told are absolutely essential for fine microsurgical work. The newcomer to microsurgery who has not yet achieved a great deal of confidence in his technique is like a babe in the woods when confronted by these enthusiastic salesmen. The novice to microsurgery should therefore find some strength and assurance in the fact that the instruments required for doing the most sophisticated microsurgery are very few and inexpensive. For the most complicated microsurgical procedures, either on rats or humans, the instrument tray should have only a few items. A sparkling tray full of many delicate little instruments of infinite variety is generally the mark of a surgeon not yet sufficiently skilled in his trade to realize that there are only a few items truly needed for competent microdissection and anastomosis (Fig. 1.10).

Jeweler's forceps, Nos. 3C, 4, or 5, which generally cost $4–7 apiece, are the basic instruments (Figs. 1.11, 1.12). Luckily these instruments are used extensively by the electronics industry for manufacturing microprocessors and integrated circuits. Because of the enormous electronics market for these forceps, the medical profession gets off relatively cheaply—it is probably one of the greatest bargains in medicine. When the tips become dull or barbed (you can usually only tell this by observing under the microscope) the forceps can either be repolished if you are truly frugal, or else simply discarded and replaced with a new pair. The 3C forceps are very handy for tougher structures such as the vas deferens and the Fallopian tube, whereas the Nos. 4 and 5 jeweler's forceps are handier for small blood vessels or epididymis in the range of 0.5 mm in diameter.

Needle holders should be of the nonlocking spring-loaded variety, held in the hand as a pencil rather than as a scissors (Figs. 1.13, 1.14). This allows one to rest the palm of his hand on a suitable support (often the patient's abdomen)