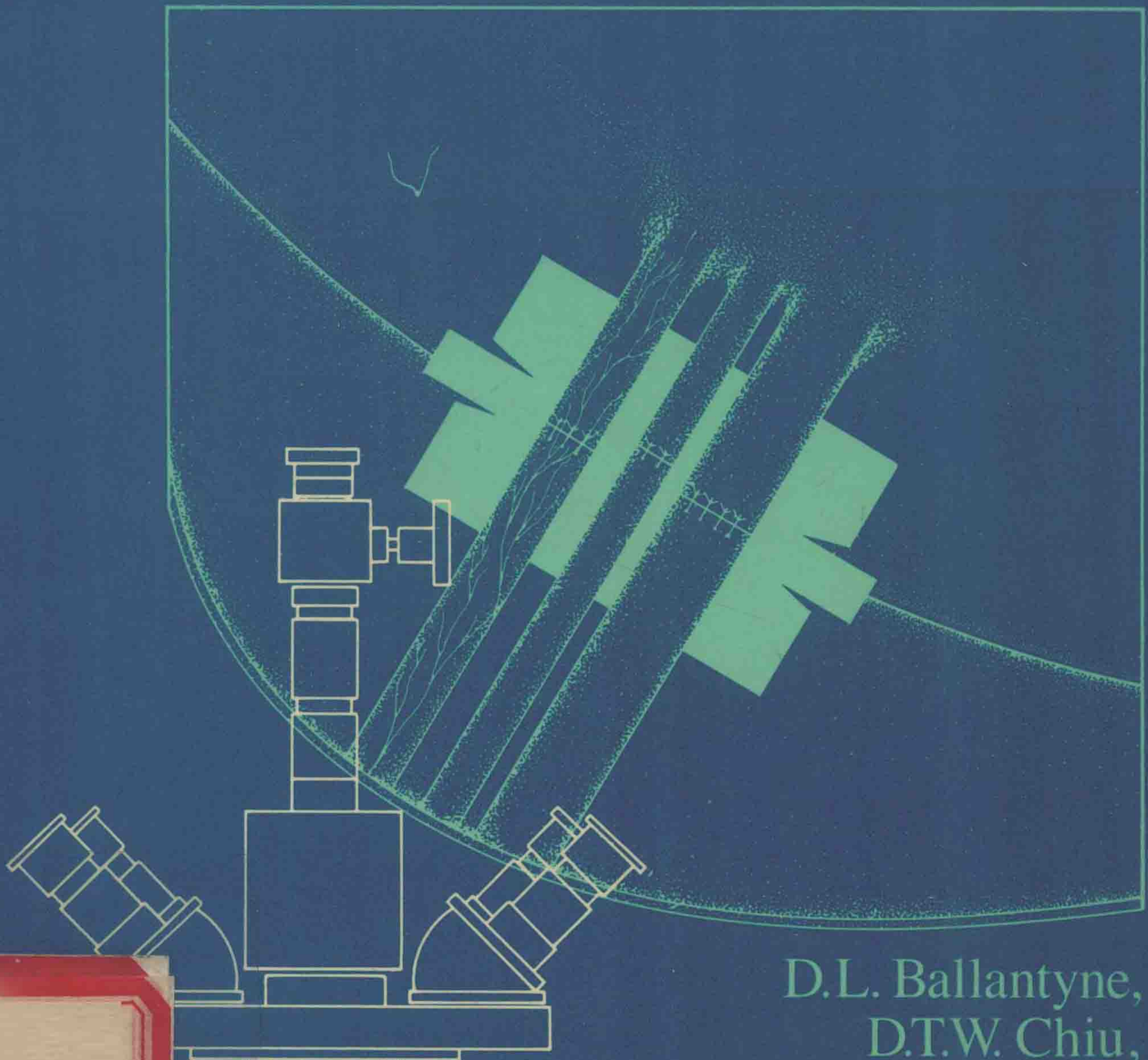
Introduction to Microsurgery

A Microvascular and Microneurological Laboratory Manual



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University Park Press • Baltimore

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A Microvascular and Microneurological Laboratory Manual

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University Park Press • Baltimore

University Park Press
International Publishers in Medicine and Allied Health
300 North Charles Street
Baltimore, Maryland 21201

Sponsoring editor: Verlencia T. Conyers
Production editor: Megan Barnard Shelton
Cover and text design by: Caliber Design Planning, Inc.
Typeset by: Waldman Graphics
Manufactured in the United States of America by: Halliday Lithograph

Library of Congress Cataloging in Publication Data

Main entry under title:

Introduction to microsurgery

Bibliography: p.77
Includes index.
1. Microsurgery—Laboratory manuals. I. Ballantyne, Donald L. [DNLM: 1. Microsurgery—laboratory manuals. WO 512 I615]
RD33.6.I588 1985 617*.05 84-29088
ISBN 0-8391-2004-4

Introduction to Microsurgery

We dedicate this manual to the late Dr. John Marquis Converse, whose encouragement and support of microsurgical training and research were invaluable.

Foreword

This manual provides the reader with a wealth of information gleaned from over 25 years of experience in experimental surgery. The senior author has been part of the development of experimental transplantation surgery since the 1950s. The fields of transplantation and microsurgery soon became closely aligned in the 1960s. It is interesting to note that most of the early work in transplantation immunology was done with split-thickness or whole-thickness skin grafts, culminating with the observations of Gibson and Medawar of the second set phenomenon. After Murray of Boston successfully transplanted a kidney in the dog, then in human identical twins, a real need for experimental microsurgical organ transplantation was created. Fisher and Lee soon demonstrated the feasibility of small organ transplantation, using relatively large suture material to anastomose vascular flanges rather than end-to-end repairs. It was not long before fine suture material and sophisticated instruments became available, permitting the end-to-end repair of 1-mm vessels.

These unique skills of the small animal organ transplanters were transferred to the microsurgeons in the microsurgical laboratory environment. The group at New York University Medical Center was among the first to foster the union of experimental tissue transplantation and microsurgery. Their experience is presented in this concise, straightforward laboratory manual.

To the neophyte totally unfamiliar with microsurgery, this is the "basic primer." It provides a systematic learning approach, beginning with instrumentation and basic manipulative techniques followed by specific experimental models. Learning microsurgery is a matter of acquiring new skills, not unlike taking up a new sport or a musical instrument. The approach must be systematic, progressive, and logical, and this text fulfills these criteria.

Of particular value are the numerous illustrations of the instruments and the basic operative maneuvers. The experienced microsurgeon will find innumerable pearls on almost every page of this manual. The manual also serves as a guide to microsurgical instructors who conduct ongoing courses for individuals from all of the surgical specialties. This text is indeed a formal introduction to microsurgery.

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Foreword

For generations physicians have looked through the microscope with great fascination, describing each small anatomic structure in great detail and observing changes brought on by injury and disease. This has led to the development of histology, pathology, and microbiology, which became the cornerstones of modern medicine. The inevitable desire to manipulate the microscopic world to benefit our patients must once have seemed quite impossible because of our large size and apparent clumsiness of hand, much like Gulliver's troubles in the world of the Lilliputians. However, what was once a fantasy has now become a reality through the advent of clinical microsurgery.

The binocular operating microscope provides us with clear and magnified views of many small structures such as the middle ear, eye, peripheral nerves, small tubular structures, and blood vessels. The fine instruments, the needles, the thinner-than-hair sutures, and the atraumatic surgical techniques have permitted us to dissect, resect, manipulate, and repair these small structures with confidence. The application of microscopic techniques in clinical medicine has made possible better functional results for nerve repairs, replantation of amputated parts, and transplantation of various tissues for reconstruction. The expanded surgical capability through microsurgery is increasingly utilized in all surgical specialties and is quietly changing our practice of medicine.

To operate in this new "Lilliputian world," the surgeon must not only learn the pertinent microscopic anatomy and physiology, but also acquire a highly refined manual dexterity. Because of the unusually fine movements required and the use of indirect vision through the microscope, even surgeons familiar with conventional surgical techniques need to acquire a new eye-microscope-hand-instrument coordination. The precise nature of the surgery also mandates that surgeons do not learn by trial and error on living patients. They should instead acquire the fundamental skills in the laboratory, much like the pilot starting his training with flight simulators, progressing to simple airplanes, and then graduating to commercial jets.

As in the training of dancers and musicians, the fundamentals must be stressed and sloppiness condemned! Although the laboratory experience is only a small part of one's training to achieve clinical competence, there is no question that the degree of mastery of the fundamental skills will later enhance or limit one's capability as a clinical microsurgeon. Only after the microscopic world has become second nature to the surgeon can he begin to exercise his imagination and artistry in surgery. The satisfaction of being able to take a boldly conceived surgical plan and execute it faultlessly through the microscopic world to benefit another human being is a privilege experienced only by a few.

Dr. Donald Ballantyne and his associates have had considerable experience in both teaching and research in the microsurgery laboratory. The methods presented in this laboratory manual are the result of many modifications over the years and have proved to be highly successful in the training of many surgical residents and postgraduate fellows. The exercises are carefully graduated to permit rapid and confident acquisition of increasingly difficult skills.

The authors are to be commended for their painstaking effort to put together such a lucid and effective training manual to help beginners master this important surgical capability.

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Preface

For the past two decades, most excellent laboratory manuals for microsurgical training have been dedicated exclusively to the techniques of microvascular surgery. The authors believe that microneurological techniques are also important and deserve more emphasis. In addition, a training center in microsurgery should have a dual function: a systematic training program for basic techniques in microvascular repair and neural microsurgery.

This manual begins with instructions in the handling of operating microscopes and microinstruments as well as basic suturing exercises. The program then presents the basic techniques of microvascular surgery. This is followed by a section on microneurosurgical techniques in which different methods of neurorrhaphy are introduced and the principles of nerve grafting and neurolysis are described. Finally, there is an exercise in reattachment surgery of the amputated rabbit ear.

As in many areas of visuomotor performance, the practice of microsurgery is learned systematically by building a fund of new skills upon those already mastered. The challenge of a potentially difficult and frustrating technique can be overcome if skills are acquired in a systematic manner. The time required varies with each individual. It is unrealistic to expect to learn microsurgery in just a few days. One should continue practicing after the initial learning experience.

Avoid alcohol, caffeine, tobacco, strenuous exercise, fatigue, or emotional upset before attempting to do microsurgery because these may cause tremors in the hand. Do not work for too long at a stretch. When tense and tired, take a break.

Difficulties increase in proportion to the magnification, so the first step is to become accustomed to working under magnification. Concentration and coordination are necessary in order to perform efficiently. Eliminate outside distractions. When a difficulty is perceived, stop, find the problem, and correct it before continuing. Study mistakes as well as successes. Do not move on too fast from one exercise to the next or your mastery of the skills will be incomplete. Slow, steady progress will produce the best results.

D.L.B.
D.T.W.C.

Acknowledgments

Preparation and publication of this book would not have been possible without the inspiration and support of Larry Carter. Special thanks are extended to Verlencia T. Conyers and Megan Barnard Shelton for their professional and efficient cooperation.

A special note of acknowledgment is due to the Society for the Rehabilitation of the Facially Disfigured, the Mary Duke Biddle Foundation, and the Foundation for Hand Research, whose combined support for microsurgical research projects as well as the experience gained from the application and basic training of microsurgical techniques has made the work presented in this manual possible.

Introduction to Microsurgery

Contents

Instrumentation

The present microsurgical instruments have been adapted from the ophthalmic instruments and subsequently modified for working with the operating microscope. They are characterized by small precision tips, light weight, balanced proportions, graded pinch closure, and dull nonreflective surfaces.

The ultimate success of microsurgery can be achieved only with good instruments. The care and maintenance of microinstruments is particularly important to their preservation. The difficulties encountered by experienced microsurgeons are severe enough without being compounded by poor instruments. It is recommended that the trainees first learn the basic principles for care and maintenance as well as handling of instruments used in microsurgery. This should be followed by a brief description of instruments needed for learning microsurgical skills. The trainees can then expand the variety, types and number of instruments with time and experience.

Care and Maintenance

Have the microscope ready and in focus, its light intensity set. Place microinstruments, irrigating syringes, sutures, and other surgical items within easy reach. Bring sharp-pointed instruments into the operating field carefully, keeping their sharp tips together to avoid damaging adjacent tissues or the hands of the assistant. These sharp tips can easily snag adventitia and rip or puncture a blood vessel. Do not permit the tips of the instruments to come in contact with hard objects or with each other. If it is necessary to make a manual adjustment of the microscope, the instruments should always first be put down on a sponge rubber mat or on a soft surface to the side of the operating area. Avoid dropping or tapping the jaws or pointed tips of a microinstrument on the operating surface in order to acquire a better position of the instrument in the fingergrip. It is preferable to put down an instrument to free a hand or to adjust the instrument in the hand. With practice it is possible to pick up a microinstrument and maneuver it into correct position with finger movements of one hand.

If there is a piece of soft tissue or blood clot attached to the inner surface of the jaws of a forceps, draw a moistened sponge lightly between the surfaces. Fine instruments can be ruined by wiping them on the drapes or gown sleeves.

Microsurgical instruments may become magnetized, but this is easily corrected with a demagnetizing coil. Place the instrument in the coil and turn on the current. While the current is still on, move the instrument slowly away from it. When the instrument is about two feet away, switch the current off.

Since the tools are delicate, they are subject to damage by careless or rough handling and to corrosion by blood and water. When not in use, the instruments should be stored in a suitable rack or placed upon a soft surface such as a sponge rubber mat, and their tips protected with silicone or plastic tubing. When cleaning or drying, do not allow the tips to come into contact with a hard object or metal surface. Do not put all the instruments into a heap.

A small ultrasonic washer (Branson Ultrasonic Cleaner; Fisher Scientific) is recommended for cleaning delicate instruments with a minimum of handling. However, Patkin (1978) recommended that, when cleaning microinstruments with fine cutting edges, ultrasonic cleaning should be used carefully and as infrequently as possible. Also, close contact between dissimilar metals immersed in the cleaning solution elicits electrolyte currents, resulting in some degree of corrosion.

If the ultrasonic cleaner is not available, immersion in an enzyme detergent solution (Haemo-Sol) is satisfactory. Special attention may be needed to clean spring handles of microneedle holders, special gripping forceps, microscissors, or vessel clamps, particularly when removing blood residue. With a syringe and a fine needle, direct a stream of water at these sites. They should be dried thoroughly before storage or further use. To avoid loss of clamp tension the vessel clamps should be opened just wide enough to permit cleaning and not to their maximum limits.

Operating Microscope

After the instructor has explained and demonstrated the proper care and handling procedures of the binocular operating microscope and its various accessories, a period of practice by the trainee is needed to become familiar with the working functions of the instrument, as well as to achieve eye-hand coordination under magnification.

The size of an object perceived by an individual depends upon the size of its retinal image. Magnification is a ratio of two retinal images of a single object when observed with the naked eye and with a magnifying glass at its fixed focal length. Since the focal length of the human eye is 250 mm, magnification is defined by the following equation:

$$M = \frac{250}{f}$$

where "f" is the focal length of the lens of a magnifying glass.

To appreciate the operating microscope, it is helpful to review basic optics. The three component parts of an operating microscope are the objective lens, the binocular assembly, and the magnification changer. The objective lens controls the focal length and the binocular assembly increases the magnification. In effect, the objective lens forms an image that is magnified by the binocular assembly. Thus, the final or total magnification is the result of the eyepiece magnification (M_e) and the focal length of the objective lens (F_o): its formula is

$$M_t = \frac{F_b}{F_o} \times M_e \times M_c$$

where M_c is the magnification factor of the magnifying changer and F_b the focal length of the objective tubes.

There are two types of magnifying changer: turret drum (manual) and zoom (mechanized). The main disadvantage of the former is its fixed setting and manual operation. In contrast, the zoom system permits the observer to select a specific magnification over a continuous range.

The focal length of the object (F_o) is equal to its working distance, and therefore it is necessary to bring the object to be viewed to the exact distance of the focal length of the lens (Hoerenz, 1980a).

The size of the field is inversely proportional to magnification, and is determined by the following formula:

$$F = \frac{200}{M_t}$$

where M_t is total or final magnification. Depth of field also decreases in a similar manner with increased magnification. For this reason, it is necessary to use maximal magnification for visualization and minimal for manipulation.

Illumination of the operating microscope is provided by an additional built-in ray path in the microscope (Hoerenz, 1980a) and fed by an incandescent lamp, a fiberoptic light, or by a combination of both light systems. It is helpful to know that a change in the working distance results in a change of illumination in the area of observation. Increasing the magnification also causes a decrease in illumination. According to Hoerenz (1980a), although the human eye is capable of adapting itself to different light levels, cameras (whether still, movie, or TV) would register the light losses as underexposures.

The operating microscope is very expensive and delicate; it is essential to know how to handle and care for it. When tightening *anything* on the microscope, including ocular lenses, suspension couplings, star knobs, and locking screws, use only the thumb and index finger in order not to overtighten.

For mounting an operating microscope, there are two principle types of support systems: mobile (floor or table stands) and fixed (ceiling and wall). Both types of support systems permit 2-dimensional movements, horizontal (rotation and longitudinal) and vertical.

Always release the brake system at the base of a movable floor stand when ready to move the stand. When moving from one area to another, lower the binocular assembly to lower the center of gravity and grasp the column of the floor stand at the lowest point possible in order to avoid tipping. Do not use the binocular assembly, observer tubes, or other attachments as a handle.

At the conclusion of work, loosen all star knobs except the one on the patient safety ring, push the microscope body and its horizontal arm assembly toward the column of the floor stand, and retighten the knobs. If the floor stand of a microscope is supplied with a patient safety ring (Figure 1), its purpose is to guard against the possibility of a patient or surgeon being injured in the event that a floating microscope is bumped or jarred and suddenly drops to a lower position. It also protects the undersurface and lower prism of the microscope body from damage by a hard surface.

The most important requisite for undertaking surgery under magnification is to obtain proper focal adjustments. When focusing, correct adjustment of the eyepieces or oculars is mandatory. Each ocular allows a spheric diopter adjustment, which varies with different manufacturers (usually with a range of -9 to $+9$), to correct the observer's refractive error. Operators with astigmatism or who need correction beyond the range of the oculars will find it necessary to wear glasses when using the microscope.

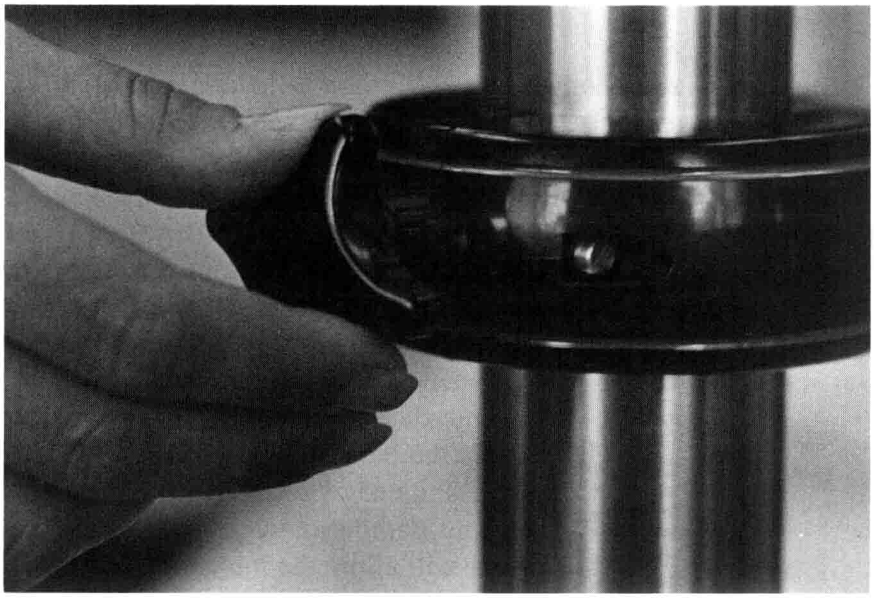

FIGURE 1 Setting the patient safety ring.

After swinging the microscope body into position above the table, switch on the desired intensity of light. Move the microscope until the illuminated field is approximately a foot from the table edge directly in front of you. Make a dot or draw a cross on a white index card to serve as a focus target and position it in the center of the working field. It is important to be seated comfortably. Adjust the seat's height to avoid strain on the neck or back. After adjusting the diopters and interpupillary distance, set the microscope at its highest magnification, focus on the target, and adjust the fine-focus control on the microscope until a sharp image is formed. The rationale for starting at the highest magnification level, particularly in parafocal microscopes, is that the minimal depth of field is extremely critical and leads to perfect focus at all magnification levels.

Detailed description and discussion of accessories for operating microscopes are beyond the scope of this laboratory manual. This information can be obtained from manufacturers by request and from several reports of Hoerenz (1980a–d, 1981).

Microsurgical Instruments

This section discusses forceps, needle holders, scissors, and clamps. No attempt is made to describe other microsurgical instruments such as coagulators, counterpressors, irrigators, and background materials in this section. These are briefly outlined as they occur in the text.

Forceps

Invaluable all-purpose gripping instruments, jeweler's forceps are classified according to the width of the bit (Figure 2). The No. 2 forceps, with its broad jaws and large contact area, makes an ideal needle holder for the trainee to develop a light touch, before switching to the traditional jaw-pin-shanks three-part needle holder.

In the delicate grip of straight No. 2 forceps, when not properly positioned or correctly driven the needle will slip or drop from the hold without damage to the vessel wall. A traditional needle holder will allow the novice microsurgeon to grip the microneedle securely in a wrong position and force the needle through the vessel wall, causing irreparable tissue damage. In addition, any instrument with strong gripping jaws can easily bend or break a delicate curved microneedle.

As illustrated in Figure 2, there are other types of forceps: Nos. 1, 3, 4, and 5. Straight No. 1 forceps are excellent for picking up free ends of thread, No. 3 for patency tests, and No. 5 for fine tissue handling.

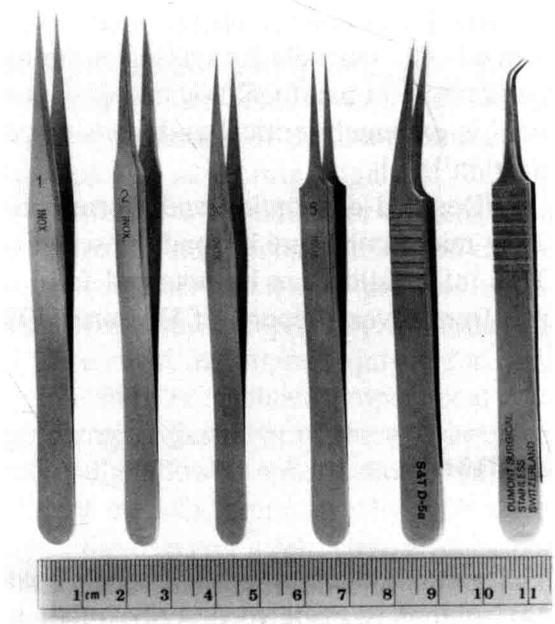

FIGURE 2 Forceps.