ARTHROSCOPY

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J.B. Lippincott Company

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With Two Contributors

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This book is dedicated
with admiration and respect to my parents,
Josephine J. and Roger R. O'Connor.

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By the street of by and by, we arrive at the house of never.

Cervantes

Preface

My purpose in preparing this monograph is to share knowledge and experience with those interested in arthroscopy during what I believe to be its watershed period. Diagnostic arthroscopy appears to be well accepted, and the basic diagnostic equipment has been developed by many instrument makers to meet the subtle differences demanded by a great number of arthroscopists. Now, the emphasis will be on the development of therapeutic equipment and techniques.

There is no substitute for learning arthroscopy one-to-one: a physician teaching another in a clinical situation. Indeed, many arthroscopists proficient in the technique are swamped by visitors. One of the problems posed by attempting to learn the technique in this way alone is that the knowledge shared is necessarily incomplete due to limitations imposed by chance and selection of patients.

The information in this monograph is based on observation. But though I feel that my interpretation of these observances is accurate, it is not written in granite. I want to add too that many ideas have been obtained from other arthroscopists and are not acknowledged because they have rapidly entered the realm of general information. For any faulty interpretation, I assume responsibility.

Arthroscopic examination is an individual situation between patient and physician in an attempt to solve a problem. Usually, as no other orthopaedist familiar with arthroscopy is present, there is no chance for consultation or spreading of the responsibility onto a committee's shoulders. Caution and reflection are vital, particularly when one is confronted by an unusual situation; stereotyped answers are of little value; statistic analyses, used to attempt to solve a given problem, are misleading. I can only stress what has been stressed often enough about other matters: when in doubt, do nothing.

Advancement of knowledge depends upon tools—mental and physical. Prior to the advent of arthroscopic examination, considerable emphasis was placed on mental tools derived from increasing personal and collective experience with interpretation of the patient's history and physical examination. This was supplemented by radiographs with the enormous limitations of the plain roentgenogram, and, later, the blind areas of the arthrograph. The addition of a new tool opens new horizons, but allows observations without an established norm. Again, emphasis must be placed on a return to the supremacy of the mental tool to correlate facts obtained by both the conventional and the newer sophisticated methods. Hopefully, this monograph will help to find a norm against which the pathologic state may be better appreciated. That additional information is needed is suggested by the fact that 60 per cent of my arthroscopic cases were referred by a multitude of orthopaedists who recognized problems that conventional methods did not clarify. Arthroscopy will also have its limitations, but these areas must also be defined.

Many persons have contributed in great measure to this monograph. Professor James Harkess of the University of Louisville supplied the original impetus; Dr. Masaki Watanabe, Dr. Sakae Takeda, and Dr. Hiroshi Ikeuchi shared with me their technique and encouragement; Dr. Keith Walker, Dr. Paul Harmon, and Dr. William McColl of West Covina and Dr. Robert Allen of Glendora, California, provided constant encouragement during the initial difficult stages of mastering the technique. Dr. Robert Jackson of Toronto, Canada, and Dr. Ward Casscells of Wilmington, Delaware, opened the North American continent to the concepts of arthroscopy, and without their original efforts mine would have been severely curtailed. The administration of the West Covina Hospital and the operating room personnel have done everything in their power to provide an atmosphere conducive to investigation.

The Richard Wolf Company, Kittlingen, Germany, directed by Herbert Schubert, with the help of optical engineer S. Hildebrandt and electronic engineer H. Wurster, helped develop the necessary equipment. Special thanks are extended to Seymour Shubin for reviewing the manuscript, and to L. Wettermann, Vice President of the Richard Wolf Company, U.S.A., for help with the chapter on endoscopic instruments and for three years of helpful suggestions in modifying the arthroscopic equipment. Dr. Robert Bechtol of Santa Rosa, California, shared his provocative thoughts on future developments in his chapter.

Last, but not least, I want to thank my assistant, Barbara Swan, for providing loyal and dependable help throughout my arthroscopic troubles; Helen Darcel for her art work; my daughter, Mary Anne, for her grammatical corrections; Lewis Reines and Carole Baker of the J. B. Lippincott Company for their encouragement and editorial assistance; and Dolores DeHaven for managing my office.

Many have contributed to this monograph, but the sole responsibility for erroneous interpretation is mine. If one wants to have absolute evidence to support a monograph on observation, he will pass the street of by and by and reach the house of never.

RICHARD L. O'CONNOR, M.D.

Contents

1 *From Endoscopy to Arthroscopy*

Lou A. Wettermann

HISTORY

The word *endoscope* is derived from two Greek words, *endo* from the word *endon,* "within," and *scope* from the word *skopein,* "an instrument for observing or seeing."

The concept of the endoscope comprises all devices for visual examination and observation of body cavities. Owing to varying anatomical relationships, there are many very substantial differences in the construction of these individual devices. For example, entirely different requirements apply for the arthroscope, cystoscope, laryngoscope, laparoscope, and gastroscope.

Medical endoscopy had its start in the early 1800s when Bozzini devised a speculum instrument to put light into the body cavity. This instrument, called the Lichtleiter (Fig. 1-1), illuminated deep cavities by reflecting light. It consisted of a tube divided in two, with a candle inside a box. Light was reflected through half of the tube by a slightly concave mirror. The operator viewed the light field through a cuplike eyepiece attached to the other half of the tube. In 1876 Nitze designed a cystoscope that used a platinum loop for illumination. He realized that the light source had to be within the distal tip, but at that time Edison was engaged in efforts

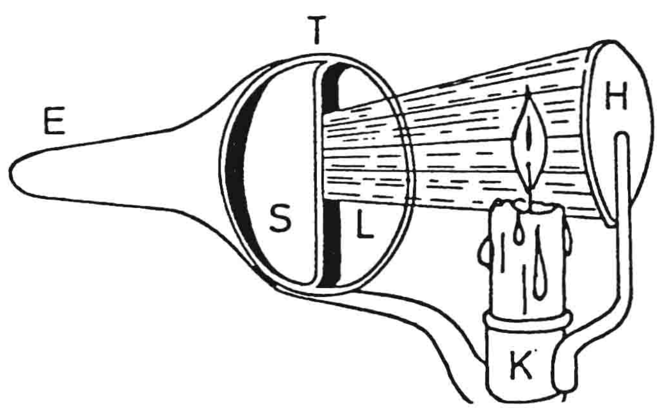

Fig. 1-1. The Lichtleiter consisted of (E) a main housing, (T) a separation wall, (S) a viewing channel, (L) a light channel, (K) a candle holder, and (H) a concave mirror.

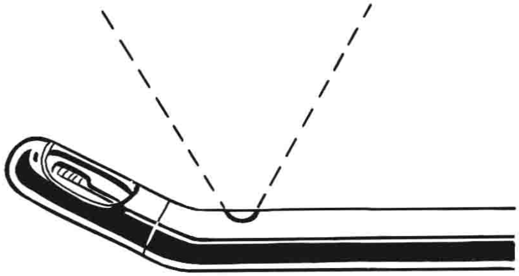

Fig. 1-2. Right-angle viewing cystoscope with incandescent lamp.

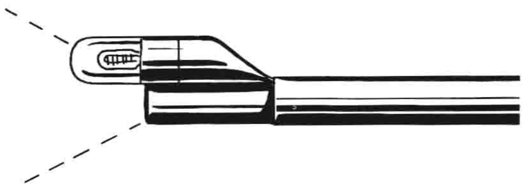

Fig. 1-3. Direct viewing endoscope with incandescent lamp.

that culminated in his invention of the light bulb, which had to be miniaturized for use in the endoscope. By 1883 the incandescent bulb had been reduced in size to fit the diameter of an endoscope, and Nitze in the following years developed one of the first true endoscopes. The lens system used in these first endoscopes was of a simple design, which had, besides a prism to reflect an image 90 degrees, only a few lenses, and which provided only limited light transmission.

FUNDAMENTALS OF ENDOSCOPES

An endoscope consists of three basic elements: mechanical parts, an illumination system, and an optical system.

Mechanical Parts

The mechanical part of an endoscope consists mainly of the instrument's rigid housing or sheath. This comes in several shapes and diameters. It must have a smooth surface, since in most cases it comes directly in contact with the mucosa of the internal organs and it is frequently inserted into narrow passages of the human body. Some endoscopes require trocar sleeves with trocars, the sleeves including stopcocks for inserting gases or fluids. The arthroscope (which is an endoscope used for examining the interior of a joint) requires a trocar for piercing the fibrous capsule. The trocar is removed and replaced with an obturator for the safe passage of the scope through the synovium or for difficult maneuvers through the joint. The trocar or obturator is then replaced with the telescope. A 15 gauge 1½ inch stainless steel needle is used for a counterdrain. The material originally used for the rigid sheaths was either brass or nickel-silver, and it was coated with nickel or chrome. Today most endoscope sheaths have incorporated the illumination as well as the optical system into their main housing so the need for thin walls with dependable rigidity becomes obvious. Thus, the use of stainless steel for sheaths has become widespread.

Illumination System

The incandescent lamp, once subminiaturized, was eventually embedded into the distal portion of the endoscope. (Fig. 1-2). Several different versions were used, depending on the viewing direction. If a 180-degree angle of vision was needed, lamps would be placed on a separate lamp carrier that positioned the illumination next to the endoscope shaft so that a straight viewing direction was achieved (Fig. 1-3).

The Optical System

It was Nitze who first incorporated a lens system into early endoscopes. It consisted mainly of an ocular transmission system and an objective lens, which, depending on its application, provided the different viewing angles needed. The con-

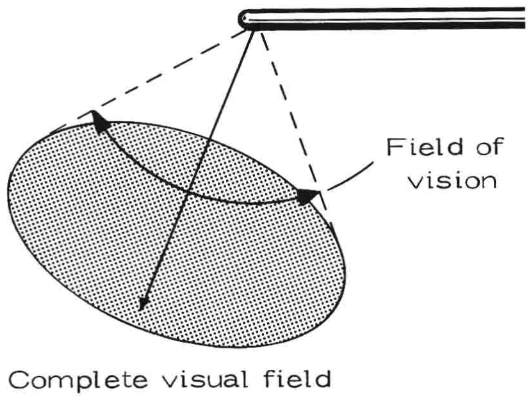

Fig. 1-4. Note the distinction between the field of vision and the complete visual field obtained with an encoscope.

struction of a modern endoscopic lens system is of special design, and therefore is not comparable to that of a microscope, binoculars, or standard astronomical telescopes. All lens systems for endoscopes are adjusted to infinity, thus allowing the examining physician to view the internal parts of the human body without increased magnification, but still within a considerable field of vision. The endoscopic lens system is therefore nothing more than a magnifying glass following the principles of Galileo, except that the objective lens is separated from the ocular by means of a lens system designed to transfer the image. The lens system consists of several lenses that reverse the image. A reverse prism is then used to achieve a noninverted image.

CLASSIFICATION OF ENDOSCOPES

Endoscopes are classified according to their viewing angle, field of vision (Fig. 1-4), method of illumination, site of illumination, type of optics, and method of introduction, and whether they are designed to be used in air or liquid. The great variety of viewing angles is illustrated in Fig. 1-5. The most common ones are sometimes referred to as follows:

Direct Vision: 180° to 170° angle of vision
Fore Oblique: 135° to 165° angle of vision
Right Angle: 110° to 90° angle of vision

MODERN TELESCOPES

Manufacturers of endoscopes* in the United States and in Europe have recently made several major innovations in their instruments, largely as a result of the introduction of fiber optics and of greatly improved lens systems. This conversion

* The telescope contains the lens system of the endoscope. The arthroscope, a specialized type of endoscope, contains the telescope and the mechanical parts necessary to provide joint irrigation.

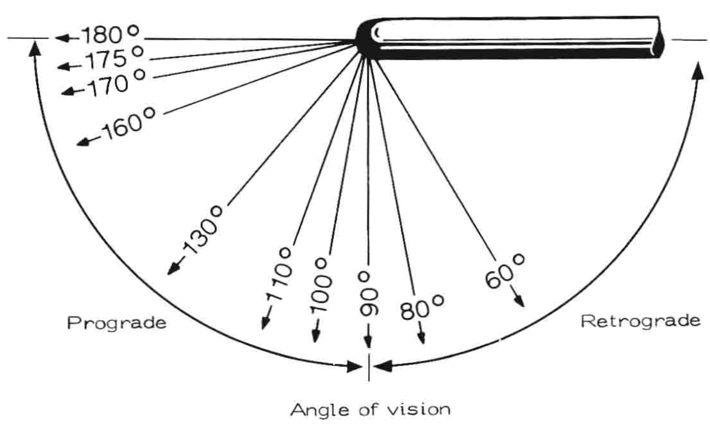

Fig. 1-5. Different angles of vision may be obtained with an endoscope.

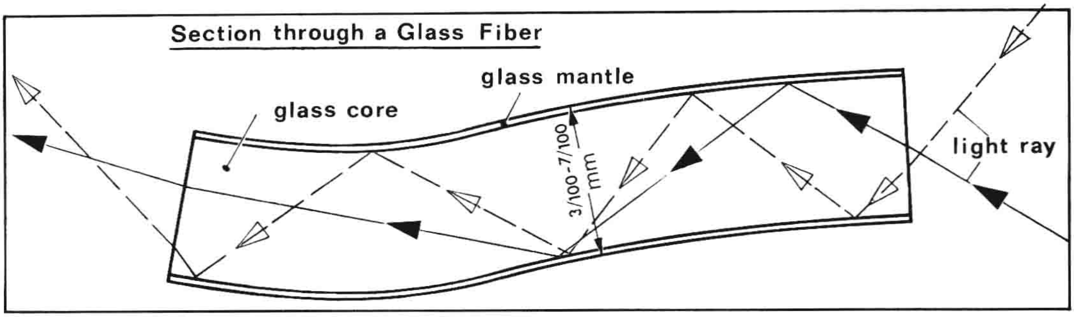

Fig. 1-6. The basic process of light transmission through optical glass fiber. The inner glass core must be coated with a thin film of glass of a lower refraction index in order to prevent light from leaking through its sides.

has greatly benefited practitioners of endoscopy.

Fiber Illumination

The development of endoscopy has always been greatly influenced by the availability of illumination. Light is a necessity for all visual examinations (especially documentation), such as 35-mm. still photography, cinema photography, and television.

The principle of using fiber optics to transmit light, or images, from one place to another through a flexible fiber bundle is not new. Early in 1950, A.C.S. Van Heel of the Netherlands began to improve the optical coating of fiber bundles in order to make them usable for illumination (Fig. 1-6), but until 1958 industry was unable to produce fiber optic bundles for transmission of either images or light at a reasonable cost. However, the resolution of such financial difficulties has rendered endoscopes with incandescent lights obsolete.

The current generation of endoscopes utilizes fiber optic illumination whenever possible. By omitting the distal incandescent lamp (Fig. 1-7), the so-called dead length of the objective is reduced to a minimum (Fig. 1-8). The incandescent lamp was a necessary extension at the distal tip of the telescope, and this extension prevented close-up examination. With a fiber illumination system, the space between the distal tip and the objective window was reduced considerably, allowing examination at a much closer distance.

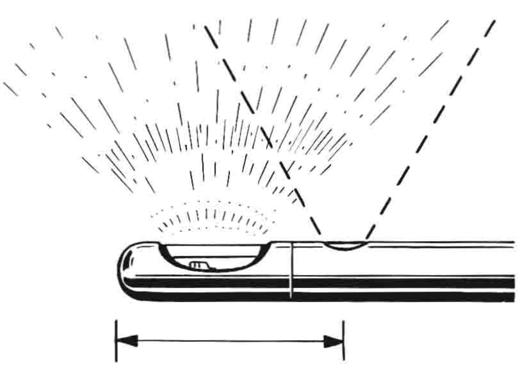

Fig. 1-7. Distal tip of an endoscope with incandescent illumination and *extended* space between tip and objective window.

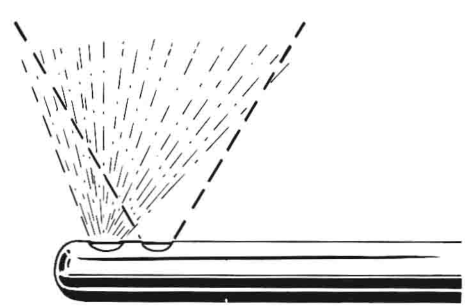

Fig. 1-8. Distal tip of an endoscope with fiber illumination and *reduced* space between tip and objective window.

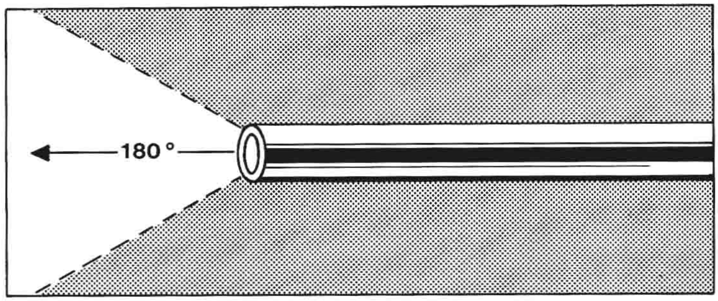

Fig. 1-9. Direct-viewing endoscope with fiber illumination (ring of light).

The light carrier with the offset lamp, which had been used prior to the availability of fiber optics (and which had caused difficulties when inserting or rotating the instrument), is rendered completely unnecessary, since it is now possible to place the fiber-illuminated bundle around the circumference of the objective window (Fig. 1-9).

An endoscope with fiber illumination (Fig. 1-10) consists of the fiber light projector with its cooling facilities, the fiber light cable connected to the projector and endoscope, and the scope with fiber illumination. The light source is now separated from the endoscope, and it is possible to produce a cold and powerful light without having to take into consideration the heat or weight factor. The advantages of a self-contained light source are as follows:

1. The size of the source is immaterial. It can therefore be of a very high intensity, and can be provided with a powerful cooling system.
2. In case of a defect, it is easy to repair or replace the light source.
3. A single light source can feed various instruments simultaneously.
4. Reliability and life of the light source are enhanced in comparison with internal illumination systems.
5. Replacement of the lamp is possible during examination.
6. The necessity to store many types of small lamps is eliminated.

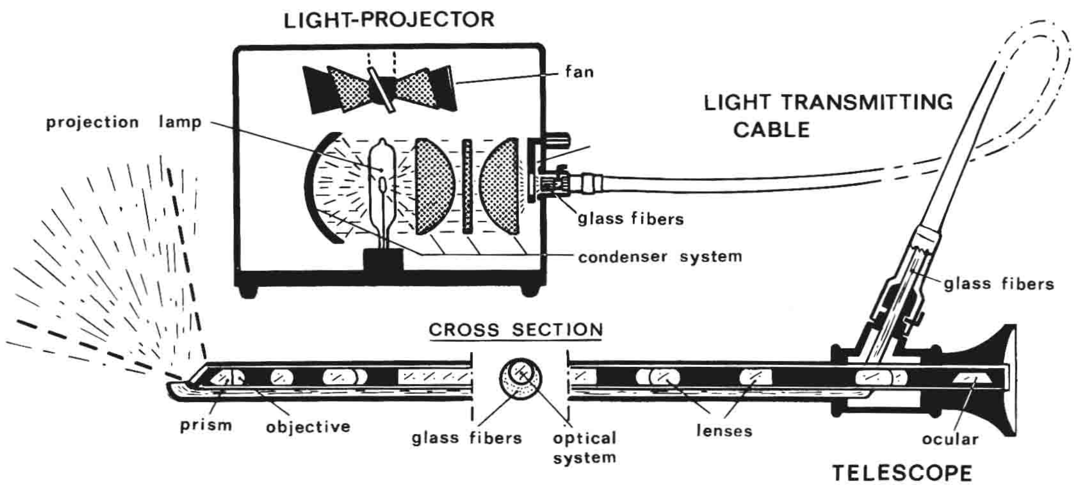

Fig. 1-10. Light is transmitted through a flexible fiberoptic light cable from a light projector to the tip of an endoscope where it provides illumination for visual examination and observation of body cavities.

Fig. 1-11. Photographic fiber light projector with two alternating light sources.

The advantages of light transmission through a fiber light cable are as follows:

1. The light emanating from the light transmission bundle is cold.

2. The light transmission cable is flexible and elastic, and its length can be selected according to clinical requirements.

3. The light transmission cable can be sterilized with a cold solution in a steam autoclave or a gas sterilizer.

4. Safety is increased during examinations by eliminating any electrical hazards.

5. Endoscope construction has been simplified by eliminating electrical wires and connecting cords.

With newer and more powerful lamps available, it is possible to utilize the newer endoscopes for most documentation systems. One model, the Marc 300/16A lamp and its power pack, is incorporated into a heavy-duty light projector (Fig. 1-11), and is designed for both still and cinema photography.

Rod Lens System

With the availability of fiber illumination and improved lens systems, the entire concept of endoscopy was revolutionized. Within the last few years all major endoscope manufacturers have introduced new lens systems. In 1960, Hopkins, an English scientist, introduced a new design for a lens system that is known today as a rod lens system, which achieved a remarkable increase in light transmission and expansion of the field of view. Instead of the conventional system in which small lenses are separated by large air spaces, it contains long rod lenses with short air intervals. The rod lens system established a milestone in the development of the conventional lens system and, with the help of computers, it was now possible to redesign the conventional lens system using newer types of optical glass and coatings, and also to perform an exact computation of lens specifications. The basic difference between the computerized conventional lens system Lumina-S and the Hopkins rod lens system is illustrated in Fig. 1-12. Both of these systems offered improved definition of details due to increased resolution, maximum brightness without loss of contrast, natural reproduction of all colors, and a large field of vision with greater magnification.

Factors Influencing the Development of Optic Systems. The evolution of lens systems in endoscopes has resulted from an ongoing adjustment between the phy-