Comprehensive arthroscopic examination of the knee

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Preface

Arthroscopy is a dynamic, colorful, and exciting experience for the physician. It is best appreciated by performing the procedure. A one-on-one method of teaching is ideal, but because of time and logistics, it is just not possible. The second-best method of experiencing arthroscopy or learning the technique is by movie photography or television.

In this book, an attempt has been made to duplicate the experience of arthroscopy by logos, photographic selection, diagrams, and design. The color illustrations were carefully chosen to be representative rather than comprehensive.

This book is written for the physician who desires the practical details necessary to successfully accomplish a complete inspection of the knee joint. A description of technical details is necessarily labored. The role of the assistant is included to help the inexperienced arthroscopist.

The physician who perseveres will be rewarded with increased knowledge from arthroscopy. The patient will benefit in better diagnostic judgments and therapeutic designs.

I acknowledge and am exceedingly grateful to my assistant, Mrs. Ruth L. Becker, LPN, who has contributed many of the details of this technique. Her contribution has been recognized by the many visiting physicians as being the most essential ingredient in my ability to perform arthroscopy so easily. I agree.

I appreciate the encouragement I received from Dr. David Shneider, who has been able to completely duplicate this technique with great facility and finesse. Using these methods, he has made observations that have added to my understanding.

Gloria Aveiro typed manuscript and revisions at times undoubtedly inconvenient for her; for this I am grateful. For most of the black-and-white photographs, I thank Tom A. Cannel.

Most of all I appreciate Mary Ann, my wife, and our daughters, Charlotte Ann and Autumn Lynn, who have been faithful in many adventures, including this book.

P.T.L.

Lanny L. Johnson, M.D.

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Chapter 1

Development

As with any development, the comprehensive arthroscopic examination of the knee evolved from the contributions of pioneers in the field of arthroscopy. Those of Casscells,[1] Jackson,[3,4] and Watanabe[9] are well known. Most orthopedists are well versed in the traditional technique, that is, the use of the large-diameter endoscope, such as a Watanabe No. 21, through which only the anterior compartments of the joint can be viewed. An elaborate irrigation system is used, and the procedure is carried out with the patient under general anesthesia.

Watanabe[10] has stated that the No. 24 arthroscope can be used in the knee joint, although such use is under investigation, but it is not suitable for general diagnostic purposes in this area. McGinty[7] and O'Connor[8] have adapted more modern endoscopes to the classic method.

Eikelaar[2] presents an excellent comprehensive historical review of arthroscopy. No attempt is made to duplicate his effort here; rather, I will detail the development of small-diameter arthroscopes and my experience with them.

INSTRUMENTATION

In 1970 the first self-focusing arthroscope was developed through the joint efforts of the Nippon Sheet Glass Company and the Department of Orthopaedic Surgery of Tokyo Teishin Hospital. This scope, 1.7 mm in diameter, was utilized through a cannula having an outside diameter of 2 mm and provided a direct view of 37° in saline. It was introduced in North America in January 1972 by Mr. Leonard J. Bonnell. To my knowledge, it was first used for arthroscopy by Drs. Clement Sledge and J. Drennen Lowell at the Robert Brigham Hospital, Boston, Massachusetts.

After viewing a single procedure, Mr. Harold L. Neuman assessed the uses of and requirements for such a small-diameter endoscope. The original Watanabe No. 24 arthroscope was redesigned in four ways. The diameter of the endoscope was increased from 1.7 to 2.2 mm, which improved the illumination by a factor of

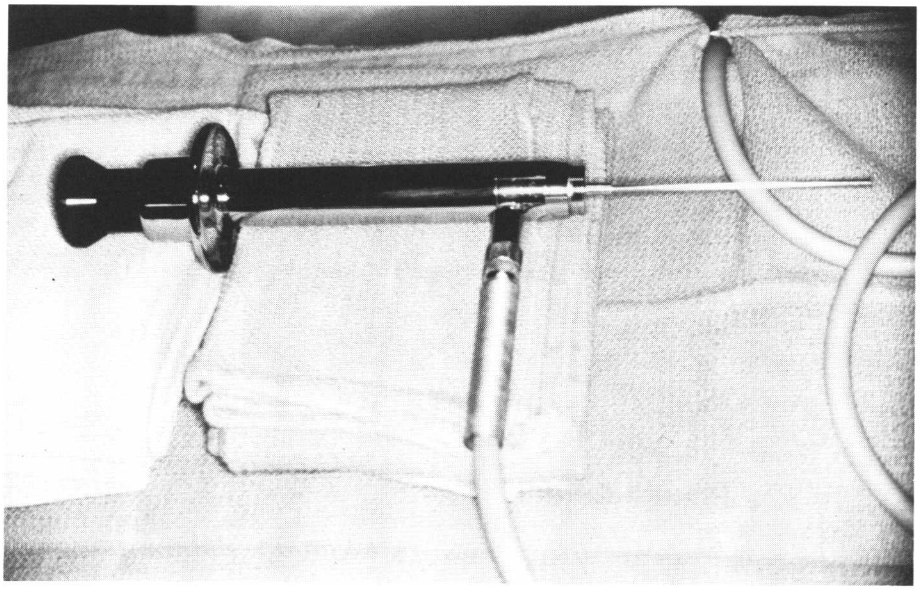

FIG. 1-1. Original model of Needlescope, with three-piece arthroscope. Headpiece screwed onto stainless steel handle. There was a barrier between handle and eyepiece to prevent contamination of the hand by the arthroscopist's head. Eyepiece was inserted manually by a separate maneuver. Disadvantage of this system was that it allowed collection of small dust particles, which when magnified obscured viewing.

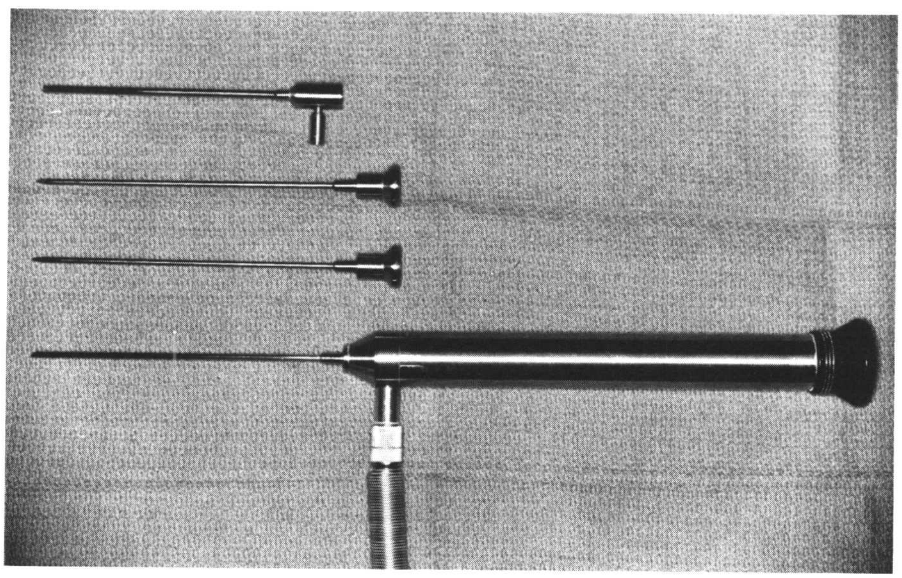

FIG. 1-2. Third model of Needlescope is a closed system with a viewing angle of approximately 70° in saline. Endoscope shown here is 2.2 mm in outside diameter. Cannula, which is superior, has an outside sheath of 2.6 mm in diameter. Sharp and blunt trocars accompany system.

four and resulted in a more rugged assembly. The design was changed to allow for a detachable light guide to improve handling and ease of sterilization. The eyepiece, which required manual focusing, was changed to a fixed-focus lens to reduce confusion and contamination during the procedure. A long lightweight handle was designed for manipulation of the lens so that the physician's head and eye were away from the sterile field and his glove was protected from becoming contaminated.

This three-piece instrument, the Needlescope, was available for marketing in the fall of 1972 (Fig. 1-1). It had a fore-oblique view of 47° in saline, but was rejected by many arthroscopists because of its fragility, low illumination, and reduced optical clarity as compared with existing large-diameter endoscopes of different construction. Additionally, the cover lens in the interior was vulnerable to the collection of small dirt particles, which when magnified obscured the view. Therefore, the second model of the Needlescope was developed with a nitrogen-sealed optical system, which gave consistently satisfactory viewing.

By June 1976 the third model of the Needlescope was being tested. It was enhanced by optical design of the terminal lens to increase its field of view in saline to 70°. Another modification improved the light illumination capacity by at least two f-stops. There now was a small-diameter endoscope with an angle of visualization equal to that of the largest scope and with a facility to document with optical clarity that was competitive with the largest diameter arthroscopes (Fig. 1-2).

TECHNIQUE

First arthroscopy with local anesthetic

The capacity to view the anterior chambers of the knee joint arthroscopically held a great attraction. However, the length of the procedure, the size of the incision including suture closure, and the use of general anesthetic detracted from its practical application. It was difficult to make a strong argument for an arthroscopic examination when the concensus was that the knee, including its anterior chambers, could be better visualized by arthrotomy in less time and with a less elaborate surgical setup than with a large-diameter endoscope.

I had not been attracted to the Watanabe technique because of the above-mentioned objections. However, on October 30, 1972, without having witnessed any arthroscopies, I examined an athlete who had undergone knee surgery but had exacerbation of knee problems with an effusion. The arthroscopic procedure was carried out with the patient under local anesthesia and with tourniquet control. The intra-articular structures were visualized, and cleansing of the joint was possible. A diagnosis of degenerative arthritis with loose bodies was established.

I was excited about the ease with which this examination was accomplished and the observations that could be made. My enthusiasm was not shared by others, however; in fact, the endoscope manufacturer doubted the success of the procedure on the basis of letters received from established arthroscopists. Although limitations in technique and understanding of the arthroscopic image were recognized, I was encouraged to offer this procedure to other patients with knee problems. Ten such arthroscopies were performed in the following month. Experience established confidence and the ability to visualize the interior compartments of the knee joint by arthroscopy with local anesthetic.

A Needlescope was purchased on the basis of satisfaction with my first arthroscopic experience. By the time the instrument arrived, the quality of the lens had been improved. Originally, the lens was processed with a thalium salt ionizing procedure. In the interval, this was changed to use cesium. Resolution was improved by a factor of 10, further enhancing the diagnostic capacity.

Because the early model of the Needlescope lacked in optical quality and had a limitation in angle of view (47° inclined), it was necessary to compensate technically. The concepts of "pistoning," or moving in and out with the endoscope, and scanning back and forth were introduced. These techniques are applicable to and commonly used with any endoscope but are essential with the Needlescope. In arthroscopy, as in surgery, one learns to work from known to unknown. When the surgeon is unsure of an anatomic relationship, he goes back to areas of known structure. In the knee the landmark of most common orientation is the tangential view of the femoral condyle, or the "horizon" of the femoral condyle. The horizon is followed by moving from one compartment to the other for orientation during inspection of the knee joint.

By 1973, arguments against the traditional arthroscopic technique were being resolved. The technique was modified to eliminate the use of general anesthetic, prolonged time needed to perform the technique, incision with suture, and the elaborate water-drainage system. With the patient under local anesthesia, it was possible to visualize the interior of the knee joint better through a 2-mm skin puncture than by the largest arthrotomy short of disarticulation.

In September 1973, Diagnostic Arthroscopy of the Knee[5] was presented at the International Congress. This paper reviewed the first 100 arthroscopies, many of them performed with the patient under local anesthesia, and showed some of the early photographic documentation on slides.

Clinical value of arthroscopy

The clinical value of arthroscopy was now established. Because it could be performed with patients under local anesthesia, they could be placed in two clinical categories. The first group included those patients for whom diagnosis could not be well established by history, physical or x-ray examination, or arthrography and in whom findings were insufficient to warrant surgical exploration under general anesthesia. Arthroscopy with local anesthetic was recommended.

The second group comprised those patients who showed clear-cut evidence of intra-articular abnormality or ligamentous injury. Arthroscopy was performed immediately preceeding an anticipated arthrotomy. The procedure substantiated that many lesions missed by unicompartmental arthrotomy were visualized by arthroscopy. Arthroscopic examination prior to arthrotomy lends confidence in that complete examination. In many cases the preoperative diagnosis was either erroneous or incomplete. Additionally, the surgical design was frequently modified after arthroscopy.

Posteromedial puncture routine

During the first year of arthroscopic experience, it was recognized that inspection of the anterior compartments and the suprapatellar pouch was inadequate. Although it was possible to document abnormalities under the meniscus, even in the areas of the coronary ligament, diagnoses of posterior tears of the medial meniscus were going unrecognized. Inspection of the posteromedial compartment was initiated on every patient in whom anterior examination showed that compartment to be normal. It was not surprising to find that a number of these patients had meniscal tears in the posterior compartment or loose bodies not visible from the front. It was also recognized that the posterior cruciate ligament was easily visualized in many patients from the posteromedial approach. Thus this approach became part of the routine examination.

Posterolateral puncture routine

Many attempts were made to view the knee posterolaterally. Even from an anterolateral approach, it is impossible to completely visualize the posterolateral compartment except in patients with marked ligamentous laxity. From that view the popliteus tendon can be seen at its origin on the lateral femoral condyle, but the mass of the meniscus and the tendon will block the view into the sulcus. Various attempts had been made from different angles to achieve access to that space. In September 1975 it was possible with regularity to enter and completely inspect the posterolateral compartment; the technique is detailed in Chapter 3. Prior to that, it was thought that an adequate view of that compartment could be achieved from an anterior approach, but direct viewing of the area showed this to be erroneous. Many meniscal lesions in the posterolateral compartment cannot be visualized from the front, even with the small-diameter endoscope. More important, the posterolateral compartment harbors most loose bodies found in the knee joint. Many can be removed through a cannula placed in the compartment. It became apparent that for complete evaluation, posterolateral inspection was required even for patients with normal anterior arthroscopic findings of the lateral compartment.

At this time we were satisfied that it was possible to inspect virtually every recess of the knee joint by direct observation.

DOCUMENTATION

Slide photography

The first photographs made to document arthroscopic observations were taken with a single-reflex camera, using available light from a 300-W source and Kodak high-speed Ektachrome ASA-160 film. The photographs were primitive at best, due to the narrow angle of view of the endoscope, the inability with still photography to create a composition including adjacent areas, and the limited light source. With the improved Model III Needlescope, the problems, except for that of composition, have been resolved.

Because it provides a larger cross-sectional area of fiber light and has a larger diameter lens, the rod-lens scope with attached Storz flash generator produces the best photographic image. Kodachrome 64 film gives the best color balance to the intra-articular tissues.

Cinephotography

Because slides are unsatisfactory for developing composition and because of the low light levels, movie photography provides the best means of documentation. In February 1973, Mr. Harold Neuman matched color film to a light source and provided an optical adaptor from the camera to the endoscope. He had built the original 300-W short-arc lamp illuminator, first known as the Blue Max and now marketed as the Dyonics Model 500 illuminator. The first movies were taken at a rather slow shutter speed with Ektachrome 7241 film. Cinephotography became the medium of choice for documenting technique.

Television

In the spring of 1976, with the utilization of the technology provided by television, it was possible to document more clearly the observations made with the Needlescope. Video equipment could produce an image at a lower light level than was possible with cinephotography. By this time videocassette recordings were being used as a means of transmitting our findings to the referring orthopedists. This allowed them not only a narrative but the same visualization of abnormalities as observed during arthroscopy.

SUMMARY

The comprehensive arthroscopic examination of the knee includes visualization of every recess in the knee joint; posteromedial and posterolateral compartments may be seen, as well as the region beneath the menisci in the area of the coronary ligaments. Further, when there are diagnostic problems this examination is easily performed with patients under local anesthesia. The same technique is adaptable for the complete inspection of the knee joint prior to surgical procedures in those patients for whom clinical diagnosis is established. The technique provides access for synovial membrane biopsy and collection of synovial fluid for microscopic studies. The comprehensive technique includes intra-articular documentation by still and cinephotography or videotape recordings. It has proved to be a simple, efficient, and reliable technique.

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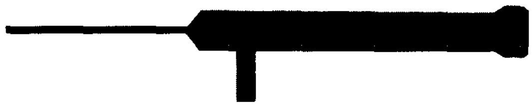
Chapter 2

Instrumentation



SELECTION OF AN ARTHROSCOPE

The selection of an arthroscope is based on the personality, vision, eye-hand coordination, and technical ability of the arthroscopist. No endoscope is the ideal for every arthroscopist. The initial purchase is usually difficult because limitations of the scope are not recognized. With the second endoscope, a system can be selected that has advantages not possible with the first. All endoscopes or other optical systems have limitations, and trade-offs may be necessary in the purchase of new equipment.

It is possible in selected patients to carry out a complete arthroscopy of the knee with virtually any endoscope, except perhaps the Watanabe No. 21, which is too large with the tungsten light bulb attached. I prefer the 1.7-mm diameter Needlescope, which when housed in its cannula has an outside diameter of 2 mm. This small-diameter endoscope allows ease of access under the menisci and into the posteromedial and posterolateral compartments that the larger diameter endoscopes do not afford. If multiple punctures are made with a large-diameter endoscope (e.g., 3.5-mm), the joint will deflate because of leakage from previous entry sites; when distention is lost, ease of access into the posteromedial and posterolateral compartments is diminished. In some patients, even a 2.2-mm Needlescope with a 2.6-mm cannula limits access for viewing the posterior horn from an anterior approach. With use of large-diameter endoscopes, the view of the knee joint that has normal stability is even more limited, whether the patient is under local or general anesthesia.

TYPES OF ARTHROSCOPES

Thin-lens system

In the classic thin-lens system (Fig. 2-1), the lenses are thin in comparison with their diameters. Air spaces separate each of the conventional lenses. The objective lens is to the left and transmits the light from the image through the relay lens system to the ocular lens. The ocular lens transmits the image to the observer's eye. The Wolfe endoscope is an example of this construction.

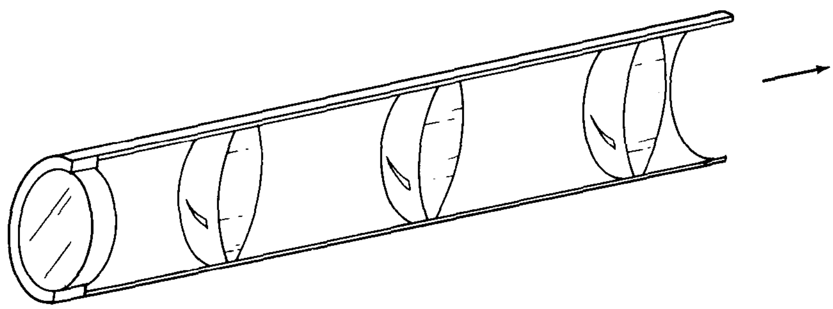


FIG. 2-1. Classic thin-lens system is series of small lenses divided by cylinders of air. Image comes through objective lens from left and is transmitted by relay lens system to ocular lens. Light is transmitted in direction of arrow to arthroscopist's eye. The relay lens system varies in different types of endoscopes.

Rod-lens system

The rod-lens system (Fig. 2-2, *A*) was designed by Professor H. H. Hopkins. In this system the lenses are thick as compared with the diameter. The surfaces are convex, and the air space between the lenses is relatively small. The cylindrical space is glass rather than air, as in the thin-lens relay system. The image is transmitted by the ocular lens to the eyepiece. The Storz-Hopkins rod-lens system (Fig. 2-2, *B*) and Dyonics rod-lens systems (Fig. 2-2, *C* and *D*) are representative.

A

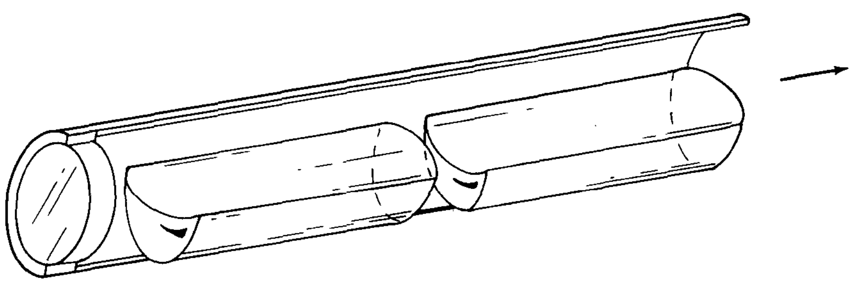
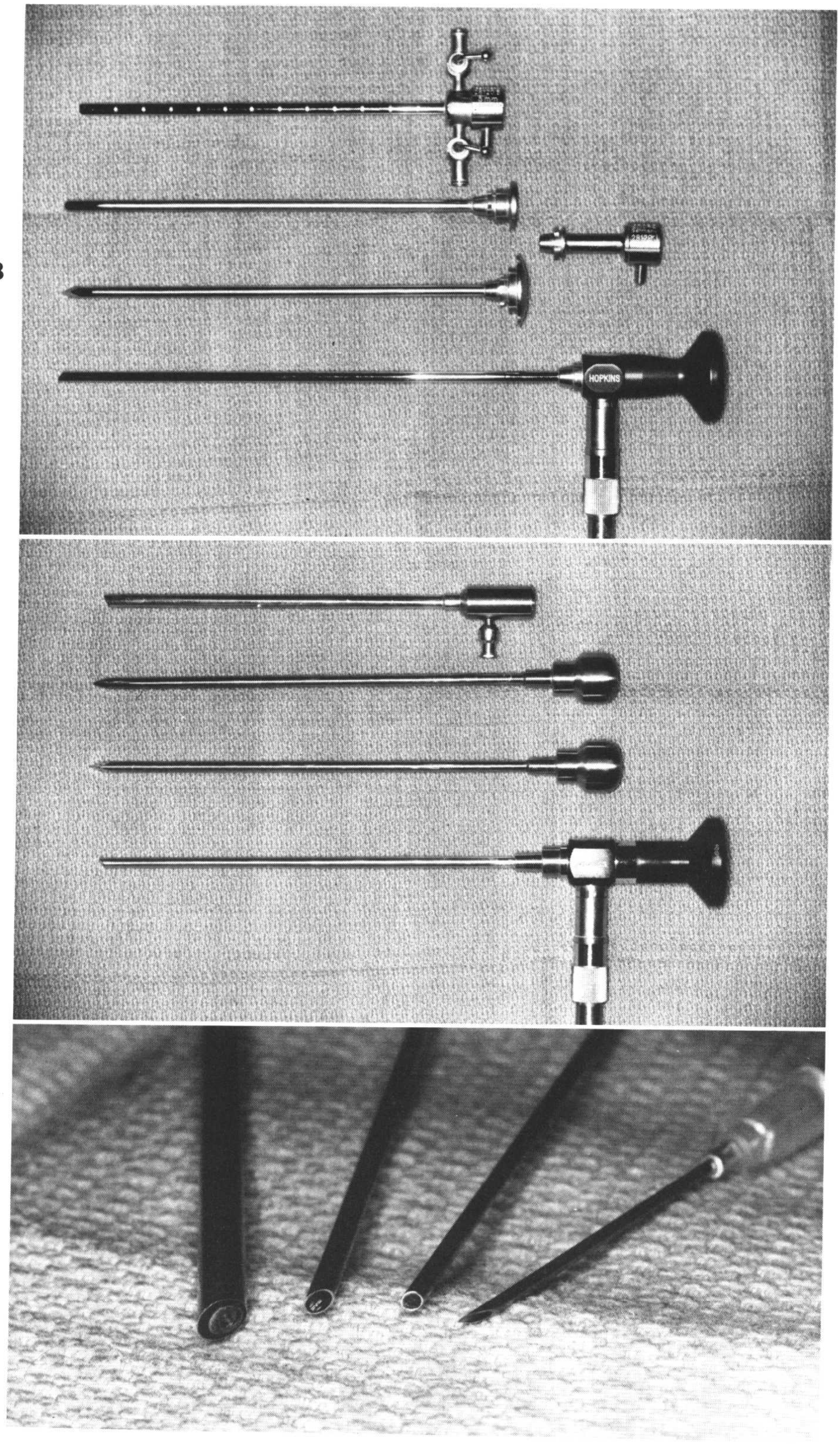


FIG. 2-2. A, Rod-lens system is series of glass cylinders separated by small areas of air, or reverse of thin-lens system. **B,** Storz rod lens system is available in two sizes, with a 2.7-mm telescope or a 4-mm telescope. Both provide excellent optical clarity. **C,** Dyonics rod lens affords excellent optical clarity and has trocar and cannula of simpler design and operation than does Storz endoscope. **D,** *Left to right,* 4.1-mm diameter Dyonics rod-lens endoscope; 2.2-mm Needlescope seen in end view; 1.7-mm Needlescope; No. 18 needle, shown for relative size comparison.



B

C

D

FIG. 2-2, cont'd. For legend see opposite page.

Coherent bundle system

The coherent bundle system (Fig. 2-3) has an objective lens that relays the light from the image. It is then transmitted through a bundle of coherent light fibers. The image is transmitted through the ocular lens to the observer's eye. With this system the viewer sees many fine dots, each of which transmits an element of the image that is being viewed. It is marketed as a No. 24–type arthroscope by the Pro-Med Company.

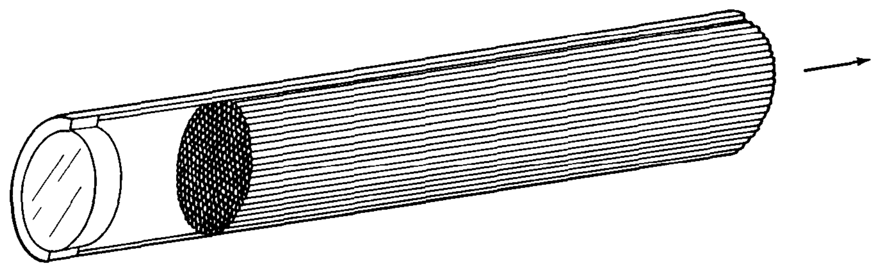


FIG. 2-3. Fused coherent bundle system transmits light by individual fibers. Composition consists of many fine dots, each transmitting an element of image.

Graded refractory index system

A graded refractory index (GRIN) lens system is one in which the entire instrument consists of a slender rod of glass. The refractory index decreases from the center to the periphery according to a specific mathematical relationship. The lens is processed by an ion-exchange treatment utilizing cesium. This endoscope is self-focusing (Selfoc). The rays of light that enter the lens from a particular point in an optic space follow helioid patterns and come into focus, periodically along the rod, producing an image.[1] The Watanabe No. 24 arthroscope (1.7-mm diameter) was the precursor of the Needlescope (Fig. 2-4).

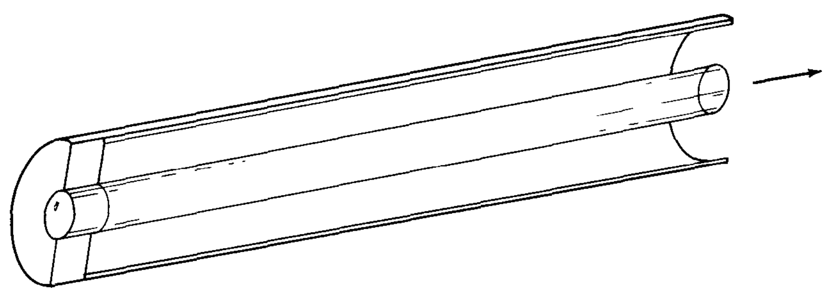


FIG. 2-4. Needlescope system consists of two graded refractory index (GRIN) lenses and an ocular lens. Objective lens, about 3 mm in length and 1 mm in diameter, gives a wide field of view. Relay lens, about 134 mm in length and 1 mm in diameter, transfers image from objective lens back to ocular lens, which magnifies image for viewing.

LIGHT SOURCES

I have utilized a variety of light sources, perhaps virtually every one on the market in North America, in demonstrating the technique of the comprehensive