During the past 5 decades, arthroscopy has dramatically changed the orthopaedic surgeon’s approach to the diagnosis and treatment of a variety of joint ailments. A high degree of clinical accuracy, combined with low morbidity, has encouraged the use of arthroscopy to assist in diagnosis, to determine prognosis, and often to provide treatment. Arthroscopic procedures should serve as adjuncts to and not as replacements for thorough clinical evaluation; arthroscopy is not a substitute for clinical skills.

Progressive improvements in the lens systems of arthroscopes and fiberoptic systems, in miniaturization, and in the accessory operative instruments have made possible advanced operative arthroscopic techniques for virtually every joint in the body, including the knee, shoulder, hip, ankle, elbow, wrist and hand, and foot. Even spinal procedures are increasingly done with endoscopic techniques. Although many arthroscopic procedures have proved superior to previous open techniques, surgical results should not be sacrificed to expand the indications for arthroscopic procedures.

**INSTRUMENTS AND EQUIPMENT**

**ARTHROSCOPE**

An arthroscope is an optical instrument. Three basic optical systems have been used in rigid arthroscopes: (1) the classic thin lens system, (2) the rod-lens system designed by Professor Hopkins of Reading, England, and (3) the graded index (GRIN) lens system. Fiberoptic technology, the use of magnifying lenses, and digital monitors have allowed advancements in arthroscopic design. Newer arthroscopes offer an increased field of view with smaller scope diameters, better depth of field with improved optics, and better flow through the sheath.

Certain features determine the optical characteristics of an arthroscope. Most important are the diameter, angle of inclination, and field of view. The angle of inclination, which is the angle between the axis of the arthroscope and a line perpendicular to the surface of the lens, varies from 0 to 120 degrees. The 25- and 30-degree arthroscopes are most commonly used. The 70- and 90-degree arthroscopes are useful in seeing around corners, such as the posterior compartments of the knee through the intercondylar notch, but have the disadvantage of making orientation by the observer more difficult.

Field of view refers to the viewing angle encompassed by the lens and varies according to the type of arthroscope. The 1.9-mm scope has a 65-degree field of view; the 2.7-mm scope, a 90-degree field of view; and the 4.0-mm scope, a 115-degree field of view. Wider viewing angles make orientation by the observer much easier. Rotation of the forward oblique viewing (25- and 30-degree) arthroscopes allows a much larger area of the joint to be observed (Fig. 49-1). Rotation of 70-degree arthroscopes produces an extremely large field of view but may create a central blind area directly in front of the scope (Fig. 49-2).
TELEVISION CAMERAS

McGinty and Johnson were among the first to introduce a television camera to the arthroscopy system. The advantages of this addition included a more comfortable operating position for the surgeon, avoidance of contamination of the operative field by the surgeon’s face, and involvement of the rest of the surgical team in the procedure. Early cameras were bulky and inconvenient, but small, solid-state cameras have been developed that can be connected directly to the arthroscope. In these camera systems, improvements in the chip and electronic circuitry have allowed reductions in size and better high-definition digital resolution. Cableless arthroscopic systems also are available in which the video signal is transmitted to the monitor from an arthroscope that contains its own miniature light source. Cameras using three-chip technology allow even greater color resolution, and digitalization of the video signal has resulted in advancements in high-quality imaging.

ACCESSORY INSTRUMENTS

The basic instrument kit consists of the following: arthroscopes (30- and 70-degree); probe; scissors; basket forceps; grasping forceps; arthroscopic knives; motorized meniscus cutter and shaver; electrosurgical, laser, and radiofrequency instruments; and miscellaneous equipment. These instruments are used in performing most routine arthroscopic surgical procedures. Additional instruments are available and are occasionally used in special circumstances. Procedure-specific instrumentation also has been developed for cruciate ligament reconstruction, meniscal repair, osteochondral transplantation, hip arthroscopy, and small joint arthroscopy, among others. Each surgeon has personal preferences regarding the type, design, and manufacturer of each instrument.

Many new instruments have been redesigned for use in advanced shoulder procedures. Instruments to pass, retrieve, and tie sutures have greatly advanced soft tissue repair procedures of the capsule, labrum, and rotator cuff (Fig. 49-3).

PROBE

The probe is perhaps the most used and important diagnostic instrument after the arthroscope. The probe has become known over the years as “the extension of the arthroscopist’s finger.” It is used in both diagnostic and operative arthroscopy and is the safest instrument that one can use in learning triangulation techniques (Fig. 49-4). The probe is essential for palpating intraarticular structures and in planning the approach to a surgical procedure. A tactile sensation soon
may be straight or hooked (Fig. 49-5). The hooked scissors are preferred because the configuration of the jaws tends to hook the tissue and pull it between the cutting edges of the scissors, rather than pushing the material away from the jaws, which can occur with the straight scissors. Optional accessory scissors designs include right and left curved scissors and angled cutting scissors. The difference between these two designs is based on the location of the angulation. The shank of the curved scissors is gently curved to accommodate right and left positioning, whereas the angled scissors, usually with a rotating type of jaw mechanism, actually cut at an angle to the shaft of the scissors. These accessory designs are useful in detaching difficult-to-reach meniscal fragments.

### BASKET FORCEPS

The basket or punch biopsy forceps is one of the most commonly used operative arthroscopic instruments (see Fig. 49-5). The standard basket forceps has an open base that permits each punch or bite of tissue to drop free within the joint and does not require the instrument to be removed from the joint and cleaned with each bite. Small fragments of tissue that drop free within the joint through the open-floor punch or basket forceps can be irrigated out or subsequently removed from the joint by suction. This instrument is available in 3- to 5-mm sizes with a straight or curved shaft. It is useful in trimming the peripheral rim of the meniscus, or it can be used instead of scissors to cut across meniscal or other tissue. Wide, low-profile baskets are excellent for meniscal work. The configuration of the jaws of the basket forceps may be straight or hooked; again, the hooked configuration is preferred. Baskets are available in an assortment of angles, including 30, 45, and 90 degrees, which are especially useful for trimming the anterior portions of the meniscus. They also are available in 15-degree down-biting and 15-degree up-biting curves to make it easier to get around the femoral condyle during resection of the posterior meniscal horn. As with other arthroscopic instruments, the proper technique is to make small bites to develop a feeling of what is normal and what is abnormal. It is better to “see and feel” rather than just “see” alone. The probe can be used to feel the consistency of a structure, such as the articular cartilage; to determine the depth of chondromalacic areas; to identify and palpate loose structures within the joint, such as tears of the menisci; to maneuver loose bodies into more accessible grasping positions; to palpate the anterior cruciate ligament and determine the tension in the ligamentous and synovial structures within the joint; to retract structures within the joint for exposure; to elevate a meniscus so that its undersurface can be viewed; and to probe the fossae and recesses, such as the popliteal hiatus within the joint. Most probes are right angled with a tip size of 3 to 4 mm, and this known size of the hook can be used to measure the size of intraarticular lesions. Magnification occurs with the arthroscope, and the closer the arthroscope, the greater the magnification. Care should be taken in using the tip of the probe, and much of the palpation with the probe within the joint is actually done with the elbow of the probe rather than the tip or toe of the instrument.

### SCISSORS

Arthroscopic scissors are 3 to 4 mm in diameter and are available in both small and large sizes. The jaws of the scissors may be straight or hooked (Fig. 49-5). The hooked scissors are preferred because the configuration of the jaws tends to hook the tissue and pull it between the cutting edges of the scissors, rather than pushing the material away from the jaws, which can occur with the straight scissors. Optional accessory scissors designs include right and left curved scissors and angled cutting scissors. The difference between these two designs is based on the location of the angulation. The shank of the curved scissors is gently curved to accommodate right and left positioning, whereas the angled scissors, usually with a rotating type of jaw mechanism, actually cut at an angle to the shaft of the scissors. These accessory designs are useful in detaching difficult-to-reach meniscal fragments.
avoid excessive pressure on the joints and pins of the instrument and to prevent frequent breakage.

Hinged, jawed suction punches are available to cleanly bite small bits of meniscus or other small tissues and suction them from the joint through a channel in the shaft of the punch. This prevents fragments of tissue from floating in the joint and blocking vision and ensures removal of all free fragments from the joint. This instrument, however, often is too large to reach tight posterior areas.

■ GRASPING FORCEPS
Grasping forceps (see Fig. 49-5) are useful to retrieve material from the joint, such as loose bodies or synovium, or to place meniscal flaps and other tissues under tension while cutting with a second instrument. Most grasping forceps have some type of ratchet closure on the handle to secure the tissue within the jaws. The jaws of the grasping forceps may be of single- or double-action design and may have regular serrated interdigitating teeth or one or two sharp teeth to better secure the grasped tissue. The double-action grasping forceps, both jaws of which open, are especially preferred for securing an osteocartilaginous loose body because the single-action types frequently allow it to slip from between the jaws.

■ KNIFE BLADES
Most arthroscopic knives currently used are disposable, single-use instruments. A variety of disposable blade designs are available: hooked or retrograde blades; regular down-cutting blades, both straight and curved; and Smillie-type end-cutting blades. Magnetic properties also are helpful in retrieving the blade if it is inadvertently broken inside the joint. These blades should be inserted through cannula sheaths or encased within a retractable sheath mechanism so that the cutting portion of the blade is exposed only when it enters the field of arthroscopic vision, not as it enters through the entry portal.

■ MOTORIZED SHAVING SYSTEMS
The motorized shaving systems are all basically of similar design, consisting of an outer, hollow sheath and an inner, hollow rotating cannula with corresponding windows (Fig. 49-6). The window of the inner sheath functions as a two-edged, cylindrical blade that spins within the outer hollow tube. Suction through the cylinder brings the fragments of soft tissue into the window, and as the blade rotates, the fragments are amputated, sucked to the outside, and collected in a suction trap. Numerous cutting tips have been developed for specific situations and functions. The diameter of the cutting tip usually is 3 to 5.5 mm, and many of the tips have variable sizes to allow access to smaller or tighter joints. Special blades have been designed for meniscal cutting or trimming, for synovial resection, and for shaving of articular cartilage. Special burrs and abraders have been designed for arthroscopic acromioplasty and anterior cruciate ligament reconstructions. Most systems use a foot pedal to control the motor and allow for variable speed and direction. Reversing the rotation of the cutting blade intermittently often improves cutting efficiency and minimizes clogging with debris. Motorized shavers have been developed for small joints with a 2-mm shaver and burr.

While the motorized shaver is being used, the outflow from the arthroscope should be closed, not only to minimize the chance of oversucking but also to prevent inadvertent suction of potentially contaminated irrigating fluids back through the joint. Finally, the cutting tip should always be within the visual field and the position of the window should be located before the rotary motion of the blade is activated.

■ ELECTROSURGICAL, LASER, AND RADIOFREQUENCY INSTRUMENTS
Electrocautery has been used as an arthroscopic tool for cutting and hemostasis most often after arthroscopic synovectomy and subacromial decompression. It also has been used for both cutting and hemostasis in lateral retinacular release for malalignment of the patella.

At a much lower cost, radiofrequency systems have been reported to produce heat energy similar to that of lasers, which have fallen out of favor. The two types available are monopolar and bipolar. Monopolar devices use a grounding pad and draw energy through the body; with bipolar devices, energy is transferred between electrodes at the site of treatment. Current controversies include the depth of tissue penetration, the amount of cell death, and the ability of the devices to monitor and to control temperature. Reported complications of radiofrequency meniscal ablation include articular cartilage damage, osteonecrosis, and tissue damage caused by the irrigant.

■ IMPLANTS
A variety of implants, both metal and biodegradable, have been developed for use in arthroscopic procedures, including suture anchors, meniscal repair devices, and devices for tendon and ligament fixation and articular cartilage repair.

Suture anchors are used to attach ligaments and tendons to bone without the need for creating a bony tunnel for the passage of sutures. Instead, sutures are passed through an eyelet on the suture anchor, which is inserted into the bone.
According to Barber and Richards, desirable characteristics of a suture anchor are that it must fix the suture to the bone, not pull out of the bone, permit an easy surgical technique (the ability to tie an arthroscopic slip knot), and not cause long-term problems; other desirable features include biocompatibility, adequate strength, easy insertion, and ability to allow early rehabilitation. Suture anchors are used most often for arthroscopic procedures around the shoulder. Polyetheretherketone (PEEK) biocomposite or metal anchors can be used and have less potential for producing osteolytic reactions that have been associated with bioabsorbable implants.

Meniscal repair devices, of varying designs and materials, allow an all-inside meniscal repair without the need for arthroscopic knot-tying, accessory portals, or incisions. The first generation meniscal repair devices were solid flexible devices placed across the tear to hold the meniscal fragments in place. Today’s fourth-generation devices are low profile, have a suture tension construct, and provide much greater fixation strength. The techniques for use of specific meniscal repair devices are discussed in Chapters 45 and 51.

Depending on the graft chosen, cruciate ligament fixation devices can be used for bone-to-bone fixation or for soft tissue-to-bone fixation. They may be made from either biodegradable or nonbiodegradable materials.

**MISCELLANEOUS EQUIPMENT**

A variety of sheaths and trocars are required for arthroscopic surgery, and they must accommodate the arthroscope and accessory equipment being used. When possible, sharp instruments should be placed through sheaths to protect the soft tissues of the skin portals. The motorized instruments can be used with or without a sheath. The initial perforation through the capsular and synovial tissue may be made with a No. 11 blade and blunt trocar or with a sharp trocar carefully passed through the appropriate instrument sheath. Some systems allow cannulas to be interchanged for inflow, arthroscope, and motorized shaver systems. Disposable plastic cannulas with sealed ends reduce fluid extravasation.

As arthroscopic surgery procedures have advanced to more joints, additional instruments have been developed. “Switching sticks” are simple rods placed through the cannula to maintain the portal while the cannula is exchanged. A dilator is used prior to exchange for a larger operating cannula. The Wissinger rod was designed to assist in establishing a portal on the opposite side of a joint from a previously established portal. Traction devices have been developed for use in the shoulder, elbow, and ankle for better exposure (see Chapters 50 and 52). There also has been an explosion of procedure-specific instruments, many of which are described in the pertinent operative sections in Chapters 50 to 52.

**CARE AND STERILIZATION OF INSTRUMENTS**

Arthroscopy equipment that is heat stable may be autoclaved for sterility. Heat- or moisture-sensitive equipment may be sterilized with a low-temperature hydrogen peroxide gas plasma. A low-temperature sterilization process, gas sterilization, and activated glutaraldehyde have been shown to be less effective and have more potential side effects.

**IRRIGATION SYSTEMS**

Irrigation and distention of the joint are essential to all arthroscopic procedures. Joint distention is maintained by lactated Ringer solution during arthroscopy. The inflow may pass directly through the arthroscopic sheath or through a separate portal by means of a cannula. For adequate flow, a 6.0- or 6.2-mm sheath should be used with the scope. We routinely use lactated Ringer solution because it is physiological and results in minimal synovial and articular surface changes. Shinjo et al. determined that lactated Ringer solution better maintained meniscal cell integrity than did isotonic sodium chloride solution.

Usually, two 5-L plastic bags of lactated Ringer solution, interconnected with a Y-connector, are suspended for use with the arthroscopic pump (Fig. 49-7). Once the inflow and outflow cannulas are established, the joint is lavaged until the fluid is clear. When a pump is not used, joint distention is increased by elevating the fluid bag, using a large-diameter tubing, or decreasing the size and number of outflow portals. For each foot of elevation of the solution bag above the level of the joint, 22 mm Hg of pressure is produced. The bag usually is placed 3 to 4 feet above the level of the joint, thus producing approximately 66 to 88 mm Hg of pressure. Arthroscopic pumps should be used carefully, and the tightness of muscle compartments and soft tissue spaces, such as the popliteal fossa, should be monitored closely. Pump pressures should be varied according to the joint being treated and the type of pump being used. When a pressure inflow system is used, joint distention pressures in the knee generally

**FIGURE 49-7** Gravity with water VAC system. Gravity or arthroscopic pump may be used to deliver fluid. Inflow may be through arthroscopic sheath or separate inflow sheath.
should be 60 to 80 mm Hg. Vision and hemostasis in the shoulder usually are best when the distention pressure is maintained approximately 30 mm Hg below the systolic blood pressure. In healthy patients, hypotensive anesthesia may be used to reduce systolic pressure to approximately 100 mm Hg, at which level pump pressure of 70 to 80 mm Hg usually provides safe distention and clear vision. Olszewski et al., in a prospective, double-blinded, randomized study, found that the addition of epinephrine (1 mg per liter of saline) significantly increased visibility and reduced the need for tourniquet inflation by 50% compared with the placebo group of patients who had not received epinephrine. In patients with hypertension or cardiac problems, we forgo the use of epinephrine. Karaoglu et al. also found that adding a small amount of epinephrine (50 mg/10 mL) to the local anesthetic mixture just before portal site injection improved arthroscopic viewing.

Because of the increased likelihood of extravasation, distention pressures in the elbow and ankle should be maintained at approximately 40 to 60 mm Hg using gravity inflow. The surgeon should be aware of individual variations of different pump flow and sensor mechanisms. We do not use pumps for distention in small joints.

TOURNIQUET

During arthroscopic procedures of the knee, ankle, elbow, and other distal joints, a tourniquet is almost always applied and is inflated as needed. Contraindications to the use of a tourniquet include a history of thrombophlebitis and significant peripheral vascular disease. Advantages of tourniquet use are increased visibility and no significantly increased postoperative morbidity with tourniquet times of less than 90 to 120 minutes. The disadvantages of routine tourniquet use include blanching of the synovium, which makes differentiation and diagnosis of various synovial disorders difficult, and the possibility of ischemic damage to muscle and nervous tissue with prolonged tourniquet time of more than 90 to 120 minutes. Many of the commercial leg holders used in knee arthroscopy require the tourniquet to be placed within it. These holders may function satisfactorily whether or not the tourniquet is inflated.

Kirkley et al., in a prospective, randomized clinical trial, found no significant differences between patients in whom a tourniquet was used and those without tourniquet use. There was a trend for less early postoperative pain and slightly better isokinetic strength testing at 2 weeks in those without tourniquet use, but visibility was rated by the surgeons as three times better with tourniquet use. These authors concluded that the use of a tourniquet at 300 mm Hg did not significantly affect overall functional outcome. In their prospective, randomized trial including 109 patients who had arthroscopic knee surgery with or without a tourniquet, Johnson et al. found no significant differences between the two groups with respect to operative view, duration of operation, pain scores, analgesic requirement, or complications. Because the use of a tourniquet did not appear to improve the operative view, these authors recommended against routine use of a tourniquet for arthroscopic knee surgery.

LEG HOLDERS

The biggest advantage of a leg holder is that it permits application of stress primarily to open the posteromedial compartment for better viewing, manipulation of the meniscus, and posterior horn meniscal surgery, especially in tight knees. Because the thigh is firmly held by the leg holder, the number of different positions in which the leg can be placed is somewhat limited. An alternative to an encompassing leg holder is a lateral post attached to the side rail of the operating table (Fig. 49-8). The lateral aspect of the distal thigh can be levered against this post for opening of the posteromedial compartment. The post does not confine or prevent the knee from being positioned in an almost unlimited number of positions, including flexion and the figure-four position; it therefore has advantages over many of the expensive commercial leg-holding devices; we use this for major knee reconstructive procedures.

Furthermore, the routine use of a leg holder, especially one that incorporates a tourniquet within the confines of the holder, may present other difficulties. In such an arrangement, wide fluctuations in the tourniquet pressures may occur when stress is applied to the leg; however, we have had no specific complications related to this. Also, the leg-holding device may fix the distal femur so securely that the applied stress can result in fractures around the knee or tearing of the ligamentous structures; such occurrences have been reported.

Thus, if the clinical evaluation suggests medial compartment meniscal disease, a leg holder can be of significant assistance. On the other hand, if a patellofemoral joint or a lateral compartment problem is anticipated, a valgus stress post may be chosen to make viewing of these compartments easier. For endoscopic repair of the anterior cruciate ligament, a lateral post should be used or the end of the table should be flexed to allow full, unobstructed knee flexion.

FIGURE 49-8 Lateral post attached to side rail of operating table.
ANESTHESIA

Diagnostic arthroscopy can be performed with the patient under local, regional, or general anesthesia. Some intraarticular operative procedures can be performed with regional and local anesthetics.

Local anesthesia can be used for many arthroscopic procedures around the knee and ankle in a cooperative patient. Intravenous sedation is used to complement the local injection. Recent articles by Hansen et al., Chu et al., Petty et al., and many others have brought to light the chondrotoxicity of lidocaine and bupivacaine particularly when combined with epinephrine, which alters the local pH. When used, lower-volume and lower-concentration injections (i.e., 1% lidocaine and 0.25% bupivacaine) are safer alternatives. Prolonged presence of local agents provided through intraarticular pain pumps should be avoided.

Regional anesthesia also can be used in certain circumstances. Both epidural and spinal anesthesia have been used successfully for arthroscopic procedures in the lower extremity; however, with prolonged tourniquet use, patients may experience “tourniquet pain.” We generally do not use spinal anesthesia. Skyhar et al. reported successful use of interscalene blocks for shoulder arthroscopy, and Galinat et al. reported 100 shoulder arthroscopies performed with interscalene blocks; procedures included débridement, subacromial decompression, and shoulder stabilization. There were no complications, although nine patients required general anesthesia because of incomplete blocks. Bert et al. reviewed 1945 ambulatory surgery patients who had interscalene blocks. Complications were reported in 63% of the patients. Eleven patients required inpatient admission, five for intractable arm pain and six for breathing difficulty. We avoid the use of blocks in patients with preexisting breathing disorders.

We also inform high-level athletes of the possibility of developing plexopathy. Peripheral blocks of the lumbar plexus nerve, combined with sciatic nerve block, can be used for many lower extremity procedures. The most commonly used peripheral nerve blocks are femoral nerve block, “three-in-one” block (lateral femoral cutaneous, obturator, and femoral nerves), lateral femoral cutaneous nerve block, and fascia iliaca compartment block. Advantages of peripheral nerve blocks include adequate muscle relaxation, intense and prolonged anesthesia, low incidence of urinary retention, and preservation of contralateral leg strength, which allows almost immediate ambulation with crutches. Disadvantages are the longer time required compared with other anesthesia techniques and the need for an experienced anesthesiologist to administer the block in a block room using ultrasound guidance.

General anesthesia is used or indicated more often in an acutely injured knee, when pain is an important factor, when significant intraarticular surgery is anticipated, or when the patient is not cooperative or is especially apprehensive. Allergy to local anesthetics, of course, requires that a general anesthetic be administered. Arthroscopic surgeons who are less experienced and who are unfamiliar with all the techniques probably are best advised to select a general anesthetic. If the need for a tourniquet to control bleeding is anticipated, as in partial or complete synovectomies or excision of adhesions, general anesthesia is recommended. Most arthroscopic procedures performed at this clinic are done with general anesthesia.

If a local anesthetic is chosen, the tourniquet is not inflated. Yoshiya et al. reported the use of a 1:1 mixture of 1% lidocaine and 0.25% bupivacaine. Usually, 50 mL of the mixture was injected intraarticularly before the procedure. When a long procedure was expected, a small amount of epinephrine was added to the mixture to help maintain hemostasis and to increase the duration of action of the anesthetic agents. These authors recommended care with the use of bupivacaine so as not to exceed its maximal dosage (2 mg/kg of body weight). At each anticipated portal, an additional 5 mL of this mixture was injected. There was only one report of nausea and no other reports of toxic reactions or central nervous system or cardiovascular complications.

Postoperative pain may be diminished by the use of oral nonsteroidal antiinflammatory medication preoperatively and postoperatively or by intramuscular or intravenous administration intraoperatively. The use of nonsteroidal antiinflammatory medication also has been shown to reduce swelling and to increase range of motion in the early postoperative period. The use of oral corticosteroids has not proved effective. Beneficial analgesic effects have been documented for 30 mL of 0.25% bupivacaine with or without the addition of 3 mg of morphine. We do not recommend the use of prolonged intraarticular pain pump catheters because of the potential for chondrocyte toxicity.

DOCUMENTATION

A systematic examination of the operative joint should be recorded with digital photographs, video clips, or both. Preoperative and postoperative photographs are valuable parts of a patient’s record and can be used to critically analyze and teach operative procedures.

ADVANTAGES

The advantages of arthroscopic procedures far outweigh the disadvantages. Among the advantages compared with arthrotony are the following.

- **Reduced postoperative morbidity.** The patient can return to sedentary work almost immediately and to more vigorous work activities within 2 to 3 weeks after most simple procedures.
- **Smaller incisions.** Arthroscopic diagnostic and operative procedures can be carried out through multiple small incisions around the joint, which are less likely to produce disfiguring scars.
- **Less intense inflammatory response.** The small incisions through the capsule and synovium result in a much less intense inflammatory response than does the standard arthrotomy. This results in less postoperative pain, faster rehabilitation, and faster return to work.
- **Improved visualization.** Better visualization is particularly important in shoulder procedures where pathology is common and can be repaired concomitantly through the use of common arthroscopic portals.
- **Absence of secondary effects.** The secondary effects of arthrotomy around the joints, such as neuroma formation,
painful disfiguring scars, and potential functional imbalance (e.g., of the extensor mechanism of the knee), are eliminated by arthroscopic techniques.

- **Reduced hospital stay.** Most arthroscopic procedures are performed on an outpatient basis.
- **Reduced complication rate.** Only infrequent complications of arthroscopic procedures have been reported.
- **Improved follow-up evaluation.** The minimal morbidity associated with arthroscopy allows the effects of a previous operative procedure, such as meniscal repair, to be reevaluated if persistent symptoms warrant further evaluation. These are often referred to as “relook” or “second-look” procedures.
- **Possibility of performing surgical procedures that are difficult or impossible to perform through open arthrotomy.** A number of surgical procedures are more easily performed with arthroscopic techniques than through open arthrotomy incisions. Many menisci that can be repaired are accessible only with arthroscopic techniques and cannot be satisfactorily viewed through arthrotomy.

**DISADVANTAGES**

The disadvantages of arthroscopy are few but may be significant to the individual arthroscopic surgeon. Not every surgeon has the temperament to perform arthroscopic surgery because it requires working through small portals with delicate and fragile instruments. The need to maneuver the instruments within the tight confines of the intraarticular space may produce significant scuffing and scoring of the articular surfaces, especially by an inexperienced surgeon. The procedures can be extremely time consuming early in one’s experience with arthroscopy. Also, the specialized equipment that is required is extensive and expensive.

Although these disadvantages can be significant, the advantages to the patients generally far outweigh them.

**INDICATIONS AND CONTRAINDICATIONS**

Intraarticular or periarticular pathologic conditions can be examined and treated arthroscopically. However, previous experience and the skill set of the operating surgeon should determine whether an arthroscopic or open technique will ensure the best possible treatment for the patient. The contraindications are few. Arthroscopy should not be used in a minimally deranged joint that will respond to the usual conservative methods of treatment. Furthermore, the surgeon should not consider arthroscopy before a careful history, thorough physical examination, and standard noninvasive diagnostic procedures have been performed. Arthroscopy is contraindicated when the risk of joint sepsis from a local skin condition is present or when a remote infection may be seeded in the operative site. Partial or complete ankylosis around the joint is a relative contraindication, although the use of arthroscopy for lysis of adhesions around the knee, shoulder, elbow, and ankle can be beneficial. Major collateral ligamentous and capsular disruptions of the joint that will permit excessive extravasation of fluids into the soft tissues are relative contraindications to arthroscopy. In this situation, the capsule should be allowed to “stick down” or should be repaired primarily before any arthroscopic procedure. Gravity inflow should be used, and outflow should be maintained to help prevent increased compartmental fluid pressures.

**BASIC ARTHROSCOPIC TECHNIQUES**

Proficiency in arthroscopic techniques requires a great deal of patience and persistence.

Techniques are best learned by assisting and performing surgical procedures with an experienced arthroscopist during residency or fellowship or in practice. Hands-on learning sources by the American Academy of Orthopaedic Surgeons and by specialty societies are excellent ways to learn new procedures. Internet surgical videos also are available at many vendor websites.

Patients’ expectations from the use of arthroscopic techniques have placed tremendous demands on practicing orthopaedic surgeons. A surgeon should not be persuaded by these pressures to perform a difficult arthroscopic procedure for which sufficient skills have yet to be developed. If an arthroscopic procedure is not progressing as expected, it may be wise to abort the procedure and return to an open method that has given good results in the past. As arthroscopic procedures become better defined and results continue to improve, the number of arthroscopic procedures is increasing steadily. There is a steep learning curve to successful completion of complicated procedures, such as shoulder stabilization and rotator cuff repair. The practicing surgeon should keep up with the literature, attend workshops, and observe these procedures being performed by highly skilled arthroscopists. Orthopaedic surgeons should perform procedures concurrent with their levels of skill and keep in mind that a skillfully performed procedure through an open arthrotomy is preferable to a poorly performed arthroscopic procedure.

**TRIANGULATION TECHNIQUE**

Triangulation involves the use of one or more instruments inserted through separate portals and brought into the optical field of the arthroscope, the tip of the instrument and the arthroscope forming the apex of a triangle. The principle of triangulation is the basis for operative arthroscopy. Triangulation separates the arthroscope from the operating instrument, allowing the viewing arthroscope to be enlarged and increasing the field of view. The angle of inclination can be varied to allow improved visual access to more areas of the joint. Separation of the instruments from the arthroscope improves depth perception and, perhaps the most significant advantage, permits independent movement of the arthroscope and the surgical instrument, which is essential for operative arthroscopy.

To begin triangulation, the arthroscope should be at a distance from the area to be probed to give a wide field of vision. When the instrument is located, the scope and instrument are advanced together toward the intended area, reducing the field of vision while increasing the magnification. A mistake commonly made by beginning arthroscopists is placing the scope too close to objects, thus losing the
larger field of vision necessary to maintain constant visual orientation.

If the surgeon becomes disoriented and has difficulty in triangulation, the accessory instrument may be brought into the joint to contact the sheath of the arthroscope. By sliding the instrument down the sheath to the arthroscope tip, the surgeon may bring the instrument into the field of vision. With practice, a surgeon develops a stereoscopic sense that allows placement of the instrument into the field of view immediately.

**COMPLICATIONS**

Complications during or after arthroscopy are infrequent and fortunately usually are minor. Most are preventable with good preoperative and intraoperative planning and attention to the details of basic techniques. Familiarity with local anatomy and gaining familiarity with new techniques through learning centers, operating with colleagues, videos, and staying current with specialty journals allow the surgeon to gain valuable information from the experiences of other colleagues. Before operative procedures, having all office notes and radiographs available is similarly beneficial. Also, before entering the operating room, reviewing the surgical procedure with the patient and having the patient write the word “wrong” on the nonoperative extremity can alleviate possible confusion on a long operative day. The Sign Your Site program of the American Academy of Orthopaedic Surgeons and the Universal Protocol recommendations of the Joint Commission on Accreditation of Healthcare Organizations include preoperative verification of the operative site, marking of the operative site by the surgeon (Fig. 49-9), and a “time out” before the procedure is begun for final verification and a final checklist.

**DAMAGE TO INTRAARTICULAR STRUCTURES**

Damage to intraarticular structures probably is the most common complication of knee arthroscopy. Scuffing of the articular cartilage surfaces by the tip of the arthroscope or the operating instrument occurs most often when the arthrosco-
pist is inexperienced, when the joint is tight, or when the procedure is long and particularly difficult. Forcing the arthroscope or other instruments between articular surfaces, such as the femoral and tibial condyles or the humeral head and glenoid cavity, may severely score their surfaces and lead to progressive chondromalacic changes and degenerative arthritis. The joint should be opened with leverage or traction first and the arthroscope allowed to slide into the space created. Use of a leg holder or a leverage post during knee surgery, as well as traction or distraction devices during shoulder, hip, and ankle procedures, is helpful. Once the arthroscope has been inserted between the articular surfaces, distraction should be maintained. If distraction is released and the scope is then retracted, the articular cartilage will be severely scored. Finally, a poorly placed portal frequently makes instrument passage and maneuvering more difficult. It is better to change the portal site or to make an accessory portal than to scuff the articular surface by forcing the instrument.

**DAMAGE TO MENISCI AND FAT PAD**

The anterior horn of either meniscus of the knee can be damaged by incision or penetration if the anterior portals are located too inferiorly (Fig. 49-10). If the portals are too close to the patellar tendon, they may traverse the fat pad. Repeated penetration of the fat pad causes swelling of the pad and
obstruction of view and may also result in hemorrhage, hypertrophy, or fibrosis of that structure.

**DAMAGE TO CRUCIATE LIGAMENTS**

Either cruciate ligament may be damaged during meniscal excision when an intercondylar attachment is cut. With knee ligament reconstructions, the intact cruciate is susceptible to injury when motorized instruments are débriding the intercondylar notch. Thus, the shaver blade should always be directed away from the intact ligament.

**DAMAGE TO EXTRAARTICULAR STRUCTURES**

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**BLOOD VESSELS**

Damage to the blood vessels around the joint may be the most serious and devastating arthroscopic complication. Vascular injury most often occurs from direct penetration or laceration but may occur from pressure caused by excessive fluid extravasation. Small’s 1986 report included 12 vascular injuries, all in knee surgery; no vascular complications were reported in his 1988 study. The popliteal artery is at risk during meniscectomy when intercondylar attachments are cut, especially when arthroscopic knives are used. Both the popliteal artery and vein have been damaged during meniscal repairs as the sutures are placed posteriorly. Most surgeons now recommend a posteromedial or posterolateral incision, with exposure of the capsule and placement of a suitable retractor to protect the popliteal vessels during meniscal repairs and for posterior cruciate ligament reconstructions.

When large, complicated procedures are performed, constant awareness of the posterior vascular structures is necessary and having the availability of a vascular surgeon is desirable. The vessels also are vulnerable if there is uncontrolled penetration during establishment of the posteromedial or posterolateral knee portals. Extensive arthroscopic synovectomies have been associated with injury to the genicular arteries, with subsequent arteriovenous fistula or pseudoaneurysm formation.

The anterior tibial artery is at risk during anterior approaches for ankle arthroscopy, especially with the anterocentral approach. Likewise, posteromedial portals are not recommended because of the proximity of the posterior artery. During elbow arthroscopy, the brachial artery may be damaged during establishment of either the anteromedial or anterolateral portal. Fluid extravasation also may compress this vessel in the antecubital fossa. In shoulder arthroscopy, the axillary artery may be injured by an arthroscopic instrument plunging through the axillary pouch. More often, axillary vessel occlusion is caused by fluid extravasation or excessive arm traction.

During shoulder arthroscopy, the acromial branch of the coracoacromial artery can be transected just lateral to the acromioclavicular joint during resection of the coracoacromial ligament.

Major superficial veins may be lacerated when portal selection is improper. In the knee, the saphenous vein may be penetrated by poor posteromedial portal location. In the shoulder, the cephalic vein may be penetrated by poor anterior portal site selection.

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**COMPARTMENT SYNDROMES**

Increased compartment pressure may occur during surgery from fluid extravasations and should be monitored during all extensive procedures. By using gravity inflow or lower pump pressures and ensuring adequate outflow, most of these complications can be avoided. When excessive extravasations occur, stopping fluid inflow, releasing any constricting dressing or tourniquets, and placing the extremity at the level of the heart are recommended. Wrapping with an Esmarch wrap from distal to proximal and then removing it may help remove the extravasated fluid. Persistence of elevated pressure should be evaluated and treated following the guidelines set for compartment syndrome (see Chapter 53).

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**NERVES**

Nerve injuries may be caused by direct trauma from a scalpel or sharp trocar, by traction from overdistraction, by mechanical compression or compression from fluid extravasation, by prolonged ischemia from excessive tourniquet use, or by a poorly defined mechanism of injury to the anatomical nervous system that results in reflex sympathetic dystrophy.

Many of these complications can be avoided by marking portals appropriately, making sure the scalpel penetrates the skin only, using a hemostat to spread down to the joint capsule in proximity to a nerve, and routinely using blunt trocars. Maintaining proper joint distention and distraction, padding nerve and bony prominences, and proper patient positioning also greatly reduce the chances of nerve complications. Familiarity with techniques and anatomy allows proper portal placement and improves surgical technique, thus minimizing tourniquet time.

Sensory and motor nerves near the joint also may be damaged. The inferior branches of the saphenous nerve or sartorial branches of the femoral nerve are the most commonly injured cutaneous nerves. The location of each of these numerous cutaneous branches varies, and therefore occasional injury to one may be unavoidable, especially if multiple portals are used. In most instances, the hypesthesia produced is of minor consequence and causes no problem. On occasion, a painful neuroma may require subsequent resection. In Small’s report, 229 nerve injuries were reported during knee arthroscopies. Thirty saphenous nerve injuries and six peroneal nerve injuries were reported in 3034 meniscal repairs. Increased experience with meniscal repairs as well as improved techniques (especially posteromedial or posterolateral exposures) dramatically lowered the incidence of nerve injury to one saphenous nerve injury in 310 meniscal repairs in Small’s second series.

During shoulder arthroscopy, the branches of the axillary nerve that course along the deep surface of the deltoid may be injured if either anterior or posterior portal sites are too far inferior. Traction neurapraxia of the brachial plexus may occur when strong traction and distraction of the shoulder have been used. The position that appears to result in the greatest traction on the brachial plexus is 30 degrees of forward elevation and 70 degrees of abduction. In 1986, Small reported one axillary nerve injury and three brachial plexus injuries in 14,329 shoulder arthroscopies. In 1988, there were no nerve injuries in 1,184 shoulder procedures. Arthroscopy
of the smaller joints, elbow and ankle, requires even greater attention to detail and general principles than in the more familiar knee arthroscopy. Neurovascular injury is the major risk of elbow arthroscopy; anterior portals place the radial and posterior interosseous nerves at risk on the lateral side and the median nerve at risk on the medial side; posteromedial portals place the ulnar nerve at risk. However, nerve palsies after elbow arthroscopy usually are transient and result from local anesthetic, tourniquet use, or blunt injury. Kelly et al. reported 12 transient nerve palsies in 473 elbow arthroscopies and identified rheumatoid arthritis and contractures as significant risk factors for the development of a temporary nerve palsy.

Regardless of the site of the arthroscopic procedure, a thorough understanding of local anatomy and precise marking of tendons and neurovascular structures are essential. Exact portal placement and proper distention before blunt entry into the joint decrease nerve vulnerability. Careful use of less aggressive motorized shavers is important in working close to neurovascular structures.

**LIGAMENTS AND TENDONS**

The medial collateral ligament may be injured by accessory medial portals around the knee, or it may be torn by severe valgus stress in an attempt to open up the medial compartment. This is a real possibility if a rigid leg holder is used and a strong valgus stress is applied. Small reported 160 knee ligament injuries in 1986, 143 of which involved a leg holder. Three femoral fractures were reported, but surprisingly none involved the use of a leg-holding device. By 1988, the frequency of this complication had decreased dramatically.

**HEMARTHROSIS**

Hemarthrosis is the most common postoperative complication, occurring most frequently after lateral retinacular releases and synovectomies. The superior lateral geniculate vessels usually are cut in lateral retinacular releases, and the inferior lateral geniculate vessels may be lacerated just anterior to the popliteal hiatus during lateral meniscectomy and synovectomy. Small, in 1988, reported the incidence of hemarthrosis as just more than 1%. The incidence increased to 4.6% during lateral retinacular releases. Persistent unexplained hemarthrosis is an indication for appropriate vascular studies and hematological clotting studies to help determine appropriate treatment.

**THROMBOPHLEBITIS**

Thrombophlebitis is potentially the most dangerous postoperative complication; fortunately, it is not common after routine arthroscopic procedures. The incidence was 0.17% in Small's 1986 evaluation of reported complications and 0.13% in 1988 in all arthroscopic procedures in the lower extremities. Stringer et al. reported deep vein thrombosis in 4.2% of 48 patients evaluated with venography after knee arthroscopy; none had pulmonary emboli. In a 1998 report, Schippinger et al., using ultrasound, phlebography, and lung scans preoperatively and 5 weeks postoperatively in 101 patients, revealed eight cases of deep vein thrombosis, four of which were silent and four of which were symptomatic. Nine emboli were detected, of which eight were silent. All patients had been given 5000 IU of low-molecular-weight heparin 12 hours before surgery. The authors found a tendency toward development of deep vein thrombosis when several preoperative risk factors were present. There was no correlation with surgical time, tourniquet use, or anesthetic. Demers et al. studied 184 patients by ultrasonography 1 week after arthroscopy; no prophylaxis was given. Thirty-three patients (17.9%) were diagnosed with deep vein thrombosis; 20 were symptomatic, and most were proximal or extensive. Deep vein thrombosis significantly increased with tourniquet time of more than 60 minutes. In a meta-analysis of patients who had not received prophylactic antithrombotic medication, Ilahi et al. found an overall rate for deep vein thrombosis to be 9.9% and proximal deep vein thrombosis to be 2.1% after knee arthroscopy.

Some reports suggest that the use of a tourniquet reduces the incidence of thrombophlebitis, whereas others suggest that the incidence is increased by the use of a tourniquet and a leg holder. Poulsen et al. associated an increased risk of deep vein thrombosis with tourniquet time exceeding 60 minutes, age older than 50 years, and previous history of deep vein thrombosis. Reigstad and Grimsgaard found that duration of surgery was the only predicting factor for postoperative complications; the use of a tourniquet did not increase the morbidity or complication rate in their 876 procedures. Deep vein thrombosis of the upper extremity is rare. Randelli et al. in an Internet survey of the Italian Society of Knee Surgery, Arthroscopy, and Sport Traumatology found six patients of a reported 9385 patients. Nonetheless, we use serial compression devices for the lower extremity when performing extensive shoulder surgery on at-risk patients. Minimizing operative and tourniquet times, avoiding postoperative immobilization, and using thromboprophylaxis (postoperative low-molecular-weight heparin) may be beneficial in patients at risk for thromboembolic complications.

**INFECTION**

Despite the early fears of infection, the actual number of reported infections has remained extremely low. Numerous investigators have reported large series, all with infection rates of less than 0.2%. This low incidence is undoubtedly the result of several factors, including limited incisions, young and healthy patients, short operating time, and irrigation and dilutional effects of the irrigating solutions. Babcock et al. noted, however, that when such infections occur, they can cause significant morbidity. They cited as risk factors the use of intraarticular corticosteroids, prolonged tourniquet time, patient age of more than 50 years, failure to prepare the surgical site again before conversion to arthrotomy, procedure complexity, and history of previous procedures and noted that several reported outbreaks of infection after arthroscopy were related to breaks in infection control or to contaminated instruments.

The use of prophylactic antibiotics is still controversial. Citing the development of septic arthritis in nine patients after knee arthroscopy, D’Angelo and Ogilvie-Harris suggested that the use of prophylactic antibiotics may be cost beneficial, considering the unpredictability of this complication and
its serious consequences. However, Bert et al. reviewed 3231 arthroscopic knee surgeries and found infection rates of 0.15% in patients who received antibiotics and 0.16% in those who did not. These authors concluded that there was no value in administering antibiotics before routine arthroscopic knee surgery. Kurzweil noted that prophylactic antibiotics may be appropriate to reduce the risk of infection in “high-risk” patients, such as those with diabetes, immune problems, and skin disorders. Judd et al. reported an infection rate of 0.68% in 1615 arthroscopic anterior cruciate ligament reconstructions and associated previous knee surgery, especially previous anterior cruciate ligament reconstruction and tibial graft fixation with a post and washer, with an increased risk of infection. Routine use of postoperative intraarticular steroids has been associated with an increased incidence of postoperative infection.

Infection rates after arthroscopy of other joints are equally low. Clarke et al. reported only one case of septic arthritis in 1054 consecutive hip arthroscopies, and infections have been reported to occur in less than 1% of patients after shoulder arthroscopy and after arthroscopy of the ankle. Kelly et al. reported an infection rate of 0.8% in 473 consecutive elbow arthroscopies.

We recommend that surgical sites be cleansed and clippers be used in a preoperative area for hair removal. Antibiotics are given as recommended by the American Academy of Orthopaedic Surgeons advisory statement for total joints in which the patient is given 1 g cefazolin intravenously within 1 hour of the skin incision. Patients older than age 80 years are given 2 g. Patients allergic to cephalosporins are given alternative antibiotic prophylaxis.

TOURNIQUET PARESIS

Temporary paresis in the extremity has been observed after tourniquet use to control bleeding in diagnostic or operative arthroscopy, usually after prolonged procedures. If a tourniquet is required, it should be deflated after 90 to 120 minutes. Carefully monitoring the tourniquet pressure and testing the accuracy of the tourniquet gauges minimize these problems. Fortunately, tourniquet paresis usually is mild and resolves within a few days.

SYNOVIAL HERNIATION AND FISTULAS

Small globules of fat and synovial tissue may herniate through any of the arthroscopic portals. Usually, the larger the portal, the greater the chance of this complication. A large fluid-filled cystic herniation rarely may occur. These fat and synovial herniations usually are small, become asymptomatic during several weeks, and do not require any specific treatment. If a herniation persists and remains symptomatic, excision of the herniated part with careful closure of the capsule may be required.

Synovial fistulas are rare, but they have followed suture reactions or stitch abscesses. Fistulas more commonly are associated with posteromedial knee and ankle portals. To improve closure, these portals should be sutured routinely rather than closed with adhesive strips. Fistulas usually do not produce significant intraarticular infections, but the patient should probably receive antibiotics, and the knee should be immobilized for 7 to 10 days to allow the fistula to close spontaneously. Surgical closure rarely is required.

INSTRUMENT BREAKAGE

Arthroscopic instruments occasionally may break within the joint. In a survey of more than 9000 cases, Mulhollan reported a 0.03% incidence of broken instruments; 0.01% required arthrotomy for removal of the broken part. Small reported incidences of 0.1% in 1986 and 0.05% in 1988. Basket forceps may be broken if one attempts to bite too large a fragment of meniscus or other tissue. The rotational pin holding the biting jaw may break or become dislodged, allowing the jaw to fall free within the joint. A similar breakage may occur with the scissors. Cutting instruments with disposable blades, especially knives, not only may break but may become detached from the handle and be dropped free within the joint. Newer instruments have shear pins within the cutting mechanism that will break before actual instrument failure.

If an instrument breaks, the surgeon should immediately close the outflow cannula but the inflow should be left open to keep the joint distended. Stopping the outflow reduces turbulence, and holding the joint still helps prevent the fragment from falling out of sight into another part of the joint. If the broken instrument is in the visual field, total attention to keeping it in view and removing it is essential. Broken instruments tend to gravitate into the medial or lateral gutters of the knee, to hide beneath the menisci, or to drop by gravity into the posterior or most dependent part of the joint. If the fragment cannot be located by thorough examination and probing of the joint, a radiograph of the joint should be made. If the broken piece is located, a suction apparatus or a magnet may be introduced through an accessory portal to stabilize and remove the small broken fragment, or an additional grasping instrument can be inserted through a third portal to secure and extract the piece.

REFERENCES


Complete references are available online at www.expertconsult.com.
SUPPLEMENTAL REFERENCES


