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The Role of Minimally Invasive Surgery in the Lumbar Spine

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Specific surgical advances of the last several decades have enabled spinal surgeons to increasingly preserve more of the normal tissue in efforts to enhance postoperative results. Improvements in viewing technologies, including microscopy, have been a major step. The development of specialized surgical instruments and implants also have allowed for the design of spine procedures that do not require the traditional extent of tissue dissection. A wide variety of spinal pathologies, such as spinal stenosis, herniated nucleus pulposus, and some forms of spinal instability, may be managed successfully with minimally invasive spine surgery techniques. New skills must be mastered to perform safe and effective minimally invasive spine surgery; these new techniques have an inherent learning curve. However, these procedures can be learned through instruction and rely on many of the same principles that practiced spine surgeons are familiar with. Minimally invasive spine surgery may have the potential to significantly reduce perioperative morbidity. Well-designed clinical studies are still needed, however, to compare the benefits of minimally invasive spine surgery with traditional management.
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Less-invasive alternatives to common operative procedures have been developed in many surgical disciplines. Among these, minimally invasive spinal surgery (MISS) is a relative newcomer. Although pioneers in the field described small incision spine procedures more than 30 years ago, only in the last decade have technological advancements produced a robust interest in less-invasive approaches to spinal problems. Many spinal procedures that historically required extensive surgical exposures are now performed through smaller access incisions. Minimally invasive techniques also are being applied increasingly to more varied spinal procedures.[1,2]

The primary goal of minimally invasive spinal surgery is to limit the disruption of the normal spinal anatomy. The theoretical advantages of less soft-tissue disruption include decreased blood loss, less postoperative pain, shorter hospitalization, improved cosmesis, and faster recovery times.[3] Minimally invasive spinal surgery comprises a collection of techniques and procedures using specialized retractors, instruments, and implants. Key technological advances include microscopes, endoscopes, tissue dilators, cannulated pedicle screws, tubular retractors, fiber optic lighting, advanced radiographic imaging, and real-time image guidance technology. Not all patients or spinal problems, however, are appropriate for a less-invasive surgical procedure. In this article, we will discuss the role of minimal access spinal procedures specifically for lumbar pathology.

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MISS Principles

The distinction among an open, mini-open, percutaneous, and a minimally invasive procedure is not always well defined. The guiding principle of less-invasive spinal surgery is to limit iatrogenic surgical injury to the paraspinal soft-tissue envelope. This principle is much more important that the length of the skin incision. Although less-invasive procedures may offer an advantage of less anatomic disruption, an adequate decompression and/or fusion must be performed to achieve results comparable with traditional open surgical ap-

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proaches. Complete treatment of the spinal pathology cannot be avoided to perform surgery through a smaller incision.

A minimally invasive spinal procedure should always begin with careful analysis of imaging studies (radiographs, magnetic resonance imaging, and computed tomography) to best define and characterize the spinal pathology. A clear and well-thought-out preoperative plan is particularly relevant to those minimally invasive cases in which direct visualization will be limited and in which the access must be carefully planned.

MISS Patient Selection and Preoperative Planning

A good candidate for spinal surgery is likely to have a good clinical outcome regardless of the surgical approach. The primary impetus for a less-invasive approach is to decrease postoperative morbidity, including postoperative pain and immobility. Minimally invasive surgery is best suited to a localized spinal problem. For example, a patient with a single large sequestered disk fragment is generally an excellent candidate for a less-invasive surgical approach. In contrast, a problem that affects a larger area of the spine, such as where a wide multilevel decompression is required (>3 levels) is less well suited to an efficient MIS approach. Similarly, a person that requires a long spinal fusion is not an ideal candidate for a minimally invasive approach, although techniques for more complex cases are constantly expanding. The more complex the spinal procedure, the more difficult it is to achieve with a minimally invasive approach. Minimally invasive procedures generally involve more equipment than traditional open procedures. The surgeon must be familiar with the specific technique that is being undertaken and should maintain a variety of surgical options when embarking on a highly complex procedure. In particular, the risk and benefits should be carefully weighed and discussed with the patient when choosing a surgical approach for a given case.

MISS Instruments and Equipment

Tubular soft-tissue dilators, retractors and instruments are available in a variety of configurations (Fig. 1). The tubular retractor typically is introduced over a series of soft-tissue dilators; these spread the fascicles of the paraspinous muscles serially, without muscle laceration. Because the instrument mobility within a tubular retractor is dictated by its diameter and length, the tube that will reach from the skin to the spine should be chosen. An overly short tubular retractor should be avoided as it will allow muscle tissue to creep into the field and obscure visualization. When placing the tubular retractor, each dilator should be advanced and docked on bone to minimize the amount of interposed soft tissue. Tubular retractors can be fixed to a table-mounted arm, to maintain position and orientation (Fig. 2). Placement of the tubular retractor is typically verified by fluoroscopy.

Operating through a tube requires specialized instruments and techniques. Hand instruments for MIS spine procedures are longer than their traditional counterparts and often are bayoneted to prevent the surgeons hand from obscuring visualization. Good lighting and magnification are essential and should be routinely used when working through a tubular retractor. A technique termed "wanding" allows access to adjacent areas of the spine; the retractor is reoriented within the same skin portal to reach an adjacent level, or even the contralateral side. Some tubular retractors have articulating components that also allow enhanced visualization of adjacent areas.

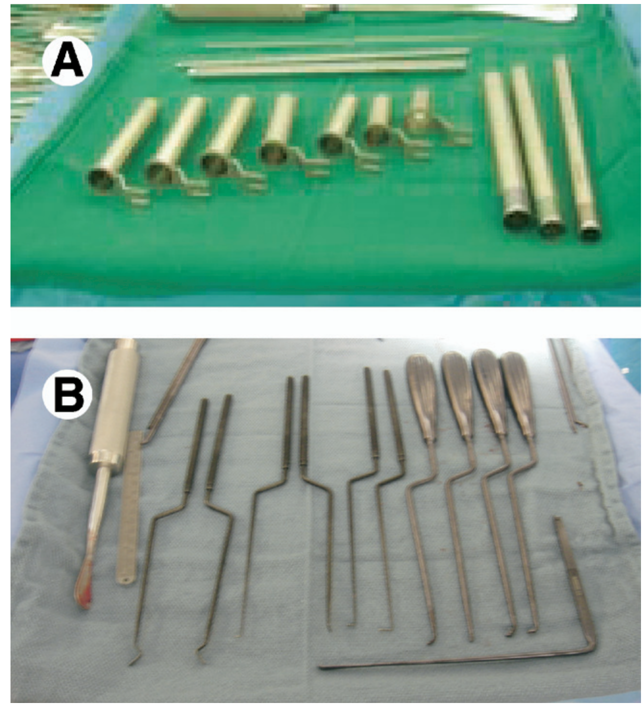

Figure 1 MISS tubular dilators (A), retractors, and angled instruments (B).

Visualization is facilitated by good lighting and magnification. Many surgeons prefer to use a microscope in conjunction with the tubular retractor. The microscope provides optimal magnification and illumination. Importantly, the microscope allows stereoscopic visualization, which allows the surgeon to focus at the bottom of the tubular retractor while allowing adequate working space between the microscope and tube.

Fluoroscopy is used for many less invasive procedures. Modern C-arm fluoroscopy should be used to plan the most appropriate incision that will allow access to all necessary structures. Some procedures, such as the placement of percutaneous pedicle screws, require a significant number of fluoroscopic images. The surgeon should limit the radiation exposure to operative personnel by always using protective lead aprons and limiting fluoroscopy "on" time. Leaded glasses are recommended and columnation of the radiation beam should be used so that only the necessary anatomy is visualized to reduce radiation exposure.