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MINIMALLY INVASIVE SPINAL (MIS) SURGERY: PAST, PRESENT, AND FUTURE

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ABSTRACT

Minimally invasive spinal surgery has rapidly evolved in the past decade through advances in imaging, access, and implant technology. The goal remains less pain, more rapid functional recovery, and lower morbidity compared to open surgical technique. Economic factors also impact newer technology. Evidence-based research must support the benefits of these new procedures to justify the added expense in technology required to develop these procedures.

INTRODUCTION

Minimally invasive spine (MIS) surgery has experienced an explosion in technology over the past decade. To be sustainable, the minimally invasive surgical approach must achieve the goal of equal outcomes when compared to open surgical procedures while at the same time preserve the safety of the procedure and minimize complications.

HISTORY

Through the efforts of pioneers collaborating with forward-looking device manufacturers, the intimidating aspects of adopting this technology have given way to enthusiastic adoption.[1,2] Surgeons who have cradled the importance of minimally invasive surgery have worked hard to modify open surgical techniques to accommodate smaller incisions, and new procedures have been developed that exploit the advances of fiber optics, the versatility of spinal implants, and advances in computer-guided real time imaging.[3] Video-assisted thoracic discectomy is an example of modification of thoracoscoic techniques to visualize the thoracic spine.[4,5] (See Figures 1.1 to 1.3.) In the hands of experts who perform this uncommon procedure on a regular basis, improvements in postoperative lung complications, reduction in post-thoracotomy pain and more rapid functional recovery have been reported. However, because thoracic spinal pathology is uncommon compared to lumbar and cervical spine pathology, this procedure remains in the hands of a selected few who perform it on a regular basis. Advances in biologics have also been useful in improving results for minimal access procedures. In the analysis of the myriad of procedures developed in the past decade that purport to be minimally invasive, the technology to be successful and sustainable must (1) minimize the approach-related trauma, (2) decrease postoperative pain and morbidity, (3) decrease complications, and (4) lead to a more rapid recovery and return to normal function. There are procedures that have achieved these goals only to be discarded as a result of the technical difficulty and learning curve. Laparoscopic anterior lumbar fusion surgery is a case in point as[6] this procedure has demonstrated improved outcomes compared to laparotomy. However, the technical expertise required resulted in longer operative times and an increase in potential for retrograde ejaculation.

FIGURE 1.1: Photo shows Dr. Regan performing endoscopic surgery on a patient with T9-10 thoracic disc herniation through three portals. The patient is a 32 year old chiropractor who presented with 6 months history of right flank pain and progressive weakness in the right leg and paresthesias in the left leg. Examination revealed unsustained clonus in the achilles worse on the right and a noticeable limp on the right as well as weakness in all motor groups in the right leg.

FIGURE 1.2: CT axial image demonstrates partially calcified disc herniation occupying greater than 50 percent of the spinal canal.

FIGURE 1.3: CT sagittal image demonstrates calcified disc at T9-10 with severe canal compromise.

The move away from threaded fusion cages spelled the end for this procedure. This approach did, however, lead to a direct lateral endoscopic approach [7] and eventually the direct lateral approach to the lumbar spine. Endoscopic techniques have largely been replaced with mini-open techniques using dilating tube retractors. The advent of electrical monitoring in the late 1990s improved the safety not only of pedicle screw placement but also the direct lateral transpsoas approach with inherent risks to the lumbar plexus.

PROGRESS AND FUTURE OF MINIMALLY INVASIVE SPINE (MIS) SURGERY

Economic forces at play in healthcare reform have resulted in further scrutiny of novel procedures and technology. The new technology to gain acceptance with insurance payers must now show improved outcomes when compared to historical controls. Additionally, improved outcomes must also factor in the cost of the procedure. The cost of new equipment including biological must be offset by decreased hospital stay, decreased complications, and/or more rapid return to health and employment. Spinal procedures are being done in outpatient surgery centers with increasing frequency. Not only is microdiscectomy commonplace but anterior cervical discectomy, disc replacement, and even anterior lumbar fusion at L5-S1 as well as disc replacement can be safely performed in surgery centers. Direct lateral spinal fusion has also gained acceptance in the hands of experienced surgeons in the surgery center. Minimal incisions mean less postoperative pain and quicker discharge from the medical facility.

Biological agents have been significant enablers of MIS technology. For example, BMP-7 has eliminated the need for iliac autograft. However, there are significant risks that have occurred with its use. The FDA issued a "black box" warning as a result of its use in the cervical spine. It has also been associated with nerve root and recently spinal cord injury when placed near exposed neural structures. Early results with mesenchymal stem cells may avoid these complications and achieve the desired results. Combined with minimal access techniques this should lead to improved outcomes.

Perhaps one of the most successful MIS procedures has been the XLIF, or direct lateral interbody fusion in which tube technology results in minimal incision and nerve stimulation aids in minimizing nerve root injury. As with any new technology there are potential added risks of vascular, ureteral, and even nerve injury. The potential disadvantages occur when the surgeon is unfamiliar with the approach and is working with less visibility and increased reliance upon nerve monitoring and guidance. An increased incidence of anterior thigh and groin dysesthesia occurs in this approach as a result of the transpsoas methodology, which places increased risk on the genitofemoral and ilioinguinal nerves in addition to the lumbar nerve roots. Improved technique, visual confirmation, and strict adherence to radiological confirmation minimize these issues. The increasing prevalence of cadaveric-based teaching centers has resulted in improvements in surgeons' familiarity with newer technology. This aspect of minimally invasive technology must not be ignored as the key to successful outcome; i.e., the combination of improving the ease of the technology through safety measures as well as surgeon training.

Improvements in image guidance have been valuable tools in facilitating MIS procedures. Multiple-level percutaneous screw placement required by minimally invasive scoliosis procedures is facilitated by the O-arm.[3] This provides real time intraoperative CAT (computerized axial tomography) scan imaging that results in improved accuracy of pedicle screw placement with less radiation to the patient and surgeon. This is a significant improvement over image-guidance technology, which must rely on preoperative MRI (magnetic resonance imaging) or CAT scans. The surgeon can also check the results of his work before terminating the anesthesia. This avoids unplanned returns to the operating room and also avoids the potential of nerve injury from screw misplacement. This technology does come at a price, however. Biplanar fluoroscopy is the alternative that increases not only the time of the procedure but also the radiation exposure.

CONCLUSION

Minimally invasive spinal surgery has increasingly become an integral part of the daily armamentarium of the progressive spinal surgeon. It is the responsibility of spine surgeons throughout the world to learn about the techniques described in the subsequent chapters. They must mentor students of these techniques, receive training in these techniques at a cost that is acceptable to society, and with outcomes that are supported by well-designed, controlled, prospective studies. It is only with proper studies that these techniques can be ultimately validated.

REFERENCES

1. Regan J, McAfee P, and Mack M, 1995. **Atlas of Endoscopic Spinal Surgery**. Quality Medical Publishing.
2. Regan J and Lieberman, 2004. **Atlas of Minimal Access Spine Surgery**. Quality Medical Publishing.
3. Abul-Kasim K, Söderberg M, Selariu E, Gunnarsson M, Kherad M. And Ohlin A, 2011. Optimization of radiation exposure and image quality of the cone-beam O-arm intraoperative imaging System in spinal surgery. *J Spinal Disord Tech* March 16.
4. Regan JJ, Mack MJ, and Picetti GD 3rd, 1995. A technical report on video-assisted thoracoscopy in thoracic spinal surgery. *Spine* (Phila Pa 1976) Apr 1: **20**(7): 831–837.
5. Anand N and Regan JJ, 2002. Video-assisted thoracoscopic surgery for thoracic disc disease. Classification and outcome study in 100 consecutive cases with a 2-year minimum follow-up period. *Spine* (Phila Pa 1976) Apr 15: **27** 871–879.

6. Regan JJ, Aronoff RJ, Ohmneiss DD, and Sengupta DK, 1999. Laparoscopic approach to L4-L5 for interbody fusion using BAK cages. Experience in the first 58 cases. *Spine* (Phila Pa 1976) Oct 15: **24**(20):2171–2174.
7. Bergey DL, Villavicencio A, Goldstein T, and Regan JJ, 2004. Endoscopic lateral transpsoas approach to the lumbar spine. *Spine* (Phil Pa 1976) Aug 1: **29**(15): 1681–1688.