Philosophy of Minimally Invasive Spine Surgery

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ABSTRACT
In an era to use minimally invasive in spine surgery as a routine procedure, this paper will check out our philosophy on that. The advantages and disadvantages of minimally invasive surgery will be discussed.
We must emphasize that the demand for minimally invasive spinal surgeries mainly comes from patients rather than surgeons. However, the concept of “being maximally effective” should not be forgotten in surgeries with minimally invasive techniques.

KEY WORDS: Complications of spine surgery, endoscopy, minimally invasive spine surgery, spine surgery

INTRODUCTION
This paper will summarize the techniques of minimally invasive spinal surgeries and try to look at its critical points, advantages and disadvantages.

Purpose of Minimally Invasive Spinal Surgeries
Aims of spine Surgery can be summarized in three prospects: (a) Neurological improvement that is mostly achieved by decompression of the spinal cord and nerve roots, (b) Resolving instability that is performed either by fusion surgery or mobility preserving stabilization surgeries, (c) Deformity correction.

Aims of minimally invasive spine surgery are principally the same. However, minimally invasive surgeries technically cause less or no damage in surrounding tissues.

Historical Perspectives
Mixter and Barr (20) have first established the relationship between disc herniation and sciatica in 1934 (20). Yasargil (36) and Caspar (4) have pioneered the minimally invasive lumbar disc surgery by using surgical microscope and developing microinstruments in the 1970’s. Hijikata has performed the first percutaneous discectomy in 1975. Kambin (17) has first used an arthroscope for discectomy in 1983. Foley and Smith (9,10) have developed a tube to perform interlaminar approaches for lumbar discectomy in 1997.

According to the techniques used, the types of minimally invasive approaches may be classified in three branches: (1) Image-guided percutaneous techniques, (2) Endoscopic techniques, (3) Mini-open surgeries

In this paper we will try to classify them according to the general surgical indications:

1- MIS in Lumbar Disc Herniation
Progress of the technique has started with chemonucleolysis in the 1970’s, and continued with percutaneous suction nucleotomies in the 1980’s and endoscopic discectomy and decompression in the 1990’s.

Kambin’s arthroscopic discectomy (17) was a real pioneer by application of a transforaminal endoscopic discectomy. Current endoscopic discectomy techniques may be summarized as interlaminar (posterior) endoscopy, transforaminal (posterolateral) endoscopy, transdiscal (posterolateral or retroperitoneal).

Minimally invasive lumbar discectomy types are as follows:
1- Automatic percutaneous lumbar discectomy (APLD) has a historical significance and lost its popularity because of insufficient decompressions of the herniated discs.
2- Transforaminal endoscopic discectomy: It is also called foraminal discectomy or “Arthroscopic discectomy” using Kambin’s terminology (17).
3- Microendoscopic (MED) (9,10).

4- Microdiscectomy: This may be considered as a classical technique and many surgeons still consider microdiscectomy as a gold standard.

Transforaminal endoscopic discectomy needs a detailed knowledge of regional anatomy, special instrument sets and familiarity to endoscope usage. In experienced hands, it may even be applied in recurrent disc herniations (14).

**Shortcomings:** Midline herniations cannot be removed by transforaminal endoscopic discectomy. Foraminal herniations and some paramedian herniations may be good candidates of this approach. In general, 20% of all disc herniations can be covered with transforaminal endoscopy. In experienced hands, it was reported to be up to 40-60%. However, interlaminar techniques can cover 80% of all disc herniations. Besides, the L5-S1 disc level cannot be operated with transforaminal techniques.

Although an endoscopic discectomy is mainly done through Kambin's triangle from the lateral position under local or general anesthesia, recently the application of endoscopy through an interlaminar approach have been developed. Foley and Smith (9,19) have pioneered a tube-guided approach (14-16 mm tubes) and called the technique “Micro Endoscopic Discectomy” (MED). It is mainly an interlaminar approach and both endoscopy and a microscope may be used for viewing the area.

Advantages are less muscle dissection and smaller incision. It may also be applied to far lateral lumbar disc herniations, and to posterior approach to cervical disc herniations. Besides, a unilateral approach and bilateral decompression can be used for spinal canal stenosis.

Khoo and Fessler (18) reported the results in the first 25 patients and compared with a second group of 25 patients treated with open decompressive laminectomy. They found the results were the same in both groups (18).

2- MIS in Cervical Disc Herniation

There are few centers performing anterior cervical discectomy using an endoscopic setup and under local anesthesia (34). However, it has not been widely accepted. Posterior microforaminotomy can be performed using a tube either endoscopically or using a microscope (37).

Tan et al (30) have reported a series of patients where anterior cervical discectomy and interbody fusion were performed by the endoscopic approach. The results were similar to the traditional approach.

3- MIS in Thoracic Disc Herniation

Endoscopic thoracic surgery has many indications. Thoracoscopic techniques may be used for removing benign intrathoracic paraspinal neurogenic tumors, central herniated thoracic discs, and for performing biopsies and thoracic sympathectomies (13). It needs 3 or 4 portals for entry and retraction of the lung.

Another MIS technique for thoracic disc herniations is thoracic microendoscopic discectomy (T-MED) an alternative to open costotransversectomy (16, 25). Isaacs et al (16) have applied technique using a cadaveric study Perez-Cruet et al (25) have used the technique in 7 patients with soft lateral or midline thoracic disc herniations and reported less blood loss and shorter hospital stays, no complications.

4- MIS in Vertebral Augmentation

Vertebroplasty and kyphoplasty are possibly the least invasive surgical approach for spinal disorders. It may be applied under local anesthesia and like a day surgery (8).

5- MIS in Thoracic and Lumbar Pedicle Screw Fixation

Percutaneous pedicle screw fixation has been proposed but could not gain much popularity. With this technique dissection and soft tissue retraction are not necessary, muscles are dilated, not cut. However, the technique needs cannulated screws, special rod inserters and extensive use of biplanar fluoroscopy (10).

Müller et al (21) have found this approach reduces surgical traumatization and destabilization of adjacent motion segments.

**Shortcomings:** If we look at the incision lines for the transcutaneous pedicle screw fixations, we can count the total incision lines are similar to open surgery. However, muscle injury is somewhat less than open surgery.

One important disadvantage is the large doses of radiation for the surgeon during transcutaneous pedicle screw fixations.

Besides, the surgery needs more sophisticated implant sets, cannulated screws, special rod inserters etc.

6- MIS for TLIF

Minimally invasive TLIF has been proposed by Foley et al (10). The inferior articular process is removed and the disc
space entered between upper and lower roots. The authors have reported excellent outcomes with low morbidity. Mummaneni and Rodts (22) have reported similar results and concluded that a mini-open technique minimizes paraspinal muscle trauma but has a moderate learning curve in patients with low-grade spondylolisthesis or degenerative disc disease. They have also reported intraoperative blood loss less than 200 ml.

The costs of MIS TLIF have also been compared with open TLIF (24) and there was some difference but not statistically significant.

Adogwa et al (1) have found that MIS-TLIF may shorten hospital stays, reduce postoperative narcotic use, and accelerate return to work, reducing both direct medical costs and indirect costs of lost work productivity associated with TLIF procedures.

7- MIS in Spine Tumors

Minimally invasive techniques can be utilized to remove extramedullary and intramedullary tumors (33). In experienced hands the technique is quite safe and effective with significant reduction in blood loss, and short hospitalization.

There are even some reports on MIS in metastatic disease and for transpedicular vertebrectomy (6). This type of approach is suggested for patients with comorbidities and contraindications for open surgery.

8- MIS in Anterior Spinal Pathologies

AxialIF approach has been proposed for L5-S1 interbody fusion. Although it is an innovative and a least invasive approach for lumbosacral area, since the fusions rates are not so high and it may require additional posterior stabilization, the initial popularity has decreased.

9- MIS in Other Spinal Pathologies

MIS has also been proposed in spinal cord untethering (Tredway 2007). The surgeons have claimed that MIS techniques may also provide the added advantage of reduced scar formation and risk of retethering (32).

Endoscopically assisted transoral-transpharyngeal approach can be used in craniovertebral junction (11). Odontoid resection can also be performed by an endoscopic transnasal transclival approach (35). This technique has significant advantages by avoiding morbid complications of transoral odontoid resection such as prolonged intubation, excessive tongue retraction, and the need for palatal incision causing swallowing difficulties. Anterior odontoid screw fixation may also be done using MIS techniques (7).

Thoracic anterior endoscopic release and fusion have also been used in scoliosis (19).

Complications Related to MIS

In general, MIS have similar complications as with open surgeries. However, there are two points that should be stressed. First, complication rates may be higher during learning curve (15). Second, there are some complications related to MIS techniques. Some examples to MIS related complications are spinal ganglion injury during lumbar transforaminal endoscopic discectomy, lumbar plexus injury during XLIF approach (25).

Although these procedures are minimally invasive, they carry similar risks to open procedures. Especially dural tears may occur more often during learning phase and handling them may need conversion to open surgeries. In a report of Ruban et al (27) the incidence of unintended durotomy was found in 53 (9.4%) of 563 patients. They, however, report that dural tears in minimally invasive spine surgeries were associated with fewer complications than previously reported for open spinal surgery. Early mobilization is possible and no incidence of postoperative cutaneous CSF fistula or other complications have occurred.

However, there are some other reports telling higher incidence of dural tears (31).

In a randomized controlled trial comparing incidence of dural tears in microendoscopic, microscopic, and open discectomy in 240 patients, dural tears, root injuries, and recurrent herniations were significantly more common in microendoscopic group. They have concluded that severe complications are more likely and costs higher with microendoscopy.

Before being a master of MIS techniques, additional training including fellowship training, cadaveric workshops, and animal lab studies are necessary (26).

Advantages of Minimally Invasive Spinal Surgeries

Less muscle damage is possibly the main advantage of MIS that results in less postoperative pain and discomfort. There are numerous studies comparing muscle damage in MIS and open surgeries. Fan et al (8) have examined the multifidus atrophy in MR images has been found to be less
in the minimally invasive surgery that was also correlated with postoperative creatinine kinase levels and VAS scores.

Stevens et al (29) have examined the maximum intramuscular pressure generated by minimally invasive and standard open retractors. They have found that the peak intramuscular pressure generated by the minimally invasive retractor was significantly less than with the open retractor.

Decreased blood loss and infection rate are the other advantages (23). O’Toole et al (23) have retrospectively reviewed 1338 minimally invasive spinal surgeries in 1274 patients and looked at infectious complications. Simple decompressive procedures comprised 78%, instrumented arthrodeses 20%, and minimally invasive intradural procedures 2% of the collected cases. The procedural rate of spinal infections was total 3 cases (0.10%) for simple decompression, and 0.74% for minimally invasive fusion/fixation. They concluded that postoperative wound infections decreased 10-fold compared with other open spinal surgery published in the literature.

In another study comparing MIS TLIF with open TLIF in SRS database, Smith et al (28) have found that the infection rate with open TLIF was twice as high (2.9%) than MIS TLIF (1.3%).

Many studies have reported that a shorter hospital stay and decreased post-operative pain are expected with minimally invasive spine surgeries. Although some reports declare improved outcome results, this is not the case in most studies and literature does not support better outcomes.

Besides, Cole and Jackson (5) have reported that lumbar discectomy may be easier than conventional techniques in obese patients.

### Advantages and disadvantages of minimally invasive spine surgeries

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<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>Less muscle damage</td>
<td>Long learning curve</td>
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<tr>
<td>Decreased Blood Loss</td>
<td>Different anatomy</td>
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<td>Decreased Infection Rate</td>
<td>Special and expensive instruments and equipment</td>
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<tr>
<td>Decreased Post-Operative Pain</td>
<td>Limited tactile feedback and biplanar imaging (lack of 3-D views)</td>
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<td>Shorter Hospital Stay</td>
<td>Manual dexterity needed to manipulate instruments through small working channels</td>
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<td>Better cosmesis</td>
<td>Complications hard to treat</td>
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<td>Cost-effectiveness</td>
<td>Graft substitutes and enhancers may be necessary</td>
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<td>Easy surgery for obese patients</td>
<td>More radiation to surgeon and patient</td>
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### CONCLUSIONS

Indications of minimally invasive spinal surgeries are same with conventional surgeries.

The main advantages of minimally invasive spinal surgeries are (1) less or no damage to surrounding tissues, especially muscles, (2) short hospital stay and quick return-to work, (3) less postoperative pain, (4) better cosmetic results.

Disadvantages of minimally invasive surgeries are long learning curve, need for special instruments and complications related to technique.

The demand for minimally invasive spinal surgeries mainly comes from patients rather than surgeons. Although there is an increasing trend to perform most spine surgeries with minimally invasive techniques, the concept of “being maximally effective” should not be forgotten.

### REFERENCES


