Endoscopic minimally invasive transforaminal interbody fusion without general anesthesia: initial clinical experience with 1-year follow-up

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OBJECTIVE One of the principal goals of minimally invasive surgery has been to speed postoperative recovery. In this case series, the authors used an endoscopic technique for interbody fusion combined with percutaneous screw fixation to obviate the need for general anesthesia.

METHODS The first 10 consecutive patients treated with a minimum of 1 year’s follow-up were included in this series. The patients were all treated using endoscopic access through Kambin’s triangle to allow for neural decompression, discectomy, endplate preparation, and interbody fusion. This was followed by percutaneous pedicle screw and connecting rod placement using liposomal bupivacaine for long-acting analgesia. No narcotics or regional anesthetics were used during surgery.

RESULTS All patients underwent the procedure successfully without conversion to open surgery. The patients’ average age was 62.2 ± 9.0 years (range 52–78 years). All patients had severe disc height collapse, and 60% had a Grade I spondylolisthesis. The mean operative time was 113.5 ± 6.3 minutes (range 105–120 minutes), and blood loss was 65 ± 38 ml (range 30–190 ml). The mean length of hospital stay was 1.4 ± 1.3 nights. There were no intraoperative or postoperative complications. Comparison of preoperative and final clinical metrics demonstrated that the Oswestry Disability Index improved from 42 ± 11.8 to 13.3 ± 15.1; the SF-36 Physical Component Summary improved from 47.6 ± 3.8 to 49.7 ± 5.4; the SF-36 Mental Component Summary decreased from 47 ± 3.9 to 46.7 ± 3.4; and the EQ-5D improved from 10.7 ± 9.5 to 14.2 ± 1.8. There were no cases of nonunion identified radiographically on follow-up imaging.

CONCLUSIONS Endoscopic fusion under conscious sedation may represent a feasible alternative to traditional lumbar spine fusion in select patients. Larger clinical series are necessary to validate that clinical improvements are sustained and that arthrodesis rates are successful when compared with open surgery. This initial experience demonstrates the possible utility of this procedure.

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Spinal fusion in the properly selected patient has been well demonstrated to be effective in improving pain, function, and quality of life.10 However, many patients resist having a surgical fusion due to concerns over the morbidity of the procedure. Typically, open lumbar fusion surgery has been perceived as an intervention that carries significant pain, recovery time, and risk. Although most patients eventually recover well from such an intervention, the economic, psychological, and social costs of the postoperative period should not be underestimated.

Over the past decade, minimally invasive transforaminal lumbar interbody fusion (MIS TLIF) has become very popular for treating a variety of lumbar spinal disorders. The use of tubular dilators for decompression in concert with specialized interbody cages and percutaneous screws has led to viable minimally invasive alternatives to open surgery.
fusion surgery. However, MIS TLIF techniques still require an open incision of the musculature for tube placement. Thus, MIS TLIF represents an incremental but not revolutionary advancement over the existing open surgical methods.

The search for newer surgical methods to achieve the goals of minimally invasive surgery (MIS), including reduced blood loss, less soft tissue destruction, shorter hospital stays, less pain, and quicker recovery, thus continues. To this end we have recently begun to explore a multimodal approach to achieve improved recovery rates after lumbar interbody fusion surgery. This approach utilizes a combination of endoscopic visualization, expandable cages, percutaneous fixation, osteobiologics, and long-acting local anesthetics so that surgery can be performed without general anesthesia. This report examines our early experience using this technique to improve early recovery after surgery for spinal fusion.

Methods

This study is a retrospective analysis of a consecutive case series involving patients treated with endoscopic single-level MIS TLIF at a single institution. A total of 10 patients undergoing endoscopic MIS TLIF with 1-year follow-up were included. The patients were evaluated for baseline demographic characteristics, pathology being treated, surgical level, blood loss, length of hospital stay, and perioperative complications. Clinical metrics included the Oswestry Disability Index (ODI), 36-Item Short Form Health Survey (SF-36), and EQ-5D. Preoperative and 1-year metrics were analyzed.

Anesthetic Technique

Because the patient is not intubated and is undergoing surgery in the prone position, careful monitoring by the anesthesiologist is critical during the operation. Supplemental oxygen is given via a face mask or nasal cannula. The patient is then sedated using a continuous infusion of propofol (Diprivan) and ketamine. This infusion is titrated to keep the patient under light to moderate sedation. No narcotic medications are given and no spinal, epidural, or regional analgesia is used.

This method has the advantage of offering the surgeon live feedback if there is any contact or tension with the neural structures as the patient will respond to this painful stimulus. In addition, this method reduces the side effects of general anesthesia, such as nausea, dysphagia, and memory loss.

Surgical Technique

Patients were positioned prone on a Jackson Table. The procedure was begun by accessing Kambin’s triangle on the side and level of the pathology using a spinal needle. Successive dilation of the access site was then performed to allow for introduction of an 8-mm–diameter working channel (joimax). The traversing and exiting nerve roots were visualized with the working channel endoscope and decompressed directly by removing any compressive bony or cartilaginous tissues using bipolar electrocautery, pituitary rongeurs, curettes, microosteotomes, and automated drills (Fig. 1). The disc space was then cleared and the endplates exposed using pituitary rongeurs, curettes, and stainless steel brushes to prepare the site for fusion.

After fusion site preparation, 2.1 mg of recombinant human bone morphogenetic protein–2 (rhBMP-2, Infuse, Medtronic Sofamor Danek) was placed into the anterior disc space followed by placement of a 22- or 25-mm OptiMesh (Spineology) cage. The mesh expandable cage was filled with pre-machined allograft matrix to increase interbody height and reduce any spondylolisthesis (Fig. 2). The cage was then crimped shut. Percutaneous pedicle screws were then placed using an anterosuperior fluoroscopic technique with Jamshidi needles. These tracts were injected with 20 cc of bupivacaine (Exparel, diluted 1:2 to 40 ml total volume) under pressure into the posterior musculature divided evenly between the 4 screw insertion tracts. These needles then allowed safe insertion of a K-wire, which was used for guiding an awl and tap into position. Appropriately sized 6- or 7-mm-diameter pedicle screws were then inserted and bilateral connecting rods were passed subfascially. Following final tightening of the set screws, the rod and screw extenders were removed, and each of the 5 small incisions was closed with a figure-of-8 Monocryl suture. It should be noted that the use of Infuse, OptiMesh, and Exparel in this application is off label for the US FDA.

Results

The demographic and baseline characteristics of the 10 patients in each group are shown in Table 1. All patients underwent a single-level unilateral TLIF surgery successfully and without conversion to an open surgery. The average age was 62.2 ± 9.0 years (range 52–78 years). The male/female ratio was 7:3. All patients had severe disc height collapse and 60% had a Grade I spondylolisthesis. The mean operative time was 113.5 ± 6.3 minutes (range 105–120 minutes), and intraoperative blood loss was 65 ± 38 ml (range 30–190 ml). The mean length of hospital stay was 1.4 ± 1.3 nights. All patients were discharged on postoperative Day 1 except for 1 patient who had no family or social support and was kept hospitalized for these reasons.

Preoperative clinical outcome measures were compared with final follow-up at 1 year. Data were complete for 90% of patients. The ODI score improved from 42 ±
11.8 to 13.3 ± 15.1 (p = 0.0001), and this change was statistically significant. The SF-36 Physical Component Summary (PCS) improved from 47.6 ± 3.8 to 49.7 ± 5.4 (p = 0.174). The SF-36 Mental Component Summary (MCS) decreased from 47 ± 3.9 to 46.7 ± 3.4 (p = 0.423). The EQ-5D score improved from 10.7 ± 9.5 to 14.2 ± 1.6 (p < 0.0001).

Radiographic imaging included flexion-extension radiographs at 3, 6, and 12 months after surgery. All cases demonstrated radiopaque allograft in the intervertebral disc space consistent with solid arthrodesis, and there were no clinical or radiographic signs of nonunion, such as implant loosening or worsening axial pain. There were no cases with a perioperative complication (i.e., no deaths, medical complications, worsening neurological status, or revision surgeries).

**Discussion**

While rapid recovery following minimally invasive decompression surgery has been achieved, obtaining these results with fusion surgery has been more elusive. Several investigators have previously reported on their attempts to accelerate recovery after lumbar spinal fusion surgery utilizing a combination of minimally invasive techniques with a specific pain management protocol. Chin et al. had a series of 16 patients treated with open TLIF in the outpatient setting. In that study the ODI improved from 52.7

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**FIG. 2.** Representative case involving a patient with L4–5 Grade I spondylolisthesis. **A and B:** Fluoroscopic images showing initial dilator access to the intervertebral disc through Kambin's triangle. **C:** Fluoroscopic image showing disc removal using a drill following endoscopic decompression. **D:** Fluoroscopic image showing final endplate preparation with a stainless steel brush. **E and F:** Fluoroscopic images showing the final construct with expandable mesh cage and percutaneous pedicle screws. **G–I:** Postoperative axial CT images.
to 37.4, blood loss averaged 161 ml, and OR time was 125 minutes. The fusion rate was 87.5% as determined by radiographs and CT in select cases. Of note, patients in this series were carefully selected for living close to a hospital, availability and willingness of family to assist the patient with postoperative care, low BMI, low cardiac risk, and a favorable American Society of Anesthesiologists rating. Pain control for discharge was achieved using 30–60 mg of ketorolac, oral diazepam, and oral narcotics.2

In another study, Eckman et al.3 attempted to perform MIS TLIF in an outpatient setting by minimizing soft tissue destruction using only a unilateral soft tissue exposure. Pedicle screws and a rod were only placed on the side of the decompression. This preserved the integrity of the contralateral soft tissue envelope, and the authors were able to discharge 73% of their patients who had undergone 1- or 2-level MIS TLIF home without hospitalization. Their study of 808 patients found that older age was predictive of the need for hospitalization. Of note, the patient population was highly selected for the ability to undergo outpatient surgery.

Aggressive pain management has also been used to achieve outpatient lumbar fusion. Matheson described using epidural analgesia in lumbar fusion as early as 1960,8 and more recently in 1997 Kakiuchi and Abe reported on a series of 57 patients, showing that a single caudal epidural injection prior to surgery reduced pain and narcotic consumption.7 A randomized, blinded study by Boezaart et al. found that of 0.3 mg of intrathecal morphine safely reduced postoperative pain.1 Pain and narcotic consumption can also be reduced using a continuous infusion of local anesthetic using an indwelling intramuscular catheter.4

As can be seen by a review of the literature, much of the emphasis on speeding recovery after lumbar fusion surgery has been directed at making outpatient surgery possible. This trend has been largely due to increasing economic pressures to reduce the costs of surgery, including postoperative inpatient care. As these economic forces are unlikely to abate, there will likely be an increasing trend toward techniques that permit outpatient lumbar spinal fusion surgery.

### Rapid Clinical Improvement Following Awake Surgery

This series represents our efforts to use a combination of several techniques and technologies to achieve a more rapid and painless recovery after lumbar spinal fusion surgery. The use of endoscopy and percutaneous screws reduces the amount of soft tissue disruption to the extent that the intervention can be tolerated without general anesthesia. Expandable cages allow for efficient placement of an interbody device to allow for fusion through Kambin’s triangle. This also permits indirect neural decompression by restoring intervertebral height. Osteobiologics are necessary to promote fusion through such a small corridor. Use of conscious sedation reduces the side effects of general anesthesia, and it also allows for live neurological monitoring through patient feedback. Finally, liposomal bupivacaine provides prolonged local analgesia during the first 3 days after surgery, which is typically the most painful period. These component techniques have all been previously applied clinically with success, but it is their combination that makes this series unique.

In this case series we were able to demonstrate that with use of this multimodal method patients were able to be discharged rapidly from the hospital following single-level MIS TLIF surgery. The hospital stay was reduced substantially. In comparison with our previously published case series, this reflects a reduction of over 2 hospital days on average.12,13 The blood loss was also reduced substantially, primarily through the use of working channel endoscopy to perform the neural decompression and discectomy. Most importantly, the clinical results were notable, with a 28.7-point reduction in ODI and a cumulative improvement of 3.5 points on the EQ-5D. These results using established spinal outcome measures clearly exceed the minimum clinically important difference (MCID) for lumbar spinal fusion surgery.9

### Study Limitations

This study has significant limitations. First, as an initial report the sample size is too small to draw definitive conclusions as to efficacy and safety. Ultimately, this procedure must be able to produce an arthrodesis rate equivalent...
to open lumbar fusion to be deemed acceptable. Definitive confirmation of fusion using 3D imaging (CT) would also be beneficial for demonstrating efficacy. Furthermore, the generalizability of the procedure is important to ensure that it can be applied in diverse institutions, settings, and surgeons’ hands.

Second, the procedure can only be applied in select cases. For example, patients with severe bilateral and central canal stenosis may not be candidates, as endoscopic decompression can be limiting and indirect decompression can only achieve so much central canal enlargement. Osteoporotic bone can also be an impediment as indirect decompression relies upon lifting the intervertebral space through pressure on the vertebral endplates from the expandable cage.

Third, this technique requires several off-label applications. Off-label use is common in general American medical practice. However, in spine surgery it has recently come under scrutiny for a variety of reasons. This technique uses expandable mesh cages, rhBMP-2, and liposomal long-acting local anesthetics off label.

Finally, many anesthesiologists will be reluctant to position a patient prone without intubation. The consequences for airway management are obvious. To overcome these problems, the procedure must be performed expeditiously, and we have a general cutoff of 120 minutes for the operation. In addition, because the incisions are small, they can be quickly closed allowing patients to be rapidly returned to a supine position if necessary; however, we have not yet encountered the need for this in clinical practice.

Conclusions

New techniques to reduce pain and improve recovery after spinal fusion are needed. Here we describe our initial experience with a multimodal approach toward achieving an “ultra-MIS surgical technique.” Ultimately, continued technological and technique advances will allow for even more effective methods to improve patient outcomes. Nevertheless, given such positive initial clinical and radiographic results we will examine the long-term results in more diverse and larger patient populations.

References


Disclosures

Dr. Wang reports a consultant relationship with DePuy-Synthes Spine Inc., Aesculap Spine, K2M, and joimax USA and receipt of patent royalty payments from DePuy-Synthes Spine, Inc.

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