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Video Article

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Innovative Nerve Root Protection in Full-Endoscopic Facet-Resecting Lumbar Interbody Fusion: Controlled Cage Glider Rotation Using the GUARD (Glider Used As a Rotary Device) Technique

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This video presents a case of L4–5 unstable spondylolisthesis treated with full-endoscopic transforaminal lumbar interbody fusion (Endo-TLIF), emphasizing the GUARD (Glider Used as a Rotary Device) technique for nerve root protection. This innovative approach involves controlled rotation of the cage glider before cage insertion to minimize the risk of nerve root injury, a significant complication in Endo-TLIF procedures. The GUARD technique, validated in previous cadaveric studies, provides enhanced safety during cage insertion by protecting the nerve root. A 48-year-old woman with a 3-year history of progressive low back pain and bilateral lower extremity radiculopathy (right-sided predominance) was diagnosed with L4–5 unstable spondylolisthesis and spinal stenosis. After failure of conservative management, she underwent uniportal full-endoscopic facet-resecting transforaminal lumbar interbody fusion using the GUARD technique. Postoperatively, the patient experienced significant symptomatic improvement and resolution of radiculopathy, without any intraoperative nerve root injury or postoperative neurological deficits. This case demonstrates the effectiveness of the GUARD technique in reducing neurological complications and improving patient outcomes.

Keywords: Endoscopes, Spinal fusion, Minimally invasive surgical procedures, Spinal nerve root injury, Nerve root protection, Surgical technique

INTRODUCTION

Endoscopic transforaminal lumbar interbody fusion (Endo-TLIF) has emerged as a minimally invasive alternative to traditional open fusion surgery, providing significant advantages such as reduced soft tissue disruption, faster postoperative recovery, and diminished postoperative pain.[1] Despite these benefits, a significant challenge in Endo-TLIF is the risk of nerve root injury, particularly during the critical step of cage insertion.[2] Given the proximity of the exiting and traversing nerve roots to the operative corridor,[3,4] ensuring their protection is critical to avoid postoperative complications.

To address this issue, the glider used as a rotary device (GUARD) technique was developed as an innovative approach aimed at enhancing nerve root protection during cage placement in uniportal Endo-TLIF. This technique involves the controlled rotation of the cage glider tip, allowing for safe insertion of the interbody cage through the working portal while minimizing the risk of impinging or compressing the nerve root.[3] The theoretical foundation of this technique is based on a previous cadaveric study, which demonstrated the close proximity of the traversing nerve root to the cage entry point during full-endoscopic facet-resecting transforaminal lumbar interbody fusion (FE fr-TLIF).[3] Improper insertion of the cage glider was shown to cause direct trauma to the nerve root, potentially leading to postoperative neurapraxia.[5] Adhering to the standard steps of the GUARD technique significantly reduces the risk of nerve root injury.

In this manuscript, we present a case report along with an accompanying surgical video that details the application of FE fr-TLIF using the GUARD technique. This report highlights the surgical techniques and outcomes, demonstrating the role of the GUARD technique in enabling safe nerve root preservation and optimizing surgical outcomes in Endo-TLIF.

CASE REPORT

1. Medical History, Clinical Presentation, and Examination Results

This case involves a 48-year-old female with no significant past medical history, who presented with a three-year history

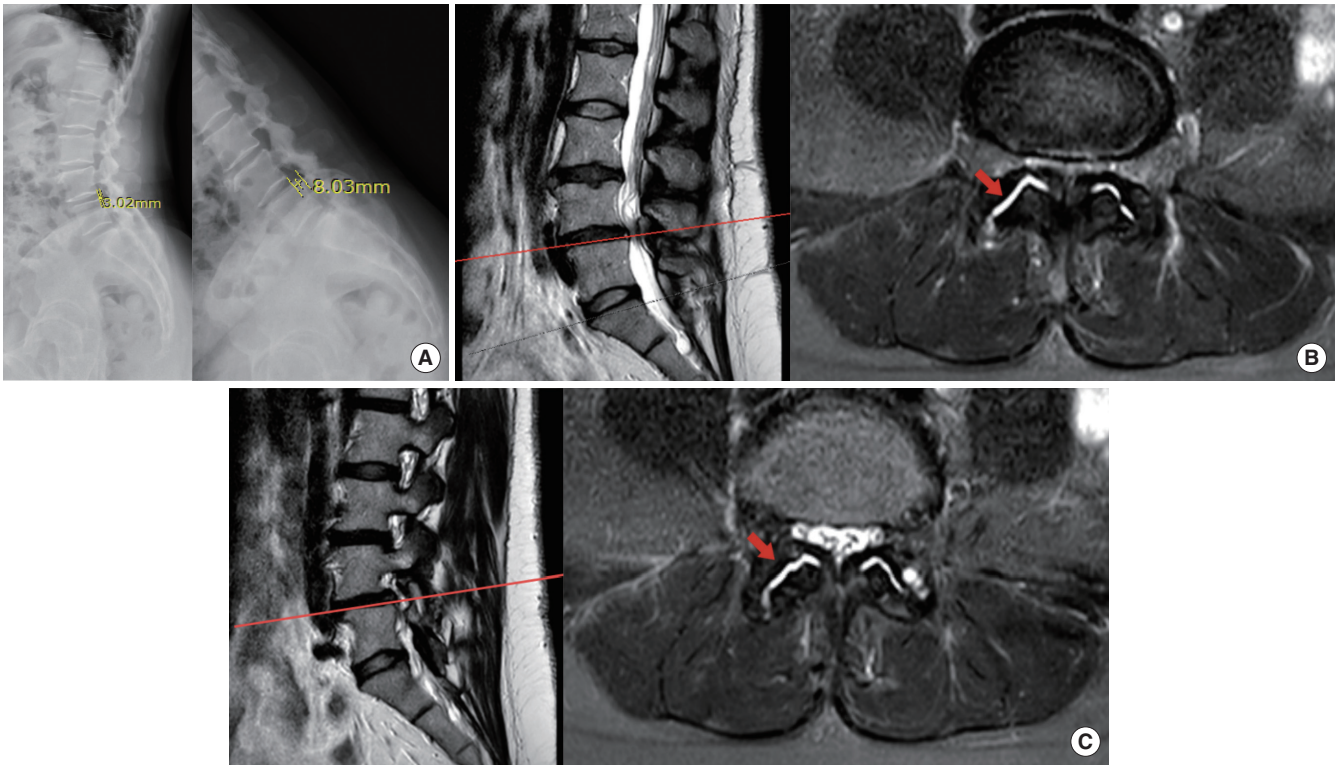

Fig. 1. Imaging of the patient. (A) Flexion/extension lumbar radiographs show L4–5 spondylolisthesis with instability, characterized by dynamic translation 5.01 mm. (B) Axial and sagittal T2-weighted magnetic resonance imaging (MRI) images at L4–5 demonstrate bilateral L4–5 facet effusion with spinal canal stenosis. The facet fluid sign is indicated by a red arrow. (C) Axial and sagittal T2-weighted MRI images of the right intervertebral foramen show right L4–5 foraminal stenosis. The facet fluid sign is indicated by a red arrow.

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of progressively worsening lower back pain and bilateral lower limb numbness, predominantly affecting the right side. The paresthesia radiated along the L5 dermatome, extending from the lateral thigh to the leg and dorsum of the foot, accompanied by intermittent lancinating pain and muscle weakness. The back pain is prominent. The symptoms were aggravated by prolonged standing and partially alleviated by rest. Thus, the patient presented to our orthopedic outpatient clinic for further evaluation. Physical examination showed mild weakness of ankle dorsiflexion and great toe extension. Bilateral leg pain was precipitated during provocative walking test. Radiographic imaging, including x-rays, revealed L4–5 spondylolisthesis with borderline dynamic translation 5.01 mm (Fig. 1A), while magnetic resonance imaging demonstrated L4–5 unstable spondylolisthesis with spinal canal stenosis, marked thecal sac indentation and bilateral facet fluid sign, indicating lumbar instability (Fig. 1B and C). Despite conservative treatments, her symptoms worsened. Recently, she reported neurological claudication, limiting her walking less than 200 m. Given the failure of conservative management and progression of neurological symptoms, surgical inter-

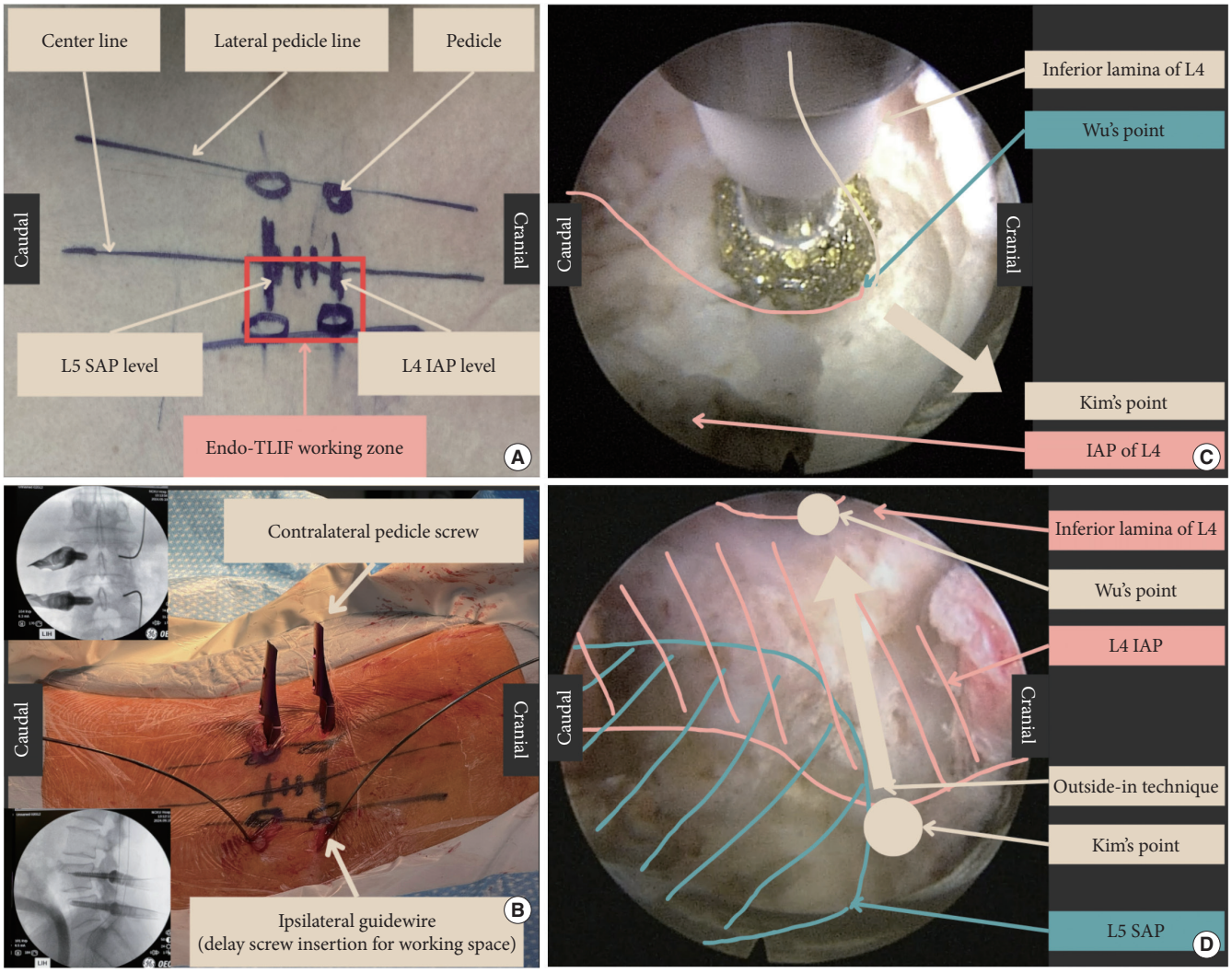

Fig. 2. Surgical steps in FE fr-TLIF. (A) Intraoperative view showing skin markings over the central spinous line, lateral pedicle line, bilateral L4–5 pedicles, L4 IAP, L5 SAP, and the working portal for Endo-TLIF. (B) Operative photo and fluoroscopic images show L4–5 contralateral pedicle screw instrumentation and ipsilateral guidewire insertion. (C) Endoscopic view of the inside-out resection technique, beginning at Wu's point, the junction of the L4 inferior lamina and L4 IAP, extending toward Kim's point. (D) Endoscopic view demonstrating the outside-in technique, proceeding from Kim's point, the superolateral confluence of the L4 IAP and L5 SAP, back toward Wu's point. TLIF, transforaminal lumbar interbody fusion; FE fr-TLIF, full-endoscopic facet-resecting TLIF; IAP, inferior articular process; SAP, superior articular process; Endo-TLIF, full-endoscopic transforaminal lumbar interbody fusion.

vention was indicated. The patient consented to undergo FE fr-TLIF using the newly developed GUARD technique. The procedure was performed by an experienced spine surgeon at a tertiary medical center, utilizing the full-endoscopic spine system (VANTAGE BIOTECH CO., LTD., Taoyuan, Taiwan).

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of National Cheng Kung University Hospital (A-ER-112-185).

2. Surgical Techniques of FE Fr-TLIF With GUARD Technique

Under general anesthesia, the patient was positioned prone on a Wilson frame. Fluoroscopic guidance was used to identify the central line of spinous process, bilateral L4–5 pedicles, the L4–5 disc space, and key anatomical landmarks, including the L4 inferior articular process (IAP) and L5 superior articular process (SAP), which were marked. Small horizontal skin incisions were made over the bilateral L4–5 pedicles. Following Jamshidi needle insertion, contralateral pedicle screw placement was completed, while ipsilateral pedicle screw placement was deferred to preserve a working corridor for the FE fr-TLIF. The incision over the ipsilateral superior pedicle was used as endoscope working portal.

Upon introducing the endoscope, the superior and inferior spinolaminar junctions were visualized. Soft tissue dissection was carried out, identifying critical landmarks, including Wu's point—the junction of the L4 inferior lamina and IAP—and Kim's point, the superolateral confluence of the L4 IAP and L5 SAP. The L4 IAP was resected using a hybrid inside-out and outside-in technique. The resection commenced with the inside-out approach from Wu's point to Kim's point, followed by the outside-in approach from Kim's point back to Wu's point, thereby completing the facetectomy (Fig. 2). The resected bone fragments were harvested as autografts for interbody fusion. After resecting the L4 IAP, the base of the L5 SAP was exposed and removed, providing additional autologous bone for grafting.

The L4–5 intervertebral disc was identified, followed by a precise annulotomy. Fluoroscopic guidance was employed to confirm the exact location of the annulotomy site, ensuring accurate placement of the interbody cage. A meticulous discectomy and thorough endplate preparation were subsequently performed, with particular attention to protecting the traversing nerve root and avoiding injury to the thecal sac (Fig. 3).

For advanced endplate preparation, the endoscope was exchanged for a shaver within the 2-tip cage glider. The 2-tip cage glider in FE fr-TLIF offers enhanced protection for both the traversing and exiting nerve roots. The GUARD technique was utilized to ensure optimal nerve root protection during glider

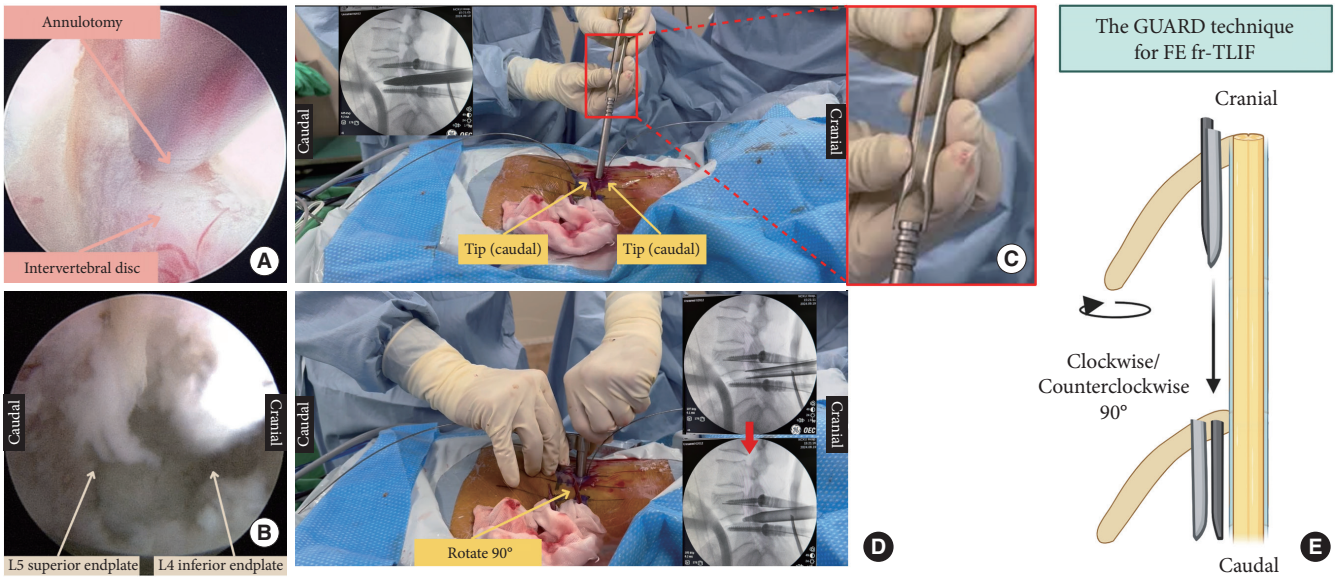

Fig. 3. Surgical stages of the FE fr-TLIF. (A) Under endoscopic view, annulotomy was performed. (B) L4–5 discectomy with subsequent endplate preparation. (C) 1st step of the GUARD technique: insertion of the 2-tip cage glider in a cranial-caudal orientation, confirmed by a lateral lumbar radiograph. (D) 2nd step of the GUARD technique: rotation of the 2-tip cage glider by 90° into a medial-lateral orientation, as demonstrated on the lateral lumbar radiograph showing the glider tips rotated accordingly. (E) The illustration summarizes the GUARD technique. FE fr-TLIF, full-endoscopic facet-resecting transforaminal lumbar interbody fusion; GUARD, glider used as a rotary device.

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insertion. After the endoscope was removed, a cannulated obturator was introduced via the guidewire, which was then removed. The first step of the GUARD technique involved inserting the 2-tip cage glider in a cranial-caudal orientation with the tip into the disc level. The second step required rotating the glider 90° into a medial-lateral orientation, providing additional protection for the nerve roots.[3] The rotation of cage glider could be visualized under endoscope based on surgeon's preference as demonstration in educational video.

Endplate preparation was completed using a shaver through the glider, with cage sizing determined by tactile feedback during the shaving or by using a cage trial. Endoscopic evaluation was subsequently performed to confirm the adequacy of the endplate preparation. Autologous bone graft, harvested from the L4 IAP and L5 SAP, along with synthetic bone graft and bone marrow aspirate, was then packed into the intervertebral disc space through the endoscopic working portal to facilitate interbody fusion. Finally, the GUARD technique was reapplied during the insertion of the 2-tip cage glider, and the interbody cage was inserted under fluoroscopic guidance through the glider while maintaining the medial-lateral orientation to protect the nerve roots. After removing the cage glider, the endoscope was reintroduced to confirm the final cage positioning and complete the decompression. The comprehensive surgical procedure is

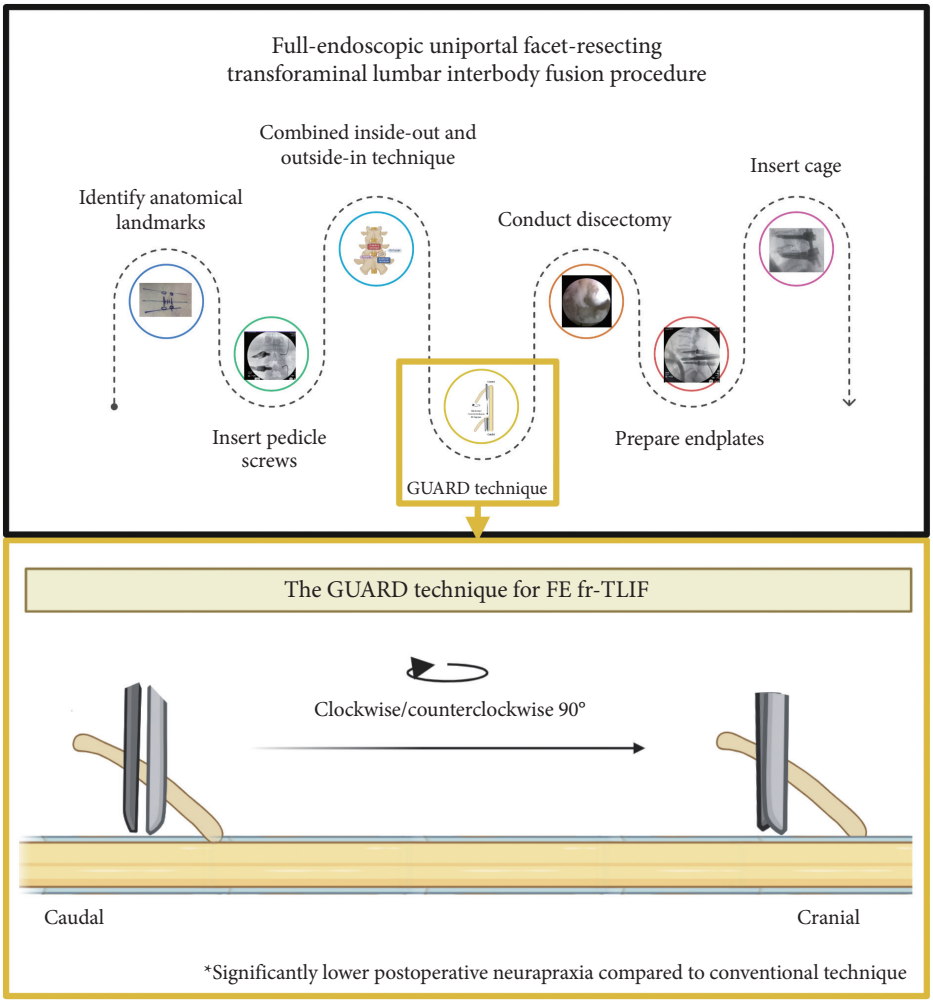

Fig. 4. Surgical algorithm for FE fr-TLIF utilizing the GUARD technique. The full-endoscopic uniportal facet-resecting transforaminal lumbar interbody fusion (TLIF) procedure consists of the following steps: identification of anatomical landmarks, contralateral pedicle screw placement, application of a combined inside-out and outside-in IAP resection technique, annulotomy, utilization of the GUARD technique for nerve root protection, discectomy, endplate preparation, and cage insertion. The GUARD technique involves: (1) 1st step: insertion of the two-tip cage glider in a cranial-caudal orientation, and (2) 2nd step: rotation of the glider by 90° to achieve a medial-lateral orientation. FE fr-TLIF, full-endoscopic facet-resecting transforaminal lumbar interbody fusion; GUARD, glider used as a rotary device; IAP, inferior articular process.

demonstrated in Fig. 4.

Following the FE fr-TLIF procedure using the GUARD technique, the patient demonstrated an uncomplicated postoperative recovery. There was a notable improvement in bilateral lower limb strength, along with a significant reduction in tingling sensations. No postoperative complications, including neurapraxia, were observed.

DISCUSSION

Endoscopic lumbar interbody fusion has garnered attention as a minimally invasive alternative to traditional open lumbar fusion, offering several advantages, including reduced soft tissue disruption, faster postoperative recovery, and diminished postoperative pain.[1,5-7] However, a major technical challenge in Endo-TLIF remains the risk of nerve root injury, particularly during the critical step of cage insertion.[2,8-10] Currently, 2 common approaches for Endo-TLIF are widely adopted: full-endoscopic facet-resecting TLIF and facet-sparing TLIF. The facet-resecting approach involves a complete facetectomy, resembling the interlaminar approach, while the facet-sparing approach is performed within Kambin's triangle, similar to the conventional transforaminal approach.

This manuscript and the accompanying educational video underscore the application of FE fr-TLIF using the GUARD technique for managing lumbar spondylolisthesis. The video emphasizes the crucial role of controlled insertion and precise rotation of the 2-tip cage glider, which minimizes the risk of nerve root irritation. The 2-tip cage glider provides protection for both the traversing and exiting nerve roots, addressing the close proximity of the traversing root and the inclination angle required during cage insertion, which can potentially irritate the exiting nerve root, as highlighted in previous literature.[2,3] By avoiding direct impingement and undue tension on neural elements—especially in cases of severe spinal stenosis with compressed nerve roots—this technique enhances patient safety during cage placement.[3] Clinical evidence supports that the GUARD technique significantly lowers the incidence of postoperative neurapraxia, contributing to improved neurological outcomes.

From an educational standpoint, the accompanying video serves as an invaluable step-by-step visual guide to the GUARD technique, illustrating critical intraoperative maneuvers designed to mitigate neurological complications during cage insertion. The real-time presentation of the entire procedure—including pedicle screw placement, the hybrid inside-out/outside-in technique, endplate preparation, and cage insertion using the GUARD technique—offers practical insights for surgeons.[11-13] The demonstrated success in reducing postoperative neurapraxia underscores the clinical significance of this technique and supports its wider application.

When comparing FE fr-TLIF with the GUARD technique to conventional FE fr-TLIF, a significant reduction in short-term radicular leg pain and the incidence of postoperative neurapraxia in the GUARD group was detected by our team. Radiographic outcomes, such as disc height restoration, spinal lordosis, endplate integrity, and fusion rates, were comparable between the 2 groups, showing no significant differences. While specific studies evaluating surgical blood loss or operative time remain limited, it is reasonable to infer that these metrics are likely similar, given that the fundamental procedural steps are unchanged.

One of the key strengths of the GUARD technique is its simplicity. The selection and insertion of the specified cage glider are straightforward, allowing for easy integration into standard surgical workflows. This accessibility makes the approach suitable for a wide range of spine surgeons. Its ease of use, combined with its proven effectiveness in protecting neural structures, supports its potential for widespread adoption. By minimizing technical complexity while enhancing neural protection, the GUARD technique represents a valuable advancement in endoscopic lumbar fusion procedures.

Based on previous studies, Kim et al.[13] recommended the use of a two-tip Harrison glider during FE fr-TLIF, while Sairyo et al.[14] suggested a one-tip glider for this procedure. However, studies detailing the selection and insertion techniques for cage gliders in both FE fr-TLIF and uniportal full-endoscopic facet-resecting transforaminal lumbar interbody fusion (FE fs-TLIF) remain limited. Our cadaveric study findings indicate that the 2-tip glider is more suitable for FE fr-TLIF, while the one-tip glider aligns well with FE fs-TLIF, each with corresponding insertion techniques. By implementing the technique modifications and careful device selection, the incidence of postoperative neuropraxia can be reduced. This technical note aims to provide a foundational surgical concept for the use of cage gliders in endo-fusion surgery. The designs and technique modifications can be adapted according to the surgeon's preference.

In conclusion, the GUARD technique represents a significant enhancement to the repertoire of spine surgeons performing full-endoscopic lumbar fusion surgery. Its integration into routine practice improves surgical safety and clinical outcomes, particularly by minimizing the risk of postoperative neurapraxia. While short-term outcomes have been promising, further

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research is warranted to validate the long-term efficacy of this technique across broader patient populations.

The GUARD technique provides an innovative and effective method for nerve root protection during FE fr-TLIF. By rotating the tip of the cage glider, surgeons can prevent nerve impingement during cage insertion, reducing the risk of postoperative neurological complications.

NOTES

Video File: The video file for this article is available at https://doi.org/10.14245/ns.2449126.563.

Conflict of Interest: The authors have nothing to disclose.

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