AOSpine Consensus Paper on Nomenclature for Working-Channel Endoscopic Spinal Procedures

Christoph P. Hofstetter, MD, PhD¹, Yong Ahn, MD, PhD², Gun Choi, MD, PhD³, J. N. A. Gibson, DSc, FRCSEd⁴, S. Ruetten, MD⁵, Yue Zhou, MD, PhD⁶, Zhen Zhou Li, MD, PhD⁷, Christoph J. Siepe, MD⁸, Ralf Wagner, MD⁹, Jun-Ho Lee, MD, PhD¹⁰, Koichi Sairyo, MD, PhD¹¹, Kyung Chul Choi, MD, PhD¹², Chien-Min Chen, MD¹³, A. E. Telfeian, MD, PhD¹⁴, Xifeng Zhang, MD, PhD¹⁵, Arun Banhot, MD¹⁶, Pramod V. Lokhande, MS, DNB, MNAMS¹⁷, N. Prada, MD¹⁸, Jian Shen, MD¹⁹, F. C. Cortinas, MD²⁰, N. P. Brooks, MD²¹, Peter Van Daele, MD²², Vit Kotheeranurak, MD²³, Saqib Hasan, MD²⁴, Gun Keorochana, MD²⁴, Mohammed Assous, MD²⁵, Roger Härtl, MD, PhD²⁶, and Jin-Sung Kim, MD, PhD²⁷

Abstract

Study Design: International consensus paper on a unified nomenclature for full-endoscopic spine surgery.

Objectives: Minimally invasive endoscopic spinal procedures have undergone rapid development during the past decade. Evolution of working-channel endoscopes and surgical instruments as well as innovation in surgical techniques have expanded the types of spinal pathology that can be addressed. However, there is in the literature a heterogeneous nomenclature defining approach corridors and procedures, and this lack of common language has hampered communication between endoscopic spine surgeons, patients, hospitals, and insurance providers.

Methods: The current report summarizes the nomenclature reported for working-channel endoscopic procedures that address cervical, thoracic, and lumbar spinal pathology.

Results: We propose a uniform system that defines the working-channel endoscope (full-endoscopic), approach corridor (anterior, posterior, interlaminar, transforaminal), spinal segment (cervical, thoracic, lumbar), and procedure performed.

¹ University of Washington, Seattle, WA, USA
² Gachon University, Incheon, South Korea
³ Wooridul Spine Hospital, Pohang, South Korea
⁴ Spire Murrayfield Hospital, Edinburgh, UK
⁵ Center for Spine Surgery and Pain Therapy, Center for Orthopedics and Traumatology of the St. Elisabeth Group-Catholic Hospital Rhein-Ruhr, St. Anna Hospital Herne/Marien Hospital Herne University Hospital of the Ruhr University of Bochum/Marien Hospital Witten, Herne, Germany
⁶ Xinquiao Hospital, Third Military Medical University, Chongqing, China
⁷ Department of Orthopedics, Xinqiao Hospital, Army Medical University, Chongqing, China
⁸ Schön Clinic Munich Harlaching, Munich, Germany
⁹ Ligamenta Spine Center, Frankfurt am Main, Germany
¹⁰ Kyung Hee University Medical Centre, Seoul, South Korea
¹¹ The University of Tokushima, Tokushima, Japan
¹² The Leon Wilte Memorial Hospital, Anyang, South Korea
¹³ Changhua Christian Hospital, Changhua, and Dayeh University, Changhua
¹⁴ Rhode Island Hospital, The Warren Alpert Medical School of Brown, Providence, RI, USA
¹⁵ The General Hospital of Chinese People’s Liberation Army, Beijing, China
¹⁶ Columbia Asia Hospital, Gurugram, Haryana, India
¹⁷ SKN Medical College, Pune, India
¹⁸ Fiscal International Clinic, Floridablanca, Colombia
¹⁹ Mohawk Valley Orthopedics, Amsterdam, NY, USA
²⁰ Hospital Angeles Pedregal Camino Santa Teresa, Mexico City, Mexico
²¹ University of Wisconsin, Madison, WI, USA
²² O.L.V. van Lourdes Ziekenhuis, Waregem, Belgium
²³ Queen Savang Vadhana Memorial Hospital, Sriracha, Chonburi, Thailand
²⁴ Ramathibodi Hospital, Mahidol University, Bangkok, Thailand
²⁵ Razi Spine Clinic-Minimally Invasive Spine Surgery, Amman, Jordan
²⁶ Weill Cornell Medical College, New York, NY, USA
²⁷ St. Mary’s Hospital, The Catholic University of Korea, Seoul, South Korea

Corresponding Author: Christoph P. Hofstetter, Department of Neurological Surgery, University of Washington, Seattle, WA 98195, USA.
Email: chh9045@uw.edu

Creative Commons Non Commercial No Derivs CC BY-NC-ND: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs 4.0 License (https://creativecommons.org/licenses/by-nc-nd/4.0/) which permits non-commercial use, reproduction and distribution of the work as published without adaptation or alteration, without further permission provided the original work is attributed as specified on the SAGE and Open Access pages (https://us.sagepub.com/en-us/nam/open-access-at-sage).
(eg, discectomy, foraminotomy). We suggest the following nomenclature for the most common full-endoscopic procedures: posterior endoscopic cervical foraminotomy (PECF), transforaminal endoscopic thoracic discectomy (TETD), transforaminal endoscopic lumbar discectomy (TELD), interlaminar endoscopic lumbar foraminotomy (TELFL), interlaminar endoscopic lateral recess decompression (IE-LRD), and lumbar endoscopic unilateral laminotomy for bilateral decompression (LE-ULBD).

Conclusions: We believe that it is critical to delineate a consensus nomenclature to facilitate uniformity of working-channel endoscopic procedures within academic scholarship. This will hopefully facilitate development, standardization of procedures, teaching, and widespread acceptance of full-endoscopic spinal procedures.

Keywords
consensus, full-endoscopic spine surgery, interlaminar, lateral recess decompression, transforaminal, minimally invasive spinal surgery, nomenclature, working-channel endoscope

Introduction
During the past 30 years, surgeons have developed minimally invasive methods to approach spinal pathology utilizing endoscopes introduced via tubular retractors. As the technology and techniques have advanced, the terminology used to describe these procedures has developed organically and has become heterogeneous and sometimes confusing to patients, providers, and payors. The purpose of this article is to provide the reader with consensus definitions to allow improved communication, study, and understanding of endoscopic techniques.

For our purposes, the endoscope will be defined as a visualization device that is placed into the body. Fundamentally the endoscope can be used as a visualization tool that with an integrated working channel also provides a surgical corridor for tools to manipulate, ablate, and resect tissue. We propose the term “full-endoscopic” to describe procedures performed with a working-channel endoscope. This distinguishes full-endoscopic procedures from “endoscope assisted” operations where tools are passed through trajectories separate from the endoscope (Figure 1).

Multiple full-endoscopic approaches to the spine have been described and performed over the past 30 years. Transforaminal approaches were established after description of the medial aspect of the foraminal annular window as an area of safe access to the disc space. Since then endoscopic discectomy became commonly offered in several surgical centers. More recently with improvements in camera technology and the development of better instruments, surgeons have more readily used the endoscope in direct approaches to the spine by interlaminar techniques allowing the treatment of degenerative spinal pathology, resecting yellow ligament, overgrown facet joints, and osteophytes. Thus, current working-channel endoscopy may be utilized to treat foraminal, central recess, and central spinal stenosis. Using a unilateral approach, bilateral decompression of central and lateral recess stenosis in the lumbar spine is feasible and has been demonstrated to result in favorable clinical outcomes. Endoscopic spine surgery has been shown to be useful in the treatment of cervical foraminal stenosis, cervical disc herniations, and thoracic disc herniations. Moreover, endoscopic spine surgery allows for compression of nerve roots within arthrodesis constructs without removal of instrumentation. By their nature, minimally invasive techniques require significantly less tissue manipulation and, therefore, cause less collateral tissue damage during the surgical approach. This has objectively been shown to minimize local and systemic inflammation, and iatrogenic muscle injury. Furthermore, several studies validate that minimally invasive endoscopic techniques do not compromise surgical outcomes, as similar or better results have been reported when compared with traditional open surgery.

Importantly, full-endoscopic spine surgery provides high-resolution, off-axis visualization of the surgical field and is associated with a favorably low rate of perioperative and postoperative complications compared with minimally invasive spine surgery (MISS) or traditional spine surgery.

Methods
The PubMed database was queried using the terms “spine,” “full-endoscopic,” “working-channel endoscope,” “spine endoscopy,” “percutaneous.” The obtained studies were reviewed, and utilization of full-endoscopic technique was verified. The previously utilized nomenclature was compared and integrated into a systematic nomenclature system (approach corridor/mode of visualization/spinal segment/type of procedure). An additional 27 authors were selected by D. Jin-Sung and Hofstetter according to the following 3 criteria: First, active involvement in teaching cadaveric courses and lecturing on full-endoscopic spine surgery. We consider this most valuable as it makes sure that all authors have a similar understanding of full-endoscopic spine procedures and carry them out utilizing comparable technique. Second, a strong publication record. We considered this important in order involve the majority of surgeons who have utilized various naming systems in the past and were therefore able to contribute, accept, and utilize the novel unified AOSpine nomenclature system. Third, geographic location of the authors played into the selection. This was done in order to also include surgeons as key opinion leaders from countries that are currently less active in full-endoscopic spine surgery. However, the geographic consideration also led to omission of some highly esteemed surgeon in countries with a high density of full-endoscopic spine surgeons. Our
nomenclature suggestions were actively discussed and adjusted with all 28 authors of the current report. The nomenclature suggestion was reviewed, discussed, and accepted in the current form by all authors and also discussed at the annual Global Spine meeting with key opinion leaders. The consensus nomenclature was developed within the AOSpine MISS taskforce.

Anterior Endoscopic Cervical Discectomy (AECD)

Background

The anterior approach to the cervical spine utilizes physiological tissue planes between the esophagus and the carotid artery and is associated with only minimal irritation of surrounding soft tissues. In the early 1990s, Courtheoux et al. adopted the use of automated percutaneous nucleotomy techniques for the treatment of cervical radiculopathy and this led to the later development of the endoscopic cervical discectomy. Although Ahn and colleagues reported in 2005 that “percutaneous endoscopic cervical discectomy” was an effective treatment option for soft disc herniations in selected patients, it is recognized that surgery may contribute to accelerated disc degeneration, given that the approach corridor includes healthy disc tissue. Whether this matters is not certain, but one way of potentially circumventing the problem is to use an anterior transcortical technique with a working corridor through the vertebral body rather than through the disc space. Ruetten and colleagues concluded that endoscopic anterior discectomy has similar long-term results to those of conventional procedures and this is borne out in a recent literature review. However, the risk of exacerbated index-level disc degeneration and changes in sagittal alignment following these procedures require further study.

Previously Used Nomenclature

- Percutaneous endoscopic cervical discectomy (PECED)
- Full-endoscopic anterior cervical discectomy (FACD)

Goal of Surgery

Resection of any disc herniation and decompression of the proximal portion of the segmental cervical nerve root.

Proposed Nomenclature

Anterior endoscopic cervical discectomy (AECD).

Rationale

Percutaneous implies a purely image-guided procedure (eg, guided by CT [computed tomography] or fluoroscopy); hence, the term is incorrect, since the endoscope provides continuous direct visualization of the treated pathology. The term “full-endoscopic” was used to distinguish working-channel...
endoscopy from non–working-channel endoscopic techniques such as micro-endoscopic or biportal. Thus, the current consensus paper proposes the term full-endoscopic as a summary term for working-channel endoscopic procedures.

**Posterior Endoscopic Cervical Foraminotomy (PECF) or Discectomy (PECD)**

**Background**

Posterior cervical foraminotomy aims at widening the cervical intervertebral foramen, while preserving segmental motion. Several minimally invasive approaches have been developed including microscope-assisted “keyhole” foraminotomy, micro-endoscope, and endoscope-assisted techniques. Ruetten and colleagues were the first to describe “full-endoscopic” cervical approaches introducing the endoscope via a small tubular retractor. Kim and colleagues reported similar clinical results comparing posterior tubular-based microscope-assisted with percutaneous endoscopic techniques. A recent publication proposed a new technique for posterior percutaneous endoscopic foraminotomy and discectomy using unilateral biportal endoscopy, claiming a wider visualization and more familiar surgical field.

**Previously Used Nomenclature**

- Full-endoscopic posterior cervical foraminotomy (FPCF)
- Posterior cervical endoscopic discectomy
- Posterior full-endoscopic cervical discectomy (PFEC)
- Posterior percutaneous endoscopic cervical foraminotomy and discectomy (PPECD)
- Posterior percutaneous endoscopic cervical discectomy (PPECD)
- Endoscopic posterior cervical foraminotomy (EPCF)

**Goal of Surgery**

Direct visualization and decompression of the exiting nerve root from its origin to the lateral margin of the caudal pedicle.

**Proposed Name**

Posterior endoscopic cervical foraminotomy (PECF) or discectomy (PECD).

**Rationale**

“Percutaneous” is not included as this has been associated with purely image-guided procedures (eg, guided by CT or fluoroscopy); hence, the term is confusing. Only an endoscope provides continuous direct visualization of the treated pathology. The term “full-endoscopic” is used to distinguish working-channel endoscopy from hybrid procedures (mini-open/tubular) that were performed with assistance of a non–working-channel endoscope.

**Cervical/Thoracic Endoscopic Unilateral Laminotomy for Bilateral Decompression (CE-ULBD/TE-ULBD)**

**Background**

The concept of unilateral laminotomy for bilateral access to the spinal canal was developed in the lumbar spine to minimize postoperative segmental instability and adapted to use in the neck. Good or fair functional outcomes were reported and the authors concluded that ULBD was a reasonable alternative to open laminectomy or laminoplasty in patients with cervical spinal stenosis from compression by the posterior elements. We are not aware of any reports on the use of working-channel endoscopes for this procedure.

**Previously Used Nomenclature**

No data.

**Proposed Name**

Cervical/thoracic endoscopic unilateral laminotomy for bilateral decompression (CE-ULBD/TE-ULBD).

**Transformal Endoscopic Thoracic Discectomy (TETD)**

**Background**

Few reports have been published on the use of working-channel endoscopy for thoracic disc herniations. Choi et al demonstrated the benefits of endoscopic transformal thoracic discectomy in 14 patients with soft lateral or central thoracic disc herniation. The approach requires a foraminotomy and is followed by a transformal discectomy. Wagner and colleagues presented a case report on a patient with a T8-T9 herniated disc, who was successfully treated by transformal endoscopic foraminoplasty and discectomy under local anesthesia. Considering the anatomy of thoracic spine and the adjoining ribs, the approach angle is limited. Foraminoplasty is mandatory in order to create a space for the working cannula with a little gain of additional angulation. This approach is well suited for disc herniations that are off midline. This approach is less suited for the upper thoracic spine since the scapula may block the approach corridor.

**Previously Used Nomenclature**

- Percutaneous endoscopic thoracic discectomy
- Transformal endoscopic discectomy
- Full-endoscopic uni-portal extraforaminal thoracic discectomy
- Fully endoscopic transformal discectomy
**Goal of Surgery**
Visualization of the annulus and adjacent parts of the vertebral bodies and the ventral portion of the thecal sac to the medial aspect of the contralateral pedicle.

**Proposed Nomenclature**
Transforaminal endoscopic thoracic discectomy (TETD).

**Rationale**
The use of the terms “percutaneous” is confusing (see above). In order to distinguish this procedure from transthoracic approaches we propose to include “transforaminal” as the designation of the approach corridor.

**Transforaminal Endoscopic Lumbar Discectomy (TELD)**

**Background**
The description of the medial aspect of the foraminal annular window “triangle of Kambin,” bordered by the exiting root rostrally, the traversing root medially, and the superior endplate of the lower lumbar vertebra inferiorly, is considered as one of the milestones in the development of transforaminal approaches for endoscopic spine surgery. This safe entry passage to the intervertebral disc allowed for the development of very limited, small needle-like nucleotomy instruments that prepared the path for development of larger instruments and working channels. This approach was pioneered by Kambin who reported the results of 175 patients undergoing bilateral biportal and unilateral uniportal techniques base on the location of the herniation.57 Yeung developed his YESS (Yeung Endoscopic Spine System) system and published his own experience with posterolateral endoscopic decompression in 307 consecutive patients with radiculopathy secondary to lumbar disc herniation.58,59 Yeung’s technique was an “inside out,” which involved advancement of the endoscope into the disc nucleus via the foraminal annular window. Disc material is then resected while withdrawing the endoscope. Recently, “outside in” techniques have been more commonly practiced, which may include partial resection of the superior articular process for access.2,60 This technique allows for visualization and identification of bony anatomical landmarks such as the medial aspect of the pedicle and for direct visualization of the traversing and exiting nerve root.

**Previously Used Nomenclature**
- Arthroscopic microdiscectomy61
- Minimally invasive disc surgery58
- Posterolateral endoscopic excision for lumbar disc herniation59
- Transforaminal posterolateral endoscopic discectomy60
- Full-endoscopic transforaminal lumbar discectomy52
- Transforaminal endoscopic discectomy63
- Percutaneous transforaminal endoscopic discectomy64,65

**Goal of Surgery**
Resection of any disc herniation visualizing segmentally decompressed nerve roots.

**Proposed Nomenclature**
Transforaminal endoscopic lumbar discectomy (TELD).

**Rationale**
The term “arthroscopic” refers to endoscopic surgery within a joint space, which does not reflect the procedure. The approach corridor is more precisely defined with “transforaminal” compared to “posterolateral.” The term “minimally invasive” is currently used for tubular approaches combined with microscopic illumination and visualization.

**Transforaminal Endoscopic Lumbar Foraminotomy (TELF)**

**Background**
Shortly after the discovery of the foraminal annular window “triangle of Kambin,” surgeons started to explore and study the intervertebral foramen and associated pathologies in more detail. Mathews66 demonstrated a foraminoscopy utilizing an endoscopic transforaminal technique. In the early 2000s, Knight et al67 reported on their experience regarding an endoscopic-guided foraminal decompression and called it a “foraminoplasty.” These procedures included undercutting of the facet joint, and endoscopic discectomy, mobilization and neurolysis of the exiting and transiting nerves, and ablation of osteophytes. Schubert and Hoogland68 described this technique for removal of a sequestered lumbar disk after decompression of foraminal stenosis (foraminoplasty), which was later popularized as the “outside-in” technique. These reports use the term “foraminoplasty” as the process of widening of foramen through which the endoscopic instruments could access and retrieve the ruptured fragments in the spinal canal. However, the term foraminotomy has been usually used to describe decompression of foramen by which an “exiting” nerve root is released.69 For this reason, we recommend the traditional term “foraminotomy” rather than “foraminoplasty” to describe decompression of a symptomatic foraminal stenosis.

**Previously Used Nomenclature**
- Endoscopic foraminoplasty67
- Endoscopic transforaminal nucleotomy with foraminoplasty68
- Percutaneous endoscopic lumbar foraminotomy69
Goal of Surgery
To visualize and decompress the affected nerve root along its passage through the foramen.

Proposed Name
Transforaminal endoscopic lumbar foraminotomy (TELF).

Rationale
The term “foraminoplasty” has been used to describe resection of the superior articular process to gain access to the foramen as a procedural step in transforaminal surgery. However, the more traditional term “foraminotomy” includes both bony decompression and also resection of soft tissue as necessary in order to relieve a compressed symptomatic nerve root. The latter is the main reason for performing this surgery and should therefore guide the nomenclature.

Endoscopic Interlaminar Discectomy
Background
The traditional surgical approach for lumbar disc herniations has been via the interlaminar space. Endoscope-assisted techniques via tubular retractors have been described as posterior endoscopic discectomy, endoscopic lumbar discectomy, or microendoscopic discectomy (MED). Other terminology was introduced with full-endoscopic techniques as detailed below.

Previously Used Nomenclature:
- Full-endoscopic interlaminar access (FEIL)
- Full-endoscopic interlaminar approach (FEIA)
- Interlaminar access (ILA) for percutaneous endoscopic lumbar discectomy (PELD)
- Percutaneous endoscopic interlaminar discectomy (PEID)
- Percutaneous endoscopic discectomy (PED)
- Microendoscopic discectomy via interlaminar approach
- Endoscopic lumbar discectomy

Goal of Surgery
Resection of any disc herniation and visualization of the decompressed nerve roots.

Proposed Nomenclature
Interlaminar endoscopic lumbar discectomy (IELD).

Rationale
The use of the terms “percutaneous” and “full-endoscopic” are redundant as outlined above. It is critical that the term for this procedure includes the approach corridor, which is “interlaminar,” to distinguish it from the transforaminal approach.

Interlaminar Endoscopic Lateral Recess Decompression (IE-LRD)
Background
Medial facetectomies aim to decompress neural elements impinged in the lateral recess underneath the superior articular process. This may be done minimally invasively using a 16 mm tubular retractor in combination with microendoscopic techniques but also by interlaminar lateral recess decompression using a working-channel endoscope. Indeed, a prospective randomized controlled trial demonstrated similar clinical effectiveness of endoscopic compared to minimally invasive lateral recess decompression.

Previously Used Nomenclature
- Full endoscopic interlaminar lateral recess decompression
- Interlaminar endoscopic lateral recess decompression

Goal of Surgery
Decompression and visualization of the neural elements within the lateral recess from the tip of the superior articular process (SAP) to the midportion of the caudal pedicle.

Proposed Nomenclature
Interlaminar endoscopic lateral recess decompression (IE-LRD).

Rationale
The use of the terms “percutaneous” and “full-endoscopic” are redundant as outlined above. It is critical that the term for this procedure includes the approach corridor, which is “interlaminar,” to distinguish it from the transforaminal approach, which also allows for lateral recess decompression.

Transforaminal Endoscopic Lateral Recess Decompression (TE-LRD)
Background
Symptomatic lateral recess stenosis is typically caused by impingement of the traversing nerve root between the annulus of the disc and SAP. Traditionally, interlaminar approaches have been utilized for decompression neural elements impinged within the lateral recess. Kambin et al first introduced the concept of transforaminal decompression of the lateral recess. The authors described decompression of the traversing nerve root by annulectomy and resection of marginal osteophytes originating from the posterior aspect of the vertebral body end plate. A recent cadaveric study demonstrated that...
the transforaminal approach combined with an extensive foraminoplasty allows for access to the lateral recess both ventral as well as dorsal to the traversing nerve root. Thus, yellow ligament and SAP dorsal to the traversing nerve root can be removed, which the authors referred to as a “ventral facetectomy.” A retrospective case series of 48 patients reports on transforaminal decompression of foraminal or lateral recess stenosis in patients with previous spinal surgery. Endoscopic transforaminal decompression resulted in “excellent” or “good” results according to Macnab criteria in 79% of patients. However, while the area of stenosis was meticulously defined according to criteria by Lee et al, no diagnostic effort was made to distinguish whether symptoms were caused by either the traversing or exiting nerve root.

Previously Used Nomenclature

- Transforaminal arthroscopic decompression of lateral recess stenosis
- Percutaneous transforaminal ventral facetectomy
- Endoscopic transforaminal lateral recess decompression

Goal of Surgery

Ventral and dorsal decompression and visualization of the traversing nerve root within the lateral recess from the rostral aspect of the annulus to the rostral portion of the caudal pedicle.

Proposed Nomenclature

Lumbar endoscopic unilateral laminotomy for bilateral decompression (LE-ULBD).

Rationale

The use of the term “percutaneous” is redundant as outlined above. The term “laminectomy” is traditionally utilized to signify complete removal of the lamina and spinous process, although, colloquially, the term is often interchanged with “laminotomy.” Given that with this technique the entire lamina is not removed but rather undercut, the term “laminotomy” will be used to reflect removal of only a portion of the lamina. The approach is performed unilaterally with bilateral decompression of the neural elements both centrally and in the lateral recess. Hence, the nomenclature “endoscopic unilateral laminotomy for bilateral decompression” reflects the procedure most accurately.

Discussion

Full endoscopic spine surgery represents the evolution of minimally invasive surgical access to spinal pathology. Although the first spinal endoscopic procedures were performed in the early 1980s in the United States, there has been a steady and persistent increase in popularity, particularly in Europe and Asia. Multiple studies have demonstrated endoscopic techniques provide equivalent outcomes to microsurgical or tubular techniques with shorter hospital stay, less local collateral tissue injury, and systemic stress. With continued evolution in surgical techniques and technological innovations, endoscopic techniques have been gaining broader appeal with techniques expanding to the cervical and thoracic spine.
As this field continues to expand and evolve, it is critical for surgeons to address the mélange of endoscopic procedures within the literature to provide a solid foundation for future scholarship. The authors believe that it is therefore critical to construct and define a consistent nomenclature framework within endoscopic spine surgery to clearly define full-endoscopic procedures and delineate their clinical effectiveness.

Moreover, a standardized nomenclature will promote scientific exchange and should facilitate further refinement of full-endoscopic procedures (Figure 2). Perhaps the most crucial function of standardization of nomenclature and techniques is to facilitate teaching of these techniques to allow the field of spine surgery to concomitantly evolve with our technological advancements. The AOspine (Arbeitsgemeinschaft für Osteosynthesefragen) poses an ideal international community to deliver knowledge, experience, and evidence regarding full-endoscopic spine surgery with the ultimate goal to improve patient care and outcomes.

**Declaration of Conflicting Interests**

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**Funding**

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This supplement was supported by funding from the Carl Zeiss Meditec Group.
prospective, randomized, controlled study. J Neurosurg Spine. 2009;10:476-485.
8. Wagner R, Telfeian AE, Kzrok G, Ippenburg M. Fully-endoscopic lumbar laminectomy for central and lateral recess stenosis: Technical note. Interdiscip Neurosurg. 2018;13:6-9.
9. Wagner R, Telfeian AE, Ippenburg M, Kzrok G. Minimally invasive fully endoscopic two-level posterior cervical foraminotomy: technical note. J Spine Surg. 2017;3:238-242.
10. Ye ZY, Kong WJ, Xin ZJ, et al. Clinical observation of posterior percutaneous full-endoscopic cervical foraminotomy as a treatment for osseous foraminal stenosis. World Neurosurg. 2017;106:945-952.
11. Ruetten S, Komp M, Merk H, Godolias G. Full-endoscopic cervical posterior foraminotomy for the operation of lateral disc herniations using 5.9-mm endoscopes: a prospective, randomized, controlled study. Spine (Phila Pa 1976). 2008;33:940-948.
12. Park JH, Jun SG, Jung JT, Lee SJ. Posterior percutaneous endoscopic cervical foraminotomy and discectomy with unilateral biportal endoscopy. Orthopedics. 2017;40:e779-e783.
13. Wagner R, Telfeian AE, Ippenburg M, et al. Transforminal endoscopic foraminoplasty and discectomy for the treatment of a thoracic disc herniation. World Neurosurg. 2016;90:194-198.
14. Heo DH, Son SK, Eum JH, Park CK. Fully endoscopic lumbar interbody fusion using a percutaneous unilateral biportal endoscopic technique: technical note and preliminary clinical results. Neurosurg Focus. 2017;43:E8.
15. McGrath LB Jr, Madhavan K, Chiang LO, Wang MY, Hofstetter CP. Early experience with endoscopic revision of lumbar spinal fusions. Neurosurg Focus. 2016;40:E10.
16. Sasaoka R, Nakamura H, Konishi S, et al. Objective assessment of reduced invasiveness in MED. Compared with conventional one-level laminotomy. Eur Spine J. 2006;15:577-582.
17. Schick U, Dohnert J, Richter A, Konig A, Vitzthum HE. Microendoscopic lumbar discectomy versus open surgery: an intraoperative EMG study. Eur Spine J. 2002;11:20-26.
18. Shin DA, Kim KN, Shin HC, Yoon DH. The efficacy of microendoscopic discectomy in reducing iatrogenic muscle injury. J Neurosurg Spine. 2008;8:39-43.
19. Garg B, Nagraja UB, Jayaswal A. Microendoscopic versus open discectomy for lumbar disc herniation: a prospective randomised study. J Orthop Surg (Hong Kong). 2011;19:30-34.
20. Hussein M, Abdeldayem A, Mattar MM. Surgical technique and effectiveness of microendoscopic discectomy for large uncontaminated lumbar disc herniations: a prospective, randomized, controlled study with 8 years of follow-up. Eur Spine J. 2014;23:1992-1999.
21. Kim HS, Patel R, Paudel B, et al. Early outcomes of endoscopic contralateral foraminal and lateral recess decompression via an interlaminar approach in patients with unilateral radiculopathy from unilateral foraminal stenosis. World Neurosurg. 2017;108:763-773.
22. Lawton CD, Smith ZA, Lam SK, Habib A, Wong RH, Fessler RG. Clinical outcomes of microendoscopic foraminotomy and decompression in the cervical spine. World Neurosurg. 2014;81:422-427.
23. Minamide A, Yoshida M, Simpson AK, et al. Microendoscopic laminotomy versus conventional laminoplasty for cervical spondylotic myelopathy: 5-year follow-up study. J Neurosurg Spine. 2017;27:403-409.
24. Minamide A, Yoshida M, Yamada H, et al. Clinical outcomes of microendoscopic decompression surgery for cervical myelopathy. Eur Spine J. 2010;19:487-493.
25. Righezzo O, Falavigna A, Avanzi O. Comparison of open discectomy with microendoscopic discectomy in lumbar disc herniations: results of a randomized controlled trial. Neurosurgery. 2007;61:545-549.
26. Ruetten S, Komp M, Godolias G. An extreme lateral access for the surgery of lumbar disc herniations inside the spinal canal using the full-endoscopic uniportal transforaminal approach—technique and prospective results of 463 patients. Spine (Phila Pa 1976). 2005;30:2570-2578.
27. Li XG, Zhong CF, Deng GB, Liang RW, Huang CM. Full-endoscopic procedures versus traditional discectomy surgery for discectomy: a systematic review and meta-analysis of current global clinical trials. Pain Physician. 2016;19:103-118.
28. Sen RD, White-Dzuro G, Ruzevick J, et al. Intra- and perioperative complications associated with endoscopic spine surgery: a multi-institutional study. World Neurosurg. 2018;120: e1054-e1060.
29. Courtheoux F, Theron J. Automated percutaneous nucleotomy in the treatment of cervicobrachial neuralgia due to disc herniation. J Neuroradiol. 1992;19:211-216.
30. Onik G, Helms CA, Ginsburg L, Hoaglund FT, Morris J. Percutaneous lumbar discectomy using a new aspiration probe. AJR Am J Roentgenol. 1985;144:1137-1140.
31. Ahn Y, Lee SH, Shin SW. Percutaneous endoscopic cervical discectomy: clinical outcome and radiographic changes. Photomed Laser Surg. 2005;23:362-368.
32. Lee JH, Lee SH. Clinical and radiographic changes after percutaneous endoscopic cervical discectomy: a long-term follow-up. Photomed Laser Surg. 2014;32:663-668.
33. Choi G, Lee SH, Bhanot A, Chae YS, Jung B, Lee S. Modified transcorporeal anterior cervical microforaminotomy for cervical radiculopathy: a technical note and early results. Eur Spine J. 2007;16:1387-1393.
34. Ruetten S, Komp M, Merk H, Godolias G. Full-endoscopic anterolateral decompression versus conventional anterior decompression and fusion in cervical disc herniation. Int Orthop. 2009;33:1677-1682.
35. Bucknall V, Gibson JA. Cervical endoscopic spinal surgery: a review of the current literature. J Orthop Surg (Hong Kong). 2018;26:2309499018758520.
36. Ahn Y, Lee SH, Lee SC, Shin SW, Chung SE. Factors predicting excellent outcome of percutaneous cervical discectomy: analysis of 111 consecutive cases. Neuroradiology. 2004;46:378-384.
37. Lee SH, Lee JH, Choi WC, Jung B, Mehta R. Anterior minimally invasive approaches for the cervical spine. Orthop Clin North Am. 2007;38:327-337.
38. Epstein NE. A review of laminoforaminotomy for the management of lateral and foraminal cervical disc herniations or spurs. Surg Neurol. 2002;57:226-233.
Ruetten S, Hahn P, Oezdemir S, Baraliakos X, Godolias G, Komp M. Operation of soft or calcified thoracic disc herniations in the full-endoscopic uniportal extraforaminal technique. *Pain Physician*. 2018;21:E331-E340.

Shen J. Fully endoscopic transforaminal discectomy under local anesthesia for thoracic disc herniations: a case series. *J Spine*. 2018;7:13.

Kambin P, O’Brien E, Zhou L, Schaffer JL. Arthroscopic microdiscectomy and selective fragmentectomy. *Clin Orthop Relat Res*. 1998;(347):150-167.

Yeung AT. Minimally invasive disc surgery with the Yeung Endoscopic Spine System (YESS). *Surg Technol Int*. 1999;8:267-277.

Yeung AT, Tsou PM. Posterolateral endoscopic excision for lumbar disc herniation: surgical technique, outcome, and complications in 307 consecutive cases. *Spine (Phila Pa 1976)*. 2002;27:722-731.

Hoogland T, Schubert M, Miklitz B, Ramirez A. Transforaminal posterolateral endoscopic discectomy with or without the combination of a low-dose chymopapain: a prospective randomized study in 280 consecutive cases. *Spine (Phila Pa 1976)*. 2006;31:E890-E897.

Kambin P, Brager MD. Percutaneous posterolateral discectomy. Anatomy and mechanism. *Clin Orthop Relat Res*. 1987;(223):145-154.

Ruetten S, Komp M, Merk H, Godolias G. Full-endoscopic technique for cervical posterior foraminotomy in the treatment of lateral disc herniations using 6.9-mm endoscopes: prospective 2-year results of 87 patients. *Minim Invasive Neurosurg*. 2007;50:219-226.

Kim CH, Kim KT, Chung CK, et al. Minimally invasive cervical foraminotomy and discectomy for laterally located soft disk herniation. *Eur Spine J*. 2015;24:3005-3012.

Kim CH, Chung CK, Kim HJ, Jahng TA, Kim DG. Early outcome of posterior cervical endoscopic discectomy: an alternative treatment choice for physically/socially active patients. *J Korean Med Sci*. 2009;24:302-306.

Yang JS, Chu L, Chen L, Chen F, Ke ZY, Deng ZL. Anterior or posterior approach of full-endoscopic cervical discectomy for cervical intervertebral disc herniation? A comparative cohort study. *Spine (Phila Pa 1976)*. 2014;39:1743-1750.

Ahn Y. Percutaneous endoscopic cervical discectomy using working channel endoscopes. *Expert Rev Med Devices*. 2016;13:601-610.

Quillo-Olvera J, Lin GX, Kim JS. Percutaneous endoscopic cervical discectomy: a technical review. *Ann Transl Med*. 2018;6:100.

Youn MS, Shon MH, Seong YJ, Shin JK, Goh TS, Lee JS. Clinical and radiological outcomes of two-level endoscopic posterior cervical foraminotomy. *Eur Spine J*. 2017;26:2450-2458.

Spetzger U, Bertalanffy H, Naujokat C, von Keyserlingk DG, Gilsbach JM. Unilateral laminotomy for bilateral decompression of lumbar spinal stenosis. Part I: anatomical and surgical considerations. *Acta Neurochir (Wien)*. 1997;139:392-396.

Dahdaleh NS, Wong AP, Smith ZA, Wong RH, Lam SK, Fessler RG. Microendoscopic decompression for cervical spondylotic myelopathy. *Neurosurg Focus*. 2013;35:E8.

Nie HF, Liu KX. Endoscopic transforaminal thoracic foraminotomy and discectomy for the treatment of thoracic disc herniation. *Minim Invasive Surg*. 2013;2013:264105.

Choi KY, Eun SS, Lee SH, Lee HY. Percutaneous endoscopic thoracic discectomy; transforaminal approach. *Minim Invasive Neurosurg*. 2010;53:25-28.

Krzok G, Telfeian AE, Wagner R, Ipenburg M. Transpedicular endoscopic surgery for lumbar spinal synovial cyst-report of two cases. *J Spine Surg (Hong Kong)*. 2016;2:310-313.

Ruetten S, Hahn P, Oezdemir S, Baraliakos X, Godolias G, Komp M. Operation of soft or calcified thoracic disc herniations in the
72. Perez-Cruet MJ, Foley KT, Isaacs RE, et al. Microendoscopic lumbar discectomy: technical note. Neurosurgery. 2002;51(5 suppl):S129-S136.
73. Wang B, Lu G, Liu W, Cheng I, Patel AA. Full-endoscopic interlaminar approach for the surgical treatment of lumbar disc herniation: the causes and prophylaxis of conversion to open. Arch Orthop Trauma Surg. 2012;132:1531-1538.
74. Ruetten S, Komp M, Godolias G. A New full-endoscopic technique for the interlaminar operation of lumbar disc herniations using 6-mm endoscopes: prospective 2-year results of 331 patients. Minim Invasive Neurosurg. 2006;49:80-87.
75. Casimiro M. Short-term outcome comparison between full-endoscopic interlaminar approach and open minimally invasive microsurgical technique for treatment of lumbar disc herniation. World Neurosurg. 2017;108:894-900.e1.
76. Shi C, Kong W, Liao W, et al. The early clinical outcomes of a percutaneous full-endoscopic interlaminar approach via a surrounding nerve root discectomy operative route for the treatment of ventral-type lumbar disc herniation. Biomed Res Int. 2018;2018:9157089.
77. Choi G, Lee SH, Raiturker PP, Lee S, Chae YS. Percutaneous endoscopic interlaminar discectomy for intracanalicular disc herniations at L5-S1 using a rigid working channel endoscope. Neurosurgery. 2006;58(1 suppl):ONS59-ONS68.
78. Dabo X, Ziqiang C, Yinchuan Z, et al. The clinical results of endoscopic interlaminar lumbar discectomy for intracanalicular disc herniation. Exp Ther Med. 2018;15:295-299.
79. Kim CH, Chung CK, Woo JW. Surgical outcome of percutaneous endoscopic interlaminar lumbar discectomy for highly migrated disk herniation. Clin Spine Surg. 2016;29:E259-E266.
80. Kim HS, Park JY. Comparative assessment of different percutaneous endoscopic interlaminar lumbar discectomy (PEID) techniques. Pain Physician. 2013;16:359-367.
81. Sasani M, Ozer AF, Oktenoglu T, Canbulat N, Sarioglu AC. Percutaneous endoscopic discectomy for far lateral lumbar disc herniations: prospective study and outcome of 66 patients. Minim Invasive Neurosurg. 2007;50:91-97.
82. Koga S, Sairyo K, Shibuya I, et al. Minimally invasive removal of a recurrent lumbar herniated nucleus pulposus by the small incised microendoscopic discectomy interlaminar approach. Asian J Endosc Surg. 2012;5:34-37.
83. Hayashi A, Oshima Y, Shiboi R, et al. Microendoscopic posterior decompression for the treatment of lumbar lateral recess stenosis. J Spine. 2016;5:317.
84. Kambin P, Casey K, O’Brien E, Zhou L. Transforaminal arthroscopic decompression of lateral recess stenosis. J Neurosurg. 1996;84:462-467.
85. Sairyo K, Higashino K, Yamashita K, et al. A new concept of transforaminal ventral facetectomy including simultaneous decompression of foraminal and lateral recess stenosis: technical considerations in a fresh cadaver model and a literature review. J Med Invest. 2017;64:1-6.
86. Lewandrowski KU. Endoscopic transforaminal and lateral recess decompression after previous spinal surgery. Int J Spine Surg. 2018;12:98-111.
87. Lee CK, Rauschninging W, Glenn W. Lateral lumbar spinal canal stenosis: classification, pathologic anatomy and surgical decompression. Spine (Phila Pa 1976). 1988;13:313-320.
88. Boukebir MA, Berlin CD, Navarro-Ramirez M, et al. Ten-step minimally invasive spine lumbar decompression and dural repair through tubular retractors. Oper Neurosurg (Hagerstown). 2017;13:232-245.
89. Alimi M, Hofstetter CP, Pyo SY, Paulo D, Härtl R. Minimally invasive laminectomy for lumbar spinal stenosis in patients with and without preoperative spondylolisthesis: clinical outcome and reoperation rates. J Neurosurg Spine. 2015;22:339-352.
90. Alimi M, Hofstetter CP, Torres-Campa JM, et al. Unilateral tubular approach for bilateral laminotomy: effect on ipsilateral and contralateral buttock and leg pain. Eur Spine J. 2017;26:389-396.
91. Thome C, Zevgaridis D, Lebota O, et al. Outcome after less-invasive decompression of lumbar spinal stenosis: a randomized comparison of unilateral laminotomy, bilateral laminotomy, and laminectomy. J Neurosurg Spine. 2005;3:129-141.
92. Lee CW, Yoon KJ, Jun JH. Percutaneous endoscopic laminotomy with flavectomy by uniporal, unilateral approach for the lumbar canal or lateral recess stenosis. World Neurosurg. 2018;113: e129-e137.
93. Tacconi L, Baldo S, Merci G, Serra G. Transforaminal percutaneous endoscopic lumbar disc decompression: outcome and complications in 270 cases [published online March 26, 2018]. J Neurosurg Sci. doi:10.23736/S0390-5616.18.04395-3
94. Choi KC, Shim HK, Hwang JS, et al. Comparison of surgical invasiveness between microdiscectomy and 3 different endoscopic discectomy techniques for lumbar disc herniation. World Neurosurg. 2018;116:e750-e758.
95. Pan L, Zhang P, Yin Q. Comparison of tissue damages caused by endoscopic lumbar discectomy and traditional lumbar discectomy: a randomised controlled trial. Int J Surg. 2014;12:534-537.
96. Chang F, Zhang T, Gao G, et al. Therapeutic effect of percutaneous endoscopic lumbar disc decompression on lumbar disc herniation and its effect on oxidative stress in patients with lumbar disc herniation. Exp Ther Med. 2018;15:295-299.
97. Tao XZ, Jing L, Li JH. Therapeutic effect of transforaminal endoscopic spine system in the treatment of prolapse of lumbar intervertebral disc. Eur Rev Med Pharmacol Sci. 2018;22(1 suppl): 103-110.
98. Parihar VS, Yadav N, Ratre S, Dubey A, Yadav YR. Endoscopic anterior approach for cervical disc disease (disc preserving surgery). World Neurosurg. 2018;115:e699-e609.
99. Liao C, Ren Q, Chu L, et al. Modified posterior percutaneous endoscopic cervical discectomy for lateral cervical disc herniation: the vertical anchoring technique. Eur Spine J. 2018;27:1460-1468.