Original Study

Surgeon training and clinical implementation of spinal endoscopy in routine practice: results of a global survey

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Background: Training of spine surgeons may impact the availability of contemporary minimally invasive spinal surgery (MIS) to patients and drive spine surgeons' clinical decision-making when applying minimally invasive spinal surgery techniques (MISST) to the treatment of common degenerative conditions of the lumbar spine. Training requirements and implementation of privileges vary in different parts of the world. The purpose of this study was to analyze the training in relation to practice patterns of surgeons who perform lumbar endoscopic spinal surgery the world over.

Methods: The authors solicited responses to an online survey sent to spine surgeons by email, and chat groups in social media networks including Facebook, WeChat, WhatsApp, and Linkedin. Surgeons were asked the following questions: (I) please indicate your training? (II) What type of MISST spinal surgery do you perform? (III) How would you rate your experience in MIS lumbar spinal surgery and what percentage of your practice is MISST? And (IV) which avenue did you use to train for the MISST you currently employ in your clinical practice today? Descriptive statistics were applied to count responses and cross-tabulated them to the surgeon's training. Pearson Chi-square measures, kappa statistics, and linear regression analysis of agreement or disagreement were performed by analyzing the distribution of variances using statistical package SPSS version 25.0.

Results: A total of 430 surgeons accessed the survey. The completion rate was 67.4%. Analyzing the responses of 292 surveys submitted by 97 neurosurgeons (33.2%), 161 orthopaedic surgeons (55.1%), and 34 surgeons of other postgraduate training (11.6%) showed that only 14% (41/292) of surgeons had completed a fellowship. Surgeons rated their skill level 33.5% of the time as master and experienced surgeon, and 35.6% of the time as novice or surgeon with some experience. There were more master (64.6% versus 29.2%) and experienced (52% versus 40%) surgeons amongst orthopaedic surgeons than amongst neurosurgeons at a statistically significant level (P=0.11). There were near twice as many orthopaedic surgeons (54.3%) using

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endoscopic procedures in the lumbar spine as their favorite MISST than neurosurgeons (35.4%; P=0.096). Endoscopic spine surgeons' main sources of knowledge acquisition were (I) learning in small meetings (57.3%), (II) attending workshops (63.1%), and (III) national and international conferences (59.8%).

Conclusions: The majority of spine surgeons reported more than half of their cases employing MISST at a high skill level. Very few MISST surgeons are fellowship trained but attend workshops and various meetings suggesting that many of them are self-thought. Orthopaedic surgeons were more likely to implement endoscopic spinal surgery into the routine clinical practice. As endoscopic spine surgery gains more traction and patient demand, minimal adequate training will be part of the ongoing debate.

Keywords: Lumbar minimally invasive spinal surgery (lumbar MIS); spinal endoscopy; training and credentialing

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Introduction

The authors of this publication were interested in better understanding the training background and practice patterns of surgeons who perform lumbar endoscopic spinal surgery. Endoscopic spinal surgery has received more attention and has become a commonly employed minimally invasive spinal surgery technique (MISST) the world over (1-21). Pioneers of the method have published their results for the last three decades and proven both the safety and efficacy of the procedure (22-25). More recent technological advances with better video-endoscopic equipment, more reliable endoscopes with larger inner working channels able to accommodate more sophisticated decompression tools, such as motorized drills, endoscopic-chisels, and Kerrison rongeurs, have prompted a paradigm shift in the accepted surgical indication for spinal endoscopy from herniated disc (26-29) to spinal stenosis (30), and even interventional intradiscal (31) and axial pain management procedures (32,33). As with any surgical technology gaining traction and becoming more mainstream as an accepted method to treat common degenerative conditions of the lumbar spine, formal training of endoscopic surgery procedures has been initiated by key-opinion leaders (KOL) in workshops organized by small specialty societies such as the International Intradiscal Therapy Society (IITS), and The International Society for the Advancement of Spine Surgery (ISASS) (34). National and international organizations have also begun to integrate cadaver workshops and symposia on spinal endoscopy as well (35-37). However, formal accredited spine fellowship programs are slow to make spinal endoscopy part of the regular curriculum, and only a few mentorship programs exist that are the hot-spots of clinical expertise. Therefore, industry-sponsored weekend cadaver workshops have remained the mainstay of training aspiring endoscopic spinal surgeons allowing them to incorporate this advanced MISST into their day-to-day practice. Many more though are simply left to becoming an autodidact of spinal endoscopy.

Patient demand for less burdensome and simpler outpatient spinal decompression procedures (38,39) for common degenerative conditions of the lumbar spine has also contributed to the reported increase in endoscopic spinal surgeries as growing evidence of lower complication rates has emerged and become common knowledge among patients as well (40-43). While patients are now actively seeking out surgeons and MISST centers (44) to receive treatments for sciatica-type low back and leg pain that are less disruptive to their lives, allow earlier social reintegration, and return to work (38-43), surgeons are still left to wonder where and under whose mentorship to train for these advanced endoscopic procedures as industry-sponsored weekend cadaver workshops rarely can go beyond introducing the endoscopic instrumentation, and basic surgical technique, and offer little in the way of teaching appropriate diagnostic workup, surgical indications, management of complications, and procedural steps commensurate with the clinical context of the various common lumbar degenerative conditions. A steeper learning curve with the endoscopic lumbar spinal surgery has long been recognized by many in the field (45), and KOLs have voiced their concerns that the lack of formalized training with an accredited core curriculum could inadvertently give spinal endoscopy an unattractive "high-complication-rate" stigma (46) similar to traditional inpatient open lumbar

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spine surgery which in current public opinion has been associated with higher blood loss, and higher infection and revision surgery rates (47-49). The training dilemma with the lack of accredited formalized endoscopic training programs for spine surgeons is being compounded by some court rulings in the United States where non-surgeons performing endoscopic lumbar surgeries have been sued by patients and reprimanded by licensing boards for practicing outside the scope of their training in interventional pain management. These law suits were typically prompted by poor management of postoperative complications from surgical procedures performed by non-surgeons without formal surgical residency or fellowship training.

Obviously, the goals of introducing spinal endoscopy into one's routine surgical practice are aimed at reducing postoperative pain, the time to postoperative narcotic independence (50-53) and diminishing the burden of decompensated cardiopulmonary medical problems (54-57) often seen in the aging baby-boomer population who suffer the most from sciatica-type low back and leg pain due to herniated disc and spinal stenosis (58).

Therefore, the purpose of this study was to understand better who is currently performing endoscopic lumbar spinal surgery at what skill level and how they trained for it. The authors intend to use this information to aid in the creation of formalized accredited spinal endoscopy training programs that reach beyond the scope of hands-on training but also teach aspiring endoscopic surgeons how to choose appropriate surgical candidates, and how to manage patient postoperatively when their clinical course deviates from the expected surgical outcomes with the various decompression techniques.

Methods

The authors solicited responses to an online survey via email, and chat groups in social networks including Facebook, WeChat, WhatsApp, and LinkedIn. The survey was available online and distributed via a link distributed through these social network media. Upon clicking on the link, the prospective surgeon respondent was taken to the Typeform website at www.typeform.com where the survey opened automatically. The survey could be answered on the computer, laptop, and any hand-held devices such as an iPad, or a cellular smartphone. The Typeform services were chosen because of its ease of use across multiple user-interface platforms. Survey accessibility on the personal smartphone by the surgeon was considered a significant advantage to facilitate recruitment of respondents, ease of use, and respondent's retention to improve survey completion.

The survey consisted of four questions. The questions were aimed at soliciting information deemed to be important factors of endoscopic MISST implementation, whereas another question requested demographic information of the respondent including the extent of postgraduate residency and fellowship training, and the percentage of his/her practice being devoted to MISST. Instead of user queries with a Likert scale, the survey was constructed of simple multiple-choice questions some of which with multiple possible answers for ease of use and to maximize respondent retention once on the web site and to facilitate survey completion. Some of the survey questions as they appeared on the prospective respondent surgeons screen are shown in *Figure 1*. Surgeons were asked the following four questions:

(I) Please indicate your training?
  (i) Neurosurgery;
  (ii) Orthopaedic surgery;
  (iii) Fellowship trained;
  (iv) N.A.

(II) What type of MISST spinal surgery do you perform?
  (i) Tubular retractor system;
  (ii) Mini-open surgery;
  (iii) Endoscopic surgery;
  (iv) N.A.

(III) How would you rate your experience in minimally invasive spinal surgery (MIS) lumbar spinal surgery and what percentage of your practice is MISST?
  (i) No experience;
  (ii) Novice surgeon;
  (iii) Some experience;
  (iv) Experienced surgeon;
  (v) Master surgeon;
  (vi) <25%;
  (vii) 25–50%;
  (viii) 50–75%;
  (ix) >75%;
  (x) I don't exactly know.

(IV) Which avenue did you use to train for the MISST you currently employ in your clinical practice today?
  (i) I attended workshops and local meetings;
  (ii) I attended national and international meetings;
  (iii) I learned from likeminded peers in small groups and subspecialty societies.

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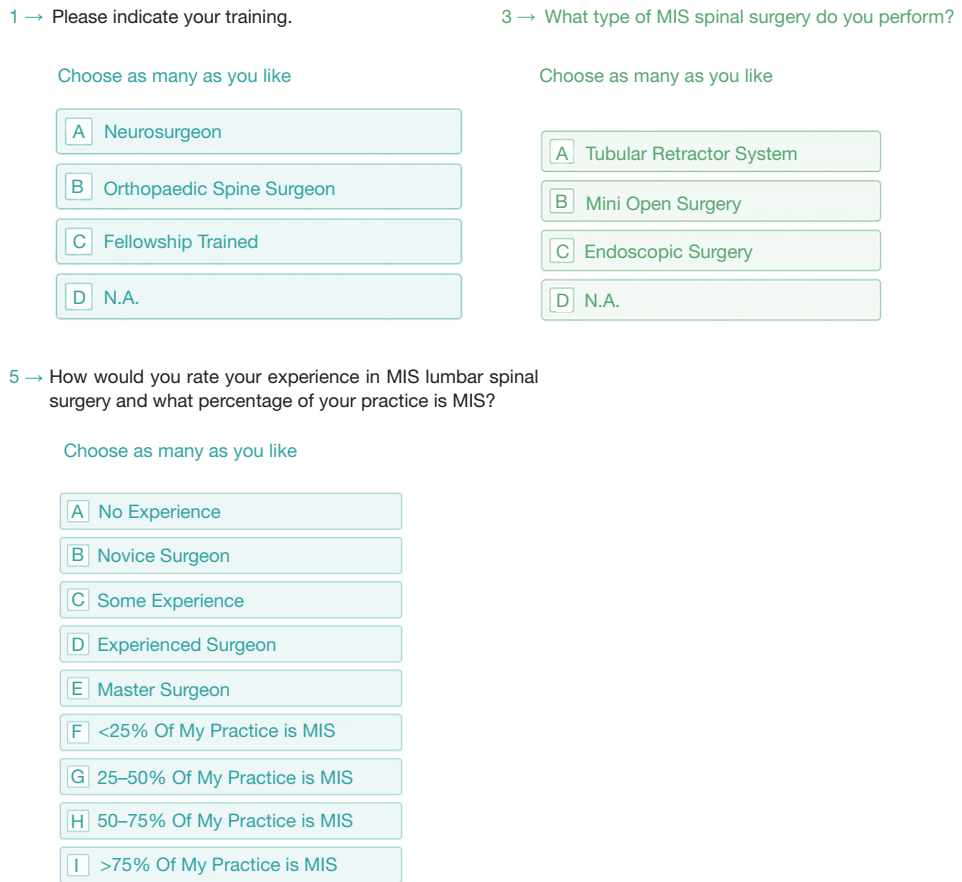

Figure 1 Representative questions of the spine surgeon opinion survey inquiring about postgraduate residency training, types of preferred MISST, experience and percentage of clinical practice devoted to MISST.

The survey ran from October 26 to November 14, 2018. The authors were blinded as to the identity of the responding surgeon at all times. Individual personal identifiers were not recorded. The typeform.com survey created a time-stamp upon initiation of the study and once the completed questionnaire was submitted. Also, a unique network identifier (ID without IP address) was recorded for each responding surgeon. Upon completion of the survey, the responses were downloaded in an Excel file format and imported into IBM SPSS (version 25) statistical software package for further data analysis.

Descriptive statistic measures were used to count responses and calculate the mean, range, and standard deviation as well as percentages. Additional crosstabulation methods were used to assess for any statistically significant association between the different surgeon responses using Pearson Chi-square and Fisher's exact test. Expected cell counts, continuity corrections, and likelihood ratios were calculated for some analyses. Kappa statistics were performed to test for statistical significance of agreement between the individual responses. As another method to assess for agreement or disagreement between the entered responses, linear regression analysis was performed to determine whether the variances in surgeons' opinions were normally distributed (agreement) or showed asymmetric distribution (disagreement). The authors also used linear regression analysis in an attempt to measure the presumed consistency of the submitted responses in lieu of unknown sample size required to have sufficient power for clinically meaningful statistical analysis. A P value of 0.05 or less was considered statistically significant. A confidence interval of 95% was considered for all statistical tests.

Results

The online survey was accessed by 430 surgeons of

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Table 1 Responding spine surgeons' training, MIS experience, and percentage of practice devoted to MIS

Variables	Frequency	Percent (%)	Valid percent (%)	Cumulative percent (%)
Responding spine surgeon's residency training				
No response	34	11.6	11.6	11.6
Neurosurgeon	97	33.2	33.2	44.9
Orthopaedic spine surgeon	161	55.1	55.1	100.0
Total	292	100.0	100.0	
Percentage of surgeon's practice devoted to MIS				
No response	121	41.4	41.4	41.4
<25% of my practice is MIS	44	15.1	15.1	56.5
>75% of my practice is MIS	59	20.2	20.2	76.7
25–50% of my practice is MIS	33	11.3	11.3	88.0
50–75% of my practice is MIS	35	12.0	12.0	100.0
Total	292	100.0	100.0	
Experience				
No response	70	24.0	24.0	24.0
Experienced surgeon	50	17.1	17.1	41.1
Master surgeon	48	16.4	16.4	57.5
No experience	20	6.8	6.8	64.4
Novice surgeon	26	8.9	8.9	73.3
Some experience	78	26.7	26.7	100.0
Total	292	100.0	100.0	

MIS, minimally invasive spinal surgery.

which 293 submitted a survey recording 292 submissions as valid responses. The survey site had 500 total visits. The completion rate was 67.4% and the average time to complete the survey was 8 minutes and 54 seconds. Twenty-eight surgeons completed the survey on a PC or laptop with 37 total and 34 unique visits with a completion rate of 87.5% and average time to finish 2 minutes and 30 seconds. The majority of surgeons [261] responded to the survey using their smartphones during 459 total and 395 unique visits with a completion rate of 66.1% taking an average time of 09 minutes and 38 seconds to complete. Only one surgeon used a tablet to complete the survey.

The majority of surgeons (161/292; 55.1%) participating in this survey were orthopaedic surgeons, followed by neurosurgeons (97/292; 33.2%), and a small group of surgeons (34/292; 11.6%) who indicated that they completed another form of postgraduate residency program (*Table 1*). The vast majority (251; 86%) of the 292 responding surgeons were not fellowship trained in MISST. In contrast, only 14% (41/292) of surgeons had completed a MISST fellowship at the time they returned the survey. Learning from likeminded peers in small groups at subspecialty society meetings was reported by 57.3% of endoscopic spine surgeons. Another 59.8% attended international and national meetings to learn about spinal endoscopy. Workshop training setting was used by 63.1% surgeons performing endoscopic spinal surgery as their preferred MISST.

In spite of the fact that the majority of responding spine surgeons lacked fellowship training, 33.5% rated their skill level as "Master Surgeon," and "Experienced Surgeon." Another 26.7% of surgeons described their MISST skill level as having "Some Experience." Only 8.9% considered themselves as "Novice Surgeon," and another 6.8%

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indicated that they had no MISST experience (*Table 1*). One third of spine surgeons (32.2%) indicated that more than half of their practice involves MISST cases compared to another 26.4% of surgeons who reported less than half of their cases employing MISST. The remaining 41.4% of surgeons were unsure what the exact percentage of MISST cases in their practice was (*Table 1*).

Cross-tabulation of the reported skill level with spinal endoscopy versus postgraduate residency training in neurosurgery, orthopaedic surgery, and other residency programs showed that there were more master (64.6%) and experienced (52%) surgeons amongst orthopaedic surgeons than amongst responding neurosurgeons at a statistical significant level (P=0.11) with 29.2% and 40%, respectively (*Tables 2,3*). Surgeons with some endoscopy experience and novice endoscopic spine surgeons were also more common amongst orthopaedic surgeons (33.3%/23.1%) when compared to the skill breakdown amongst neurosurgeons (9%/3.8%). Analysis of implementation of spinal endoscopy into day-to-day clinical practice showed that there were near twice as many orthopaedic surgeons (54.3%) using endoscopic procedures in the lumbar spine as their favorite MISST than neurosurgeons (35.4%). However, within the endoscopy trained group of orthopaedic and neurosurgeons, this difference was much smaller and not statistically significant with a P value of 0.096 (*Tables 4,5*).

Discussion

Findings of this opinion survey of 292 spine surgeons who returned a completed online questionnaire indicate that spinal endoscopy is more frequently adopted by orthopaedic surgeons, who also seem to perform it at a higher self-reported skill level and employ it to a more significant percentage of their clinical practice. Responding neurosurgeons (n=97) were less represented in this study group than orthopaedic surgeons (n=161), and it is conceivable that this underlying dichotomy in the study population could have skewed the interpretation of the cross-tabulation results in favor of orthopaedic surgeons. However, the statistical analysis included a thorough review of variances as well as kappa and linear regression analysis of agreement as responses came in throughout the survey period confirming consistency of asymmetric distribution of variance with a statistical deviation of actual from expected variable combination counts at a significant P level for most cross-tabulation results described herein. Thus, this team of authors considered the reported differences in skill level, and formal training in endoscopic spinal surgery not only statistically significant whenever a P value of less than or equal to 0.05 was found, but also clinically meaningful.

This online survey proofed an effective means of collecting factual clinical information from spine surgeons in real time. This survey reached 430 surgeons with 292 valid submissions. The completion rate was 67.4%, and surgeons that used a computer or laptop took significantly less time to complete. The smartphone accessibility of the survey extended its reach to more surgeons who could respond on-the-go anytime and anywhere regardless of busy work schedules. However, the average time to complete more than tripled when using a smartphone (08:54) as if a computer or laptop was used. Presumably, the smaller screen size on the smartphone is of a disadvantage when conducting a survey on complex clinical questions. This should be taken into account in future survey design as completion rates may drop with increasing survey complexity when answered on a small-screen handheld device.

This survey study on training and skill level of endoscopic MISST amongst spine surgeons was blinded, and the team of authors had no information as to the identity of the responding spine surgeons, hence, minimizing the impact of intuition and hindsight bias amongst the investigators. Moreover, the study investigators did not know the distribution of responses and which underlying trends would emerge when the survey launched. Hence, it was unclear at the outset of the online data acquisition when sufficient statistical sample size would have been achieved to close the study. Linear regression monitoring of the change in response rates to the questions over the three weeks and kappa analysis of agreement in the 292 survey submissions showed a relatively stable distribution of asymmetric variances suggesting that similar percentage response rates could have been reasonably expected with a broader polling sample. This added to the authors' confidence that results presented herein are in fact representative of current opinions regarding endoscopic MISST training and skill level amongst spine surgeons.

A small subgroup of surgeons who indicated that they perform endoscopic spinal surgery had a different postgraduate residency training which was not recorded by this survey. Presumably, these surgeons were osteopathic physicians, pain management physicians, radiologists, or anesthesiologist who have also traditionally treated patients for spinal pain and have also ventured into treating sciatica-type low back- and leg pain. Reportedly, this

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Table 2 Spine surgeons' MISST clinical experience rating versus residency training

Variables	Category	Residency training			
		Some other training	Neurosurgeon	Orthopaedic spine surgeon	Total
Experience	Count	17	20	33	70
	Expected count	8.2	23.3	38.6	70.0
	% within experience	24.3	28.6	47.1	100.0
Experienced surgeon	Count	4	20	26	50
	Expected count	5.8	16.6	27.6	50.0
	% within experience	8.0	40.0	52.0	100.0
Master surgeon	Count	3	14	31	48
	Expected count	5.6	15.9	26.5	48.0
	% within experience	6.3	29.2	64.6	100.0
No experience	Count	2	11	7	20
	Expected count	2.3	6.6	11.0	20.0
	% within experience	10.0	55.0	35.0	100.0
Novice surgeon	Count	1	6	19	26
	Expected count	3.0	8.6	14.3	26.0
	% within experience	3.8	23.1	73.1	100.0
Some experience	Count	7	26	45	78
	Expected count	9.1	25.9	43.0	78.0
	% within experience	9.0	33.3	57.7	100.0
Total	Count	34	97	161	292
	Expected count	34.0	97.0	161.0	292.0
	% within experience	11.6	33.2	55.1	100.0

MISST, minimally invasive spinal surgery technique.

Table 3 Chi-square testing results of MISST experience versus residency training

Variables	Value	df	Asymptotic significance (2-sided)
Pearson Chi-square	23.063[a]	10	0.011
Likelihood ratio	21.285	10	0.019
N of valid cases	292	–	–

[a], 2 cells (11.1%) have expected count less than 5. The minimum expected count is 2.33. MISST, minimally invasive spinal surgery technique.

trend has evolved in large part because both orthopaedic and neurosurgeons have long neglected spinal endoscopy (59-61). Therefore, pain management physicians, in spite of lacking formal training in spine surgery, by default have thrived in spinal endoscopy because of unanswered patient demand (62,63). However, this survey did not collect any relevant information in that regard and making any statements beyond that fact other than other types of surgeons, besides orthopaedic and neurosurgeons, are performing endoscopic spinal surgery would be speculation.

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Table 4 Residency training versus endoscopic spinal surgery implementation into clinical practice

Variables	Category	Residency training			
		Some other training	Neurosurgeon	Orthopaedic spine surgeon	Total
No, I am not trained in spinal endoscopy	Count	5	37	75	117
	Expected count	9.2	39.7	68.1	117.0
	% within endoscopic surgery	4.3	31.6	64.1	100.0
	% within training	21.7	37.4	44.1	40.1
Yes, spinal endoscopy is my favorite MIS technique	Count	18	62	95	175
	Expected count	13.8	59.3	101.9	175.0
	% within endoscopic surgery	10.3	35.4	54.3	100.0
	% within training	78.3	62.6	55.9	59.9
Total	Count	23	99	170	292
	Expected count	23.0	99.0	170.0	292.0
	% within endoscopic surgery	7.9	33.9	58.2	100.0
	% within training	100.0	100.0	100.0	100.0

MIS, minimally invasive spinal surgery.

Table 5 Chi-square testing results of residency training versus spinal endoscopy implementation into clinical practice

Variables	Value	df	Asymptotic significance (2-sided)
Pearson Chi-square	4.678[a]	2	0.096
Likelihood ratio	4.943	2	0.084
N of valid cases	292	–	–

[a], 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.22.

Additional analysis of the training background of the responding spine surgeons revealed that only 14% of them were, in fact, fellowship-trained spine surgeons. Therefore, formal study of the impact of spine fellowship training on the skill level of endoscopic spine surgeons was impractical due to low statistical power for this variable. In spite of lack of formal fellowship training in the majority (86%) of spine surgeons and the seemingly contradictory high percentage of experienced and master spine surgeons with 61.6% of them indicating that a substantial portion of the clinical practice was devoted to performing MISST surgeries suggested that the majority of them were autodidacts and self-taught in endoscopic surgery in particular. Unfortunately, this survey did not collect any information on how many years in practice these responding surgeons were after graduating from the respective postgraduate training programs. Neither did the study obtain any information as to whether spine fellowships are keeping up with the fast-moving field of endoscopic MISST. However, the survey results imply that they are not, or at a minimum are not the training centers of contemporary endoscopic MISST. The combination of most surgeons having reported no fellowship training, and 47.6% of them having received their MISST training in small workshops corroborates the conclusion of spine fellowships lagging in teaching contemporary endoscopic MISST.

Another interesting observation related to the statistically significant dichotomy between novice and somewhat experienced orthopaedic and neurosurgeons routinely performing MISST procedures. A higher percentage of these self-reported less experienced surgeon was noted among orthopaedic than neurosurgeon at nearly twice the rate suggesting that orthopedic surgeons are not only more interested in pursuing MISST than neurosurgeons, but also

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indicating that many of them are self-thought since very few of them actually completed a fellowship program in spinal surgery. This trend also seemed to be valid for endoscopic spinal surgery with 53.4%% of orthopaedic surgeons reporting that endoscopic surgery is their preferred MIST versus 35.4% of neurosurgeons, respectively. However, this difference did not meet statistical significance assumptions. In summary, results of this survey study among spine surgeons show that endoscopic spinal surgery has received significant traction; an observation that has been corroborated by others (64,65) who stipulated that endoscopic spinal surgery will evolve into mainstay of MISST (59,61).

Conclusions

This online survey reached 430 spine surgeons in just three weeks suggesting that making a questionnaire accessible on a hand-held device facilitates data acquisition from spine surgeons. This study indicates that the majority of spine surgeons embraced MISST as mainstream and considered them integral part of their clinical practice. Fellowship training among spine surgeons embracing contemporary MISST is currently uncommon. Orthopaedic surgeons were found to be more likely to have implemented contemporary MISST and endoscopic spinal surgery into the routine clinical practice. Workshops and local meetings are currently the main training avenues for endoscopic spinal surgery. Training requirements and implementation of privileges for endoscopic spinal surgery vary in different parts of the world. With increasing traction and patient demand, minimum adequate training will be part of the ongoing debate.

Acknowledgments

None.

Footnote

Conflicts of Interest: The first author has no direct or indirect conflicts. This manuscript is not meant for or intended to endorse any products or push any other agenda other than the associated clinical outcomes with endoscopic spine surgery. The motive for compiling this clinically relevant information is by no means created and/or correlated to directly enrich anyone due to its publication. This publication was intended to substantiate contemporary endoscopic spinal surgery concepts to facilitate technology advancements. Jorge Felipe Ramírez León is shareholder & President of Board of Directors Ortomac, Colombia, consultant Elliquence, USA. The senior author designed and trademarked his *inside-out* YESS™ technique and receives royalties from the sale of his inventions. Indirect conflicts of interest (honoraria, consultancies to sponsoring organizations are donated to IITS.org, a 501c 3 organization).

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Participants were informed in the introduction of the survey that their choices will be analyzed and published without personal identifiers. The respondent surgeon's agreed to publishing their responses by entering the survey.

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