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Polytomous Rasch Analyses of Surgeons' Decision-Making on Choice of Procedure in Endoscopic Lumbar Spinal Stenosis Decompression Surgeries

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ABSTRACT

Background: With the growing prevalence of lumbar spinal stenosis, endoscopic surgery, which incorporates techniques such as transforaminal, interlaminar, and unilateral biportal (UBE) endoscopy, is increasingly considered. However, the patient selection criteria are debated among spine surgeons.

Objective: This study used a polytomous Rasch analysis to evaluate the factors influencing surgeon decision-making in selecting patients for endoscopic surgical treatment of lumbar spinal stenosis.

Methods: A comprehensive survey was distributed to a representative sample of 296 spine surgeons. Questions encompassed various patient-related and clinical factors, and responses were captured on a logit scale graphically displaying person-item maps and category probability curves for each test item. Using a Rasch analysis, the data were subsequently analyzed to determine the latent traits influencing decision-making.

Results: The Rasch analysis revealed that surgeons' preferences for transforaminal, interlaminar, and UBE techniques were easily influenced by comfort level and experience with the endoscopic procedure and patient-related factors. Harder-to-agree items included technological aspects, favorable clinical outcomes, and postoperative functional recovery and rehabilitation. Descriptive statistics suggested interlaminar as the best endoscopic spinal stenosis decompression technique. However, logit person-item analysis integral to the Rasch methodology showed highest intensity for transforaminal followed by interlaminar endoscopic lumbar stenosis decompression. The UBE technique was the hardest to agree on with a disordered person-item analysis and thresholds in category probability curve plots.

Conclusion: Surgeon decision-making in selecting patients for endoscopic surgery for lumbar spinal stenosis is multifaceted. While the framework of clinical guidelines remains paramount, on-the-ground experience-based factors significantly influence surgeons' selection of patients for endoscopic lumbar spinal stenosis surgeries. The Rasch methodology allows for a more granular psychometric evaluation of surgeon decision-making and accounts better for years-long experience that may be lost in standardized clinical guideline development. This new approach to assessing spine surgeons' thought processes may improve the implementation of evidence-based protocol change dictated by technological advances was endorsed by the Interamerican Society for Minimally Invasive Spine Surgery (SICCMI), the International Society for Minimal Intervention in Spinal Surgery (ISMISS), the Mexican Spine Society (AMCICO), the Brazilian Spine Society (SBC), the Society for Minimally Invasive Spine Surgery (SMISS), the Korean Minimally Invasive Spine Society (KOMISS), and the International Society for the Advancement of Spine Surgery (ISASS).

Endoscopic Minimally Invasive Surgery

Keywords: endoscopic lumbar decompression, transforaminal, interlaminar, UBE technique, surgical decision-making, polytomous Rasch methodology

INTRODUCTION

Three endoscopic decompression techniques have emerged as the standards in the treatment of symptomatic lumbar spinal stenosis: (1) the transforaminal,[1–5] (2) the interlaminar,[6–11] and (3) the unilateral biportal endoscopic (UBE)[12–16] technique. The decision on which approach and technique to employ is a multifaceted process, particularly when selecting the most appropriate endoscopic lumbar decompression surgery for spinal stenosis. This condition is characterized by the narrowing within the spine, causing encroachment of neural elements in the central and lateral canal and the neuroforamina. This degenerative process may lead to pain, numbness, and muscle weakness and can impair walking endurance with a clinical syndrome characterized by neurogenic claudication. The choice of surgical technique is critical because it can significantly impact the patient's symptom relief, recovery, and overall quality of life postoperatively.

The Rasch model,[17–24] a form of item response theory, presents a sophisticated means of analyzing complex decision-making processes such as those involved in endoscopic spine surgery. The Rasch model offers a nuanced analysis that goes beyond mere right or wrong choices, instead revealing the probabilistic nature[24] of decisions based on the interaction between the difficulty of the decision and the expertise of the spinal surgeon. In the intricate and high-stakes field of spine surgery, decision-making is a complex process influenced by myriad factors, ranging from patient-specific characteristics to surgeon expertise and systemic variables. Traditional descriptive statistical techniques can fall short in capturing the subtleties of this decision-making process, necessitating a more refined analytical approach. The Rasch model is a mathematical model for analyzing categorical data, such as answers to questions on a reading assessment or survey responses. The Rasch model offers several key advantages:

1. **Quantifying Decision Difficulty and Surgeon Ability**: The model does not only take into account whether a decision was "correct" or "preferred," but also the "difficulty" of each decision, providing a context-dependent view. It aligns this with the surgeon's "ability" or skill level, derived from the consistency of their decisions with those of the expert community.
2. **Creating an Interval-Level Measurement Scale**: While most survey data are ordinal, the Rasch model provides the means to construct an interval-level scale for decision-making ability. This offers more precision and the ability to make meaningful comparisons between individuals or groups, a crucial aspect in the continuous professional development and comparative assessments between surgical teams or techniques.
3. **Invariance and Comparison**: One of the critical properties of the Rasch model is the characteristic of invariance, which allows for the creation of a stable measurement scale. This property ensures that the measurement of an individual's ability is independent of the particular items used for the assessment, making it possible to compare decisions across different contexts and patient cases.
4. **Identifying Misfitting Items**: In the context of surveys or test items used to assess decision-making, the Rasch model can identify "misfitting" items that do not conform to the expectations of the model. These could be decisions that do not contribute constructively to an understanding of a surgeon's competence or expertise, helping in refining assessment tools.
5. **Continuous Improvement, Education, and Clinical Guideline Development**: The insights derived from Rasch analysis can be pivotal in guiding educational interventions, professional development, and systemic improvements, thereby affecting the development of new clinical treatment guidelines. By identifying specific areas of strength and weakness in decision-making, targeted training can be designed, ultimately aiming to enhance patient outcomes.

In this study, the authors employed the polytomous Rasch model to facilitate a deeper understanding of surgical decision-making in the clinical application of the various lumbar endoscopic decompression techniques by treating it as a probabilistic, rather than deterministic, process. This type of analysis respects the complexity of clinical judgment, accommodating the shades of gray that characterize real-world decisions, and surgeons' perceptions of best treatments. By adopting the Rasch analysis, the authors attempted to better understand these surgeon perceptions in a more nuanced, patient-centered, and data-driven paradigm in surgical spine care, realizing that evidence-based education and high-grade clinical outcome studies may not always lead to the desired protocol change because they may contradict surgeons' perceptions of best treatment.

MATERIALS AND METHODS

Surgeon Survey

The authors distributed an online survey via www.typeform.com to 296 potential surgeon respondents through email, chat groups, and messaging platforms such as WhatsApp. Surgeons were prompted to share their views on the various factors that influence the selection of transforaminal, interlaminar, and UBE endoscopic decompression techniques for treating lumbar spinal stenosis. They were asked to indicate their level of agreement with the following 6 statements using a Likert scale from 1 to 5, where 1 = strongly disagree and 5 = strongly agree:

1. **Comfort and Familiarity**: "My decision to select a specific endoscopic decompression technique (transforaminal, interlaminar, or UBE) is heavily influenced by my familiarity and comfort with the procedure."
2. **Patient-Related Factors**: "Patient factors (eg, age, health status, severity, and location of stenosis) are the most crucial determinants in choosing among transforaminal, interlaminar, and UBE endoscopic decompression techniques."
3. **Expected Surgical Outcomes**: "My choice between transforaminal, interlaminar, and UBE endoscopic decompression is significantly influenced by the expected surgical outcomes of each technique."
4. **Technical and Instrumental Aspects**: "The technical and instrumental aspects (eg, availability and familiarity with specific tools and technology) of the endoscopic decompression techniques strongly sway my decision toward one technique over the others."
5. **Postoperative Recovery and Rehabilitation**: "The anticipated postoperative recovery and rehabilitation profile of the patient play a pivotal role in determining the choice of endoscopic decompression technique."
6. **Which endoscopic procedure is the best?**: "Taking all the pros and cons into consideration, please rate your preference for lumbar spinal stenosis with the transforaminal, interlaminar, or UBE technique."

Additionally, surgeons were asked to provide details about their practice environment, postgraduate education, and experience with endoscopic procedures. Additional comments and thoughts or experiences that influenced surgeons' decision-making in selecting an endoscopic decompression technique for lumbar spinal stenosis were also solicited. Surgeons could upload representative case examples. This survey study was conducted from 16 October 2023 to 18 October 2023. The data were exported to Microsoft Excel and then analyzed using IBM SPSS (version 27) and Jamovi (version 2.3) software. The analysis employed descriptive metrics to quantify replies and compute averages, ranges, standard deviations, and percentages. The χ^2 test was used to gauge the correlation between variables. A P value below 0.05 was deemed significant, with a 95% confidence interval applied to all statistical evaluations.

The Rasch Methodology

The authors employed the polytomous Rasch model analysis described by Andrich[22]:

$$\Pr\{X_{ni} = x\} = \frac{\exp \sum_{k=0}^{x} (\beta_n - (\delta_i - \tau_k))}{\sum_{j=0}^{m} \exp \sum_{k=0}^{j} (\beta_n - (\delta_i - \tau_k))}$$

where δ_i is the difficulty of item I, and τ_k is the kth threshold location of the rating scale that is in common with all the items. m is the maximum score and is identical for all the items. τ_0 is chosen for computational convenience. When employed in a specific empirical scenario, this model posits that the likelihood of a certain result is a probabilistic outcome driven by these individual and item characteristics. Ordered response data incorporates the likelihood of an answer falling into a specific category (for instance, the chance of choosing strongly agree, agree, disagree, or strongly disagree). The category probability curve (CPC) visually depicts the relationship between the probability of a particular category being chosen and the respondent's stance generated for each category. This curve displays a person's location in logits, representing their natural log odds (x axis) of agreement with a series of items. Individuals exhibiting stronger adherence to the attitude being evaluated tend to affirm items more favorably, resulting in their locations (in logits) appearing further to the right on the scale. Therefore, the CPC illustrates the likelihood of a responding surgeon choosing a certain response category, dependent on their degree of agreement with the item as well as the item's intensity or challenge.

In our study, the CPCs for each of the 6 items are presented with the 5 possible categories. In ordered response data, ascending scores signify growing concurrence with a specific statement or item. In our study, the "ability" reflects the intensity of a surgeon's agreement with the survey question, while "item difficulty" indicates the surgeon's ease of endorsement of the item. The crossover between CPCs of 2 neighboring categories having an equal likelihood of selection is known as the threshold. For data to conform to the Rasch model, these threshold points must be properly sequenced. This implies that respondents perceive choosing "strongly agree" as indicative of a more profound affinity for the underlying attribute than merely selecting "agree." Consequently, surgeons with elevated overall degrees of the intrinsic characteristic in question would uniformly opt for higher-ranking responses, while those with diminished levels of the trait would habitually select responses with lower scores.

In mathematical terms, the Rasch model represents the log odds (or logit) of a person successfully responding to an item as the difference between the person's ability and the item's difficulty. This model employs χ^2 fit statistics to control the applicability of data to the model. The χ^2 in common use is known as outfit and infit. The compatibility of individual items with the model was assessed through (1) analysis of individual item log residual fit statistics, (2) the item-trait interaction fit test (utilizing a χ^2 method), and (3) visual examination of the item characteristic curves (ICCs). The collective outcomes of these methods informed the determination of whether items properly conformed to or deviated from the model. A negative fit residual signifies that an item discriminates more than the average discrimination across all items, whereas a positive value indicates subpar discrimination. Typically, log residual fit statistics falling between −2.5 and 2.5 are deemed acceptable. The χ^2 test hypothesizes no discrepancy between observed and expected values for a specific CPC.

RESULTS

A digital questionnaire designed to objectively gauge the psychometric components of surgeons' decision-making when selecting lumbar endoscopic spinal decompression procedures when surgically treating patients suffering from symptomatic spinal stenosis was accessed by 296 spine specialists. Of these, 169 embarked on the survey, with 83 providing complete, valid inputs—a response rate of 49.1%. The array of respondents predominantly comprised neurosurgeons (44.6%) and orthopedic specialists (36.1%). Another 12% of respondents were exclusively devoted to spinal surgeries, and a meager 2.4% focused on pain management; thus, 96.9% had surgical postgraduate training. Private practice was indicated as the primary workplace by 66.3% of the respondents, whereas 31.3% practiced in institutions, with the remaining 2.4% serving in other practice environments (Figure 1). Based on surgeon demographic identifying information, the authors were able to ascertain that responding surgeons had a minimum experience of 5 years with an annualized volume of at least 85 lumbar endoscopic surgery cases.

In terms of professional affiliations (Figure 1), the roster included esteemed memberships from NASS, the North American Spine Society (30.1%); the Brazilian Society of Orthopedics and Traumatology (SBOT, Sociedade Brasiliera de Ortopedia y Traumatologia; 30.1%); the Brazilian Spine Society (SBC, Sociedade Brasiliera de Columna; 28.9%), the Interamerican Society for Minimally Invasive Spinal Surgery (SICCMI, Sociedad Interamericana De Cirugia De Columna Minimamente Invasiva; 16.9%); AAOS, American Academy of Orthopedic Surgeons – 13.3%; KOMISS, Korean Minimally Invasive Spine Society – 13.3%; KOSESS Korean Endoscopic Spinal Surgery Society – 13.3%; SILACO, Sociedad Iberolatinoamericana de Columna – 12.0%; SMISS, Society For Minimally Invasive Spine Surgery – 10.8%; the Mexican Spine Society (AMCICO, Asociación Mexicana de Cirujanos de Columna, A. C.; 9.6%); the Latin American Federation of Neurosurgical Societies (FLANC, Federacion Latinoamericana de Sociedades De Neurocirurgia; 6.0%); the Brazilian Neurosurgery Society (SBN, Sociedade Brasiliera de Neurocirurgia; 6.0%); ISASS, International Society For The Advancement Of Spine Surgery – 4.8%; the Colombian Spine Society (Sociedad Colombiana de Cirurgia – SOCCOL 4.8%); the European Spine Society – 3.6%; AANS, American Association of Neurological Surgeons – 2.4%; Asean MISST – 2.4%; CNS, Congress of Neurological Surgeons – 2.4%; the Mexican Endoscopic Spine Surgery

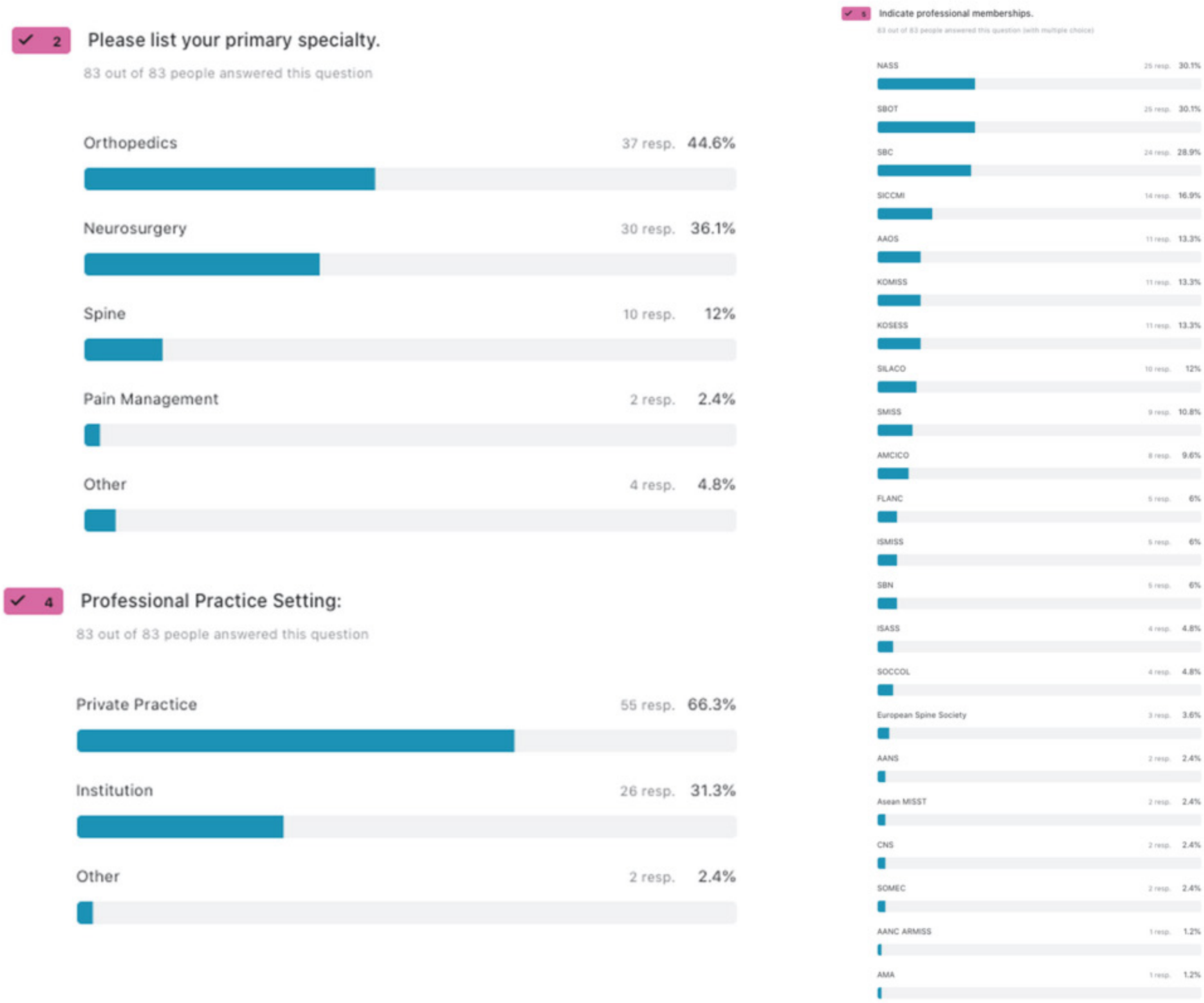

Figure 1. The majority of responding surgeons were orthopedists (44.6%), followed by neurosurgeons (36.1%) and designated spine specialists (12.0%). Only 2.4% of respondents were pain management physicians. Most respondents were in private practice (66.3%), and 31.3% practiced in institutions. The represented respondents' societies in decreasing order (considering multiple memberships per respondent) were as follows: NASS, North American Spine Society (30.1%); Brazilian Society of Orthopedics and Traumatology (SBOT, Sociedade Brasiliera de Ortopedia y Traumatologia; 30.1%); Brazilian Spine Society (SBC, Sociedade Brasiliera de Columna; 28.9%); Interamerican Society for Minimally Invasive Spinal Surgery (SICCMI, Sociedad Interamericana De Cirugia De Columna Minimamente Invasiva; 16.9%); AAOS, American Academy of Orthopedic Surgeons (13.3%); KOMISS, Korean Minimally Invasive Spine Society (13.3%); KOSESS Korean Endoscopic Spinal Surgery Society (13.3%); SILACO, Sociedad Iberolatinoamericana de Columna (12.0%); SMISS, Society For Minimally Invasive Spine Surgery (10.8%); Mexican Spine Society (AMCICO, Asociación Mexicana de Cirujanos de Columna, A. C.; 9.6%); Latin American Federation of Neurosurgical Societies (FLANC, Federacion Latinoamericana de Sociedades De Neurocirurgia; 6.0%); Brazilian Neurosurgery Society (SBN, Sociedade Brasiliera de Neurocirurgia; 6.0%); ISASS, International Society For The Advancement Of Spine Surgery (4.8%); Colombian Spine Society (Sociedad Colombiana de Cirurgia, SOCCOL; 4.8%); European Spine Society (3.6%); AANS, American Association of Neurological Surgeons (2.4%); Asean MISST (2.4%); CNS, Congress of Neurological Surgeons (2.4%); Mexican Endoscopic Spine Surgery Society (SOMEC, Sociedad Mexicana de Endoscopia de Columna; 2.4%); AMA, American Medical Assocition (1.2%); and German Spine Society (DWG, Deutsche Wirbelsäulengesellschaft; 1.2%).

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The item response theory polytomous Rasch partial agreement analysis was employed to assess spine surgeons' level of endorsement of 6 test items (Figure 2), including patient outcomes, comfort with the procedure, instruments, patient factors, rehabilitation, and preferred lumbar endoscopic stenosis decompression technique—transforaminal, interlaminar, or UBE (Table 1). The resulting Wright plot is shown in Figure 3. It suggests one assessment gap and some redundancy between test items such as patient outcomes, technical aspects and instruments, patient rehabilitation considerations, and the transforaminal and UBE decompression techniques. A more granular assessment of surgeons' decision-making in endoscopic spine surgery is given in the corresponding person-item map (Figure 4), which shows the logarithmically transformed person and item positions on a unified continuum using the logit measurement unit, transitioning ordinal data to

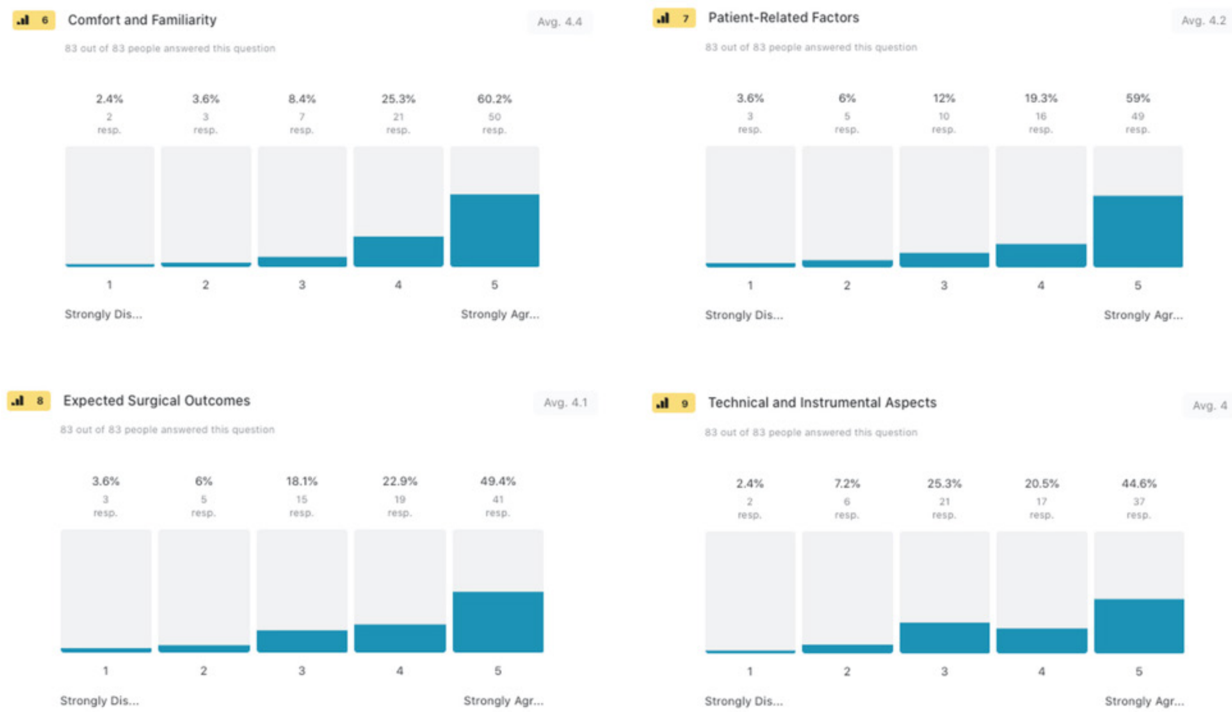

Figure 2. Descriptive statistics showed comfort level and procedural familiarity (60.2%) and patient-related factors (59.0%) being the most influential factors when choosing a lumbar endoscopic decompression procedure. Secondary components of surgical decision-making were expected surgical outcomes (49.4%) and technical and instrumental aspects (44.6%).

equal-interval data. A surgeon's logit location indicates their natural log odds of partial agreement with the test items. The items "comfort level with the endoscopic procedure," "patient-related factors," "interlaminar," and "transforaminal technique" were the easiest to agree on (Tables 1 and 2). These items also had the smallest spread of logit locations. The most challenging item to agree on was "clinical outcomes," "postoperative rehabilitation," and "UBE."

Table 1. Rasch model item statistics of the rating scale model for confounding factors impacting surgical decision-making.

Test Items	Measure	SE Measure	Infit	Outfit
Comfort	−1.353	0.133	0.924	0.809
Patient	−1.159	0.122	1.448	1.542
Outcome	−0.993	0.114	0.936	0.963
Instruments	−0.867	0.110	0.761	0.749
Rehab	−0.785	0.107	1.058	1.048

Model Fit	Person Reliability	*P*
Scale	0.381	0.061

Note: Infit = Information-weighted mean square based on the χ^2 statistic with each observation weighted by its statistical information (model variance). This is more sensitive to unexpected patterns of observations by persons on items that are roughly targeted at them (and vice-versa). Outfit = Outlier-sensitive means square statistic is more sensitive to unexpected observations by surgeons. Infit and outfit data between 0.6 and 1.4 indicate good fit of the Rasch model. MADaQ3 = Mean of absolute values of centered Q_3 statistic with *P* value obtained by Holm adjustment; Ho = the data fit the Rasch model.

Contrary to the descriptive statistical analysis (Figure 5), the mean logit location (Figure 3 and Figure 4 with items more shifted to the right of the plot) showed more intense partial agreement for the individual categories of the transforaminal rather than the interlaminar test item, indicating that the transforaminal technique was considered the best and most accepted lumbar endoscopic stenosis decompression procedure by surgeons versed in its practice. In comparison, the items testing the importance of endoscopic instruments, clinical outcomes, rehabilitation, and the relevance of UBE had a wider disorderly spread of logit locations. The person-item maps also illustrate that items were reasonably well distributed. However, some surgeons could not be measured as reliably as the majority by this set of items, indicating the test items were either too intense or not intense enough for them. The black circles highlight these areas. The analysis also showed disordered thresholds of endorsement for the 5 test items shown in the left plot and UBE (right-sided plot), suggesting that surgeons had difficulty consistently discriminating between response categories ranging from strongly disagree (1), disagree (2), agree (3), to strongly agree (4)—a problem observed when there are too many response options (all disordered items shown in red). Examining the order and location of these test

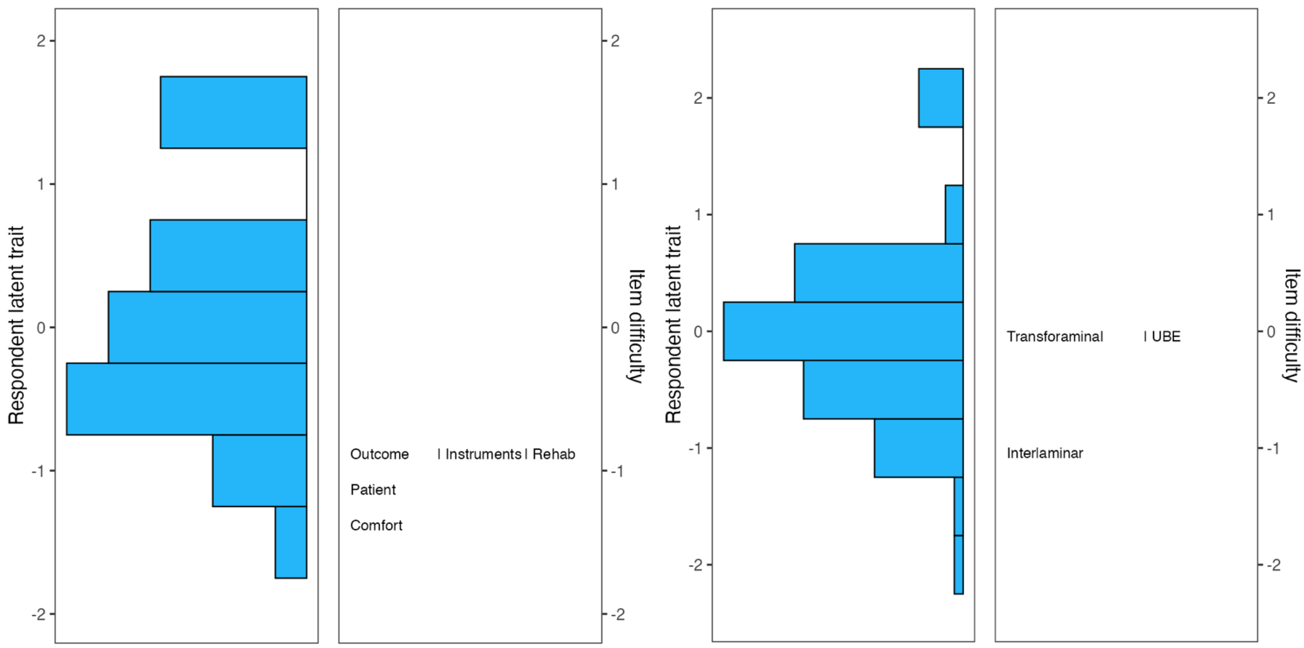

Figure 3. The item response theory polytomous Rasch partial agreement analysis was employed to assess spine surgeons' level of endorsement of 6 test items (patient outcomes, comfort with the procedure, instruments, patient factors, rehabilitation, and preferred lumbar endoscopic stenosis decompression technique) regarding the endoscopic lumbar decompression surgery (Table 1). Shown is the resulting Wright plot. On the left, the responding surgeons' latent traits are written in logits (log odds) as estimates of true intervals of item difficulty and surgeon ability. The surgeons represented by horizontal bars at the top indicated a higher level of endorsement for the individual test components of endoscopic spinal surgery (positive logits) than those on the bottom (negative logits). On the right, the higher-level endorsement harder to agree on items are listed at the top vs the easier to agree ones on the bottom. There was an assessment gap at the top of the Wright plot and redundancy between test items such as patient outcomes, technical aspects and instruments, patient rehabilitation considerations, and transforaminal and unilateral biportal (UBE) technique, illustrating the need for a more granular assessment of surgeons' decisions by refining the test.

items reveals an uneven distribution of the ranked order of item difficulties or intensities along the logit continuum. The authors considered collapsing adjacent item categories for these 6 items where the problem occurred. However, they refrained from doing so to expose the wide variety of item difficulties or intensities as they illustrate the true complexity of the thought process of surgical decision-making. In comparison, the logits for item categories regarding transforaminal and interlaminar technique were ordered (all ordered items shown in black), suggesting a good fit to the Rasch model without any statistically significant difference between the observed values and the values predicted by the model (Table 2).

In addition to the infit/outfit statistics, each item underwent a visual review of its graphical representation using its ICC to assess the alignment between anticipated and actual values. Figure 6 displays the ICCs for the item "transforaminal" (on the left)—deemed the best fit, in contrast to "instruments" (on the right)—now regarded as one of the least fitting items. Dots graphically denote the average response of individuals in each class interval, while the solid blue curve represents the expected values (Figure 6). Given the close alignment of these points for every test item, none were excluded. CPC was constructed for each of the 8 test items to visually depict the relationship between the probability of a particular category being chosen and the respondent surgeon's stance generated for each category. Ordered sequencing of the thresholds (crossover between CPCs of 2 neighboring categories having an equal likelihood of selection) was graphically demonstrated for the "transforaminal" and "interlaminar" test items (Figure 7; Tables 1 and 2). Hence, the data conformed to the Rasch model. This good fit was not observed for the other test items, including "UBE," where these threshold points were disorderly sequenced (Figure 7; Tables 1 and 2). Figure 7 illustrates that for test item "UBE," the first threshold (ie, where the probability of responding in either category 0 or 1 intersects) occurred after the second threshold (where categories 1 and 2 intersect) along the logit continuum, suggesting that for persons located anywhere along the response continuum, and especially for those persons located at the maximum value for this category, disagreeing with the item (ie, selecting category strongly disagree) is never the most probable response. Disordered threshold sequencing was also observed for the items "comfort with the technique" (threshold sequence 3, 2, 1, and 4), "patient-related factors" (threshold sequence 2, 1,

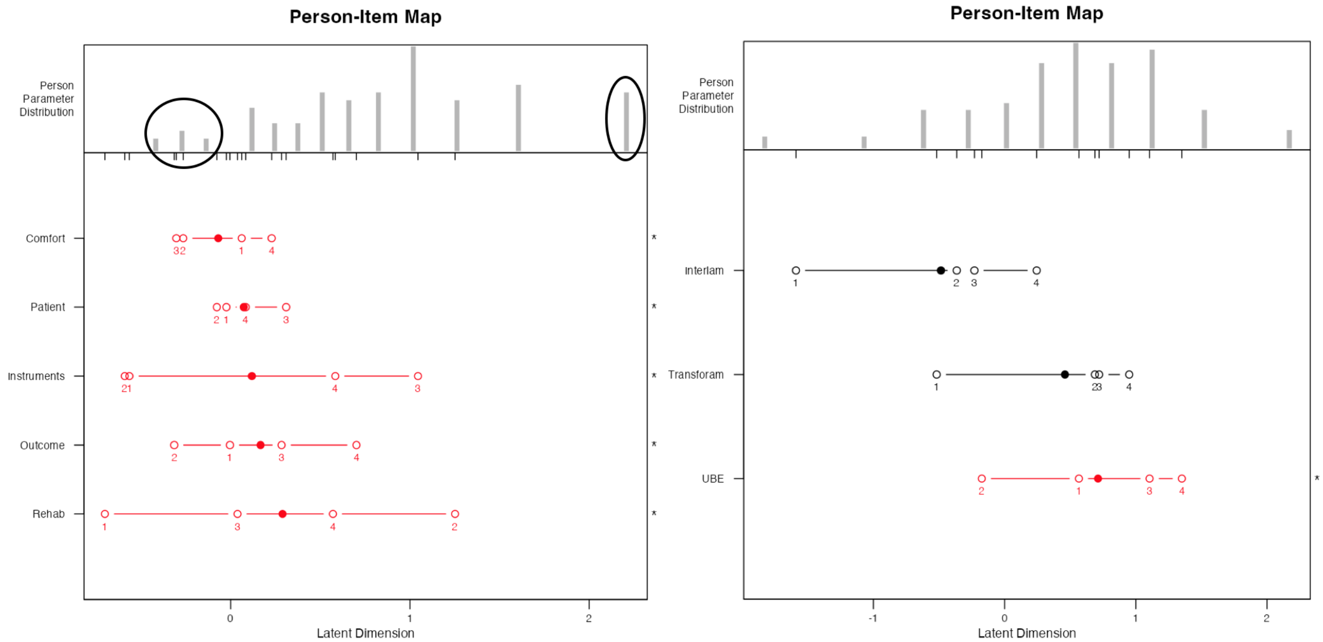

Figure 4. The person-item maps show the logarithmically transformed person and item positions on a unified continuum using the logit measurement unit, transitioning ordinal data to equal-interval data. This method charts both person and item positions (in logits) along the x axis. Within Rasch modeling, these values are labeled as "locations" rather than "scores." A surgeon's logit location indicates their natural log odds of agreement with a series of items. Individuals with pronounced adherence to the considered attitude affirm items favorably, positioning them further to the right on the scale. The solid dots indicate the mean person location scores. The items "comfort level with the endoscopic procedure," "patient-related factors," "interlaminar," and "transforaminal technique" were easier to agree on (Tables 1 and 2). These items also had the smallest spread of logit locations. The more challenging items to agree on were "clinical outcomes," "postoperative rehabilitation," and "unilateral biportal (UBE)." Contrary to the descriptive statistical analysis (Figure 5), the mean logit location (items more shifted to the right of the plot) showed more intense partial agreement for the transforaminal rather than the interlaminar technique being the best lumbar endoscopic stenosis decompression procedure. In comparison, the items testing the importance of endoscopic instruments, clinical outcomes, rehabilitation, and the relevance of UBE had a wider spread of logit locations. The person-item maps also illustrate that items were reasonably well distributed. However, some surgeons could not be measured as reliably as the majority by this set of items, indicating the test items were either too intense or not intense enough for them. The black circles highlight these areas. The analysis also showed disordered thresholds of endorsement for the 5 test items shown in the left plot and UBE (right-sided plot), suggesting that surgeons had difficulty consistently discriminating between response categories ranging from strongly disagree (1), disagree (2), agree (3), to strongly agree (4)—a problem observed when there are too many response options (all disordered items shown in red). Examining the order and location of these test items revealed an uneven distribution of the ranked order of item difficulties or intensities along the logit continuum. The authors considered collapsing adjacent item categories for these 6 items where the problem occurred. However, they refrained from doing so to expose the wide variety of item difficulties or intensities as they may illustrate the true complexity of the thought process of surgical decision-making. In comparison, the logits for item categories regarding transforaminal and interlaminar technique were ordered (all ordered items shown in black), suggesting a good fit to the Rasch model without any statistically significant difference between the observed values and the values predicted by the model (Table 2).

Table 2. Rasch model analysis item statistics of the rating scale model for selecting 1 of 3 endoscopic techniques as the best for lumbar spinal stenosis decompression.

Endoscopic Techniques	Measure	SE Measure	Infit	Outfit
Transforaminal	−0.0967	0.0959	1.024	1.027
Interlaminar	−1.0080	0.1177	0.985	0.990
UBE	0.0136	0.0959	0.956	0.951

Model Fit	Person Reliability	*P*
Scale	0.328	1.000

Note: Infit = Information-weighted mean square based on the χ^2 statistic with each observation weighted by its statistical information (model variance). This is more sensitive to unexpected patterns of observations by persons on items that are roughly targeted at them (and vice-versa). Outfit = Outlier-sensitive means square statistic is more sensitive to unexpected observations by surgeons. Infit and outfit data between 0.6 and 1.4 indicate good fit of the Rasch model. MADaQ3 = Mean of absolute values of centered Q_3 statistic with *P* value obtained by Holm adjustment; Ho = the data fit the Rasch model.

4, and 3), "instrument and technical factors" (threshold sequence 2, 1, 4, and 3), "outcomes" (threshold sequence 2, 1, 4, and 3), and "rehabilitation" (threshold sequence 1, 3, 4, and 2).

DISCUSSION

Spine surgeons rely on their personal perceptions and clinical experiences when making crucial surgical decisions. In the fast-moving field of endoscopic spine surgery, 3 techniques have emerged—(1) the transforaminal,[1–5] (2) the interlaminar,[6–11] and (3) the UBE[12–16] techniques. The current clinical evidence suggests that all 3 produce favorable clinical outcomes in treating lumbar spinal stenosis. While high-grade clinical evidence and clinical guidelines are essential

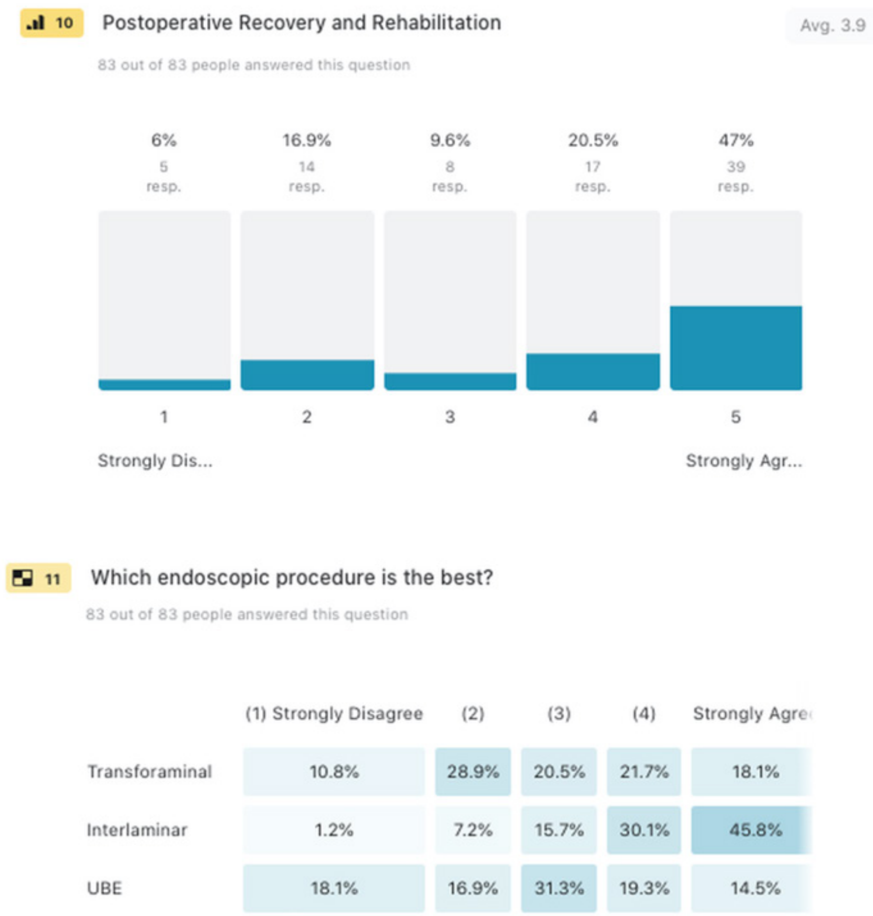

Figure 5. Ease of postoperative recovery (47%) was also considered an essential confounding factor in surgeons' decision-making on the most appropriate choice of lumbar endoscopic decompression surgery for symptomatic spinal stenosis. However, the descriptive statistical breakdown of the level of agreement or disagreement of the best endoscopic technique for lumbar spinal stenosis decompression lacked granular detail. Although the descriptive cross-tabulation analysis on its surface suggested that the transforaminal technique (39.8%) was least applicable to lumbar endoscopic spinal stenosis decompression and the interlaminar technique (75.9), no conclusion could be drawn about the unilateral biportal (UBE) technique with 33.8% identifying the technique as an applicable to endoscopic decompression of lumbar spinal stenosis, vs 35% disagreeing with that statement, and 31.3% of responding surgeons being undecided.

in establishing standard-care parameters, the nuanced nature of each patient's case means that a surgeon's perception of what is best for the patient may supersede these clinical guidelines or protocol changes suggested by recent high-grade clinical studies. Surgeons spend years honing their craft, developing intuition, and cultivating an in-depth understanding of their patient's unique needs, fears, and expectations. This intimate, patient-centric approach fosters trust and understanding that standardized guidelines alone cannot achieve. Therefore, even in the face of established evidence or guidelines, spine surgeons might prioritize their perceptions of optimal patient care, believing that their hands-on experience and familiarity with individual patients provide insights that generalized recommendations might overlook.

Furthermore, spine surgeons' decisions are influenced by complex factors, including their training, experience, and, importantly, their perceptions of the best care for their patients. The patient's anatomy, medical comorbidities, and painful pathology, particularly after previous surgery, are additional confounding factors that influence the surgeon's perception, developed through years of hands-on experience. These perceptions often become the primary guiding force because spine surgeons may feel that even the highest-grade evidence provided by double-blinded randomized prospective clinical trials may not apply to their particular patient. After all, the derived clinical guidelines were often developed from studies with their own limitations, such as inclusion and exclusion criteria, which might not always encompass the broad spectrum of patients surgeons encounter in real-world settings. In addition, the patient-surgeon relationship plays a pivotal role. Spine surgeons gain insights into a patient's lifestyle, occupation, aspirations, and fears

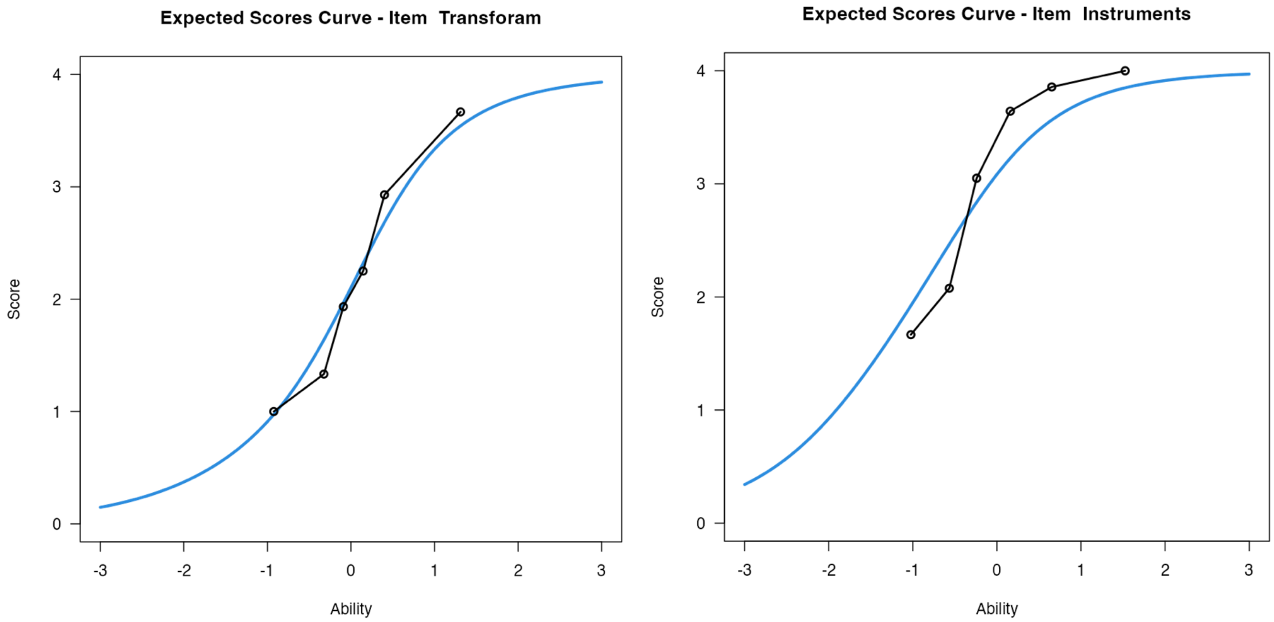

Figure 6. Each item underwent a visual review of its graphical representation using its item characteristic curve (ICC) to assess the alignment between anticipated and actual values. Exemplary ICCs are displayed for the item "transforaminal" (on the left)—deemed the best fit, in contrast to "instruments" (on the right)—now regarded as one of the least fitting items. Dots graphically denote the average response of individuals in each class interval, while the solid blue curve represents the expected values predicted by the Rasch model. Given the close alignment of these points for every 1 of the 8 test items (only 2 shown here), none were excluded.

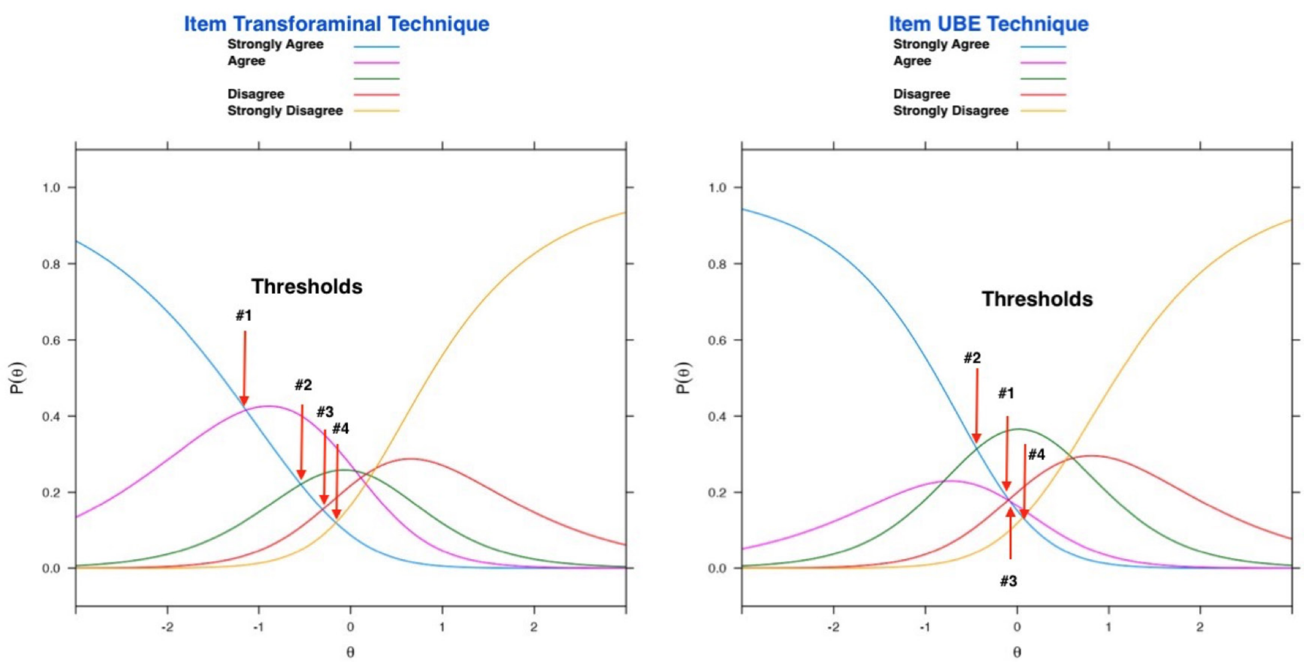

Figure 7. Category probability curve (CPC) is shown for test items "transforaminal" and unilateral biportal ("UBE"). They visually depict the relationship between the probability of a particular category being chosen and the respondent surgeon's stance, generated for each category. Ordered sequencing of the thresholds (crossover between CPCs of 2 neighboring categories having an equal likelihood of selection) was graphically demonstrated for "transforaminal." Hence, the data conformed to the Rasch model. This was not the case for the other test items including "UBE" where these threshold points were disorderly sequenced, where the first threshold (ie, where the probability of responding in either category 0 or 1 intersect) occurred after the second threshold (where categories 1 and 2 intersect) along the logit continuum suggesting that for surgeons located anywhere along the response continuum, and especially for those surgeons located at the maximum value for this category, disagreeing with the item (ie, selecting category strongly disagree) is never the most probable response.

through discussions. These insights, which may go beyond the clinical guidelines' foundational framework, can significantly influence surgical decisions, particularly in early adoption scenarios. Through continuous education and peer interactions, spine surgeons often employ new methods they perceive to offer better patient outcomes. Endoscopic spine surgery is one such example, where its most recent innovations and techniques are yet to be fully integrated into formal guidelines. Since the on-the-ground decision-making often leans heavily on spine surgeons' perceptions of best patient care, stemming from their expertise, experience, and the trust they build with their patients, the authors of this study were keenly interested in better understanding the surgical decision-making when recommending the endoscopic spinal surgery platform in the treatment of lumbar spinal stenosis. They surveyed 296 spine specialists with a response rate of 49.1%. Of the 83 surgeons who completed the survey, 44.6% were neurosurgeons, 36.1% were orthopedic surgeons, and another 12% were exclusively devoted to spinal surgeries. The majority of responding surgeons (66.3%) worked in private practice and represented a myriad of respectable spine societies.

The polytomous Rasch model analysis[25,26] is suitable for psychometrically measuring the intensity of agreement by employing fit statistics alongside visual analysis to determine whether a group of items forms a unidimensional scale with consistent interval characteristics, thus maintaining scale scores across diverse groups. Central to the model is the principle of invariance, with the analysis aimed at pinpointing data irregularities that could jeopardize this uniformity in measurement. Identifying these irregularities enhances comprehension of the attribute under assessment.[27] Traditionally, the objective is to refine the data's alignment with the model's criteria until there is an adequate correlation to ensure stable measures in a distinct test item. This objective can be realized by removing or altering items, creating new ones, occasionally excluding specific individuals, or extending the assessment to additional person groups. In the authors' application, we used the Rasch analysis to understand the psychometrics of surgical decision-making better when choosing between the various lumbar endoscopic decompression surgeries to treat spinal stenosis. In the absence of an right or wrong external unbiased criterion to further calibrate the questions before launching the survey, the authors employed the Rasch methodology as an examination tool which primarily uses internal criteria to evaluate and measure responses to items within a test or survey and report on those in which the expected order of response categories did progress in a clear, linear manner, and on those that did not. We intentionally did not collapse item characteristics to improve the fit of the model. Instead, we merely analyzed the fit to expose disordered thresholds, especially for those persons located at the maximum value for a category, disagreeing with the item where selecting a category strongly disagree is never the most probable response. Descriptive statistics alone would never be able to expose the intensity of agreement that ultimately reflects the surgeon's ability while highlighting the ease of endorsement by selecting an item difficulty. For example, the mean logit location analysis showed more intense partial agreement (Figure 4) for the individual categories of the transforaminal rather than the interlaminar test item, indicating that the transforaminal technique was considered the best lumbar endoscopic stenosis decompression procedure by responding surgeons contrary to the descriptive statistics outcome (Figure 5). In comparison, the items testing the importance of endoscopic instruments, clinical outcomes, rehabilitation, and the relevance of UBE had disordered thresholds (Figure 7) and broader spread of logit locations (Figure 6). The person-item maps also illustrate that some surgeons could not be measured as reliably as the majority by this set of items, indicating the test items were either too intense or not intense enough for them.

The psychometric Rasch analysis can expose these otherwise hidden nuances in surgical decision-making by logarithmically transforming person and item positions, which then can be depicted on a unified continuum using a standard measurement unit called a logit, thus transitioning ordinal data into equal-interval data. An item's position can be understood as the overall challenge responding surgeons faced in positively answering a specific item. Items situated to the right of the continuum's central point of 0 logits (meaning they have a positive logit value) present more of a challenge for endorsement than those on the left (with a negative logit value). The item's content clarifies what constitutes more or less of the measured concept. Items of higher intensity are typically confirmed solely by individuals with elevated cumulative scores across various items. This new approach to assessing spine surgeons' thought processes was endorsed by the Interamerican Society for Minimally Invasive Spine Surgery (SICCMI), the International Society for Minimal Intervention in Spinal Surgery (ISMISS), the Mexican Spine Society (AMCICO), the Brazilian Spine Society (SBC), the Society for Minimally Invasive Spine Surgery (SMISS), the Korean Minimally Invasive Spine Society

(KOMISS), and the International Society for the Advancement 0f Spine Surgery (ISASS) as their leadership thought it may improve the implementation of evidence-based protocol change dictated by technological advances.

In contrast, simpler or less intense items tend to receive affirmation from a broader respondent base, encompassing even those with lower aggregate scores. In our study, the easiest items to agree on were comfort level with the endoscopic procedure and patient-related factors, suggesting that these items are less controversial when selecting patients for lumbar endoscopic stenosis decompression. Regarding the preferred procedure, the items "interlaminar" and "transforaminal technique" were the easiest to agree on, indicating that surgeons had high confidence in these procedures being effective in treating lumbar spinal stenosis. The most challenging items to agree on were clinical outcomes and postoperative rehabilitation, suggesting that patient selection is most controversially influenced by concerns regarding the ability to achieve adequate clinical outcomes and recovery of day-to-day functioning with the endoscopic surgery platform when treating patients for lumbar spinal stenosis. The UBE procedure was the most controversial and the hardest for surgeons to agree on its suitability for endoscopic lumbar spinal stenosis treatment. While one possible explanation for the disorderly UBE item thresholds is the lack of scale sensitivity to capture nuanced differences in respondents' attitudes or perceptions, leading to unexpected jumps or reversals in category use, the more reasonable explanation is the relative novelty of this emerging endoscopic surgical technique with less adoption, surgeon acceptance, or broader clinical experience than with the other two more traditional transforaminal and interlaminar techniques. Future closer examination of the disordered responses found in this study may potentially overcome the limitations inherent to the authors' current study methodology and findings.

CONCLUSIONS

Understanding surgeons' thought processes in preoperative decision-making and patient selection for spinal surgery may offer additional insights into how clinical evidence is applied in day-to-day practice under real-world conditions. The application of logits in clinical research offers multiple benefits compared with raw scores. One significant advantage is that they provide a unified scale with a standard unit, enabling researchers to effortlessly visualize the relative difficulty or intensity of items and pinpoint an individual's position concerning all items.[23] Furthermore, transforming ordinal data into equal-interval data ensures that any logit variance represents a consistent capability or inherent trait possession disparity.[23] As a result, the summation of item or person logit positions can be incorporated into conventional statistical evaluations used to update clinical guidelines. In addition, unlike unprocessed scores for persons and items, these logit measures facilitate comparisons among patients within the same cohort, irrespective of the items selected, as well as item comparisons regardless of the participants included in the analysis.[28] This approach may highlight underlying hidden dynamics in patient selection for endoscopic lumbar spine surgery, changing how we interpret high-grade evidence and formulate clinical guidelines.

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