Selective Nerve Root Injections Can Predict Surgical Outcome For Lumbar and Cervical Radiculopathy

Comparison to Magnetic Resonance Imaging

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Objective: Diagnostic selective nerve root injection (SNI) results were analyzed in 101 patients who underwent lumbar or cervical decompression for radiculopathy and compared to surgical outcome 1 year postoperatively. A comparison of surgical outcomes was also examined between magnetic resonance imaging (MRI) and SNI results.

Results: Of the 101 patients, 91 (90%) had positive and 10 had negative SNI results at the level operated. Ninety-one percent of the patients with a positive SNI had good surgical outcomes, whereas 60% of the patients with a negative SNI had good outcomes. Of the patients with a positive MRI result, 87% had good surgical outcomes, whereas a similar percentage of the patients with a negative MRI (85%) had good surgical outcomes. When findings between SNI and MRI differed (n = 20), surgery at a level consistent with the SNI was more strongly associated with a good surgical outcome. Of the patients with a poor surgical outcome, surgery was most often performed at a level inconsistent with the SNI finding.

Conclusions: Our study found that a diagnostic SNI can safely and accurately discern the presence or absence of cervical or lumbar radiculopathy. The diagnostic SNI can persuade surgeons from operating on an initially suspicious, but incorrect, level of radiculopathy. In cases where MRI findings are equivocal, multilevel, and/or do not agree with the patient’s symptoms, the result of a negative diagnostic SNI (ie, lack of presence of radiculopathy) becomes superior in predicting the absence of an offending lesion.

Key Words: selective nerve root injection, radiculopathy, nerve root compression


To ensure a successful surgical outcome in nerve root decompression surgery, it is of paramount importance to have a precise preoperative diagnosis. Despite well-planned procedures, the reoperation rates after lumbar discectomy are reported to range from 5% to 50%, with an average estimate of 15%. Lack of improvement and repeated surgeries may lead to inexact methods that are used to determine surgical localization. Static imaging studies may not correspond with clinical signs or symptoms. Confounding factors may include patients with equivocal, multilevel, or extraforaminal pathology and nerve root anomalies. “Positive findings” on magnetic resonance imaging (MRI) occur in up to 60% of asymptomatic subjects, and it is well accepted that the presence of mechanical compression is not always associated with painful radiculopathy. All of these factors make it difficult for the surgeon to determine the best surgical approach. Equivocal or multilevel pathology on imaging studies may result in a decision to do surgery at multiple levels despite a singularly painful lesion. However, pain emanating from multiple spinal sources at the same time is uncommon. Although multilevel surgery may result in an initially “good” surgical outcome, these patients have a higher predisposition to instability from a multilevel laminectomy and, in instances of fusion, adjacent-level degeneration and pseudoarthrosis.

When careful evaluation and imaging do not make the diagnosis clear in patients presenting with radicular or radicular-like symptoms, some clinicians consider a selective nerve root injection (SNI) to be a pivotal diagnostic test in making a determination for surgery. This test uses pain relief as a diagnostic endpoint in attempting to detect the presence of radiculopathy. If complete pain relief occurs, the SNI result ostensibly indicates the presence of pain transmission within the distribution of the nerve root examined. The objectives of this study were to assess the relationship between SNI data on the affected level with the level operated by the surgeon, independently examine SNI and MRI results, and compare SNI and MRI 1-year surgical outcomes in patients undergoing cervical and lumbar decompression for radiculopathy. The purpose was to determine which test best predicts surgical outcome.

MATERIALS AND METHODS

The database of SNIs performed at our institution from 1996 to 1999 reveals 573 patients who had suspected cervical or lumbar radiculopathy. Subsequently, 104 patients underwent surgical decompression. Two of the 104 were lost to follow-up, and 1 patient had spinal trauma 8 months after surgery. Therefore, a total of 101 patient records were available for review. To be included in this study, each patient must have
undergone SNI, MRI, and a nerve root decompression surgery and had a follow-up evaluation >12 months post surgery.

Strict criteria were adhered to in performing the SNIs, including use of fluoroscopy with contrast material, nerve stimulation, and limited volume of local anesthetic. The SNI was considered a positive test if >95% pain relief occurred. At our institution, the majority of patients with radiculopathy who undergo surgical decompression do not have SNI prior to their surgery. SNIs are reserved for patients with symptoms refractory to conservative treatment of at least 6 weeks and with discrepancies between presenting examination and radiologic imagery. The purpose is to confirm or reject a level of suspicion before surgical consideration.

The following information was collected from each patient record: history, pre- and postsurgery physical examinations, imaging and electrodiagnostic results, preprocedural pain Visual Analog Scale (VAS; 0–10) scores measuring leg pain intensity, and presence of pain-provoking maneuvers (ie, straight-leg raise, walking). Surgeon’s follow-up records were collected and reviewed as well as follow-up questionnaires and telephone interviews. A good surgical outcome was defined as a residual VAS score of ≤2 and the patient’s opinion that s/he would do the surgery again and was either satisfied or very satisfied with the surgical outcome at follow-up after 12 months. A bad outcome was defined as a residual VAS score of ≥3 and the opinion that s/he would not do surgery again or was unsatisfied at 12 months.

An independent radiologist reviewed the MR images. An MR image was defined as positive if it displayed blatant evidence of nerve root compression by disc extrusion and/or severe spinal canal/lateral recess/neuroforaminal compromise. An MR image was considered negative in the presence of equivocal thecal sac effacement, focal noncompressing disc herniation, mild to moderate spinal canal/lateral recess stenosis, or mild to moderate neuroforaminal narrowing.

**SNI Procedural Methods**

Patients undergoing lumbar SNI were placed in the prone position, and patients undergoing cervical SNI were placed in the supine position. The procedure was conducted with fluoroscopic guidance and without sedation. The skin was anesthetized with 1% lidocaine. A 2-, 4- or 6-in (22-, 21-, or 20-gauge, respectively) stimulating needle (B. Braun Medical, Bethlehem, PA) was used in the approach to the selected nerve root with stimulator settings of 0.5–1 mA and 2 Hz. In the lumbar area, the needle tip was directed to the anterosuperior aspect of the neuroforamen from a posteroinferior and paramedian approach. In the cervical area, the needle tip was directed tangentially, within the posteroinferior aspect of the neuroforamen, from an anterolateral and slightly inferior approach. To avoid penetration of the vertebral artery, the needle was placed between the lateral aspect and the midpoint of the ipsilateral lateral mass. Close attention to intensity of nerve stimulation was monitored to avoid nerve root impalement. The distribution of nerve stimulation was noted and compared with the patient’s usual area of pain. Iohexol (Omnipaque 300 Bracco Diagnostics, Princeton, NJ) was injected to the minimal amount necessary to confirm visualization of a neurogram (0.25–0.75 mL) and closely observed for epidural, extraradicular, or intravascular flow. Hard copy images in the anteroposterior and lateral views were obtained for lumbar SNI (Fig. 1). Anteroposterior and oblique views (Fig. 2) were obtained for cervical SNI documentation. To obviate epidural spread, 0.5–0.75 mL of 2% lidocaine was injected, taking into consideration the amount of contrast agent needed for neurography. The patient was then assessed for change in VAS and percentage of pain relief. The primary response required for an SNI to be considered positive was a VAS score of 0–1 and immediate relief of >95% of the
patient’s extremity pain, even when pain-provoking maneuvers specific to the patient’s symptoms were performed. Indeterminate results were those in which pain relief was between 80% and 95%. In such patients, a comparative block technique was performed.\(^9\) In this technique, the patient is subjected to a repeat nerve block at a later date, using a local anesthetic of a known different duration of action (eg, lidocaine versus bupivacaine). The degree and duration of initial pain relief from each of the local anesthetics are compared. If the patient had >95% relief of pain on both occasions and longer-acting relief occurred when the longer-duration agent was used, the SNI response was considered positive.

**Statistical Analyses**

To compare associations between surgical outcomes and presurgical diagnostic tests, the sensitivity, specificity, and positive/negative likelihood ratios were calculated. Confidence intervals (CIs) were estimated using the methods described by Simel et al.\(^11\) Ratios outside the CI were considered statistically significant with the probability of a type II error of <5% \((P < 0.05)\). We also report corresponding relative risk ratios.

All patients had institutional review board–approved informed consent.

**RESULTS**

Of the entire 573 patients who had SNIs, there were 101 patients who subsequently underwent surgical decompression with postsurgical follow-up of >12 months available for review. A total of 111 SNIs were performed on the 101 patients. The duration of symptoms prior to SNI ranged from 1.5 to 27 months (mean 4.7 months), the interval between SNI and surgery was 1–3 months (mean 1.5 months), and the postsurgical follow-up ranged from 12 to 26 months (mean 16.2 months). There were 18 patients who had cervical and 83 patients who had lumbar spine surgery. Of the 20 patients who had a history of previous spinal surgery, 15 had surgery at the same and/or adjacent level(s) and 5 had surgery at nonadjacent levels.

Of the 101 patients, 91 (90%) had positive and 10 negative SNI results at the level operated. Most patients (88%) had a good surgical outcome, and there were no complications from the SNI procedure (Table 1). Of the 91 patients with a positive SNI, 84 had an initial positive test with no further testing prior to surgery. Seven patients had an initial negative SNI at the level requested by the surgeon, followed by a positive SNI at an adjacent level; all had surgery at the positive level. The surgeon’s notes in these seven patients indicated that the SNI was decisive in determining the level operated, and all patients had good surgical outcome at 1 year. Overall, 83 (91%) of the patients with positive SNIs had good surgical outcomes.

**TABLE 1. Outcomes at >12 Months (n = 101)**

<table>
<thead>
<tr>
<th>Outcome</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Analog Scale (VAS)</td>
<td></td>
</tr>
<tr>
<td>VAS ≤2</td>
<td>89</td>
</tr>
<tr>
<td>VAS ≥3</td>
<td>12</td>
</tr>
<tr>
<td>Patient satisfaction</td>
<td></td>
</tr>
<tr>
<td>Very satisfied</td>
<td>62</td>
</tr>
<tr>
<td>Satisfied</td>
<td>27</td>
</tr>
<tr>
<td>Unsatisfied</td>
<td>9</td>
</tr>
<tr>
<td>Very unsatisfied</td>
<td>3</td>
</tr>
<tr>
<td>Would do surgery again</td>
<td></td>
</tr>
<tr>
<td>Would do surgery again</td>
<td>89</td>
</tr>
<tr>
<td>Would not do surgery again</td>
<td>12</td>
</tr>
</tbody>
</table>
Of the 10 patients with a negative SNI, 7 had an initial negative test with no further testing prior to surgery. The remaining three patients had a subsequent negative SNI at an adjacent level and had surgery at this level. Six (60%) of these patients had good outcomes (Fig. 3).

MRI

Of the total 101 patients, 86 (85%) had MRI findings consistent with the level of surgery (MRI positive), 13 had a negative MRI result, and 2 patients had no MRI. Of the patients with a positive MRI result, 75 (87%) had good surgical outcomes. A similar percentage of the patients with a negative MRI result (11/13 patients, 85%) also had a good surgical outcome. The predictive value of SNI is significantly better than MRI (likelihood ratio 0.22 vs 0.83, \(P < 0.05\)), indicating the chance of a good surgical outcome for patients with a negative SNI was significantly less than for those with a negative or equivocal MRI. The relative risk for a poor surgical outcome at a level inconsistent with SNI findings was 4.04 (1.52–10.78, \(P = 0.02\)). Patients with surgery inconsistent with the level indicated by SNI were more likely to have a poor surgical outcome (relative risk = 4.0, \(P = 0.02\)), whereas patients with surgery inconsistent with the level indicated by MRI had similar surgical outcome as patients with concordant surgery (relative risk = 1.2, \(P = 0.68\)). Sensitivity and specificity of SNI results and MRI results with surgical outcome were similar, but results based on SNI were superior to MRI in predicting a poor surgical outcome (\(P = 0.01\)).

When findings between SNI and MRI differed (n = 20), surgery at a level consistent with the SNI was more strongly associated with a good surgical outcome. Among these 20 patients, 16 (80%) had a good surgical outcome, with most (69%) having surgery performed at a level consistent with the SNI. Of the four patients with a poor surgical outcome, surgery was most often (75%) performed at a level inconsistent with the SNI finding.

Positive predictive value (PPV) and negative predictive value (NPV) of SNI versus MRI associated with 1-year surgical outcomes are presented in Table 2. Both the PPV (91.2) and the NPV (40.0) of SNI findings were significantly greater than 0 (\(P < 0.001\) and \(P = 0.01\), respectively), whereas only the PPVs (88.4) of MRI findings were significantly greater than 0 (\(P < 0.001\)). The NPV of SNI was significantly better than that associated with MRI findings (\(z = 2.46, P = 0.01\)).

**FIGURE 3.** Selective nerve root injection results.
Patients having surgery on positive SNI levels were 9.1 times more likely to have good outcomes than those who had surgery on negative SNI levels ($P = 0.01$).

**DISCUSSION**

We have demonstrated two pertinent advantages to the use of SNIs for diagnostic purposes. First, they are most useful in localizing radicular pain in patients with equivocal MRI findings. Second, the diagnostic SNI can, in some cases, persuade surgeons from operating on an initially suspicious, but incorrect, level of radiculopathy. There were seven patients who initially had a negative SNI result at the level the surgeon initially suspected as being the level of radiculopathy. Subsequent SNIs at an adjacent level were positive. All of these patients underwent surgery at the subsequently positive level with good surgical outcome. These patients’ surgical notes indicated that SNI results did influence the surgeon’s decision-making process in all cases. Positive SNI results are associated with good surgical outcomes most of the time and were most helpful when MRI results were equivocal, multilevel, and/or did not agree with the patient’s symptoms. There were 10 patients who underwent surgery at a spinal level with a negative SNI result. A good surgical outcome occurred in only 60% (6/10) of these patients compared with 88% of all SNI patients. The small number of patients in this situation warrants cautious interpretation of the results.

Studies that report on the diagnostic applicability of SNIs have produced mixed results. Protocols described in these studies include the use of fluoroscopy with or without neurography and a paresthesia technique to identify the nerve and use of 1–3 mL of local anesthetic to anesthetize the nerve, in which case >50% pain relief or “good relief” is used to assess the result. In 1998, Slosar et al sharply criticized the use of SNIs in patients being considered for operative intervention. Most of their findings were based on studies demonstrating poor results in patients with chronic radiculopathy who, after SNI was used to identify a putatively painful nerve root, underwent a dorsal rhizotomy procedure. Although these data may be valid for patients who undergo dorsal rhizotomy, a procedure complicated by high failure rates, the results should not be equated to results seen in patients who undergo nerve root decompression. Recently, Apsinall et al reported on the value of SNIs in the evaluation of sciatica with normal MRI scans. In their study, 40 patients with normal MRI were further investigated with an SNI. Of 11 patients who had temporary relief after SNI, all of them underwent surgical exploration. In nine cases, compression was identified at the ligamentum flavum and in two cases at the neural foramen. Nine of these patients had complete relief of their symptoms after surgery. In our study, there were 13 patients with “normal” MRI, all of whom underwent surgical exploration.

**TABLE 2. Predictive Values of SNI and MRI**

<table>
<thead>
<tr>
<th>SNI Surgical Outcome</th>
<th>MRI Surgical Outcome</th>
<th>SNI vs MRI Surgical Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td>Negative or</td>
<td>Negative or</td>
<td>Negative or</td>
</tr>
<tr>
<td>indeterminate</td>
<td>indeterminate</td>
<td>indeterminate</td>
</tr>
<tr>
<td>Totals</td>
<td>Totals</td>
<td>Totals</td>
</tr>
<tr>
<td>Value</td>
<td>95% CI</td>
<td>Prob. &gt; 0</td>
</tr>
<tr>
<td>PPV</td>
<td>91.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>NPV</td>
<td>40.0</td>
<td>0.01</td>
</tr>
<tr>
<td>Positive</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td>Negative or</td>
<td>Negative or</td>
<td>Negative or</td>
</tr>
<tr>
<td>indeterminate</td>
<td>indeterminate</td>
<td>indeterminate</td>
</tr>
<tr>
<td>Totals</td>
<td>Totals</td>
<td>Totals</td>
</tr>
<tr>
<td>Value</td>
<td>95% CI</td>
<td>Prob. &gt; 0</td>
</tr>
<tr>
<td>PPV</td>
<td>88.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>NPV</td>
<td>15.4</td>
<td>0.12</td>
</tr>
</tbody>
</table>

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All 13 had evidence of nerve root compression upon surgical exploration, and 11 had a good surgical outcome.

We believe the nerve stimulator is an excellent tool to identify proximity of the nerve while avoiding deliberate impalement of the nerve root. Permanent neuropathies are reported to occur more frequently with the use of the paresthesia technique.\(^2\) Also, concordance of nerve stimulation with the area of a patient’s pain distribution should serve as corroborative, but not absolute, evidence that the nerve being stimulated is the painful nerve.\(^3\) We have found this technique particularly useful when the patient’s pain referral (dynatome) occurs outside a specific nerve root’s expected dermatomal distribution and nerve stimulation elicits paresthesias within the same area.

An important component to increasing specificity of a diagnostic SNI is the meticulous use of a low-volume anesthetic when anesthetizing the nerve root. Castro et al\(^2\) demonstrated that diffusion of contrast material to the adjacent, ipsilateral nerve root(s), via epidural space or extraradicularly, occurs in the majority of patients when \(\geq 1\) mL is placed on a nerve root. In our literature review, we found that studies investigating diagnostic accuracy of SNIs in a clinical setting typically have used volumes between 1 and 3 mL, thereby substantially reducing the specificity of the injection.\(^4\) The maximum volume of local anesthetic used in our technique is 0.75 mL with a range of 0.5–0.75 mL. The volume is ultimately determined by first observing the nature of contrast agent spread along the nerve root. Typically, injection of contrast agent follows along the periradicular sheath before spreading into the epidural space or extraspinal to the plexus or soft tissues. Injection of contrast material also ensures avoidance of subsequent intravascular injection of local anesthetic. A pitfall in this technique is the possibility of a false-negative result if not enough anesthetic infiltrates a truly painful nerve root. Hence, the patient’s pain will remain unresolved. Although minimal volumes or concentrations of local anesthetic to anesthetize the nerve root have never been reported, objective evidence of sensory and/or motor blockade frequently, but not reliably, occurs with this technique and is noted. Increasing the concentration of local anesthetic while maintaining this minimal volume technique may provide a more reliable anesthetic block. Although this could be recommended for lumbar-level SNIs, we would advise against it at the cervical level owing to a greater risk of seizure.

Pain relief as a diagnostic tool remains difficult to interpret, regardless of its application. Inherent in any diagnostic study that uses degree of pain relief as a determination of result is the placebo response. Formal studies have shown that 30% of patients ostensibly undergoing lumbar zygapophysial joint blocks can report complete relief of their back pain following a subcutaneous injection of normal saline.\(^26\) False-positive responses occur in 27–38% after single injections at the facet level.\(^27,28\) Although false-positive response rates for SNIs have not been specifically studied, one could presume similar response rates would result. Moreover, variable (not complete) degrees of response commonly occur after injection. If such results are considered “positive,” they would lead to reducing the test’s specificity. In a study comparing pain relief after local anesthetic blocks for sciatica of spinal origin to areas of pain referral (facet joint, sciatic nerve, and subcutaneous tissue), North et al\(^20\) concluded that SNIs were not specific in diagnosing radiculopathy. However, if \(>90\%) relief were applied as a diagnostic criterion, the majority of the SNIs in their study would have been considered positive tests, and the majority of facet joint, sciatic nerve, and subcutaneous blocks would have been considered negative tests. Moreover, only patients who underwent SNI sustained complete pain relief for at least 1 hour \((P < 0.05)\). Although the criterion of pain relief for at least 1 hour was not used in our study, it supports the concept that SNIs can be specific for determining level of radiculopathy when compared with injections anatomically remote from the pathology causing the pain. Also, in the North et al study,\(^20\) the volume of local anesthetic injected at the nerve root level was 3 mL. This is a relatively large amount and would be expected to consistently spread in an uncontrolled manner to adjacent tissue, thereby reducing specificity.

Uncontrolled local anesthetic, spread unknowingly to other “pain generator” tissue(s), could also be misinterpreted as a positive SNI test. SNIs are not truly “selective” in their ability to anesthetize only the ventral ramus of the nerve root, which comprises the putatively painful component nerve to the extremity. Injection of a local anesthetic immediately outside the neuroforamen, before the dorsal and ventral rami divide, will also block the dorsal ramus. This latter ramus innervates structures of the spinal segment, where radicular-like symptoms may derive. If structures(s) innervated by the spinal segmental nerves are primary or secondary components to the patient’s symptoms, then anesthetizing the dorsal ramus may result in a falsely positive result. Also, local anesthetic infiltration completely outside the nerve distribution can relieve a patient’s pain.\(^29\) A theoretical explanation for this is that the cell bodies within the spinothalamic tract of the dorsal horn may have lower thresholds for excitation and expanded receptive fields after nerve injury.\(^30\) Normal background afferent excitatory input within these cells bodies may therefore be sensed as pain.\(^31\)

Other important limitations of SNIs are that they do not contribute information regarding the locality or pathologic process that is responsible for inciting pain. Local anesthetic nerve blocks proximal or distal to the “pain generator” area can provide temporary pain relief. For example, a peripheral local anesthetic block in the area where pain is perceived can relieve central pain,\(^32,33\) and radiculopathy can be relieved by an ipsilateral sciatic nerve block.\(^29,34,35\) This latter effect is most likely related to the requirement of peripheral input to propagate radiculopathy. Theoretical explanations include nonnoxious afferent activity that becomes “amplified” at the site of the injured nerve root or dorsal root ganglia; cross-talk, or nonnoxious afferent conduction transfers to pain-relaying nerve tracts;\(^36,37\) preferential injury of large myelinated afferents resulting in “disinhibition” of unmyelinated nociceptive input; and antidromic activity from injured sensory nerves, which may cause peripheral tissue release of substance P and perhaps other substances (such as bradykinin, histamine, and 5-hydroxytryptamine–prostaglandin, producing changes in nociceptor sensitivity).\(^18–40\)

Finally, complications that could occur from SNI include infection, bleeding, allergic reaction, nerve root injury,
spinal cord injury, seizure, and stroke. Only recently has there been a case report of three patients sustaining serious complications due to lumbar SNI, including paraplegia or paraparesis. Undetected needle penetration and injection of a depot steroid into a spinal artery or artery of Adamkiewicz resulting in spinal cord infarction were the proposed mechanisms. Indeed, all commonly used depot steroids used in intraspinal injections are suspensions of particulate material. Accidental vertebral artery puncture during cervical epidural procedure and trigger point block, leading to medullary infarct, have been reported. Of particular concern are serious central nervous system complications after cervical SNI, including paralysis, stroke, and death. The precarious arterial supply of the anterior cervical spinal cord, which is supplied by the radicular artery via the vertebral artery, may have an increased propensity for severe vasospasm or direct injection. Although the authors are aware of instances of these catastrophic events by other injectors, only one case of fatal spinal cord infarction attributed to a transformaminal corticosteroid injection has been reported. Steps we consider important for preventing, but not completely avoiding, spinal cord/intramedullary infarction include proper needle placement within the neuroforamen. At the cervical level, this requires placement posteriorly and immediately lateral to the midpoint of the lateral mass from an anteroposterior view. Other steps include injection of contrast material under real-time fluoroscopic guidance to observe for intravascular flow.

CONCLUSION

Using neurography and stimulation for nerve root identification, meticulous low-volume local anesthetic instillation for nerve root block, and strict criteria in assessing pain relief, we have found that SNIs can be performed safely and accurately to discern the presence or absence of lumbar and cervical radiculopathy in patients with otherwise equivocal imagery. Our study found that diagnostic SNI can safely and accurately discern the presence or absence of cervical or lumbar radiculopathy. We believe these results are directly related to rigorously applying standardized SNI procedure methods.

When comparing SNI results with MRI, we found that SNI is no more predictive of the level of the offending lesion when it is not obvious on MRI. As imaging is important in understanding the pathologic process that causes radiculopathy, we recommend against the use of SNI as a diagnostic tool in single-level, clear-cut causes of radiculopathy. However, in cases where MRI findings are equivocal, multilevel, and/or do not agree with the patient’s symptoms, the result of a negative diagnostic SNI (ie, lack of presence of radiculopathy) becomes superior in predicting the absence of an offending lesion.

Although we agree that SNIs should never be relied upon as the sole diagnostic maneuver, we have found SNIs can be performed with accuracy and can be considered a pivotal test in determining the presence or, in particular, the absence of radiculopathy. This important finding could potentially reduce the number of operated levels when spinal surgery is planned.

REFERENCES