Retrospective Study

Clinical Outcomes of Posterior Percutaneous Endoscopic Cervical Foraminotomy and Discectomy Assisted with SNRB in Treating Cervical Radiculopathy with Diagnostic Uncertainty

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Background: Selective nerve root block (SNRB) has been used to facilitate the diagnostic process when radiologic abnormalities are not correlated with clinical symptomatology in patients with cervical radiculopathy. Meanwhile, minimally invasive posterior percutaneous endoscopic cervical foraminotomy and discectomy (PPECFD) has been widely used to treat cervical radiculopathy because of its advantages. However, combination of these 2 procedures in the treatment of cervical radiculopathy with diagnostic uncertainty has not been reported.

Objectives: To examine the clinical outcomes of PPECFD assisted with SNRB in patients who had cervical radiculopathy with diagnostic uncertainty.

Study Design: A retrospective design was used.

Setting: This study was conducted in a university-affiliated tertiary hospital in Shanghai, China.

Methods: Thirty consecutive patients with cervical radicular pain who had diagnostic uncertainty were included (January 2018 to January 2019). Diagnostic SNRB was performed to identify the responsible nerve root(s). PPECFD was selected as the treatment when the SNRB result was positive. Clinical outcomes were assessed by the Visual Analog Scale (VAS), Neck Disability Index (NDI), and modified Macnab criteria. Pre- and post-operative radiologic and clinical parameters were evaluated. Other information was retrieved from the electronic records.

Results: All patients had successful SNRB procedures. Four were excluded from the analysis because of the negative results of the SNRB. Among the remaining 26 patients who underwent the subsequent PPECFD surgery, the mean follow-up was 14 months. Compared with preoperative values, the mean VAS scores for radicular arm pain and neck pain, as well as the NDI score, improved significantly. According to the Macnab criteria, 22 patients (84.6%) had excellent or good results. No major peri- and postoperative complications were observed.

Limitations: This study used a retrospective design with relatively small sample size and medium follow-up duration.

Conclusions: Diagnostic SNRB may be a helpful tool to identify the origin of cervical radicular pain for patients with diagnostic uncertainty. With the guidance of SNRB, PPECFD is likely to be an effective and safe option for the treatment of cervical radiculopathy with diagnostic uncertainty.

Key words: Cervical radiculopathy, selective nerve root block, percutaneous endoscopic cervical foraminotomy and discectomy, diagnostic, uncertainty

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Cervical radiculopathy is a common neurologic disorder characterized by pain in the arm and neck, which is mainly attributed to intervertebral disc herniation or foraminal stenosis (1,2). Depending on the etiology, cervical radiculopathy can be treated with conservative methods but often requires surgical decompression. Anterior cervical decompression and fusion (ACDF) has been the standard treatment as it is a safe method with good fusion rates (3,4). However, ACDF may result in pseudarthrosis, access complications, dysphagia, dysphonia, or esophageal perforation (5). Compared with the anterior approaches, posterior approaches are equally effective (6,7). Nonetheless, adverse outcomes (e.g., access-related neck pain and wound infection) have been reported (7). Subsequently, modifications to reduce the disadvantages of the earlier described methods have been proposed, including cervical disc arthroplasty (8) and minimally invasive posterior cervical approach (e.g., tubular-assisted or endoscope-assisted foraminotomy) (9,10). Among these methods, posterior percutaneous endoscopic cervical foraminotomy and discectomy (PPECFD) has acceptable outcomes, less injury, and lower complications (10-12). Whichever procedure is chosen, identification of the nerve root responsible for the pain is essential.

In most patients with cervical radiculopathy, localization of the nerve root compression can be achieved by careful evaluation of the clinical symptoms, physical examinations, and imaging findings. In some cases, however, determining which nerve root(s) is responsible for the pain or whether the pain is a consequence of a particular nerve root compression can be challenging. For instance, in patients with cervical radiculopathy and multilevel degeneration, the evaluation tools may not provide definitive evidence about the target nerve root(s), as current imaging technology often demonstrates asymptomatic degenerative changes (13,14). In other patients, there may be a poor correlation between subjective perception of symptoms and objective imaging findings, as the symptoms do not necessarily involve the classic dermatomal patterns (15). In some patients, even radicular pain may be present in the absence of imaging abnormalities as a result of chemical irritation of the nerve root. Therefore the diagnosis remains uncertain for patients with suspected cervical radiculopathy in whom the clinical and imaging findings are equivocal or inconsistent. In these cases, diagnostic selective nerve root block (SNRB) could be used to determine the etiology of pain (16,17).

SNRB is a highly target-oriented procedure, which has been commonly used for therapeutic and diagnostic purposes in patients with cervical and lumbar radiculopathy (18,19). Using SNRB, pain can be alleviated by injecting anesthetic agents and/or corticosteroid directly near the dorsal root ganglion and the compressed nerve root. This procedure may elucidate the level of pain generation (20,21). Because SNRB typically anesthetizes only one spinal nerve, it was considered an accurate diagnostic tool to identify the involved nerve root(s) in patients with negative or inconclusive imaging findings (21,22). Previously, SNRB was used to localize the pain generator, especially in the lumbar spine (23). Successful use of the combination of SNRB and other treatments (e.g., pulsed radiofrequency or decompression surgery) in the cervical spine has also been described (19,24). Additionally, SNRB could provide important prognostic information about the surgical outcomes and has shown high validity and predictive value (25,26).

In patients with cervical radiculopathy, radicular pain is the main complaint, and the goal of the treatment is to minimize this pain. In light of the potential advantages of minimally invasive PPECFD and the wide use of SNRB in distinguishing pain- and nonpain-mediating nerve roots, there is a need to examine the clinical outcomes of the combination of these 2 methods. Thus the aim of this study was to report the clinical outcomes in a series of patients who had cervical radiculopathy with diagnostic uncertainty and were treated with PPECFD assisted with SNRB.

Methods

Patients' Characteristics

All procedures performed in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consent of the procedures was obtained from all patients included in the study. Between January 2018 and January 2019, 30 consecutive patients with possible cervical radiculopathy were identified. These patients underwent diagnostic cervical SNRB by a senior surgeon (XG).

Patients were included if there was a high diagnostic uncertainty based on their symptoms, medical history, physical examination, and imaging results. The following situations were considered diagnostic uncertainty: it was not clear whether the patient was

experiencing pain originated from the nerve root; the compression of a suspected nerve root was ambiguous based on the imaging results; and when there were multilevel degenerative changes without a definitive suspect nerve root. Other inclusion criteria included (1) unilateral arm and/or neck radicular pain; (2) failed conservative treatment of more than 6 weeks (including nonsteroid analgesics, neurotrophic drug, physical therapy, and rest); and (3) aged between 18 to 70 years. The exclusion criteria included (1) isolated neck pain; (2) cervical segmental instability or deformities; (3) cervical disc herniation with calcification; (4) myelopathy; (5) developmental cervical spinal stenosis; (6) ossification of the posterior longitudinal ligament; (7) cervical spine infection or tumor; (8) patients with pregnancy or severe psychiatric disorders; and (9) patients receiving therapeutic SNRB, in whom the diagnosis was clear.

Patients received detailed clinical examinations, including medical history, neurologic examination, psychological assessment, and assessment of pain intensity and duration. In addition, x-ray, computed tomography (CT), and magnetic resonance imaging (MRI) were performed for all patients to rule out conditions defined in the exclusion criteria. Based on the examination results, SNRB was performed on the potential target nerve root(s).

Cervical SNRB Technique

Block Logistics

All patients underwent SNRB, starting at the most highly suspected level. No analgesics were given within 24 hours before the procedure. Patients were asked to rate their arm and neck pain on a Visual Analog Scale (VAS) 30 minutes before the SNRB. They also underwent provocation with active neck motion when arm and neck pain were assessed. Thirty minutes after the SNRB, the clinical assessments including neck provocation and VAS rating were repeated. If the first block showed negative results, then the second block was considered (Fig. 1D–1G). At least 4 hours had to elapse between the first and the second block to reduce the risk of persisting effect from the first injection.

Block Technique

The procedure was similar as described in a previous study (21). Briefly, patients were laid in a supine position on a radiolucent table in an x-ray suite. The patient's head was rotated slightly away from the side to be injected to provide easier access. The C-arm was rotated into a 45° oblique position. An oblique fluoroscopy image of the cervical spine was then obtained, and the target intervertebral foramen was marked on the skin. The injection site was prepared and draped in the standard sterile manner. The skin was injected with 1% lidocaine using an 8G-long needle. The needle was then advanced slowly toward the lateral mass of the posterior foramen under fluoroscopic visualization. The needle tip contacted the lateral mass adjacent to the caudal half of the foramen and was then rotated medially toward the extreme posterior portion of the foramen and advanced 2 mm beyond the point. At this point, the C-arm was rotated into the anteroposterior (AP) plane. Under repeated fluoroscopic views, the needle was slowly advanced until it was under the lateral border of the pedicle immediately above the target foramen. The needle tip should not go beyond the midportion of the pedicle in an AP view. Once the needle was in the correct position (Figs. 1D, 1F, and 2G), 0.5-mL iohexol (contrast medium) (300 mg/mL; Omnipaque GE Healthcare Ireland, Cork, Ireland) was injected slowly under the fluoroscopic guidance to determine the distribution of the contrast medium (Figs. 1E, 1G, and 2H). Once the position of the needle was properly established, 0.5-mL 1% lidocaine was then injected. After 15 to 30 seconds, the patient was asked about their feeling.

Evaluation of Root Block

If the patient reported an arm pain reduction, with a corresponding VAS reduction of 50% or more, the root was classified as significant for mediating the radicular pain. Significant subjective radicular pain combined with significant MRI findings and a positive SNRB were indications for treatment. Once the diagnosis of cervical radiculopathy was confirmed, PPECFD was performed.

Surgical Technique

The surgical process was consistent with the previous reports (11). Briefly, under the general anesthesia, patients were placed in the prone position with the head and arm fixed in place with tapes. The neck was adjusted on the table in a slightly flexed and high-low position to reduce the overlapping of the facet joints and lower the pressure of the venous plexus. The surgical area was prepared and draped in the standard sterile manner. An 8G, 10-cm needle was first used to identify the target segment and the medial side of the facet joint under lateral and AP fluoroscopy. After

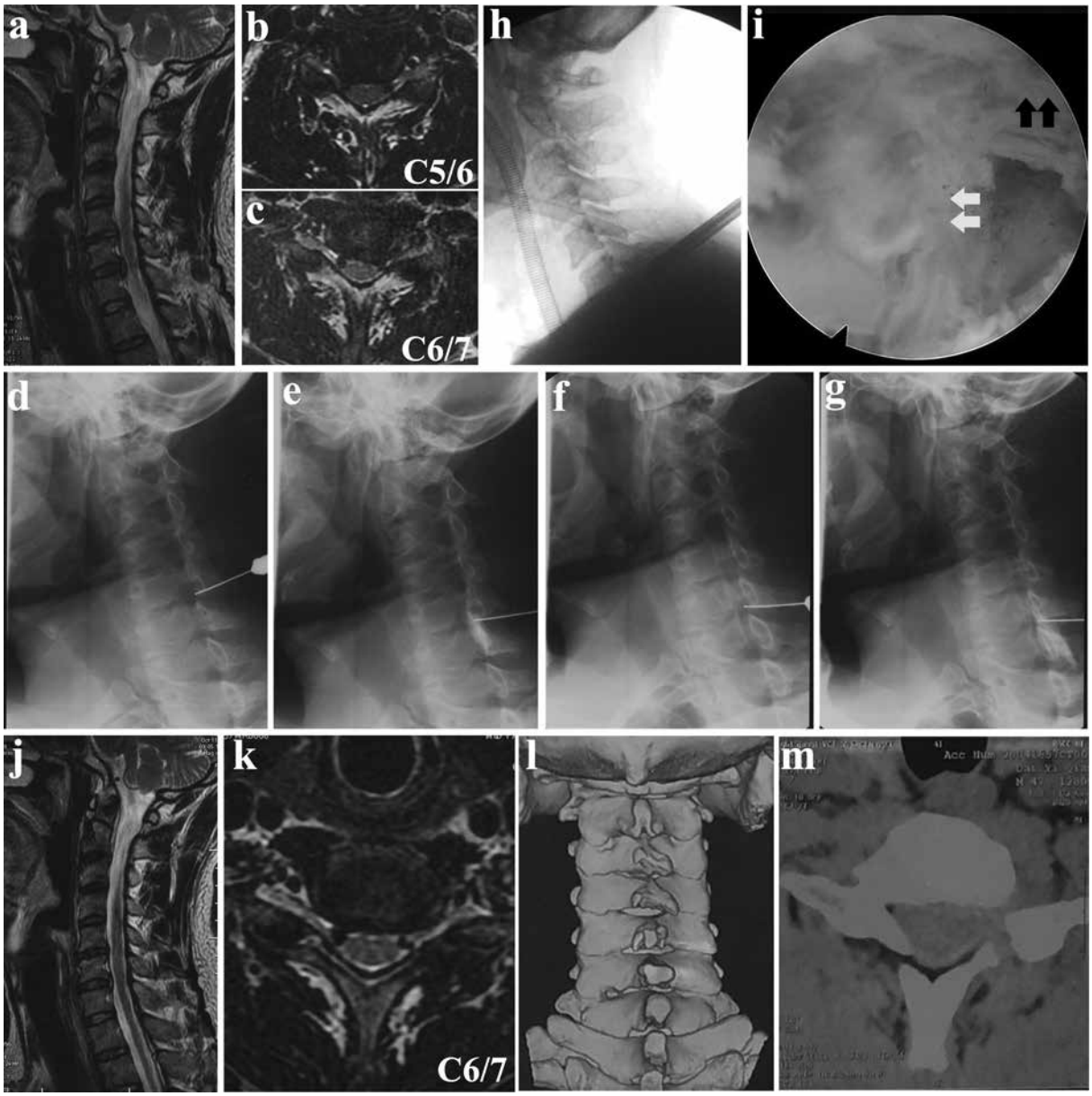

Fig. 1. *A 46-year-old man presented with neck and left arm pain radiating to the radial side. The patient also complained of numbness of left thumb and index finger, and atrophy of the left triceps brachii. The T2-weighted (A) sagittal and (B, C) axial MRI show a herniated disc at the left side of the C6/7 level and stenosis at the C5/6 level. (D–F) An SNRB was first performed on the left side of the C6 nerve root. The pain was not alleviated. (E–G) SNRB was then performed on the left side of the C7 nerve root. The pain was alleviated immediately. (H) Placement of the working channel on the C6/7 level during the operation. (I) Freed cervical dural sac (black arrow) and nerve root (red arrow) after full decompression. (J, K) Postoperative (3 months) MRI scans demonstrate removal of the disc and decompression of the dural sac, although there was a residual portion of the annulus forming a capsule around the herniated nucleus. Postoperative view of (L) 3D reconstruction and (M) axial CT scan show the keyhole decompression field, which preserved most of the facet joint.*

confirming the right entry point, a 9-mm skin incision was made, and an obturator (6.9-mm outer diameter) was then introduced (Figs. 1H and 2I). The tip of the obturator was placed at the V-point under fluoroscopic guidance, and the boundaries of the inferior lamina, superior lamina, and medial margin of the facet joint

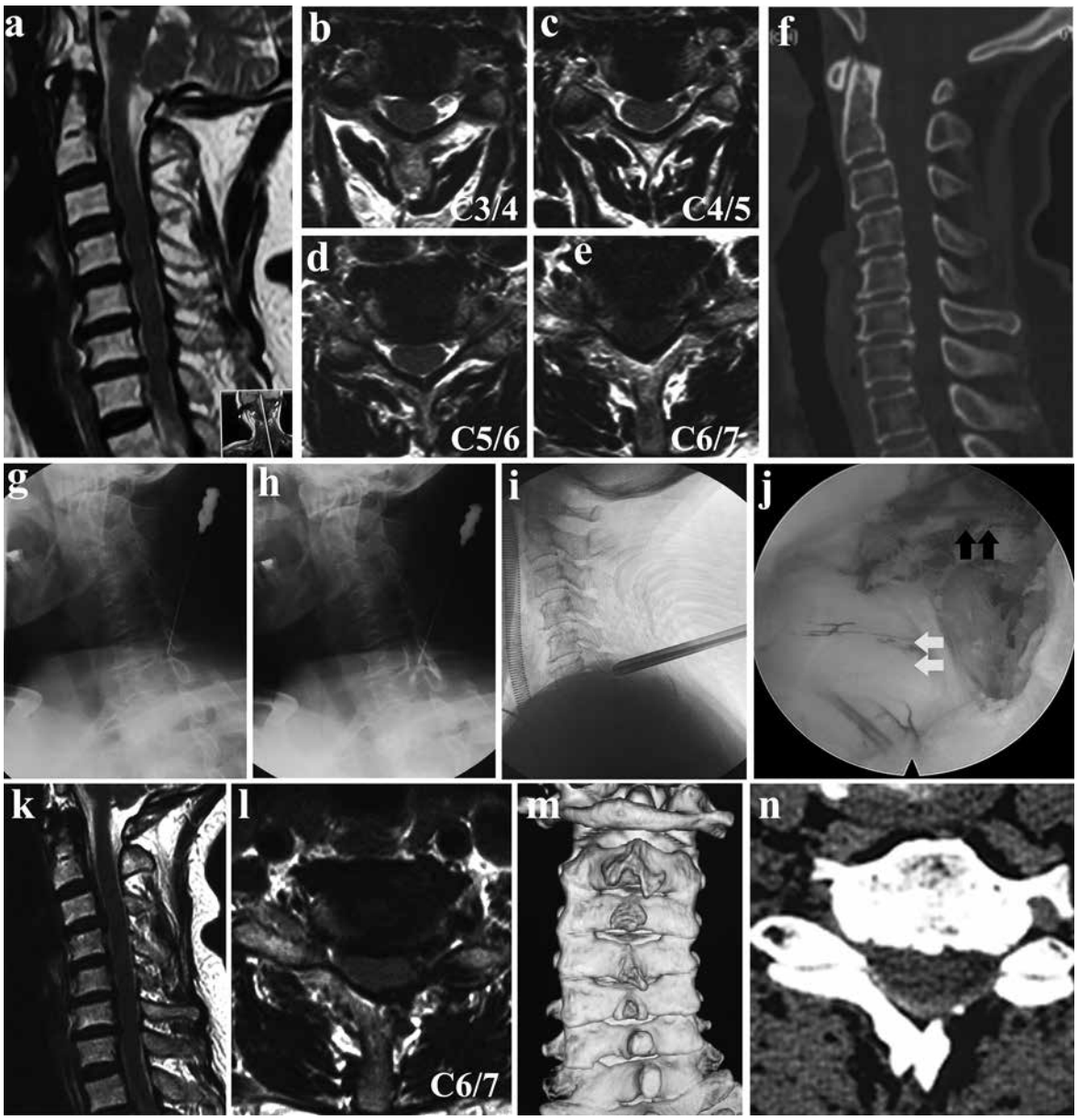

Fig. 2. *A 70-year-old woman presented with neck, shoulder, and left arm pain radiating to the ulnar side. The T2-weighted (A) sagittal and (B–E) axial MRI show multilevel disc herniation at the C3/4, C4/5, C5/6, and C6/7 levels. (F) Preoperative CT scan shows no calcification and ossification. (G, H) An SNRB was performed on the left side of the C7 nerve root. The pain was alleviated over 80%. (I) Placement of the working channel on the C6/7 level. (J) Freed cervical dural sac (black arrow) and nerve root (red arrow) after full decompression. (K, L) Postoperative (6 months) MRI scans demonstrate removal of the disc and decompression of the dural sac at the C6/7 level. (M, N) Postoperative view of 3D reconstruction and axial CT scan show the keyhole decompression field.*

were palpated with the obturator. The oblique-type working channel was introduced via the obturator, and the endoscope was introduced. Further operations were performed under visual control and continuous irrigation with 0.9% saline solution. This solution was hung 1 m above the patient and connected to the endoscopic equipment.

After clearing out the soft tissue around the V-point, a high-speed drill was used to polish the lateral part of the inferior lamina, the medial part of the facet

joint (no more than 50%), and the lateral part of the superior lamina. The thin bone was then removed with a rongeur. The ligamentum flavum was removed, and the vessels were coagulated using a bipolar radiofrequency coagulator to expose the lateral edge of the dural sac and the exiting nerve root. Protruding nucleus pulposus and osteophytes were identified from the axillar or shoulder of the nerve root and removed using a pituitary rongeur. The decompressions were indirect in the case of osteophytes and direct in the case of the soft disc. When the intervertebral foramen was enlarged and the nerve root was decompressed (Figs. 1I and 2J), the endoscope and working channel were carefully removed. The skin was closed with a single stitch. The patients were discharged 1 or 2 days after the operation and advised to wear a neck collar for 1 week.

Outcome Evaluation

Patient follow-up was conducted at the outpatient clinic combined with telephone calls at 1, 3, 6, and 12 months postoperatively. The examinations included clinical outcomes and radiologic imaging. The pain was measured by the VAS for neck (neck-VAS) and arm (arm-VAS). Functional status was assessed using the Neck Disability Index (NDI). The global outcome was assessed using the modified Macnab criteria. The excellent and good outcomes were grouped as clinical success, whereas fair and poor outcomes were grouped as clinical failure. The radiologic parameters at pre- and postoperation were evaluated using x-ray, CT, and MRI scans (Figs. 1 and 2). Complications were also recorded.

Statistical Analysis

The SPSS Version 20.0 (IBM Corporation, Armonk, NY) was used for statistical analyses. Continuous variables were presented as mean (standard deviation [SD]). Categorical variables were presented as frequency (%). A paired t-test was used to compare the clinical outcomes between the preoperative value and that during each follow-up time point. The statistical significance level was set at $P < 0.05$.

Results

Baseline Characteristics

Of the 30 patients, 26 had positive SNRB results. These patients received the treatment with PPECFD subsequently. The other 4 received conservative treatment and were excluded from the analyses. Of these remaining 26 patients, 16 were men (61.5%). Their age ranged from 34 to 66 years (mean 48.5 years). The duration of symptoms ranged from 3 to 20 months (mean 8.8 months). Two operations were performed at C4/5 level, 13 at C5/6, 10 at C6/7, and 1 at C7/T1. The imaging results showed that 18 were soft disc herniations and 8 were foraminal stenosis, 12 were left-sided and 14 were right-sided. The mean operative time was 85 minutes (range, 55–125 minutes). There was no significant blood loss. Two cases of temporary postoperative dysesthesia had an effective pain relief 5 days after the operation after taking analgesic drugs. The demographic characteristics are summarized in Table 1.

Clinical Outcomes

All of the 26 patients had adequate clinical and radiologic follow-ups (Table 2). At 1-month follow-up, the values of neck-VAS, arm-VAS, and NDI decreased significantly as compared with preoperation. These decreases remained significant throughout the follow-up. According to the modified Macnab criteria, clinical success was achieved in 21 patients at 1-month follow-up, including 12 excellent outcomes and 9 good outcomes. One patient had a poor outcome and received follow-up conservative treatment. The symptoms were relieved after 8-week treatment. At the 12-month follow-up, an excellent postoperative outcome was achieved in 18 patients, a good outcome was achieved in 4 patients, and a fair outcome was observed in 4 patients. No one had a poor outcome.

Complications

There were no severe intra- or post-operative complications, such as dural sac tear, cervical spinal cord or nerve root injury, postoperative bleeding or hematoma formation, infection, thrombosis, or postoperative cervical instability. No patient needed additional surgery for sustained or aggravated symptoms during the postoperative periods.

Discussion

In this study, we included 26 patients who had cervical radiculopathy with diagnostic uncertainty in their symptomatology and imaging. The SNRB was used to identify the target pathology prior to the surgery. After confirming the responsible level, a PPECFD was used for treatment. All surgeries were performed successfully with no major complications. At 1-year follow-up, the neck and arm pain were relieved as indicated by the VAS scores. The modified Macnab results were improved, suggesting increased global outcomes.

Identification of the origin of cervical radicular pain is difficult when radiologic abnormalities are not correlated with clinical symptomatology. Previous evidence shows that clinical and radiologic findings may not be accurate, especially regarding specificity (13). Multilevel degenerative pathology is frequently found in the cervical spine; however, it is usually challenging to determine with certainty which disc in the multi-degenerated cervical spine is symptomatic. Imaging studies (e.g., MRI) can only provide morphologic information and do not tell the clinical significance of the findings (17). In these situations, spine surgeons need to differentiate the target level of disc herniation with asymptomatic radiographic disc herniation.

Physical examinations and self-reported symptoms provide clues to differentiate the target level of cervical disc herniation. Unfortunately, some patients with cervical radicular pain have a nontypical distribution of neurologic deficits. Anderberg et al (17) reported only a 28% correlation between the dermatomal distribution of radicular pain and the putative symptomatic nerve root in patients with cervical radiculopathy and multilevel spinal degeneration. These results are consistent with those from the Murphy et al (27) study. The authors found that pain related to cervical nerve roots was nondermatomal in approximately 70% of the cases. Frequent occurrence of anastomoses between cervical nerve roots may contribute to the clinical diagnostic challenges (28). Therefore for patients with cervical radiculopathy who have atypical presentations, identifying the target nerve root from clinical symptoms and imaging findings only could be difficult. In such patients, SNRB could be used as a helpful differential diagnostic tool.

The value of diagnostic SNRB in the preoperative evaluation of patients with negative or inconclusive imaging studies and clinical findings of the neurologic deficit was first described by Macnab (29) in 1971. Since then, SNRB has been frequently used to diagnose and confirm the pain-generating nerve root in patients with equivocal anatomic findings (22,30). In 2007, a systematic review (18) concluded that current evidence supports selective nerve root injection as a diagnostic test for equivocal radicular pain. Despite the widespread use of SNRB, its reported accuracy for determining the symptomatic level varies from 31% to 100% (23). The diagnostic accuracy of SNRB is limited due to several reasons, including the use of excessive injectate volumes, the spread of the local anesthetic agent, the inability of the patients to discern pain provocation and/or pain relief, and variations in der-

Table 1. *Patient demographics, diagnosis, and nerve roots involved (n = 26).*

Demographics	Mean (SD)/n (%)
Age (yr)	48.5 (8.2)
Gender (male)	16 (61.5%)
Duration of symptoms (mo)	8.8 (4.1)
Body mass index (kg/m^2)	22.4 (1.9)
Pathology	
Soft disc herniations	18 (69.2%)
Foraminal stenosis	8 (30.8%)
Surgical level	
C4/5	2 (7.7%)
C5/6	13 (50.0%)
C6/7	10 (38.5%)
C7/T1	1 (3.8%)
Surgical side	
Left	12 (46.2%)
Right	14 (53.8%)
Surgical time (min)	85.0 (16.7)
Hospitalization stay (d)	3.5 (0.7)
Comorbidities	
Hypertension	8 (30.8%)
Diabetes	6 (23.1%)
Tobacco use	6 (23.1%)
Follow-up (mo)	14.7 (2.7)

Table 2. *Clinical outcomes of the patients.*

	Preoperative	Postoperative			
		1 month	3 months	6 months	12 months
Arm-VAS	6.31 ± 1.0	1.96 ± 1.22*	1.73 ± 1.12*	1.50 ± 1.21*	1.27 ± 1.37*
Neck-VAS	5.62 ± 1.24	1.88 ± 1.11*	1.42 ± 0.81*	1.35 ± 0.89*	1.12 ± 1.03*
NDI	23.38 ± 6.50	7.35 ± 3.93*	6.08 ± 3.57*	5.08 ± 3.80*	4.65 ± 4.13*
Macnab criteria†		12: 9: 4: 1	14: 8: 4: 0	18: 4: 4: 0	18: 4: 4: 0

Values are presented as mean ± SD.
*$P < 0.05$, comparison with preoperative values.
†The number of patients with excellent, good, fair, and poor outcomes.

matomal maps. One caveat that should be noted when performing SNRB is the need to limit injectate volumes to optimize specificity (18). Furman et al (31) found that the lumbar segmental nerve root block may not be diagnostically selective if the volume exceeds 0.5 mL. In the cervical spine, Anderberg et al (32) found that SNRB performed with 0.6 mL was equally effective but more sensitive than those done with 1.1 or 1.7 mL. In the present study, we only injected 0.5-mL lidocaine into the target area, which might have improved the specificity. To reduce the rate of false SNRB results and improve the procedure for more reliable pain estimation, we also introduced the provocation of the cervical spine, thereby highlighting the mechanical component (17). Furthermore, prior to the injection of the active drug, a small amount of contrast medium was injected to confirm the correct needle position. In most of the cases, the spread of the contrast medium was excellent, outlining the contour of the target cervical nerve roots with minimal spread into the central epidural space.

The goal of diagnostic SNRB is to identify the pain generator, which can help clinicians to individualize the treatment. The clinical outcomes of most therapeutic options also depend on an accurate diagnosis. Several authors have attempted to correlate the results of SNRB with surgical findings and outcomes. Nachemson (33) found that diagnostic SNRB could provide important prognostic information about the surgical outcomes. Haueisen et al (34) reported good postoperative results in a retrospective study of patients who had lumbosacral radiculopathy and underwent surgical exploration based on the SNRB. In another retrospective study, Schutz et al (35) reported that among the 15 patients who received an operation at the level indicated by the SNRB, 13 (87%) had findings correlated with the results of the diagnostic block. Jasper et al (36) found that patients with multilevel lumbar pathologies receiving only one endoscopic discectomy had an average relief of 69.7% attributed to correct diagnosis of the inflicting level with SNRB. Similarly, in patients receiving lumbar (n = 83) or cervical (n = 18) decompression (19), 90% of those with a positive SNRB result had a good outcome at 16-month follow-up versus 60% of those with a negative result. This finding indicates that preoperative SNRB can improve both lumbar and cervical surgical outcomes. Stronger evidence is also available supporting SNRB as a predictive tool for cervical decompression outcomes. In a prospective study, Anderberg et al (16) found that all patients experienced eradication of radicular symptoms after receiving cervical decompression based on post-block pain relief and radiologic findings, although 5 continued to have shoulder pain. In a later study performed in patients with multilevel cervical disc pathology, 9 of the 11 patients had good or excellent surgical outcomes after receiving cervical nerve root block (17). In our study, excellent and good outcomes were achieved in over 80% of the patients, consistent with previous evidence (18). Nonetheless, 4 patients did not have a satisfactory outcome. For these patients, persistent nerve root compression was excluded from MRI, suggesting that either the diagnosis was incorrect and the SNRB was a true false positive, or decompression did not reverse the cause of the pain.

In this study, we used PPECFD as the therapeutic regimen after confirming the target level. The main reason is that PPECFD is considered a safe and effective treatment for cervical radiculopathy (10,11). Minimally invasive surgical techniques have several advantages over traditional open surgery (9). A follow-up study of 175 patients found that 2 years after receiving PPECFD operations, 87.4% of the patients reported no recurrence of neck or shoulder pain, and only 9.2% experienced occasional pain (12). Although PPECFD had a similar effect on decompression with conventional ACDF, it reduced operation-related traumatization (9). Patients included in this study did not have a definitive diagnosis. Minimally invasive decompression thus may be a better choice for them. If the decompression levels were accurate, the procedure would result in good outcomes. Even if the outcomes were not as good as we had expected, this procedure would not cause severe damages. Therefore PPECFD may be more suitable for patients who had cervical radiculopathy with diagnostic uncertainty.

This study has several limitations. First, the sample size was relatively small, and the follow-up period was not long enough. Second, we did not have a comparison group. Futures studies comparing the PPECFD with other therapeutic options (e.g., fusion surgery) may shed more light on the effect of PPECFD on the clinical outcomes. Third, although data regarding the response to SNRB and subsequent surgery were collected prospectively, this study was retrospective in design, which limited the causal inference. There might also be bias because of the lack of blinding of the surgeons to both the initial diagnostic imaging and the SNRB results. Prospective studies with larger sample size and longer duration of follow-up may help to confirm the safety and efficacy of these combined techniques.

Conclusions

In clinical practice, it is difficult to identify the pain generator among patients with cervical radiculopathy when radiologic abnormalities are not correlated with clinical symptomatology. In such patients, diagnostic SNRB may be useful to determine the target of subsequent treatments. With the guidance of SNRB, PPECFD appears to be an effective, safe, and minimally invasive method in the management of cervical radiculopathy with diagnostic uncertainty.

Authors' Contributions

XG had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analyses. XG and XY designed the study protocol. CS and NX followed up with the patients and wrote the first draft of the manuscript. BS and RC retrieved the data. HH and GX were responsible for statistical analyses of the data. All authors revised the article critically for intellectual content and approved the final version.

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