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Efficacy and Outcomes of Selective Nerve Root Blocks in Diagnosis: A Systematic Review

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Abstract **Review Article**

Background: Selective nerve root blocks or transforaminal epidural injections are commonly utilized for both diagnosing and treating various spinal disorders, such as radiculopathy or nerve compression. However, there is currently no clear consensus on their role as a diagnostic tool. The effectiveness of these injections in accurately diagnosing the underlying cause of spinal pain remains uncertain, as studies show mixed results regarding their diagnostic reliability. While these injections can provide temporary pain relief and may help identify the specific nerve root involved, their long-term diagnostic value is still a topic of debate. A systematic review of clinical studies was conducted to evaluate the accuracy of selective nerve root injections for diagnosing spinal pain. Methodological quality was assessed using the PRISMA guidelines. Studies were categorized based on the strength of evidence into five levels: problem identification, literature searching, data review and evaluation, data synthesis and analysis or data presentation. Studies were categorized based on the strength of evidence into five levels: conclusive, strong, moderate, limited, or indeterminate. The review included an extensive literature search across multiple databases such as PubMed, Google Scholar and EMBASE. There is limited evidence regarding the effectiveness of selective nerve root injections as a diagnostic tool for spinal pain. Although the research is insufficient to provide stronger support, the existing literature suggests that selective nerve root injections can be useful in diagnosing uncertain cases of radicular pain. Moderate evidence supports their use in preoperative evaluations, particularly when imaging studies are negative or inconclusive. While the positive predictive value of these injections is low, they are valuable for their negative predictive value, meaning they are more effective in ruling out conditions than in confirming them.

Keywords: Selective nerve root block, transforaminal epidural injection, spinal pain, discogenic pain, radiculopathy, nerve root pain.

INTRODUCTION

Spinal pain is often challenging to diagnose accurately because many abnormalities detected through imaging studies do not cause pain. Aside from fractures, spinal disorders causing pain are typically classified into four main categories: compressive, inflammatory, degenerative, or multifactorial. These categories reflect different underlying mechanisms contributing to the pain, which can make diagnosis complex [1-7]. To be recognized as a source of pain, a structure must have a nerve supply, be capable of producing clinically identifiable pain, and be prone to injury or disease.

Fluoroscopic (x-ray) guided local anesthetic injections are used to test painful structures. When a structure is selectively anesthetized and the patient experiences pain relief for the duration of the anesthetic, it is identified as the pain source. The neural foramen, a bony passageway between adjacent vertebrae, is a common location for compressive and inflammatory disorders affecting spinal nerve roots [7,8]. Regarding their potential therapeutic benefit, spinal injections have drawn a lot of attention. More specifically, as techniques have improved with the use of fluoroscopic or CT guidance, the use of epidural steroid injections in the treatment of spinal diseases has advanced [1-6,9,10]. Indications for spinal injections

encompass radicular pain, spinal stenosis, and lower back pain attributed to discogenic causes. However, using foraminal and nerve root injections as diagnostic tools lacks a standardized application method, and there is ongoing debate regarding the terminology [1-4,11-18]. Manchikanti and Singh [17,19] observed that the terms used to refer to transforaminal injections have changed over time, encompassing periradicular injections, selective nerve root blocks, selective nerve root sleeve injections, selective epidurals, selective spinal nerve blocks, and selective ventral ramus blocks. According to Bogduk [20] this method is called a lumbar nerve block, where a lumbar spinal nerve (or the SI spinal nerve) aliquot is applied to selectively anesthetize the nerve and its roots. Gajraj [21] emphasized that to ensure a nerve root block is selective, it should be performed extraforaminally, beyond the division of the ventral and dorsal rami. Otherwise, there is a risk of anesthetizing all structures innervated by the dorsal rami. Consequently, it is recommended to use the term "transforaminal epidural steroid injection" for the therapeutic technique and "selective spinal block" or "selective ventral ramus block" for the diagnostic method. To address the confusion, Datta and Pai [22] argued that the term “transforaminal” is misleading, as it implies that the needle passes through the foramen, whereas it actually remains paraforaminal. They suggested rephrasing “selective nerve root block” to “paraforaminal injection” since the medication does not preferentially target the ventral ramus. Alternative terms proposed include “periradicular,” “nerve root infiltration (NRI),” “transforaminal selective nerve root block,” “segmental nerve root block,” and “lumbar nerve block.” [16, 17, 20, 23]

Manchikanti and Singh [17,19] observed that, presumably based on anatomical differences, Karppinen *et al.,* [12, 16, 23] injected contrast of 0.5–1.0 mL for diagnostic purposes followed by a therapeutic injection of 40 mg of methylprednisone, bupivacaine, or isotonic sodium chloride solution in a volume of 2 mL for L4 or L5 blocks and 3 mL for S1. Although ventral location may still be advantageous, higher quantities of injectate may produce broad blockage similar to an interlaminar injection. Some who adhere to strictures maintain that transforaminal injections and selective nerve root block are two different and distinct methods. Many people have used them interchangeably over the years. Although there is some variation in its application, the procedure has potential as a diagnostic tool, though its reliability is not entirely obvious [17, 25-27]. Steindler and Luck [25] established the benefits of both stimulating and analgesic spinal injections in 1938. In 1971, MacNab2 [6] provided evidence of the usefulness of diagnostic selective nerve root blocks in the preoperative assessment of patients exhibiting both clinical signs of nerve root irritation and negative or inconclusive imaging investigations. Since then, imaging investigations that revealed possible compression of many nerve roots have led to the use of nerve blocks to identify the cause of radicular pain [26-36]. The rationale behind a diagnostic spinal nerve block is that if a specific spinal nerve is responsible for a patient's symptoms, then temporarily anesthetizing that nerve should provide relief from those symptomsn [20] Bogduk [20] further proposed that if pain is the symptom, anesthetizing the affected nerve should relieve the pain. If the symptom is paresthesia, numbing the responsible nerve should result in a loss of sensation in the area where the paresthesia was previously experienced. Conversely, if the symptom is numbness, anesthetizing the relevant nerve should either not alter the numbness or possibly intensify it. Bogduk also suggested that if a nerve not responsible for the patient’s symptoms is anesthetized, there will be no relief of pain and numbness may occur in areas unrelated to the patient’s usual symptoms of paresthesia or numbness.

Lumbar spinal nerve blocks are considered conceptually valid because anesthetizing a specific nerve should alleviate symptoms mediated by that nerve. Face validity is confirmed by using fluoroscopy to guide the injection, with the contrast medium clearly outlining the target nerve root and not spreading to other structures. To establish construct validity, selective nerve root blocks must be conducted under controlled conditions to minimize the risk of false positives. However, there are currently no detailed procedures described for ensuring this validity. Therefore, when selective nerve root blocks are indicated, they are generally assumed to have no false-positive effects [20]. In 1992, Nachemson [37] analyzed the literature on low back pain and found that diagnostic selective nerve root blocks offered valuable prognostic information regarding surgical outcomes. Van Akkerveeken [34] described the sensitivity, specificity, and predictive value of these diagnostic blocks. He demonstrated that for a block to be considered positive, it needed to reproduce symptoms during root stimulation and provide complete pain relief following the anesthetic infusion. The aim this systematic review was conducted to evaluate whether selective nerve root injections are an effective diagnostic method for spinal disorders.

Objectives

The main objective of this review was to assess the accuracy of selective nerve root injections in diagnosing spinal disorders.

METHODOLOGY & MATERIALS

Selection Criteria:

i. Inclusion Criteria:

a. Both controlled and uncontrolled clinical studies that incorporated diagnostic selective nerve root injections were included in the study.
b. Participants experiencing pain of spinal origin were included.
c. Selective nerve root injections were performed under fluoroscopic guidance.

d. Pain relief, correlation with other diagnostic tests or therapeutic outcomes.

ii. Exclusion Criteria:

a. Non-clinical studies, expert opinions, or definitive therapeutic studies were excluded.
b. Non-selective nerve injections, the route of administration was not specifically described, were assumed to be interlaminar and were therefore excluded from this review.

Study Design:

This review was conducted using PRISMA guidelines. The review consisted of 5 steps: (1) problem identification; (2) literature searching; (3) data review and evaluation; (4) data synthesis and analysis; and (5) data presentation.

Search Method:

The current review performed a search for relevant articles in electronic databases: PubMed, Google Scholar and Embase.

The specific search terms, such as "diagnostic techniques & procedures," "nerve root block injections," and "spine," to identify the most pertinent studies for this review. These terms were chosen to capture a wide range of studies related to diagnostic methods and the use of nerve root block injections for spinal disorders. The search deliberately excluded terms associated with facet joints and zygapophyseal joints to focus solely on nerve root injections. Only articles published in English were included; however, foreign language articles were considered if an English translation was available, ensuring comprehensive coverage of relevant research. To further expand the scope of the review, the reference sections of the selected articles were examined. This process aimed to uncover additional relevant studies that might not have been identified through the initial search. By reviewing these references, the goal was to ensure a comprehensive inclusion of all pertinent research related to selective nerve root injections and spinal disorders.

Data collection:

We gathered information by picking out specific data from different studies. This review involved several systematic steps to ensure the accurate gathering of relevant information. Initially, a computerized database search was performed using specific search terms related to the review's focus. This search yielded initial data, including author names, titles, keywords, and abstracts, which were then reviewed to apply exclusion criteria. When the abstract did not provide sufficient information to determine relevance, the full journal article was obtained and examined. The assessment focused on key aspects such as study design, number of patients, outcomes studied, duration of the study, and the quality of the study. After evaluating the articles, relevant data was abstracted to provide a detailed and comprehensive overview. This data collection process was designed to assess the effectiveness and accuracy of selective nerve root injections in diagnosing spinal disorders.

The search resulted in 130 articles which were identified in the initial databases (Figure 1). After duplicates were removed, 85 articles remained. Of these, 55 were excluded based on titles and abstracts screened; 22 full articles were excluded for not meeting inclusion criteria. Finally, 8 publications met the criteria and were included in this review.

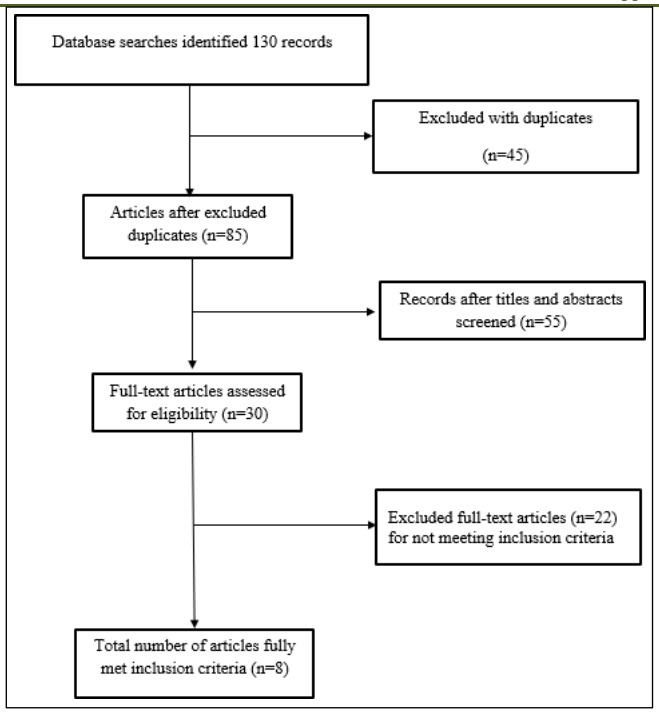

Figure 1: Flow chart of systematic review of literature selection process for the present research

RESULT

In the present review, we included 8 papers: one was a prospective-cohort one was a retrospective case, two was a prospective case series, three was a retrospective study, one was a Prospective study (Table 1). The total number of patients was 499.

In a 2006 study by Anderberg *et al.*, [38] the distribution patterns of transforaminal injections in the cervical spine were evaluated using multislice computed tomography. The study involved three groups of patients, with different volumes of injectate (0.6, 1.1, and 1.7 mL) administered using the transforaminal technique, along with a small amount of contrast media. The findings indicated that only the 0.6 mL injections were selective enough to be considered appropriate for diagnostic investigations, suggesting that larger volumes may not provide the same diagnostic specificity.

In a retrospective study by Dooley *et al.*, [31] mechanical nerve stimulation was followed by selective nerve root blocks and subsequent surgical treatment. The study confirmed that 85% of patients with single-root involvement experienced concordant pain during mechanical nerve stimulation with needle placement and pain relief after anesthetic application along the nerve root. This approach proved effective not only in identifying single-root involvement but also in distinguishing patients without spinal issues from those with multiple levels of nerve root involvement, aiding in more precise diagnosis and treatment planning.

Faraj and Mulholland [22] assessed the use of a nerve stimulator in response to the unpredictability of nerve root infiltration (NRI) with local anesthetics and steroids. They suggested that the uncertainty arises because the targeted nerve root causing the pain might not be correctly infiltrated. To address this, they advocated for the use of a nerve stimulator to accurately identify the specific nerve root before performing the infiltration, thereby improving the precision and effectiveness of the procedure.

Haueisen *et al.*, [30] conducted an early study on patients experiencing radicular symptoms after laminectomy, comparing the diagnostic accuracy of spinal nerve root injections using lidocaine to myelograms for identifying surgical pathology and outcomes. Among the 105 patients who underwent selective nerve root injections, 55 had surgical reexplorations. The nerve root injections accurately diagnosed 43 out of 55 patients (93%) with surgical pathology, while myelograms were accurate in only 24% of cases. After an average follow-up of 20 months, 73% of the patients showed improvement. The study concluded that selective nerve root blocks are valuable for accurate diagnosis in patients with surgically altered spinal anatomy.

Herron [35] evaluated the use of selective nerve root blocks to confirm the spinal origin of pain complaints. The study found that surgical outcomes were most favorable in patients with lumbar disc herniation and spinal stenosis, while those with a history of prior surgery had poorer outcomes. The use of selective nerve root blocks was instrumental in narrowing the pool of potential surgical candidates from 215 to 71, who then proceeded with surgical repair.

Schutz *et al.,* [27] conducted a retrospective study involving selective nerve root blocks in 23 patients. Out of these, 15 patients underwent surgery at the level indicated by the diagnostic block. Positive findings that aligned with the diagnostic results were observed in 13 out of these 15 patients (87%). However, 18% of the tests were unsuccessful due to intolerable pain during the procedure or failure to stimulate the targeted nerve root, particularly at the S1 level.

Slipman *et al.,* [39] investigated the impact of mechanical stimulation on 87 patients, focusing on 134 cervical nerve roots. Patients were asked to describe their referred symptoms using a pain diagram, which was used to create a "dynatomal" map. This map was then compared to traditional dermatomal maps. The study found that the dynatomal map closely resembled classic dermatomal maps but often showed greater overlap with other dermatomes and had a broader distribution. This research highlighted the potential advantages of using a selective approach in diagnosing spinal pain, suggesting that dynatomal mapping could provide more detailed and comprehensive insights into pain distribution.

Tajima [29] conducted an early study comparing the effectiveness of mechanical stimulation and anesthetic response in 106 patients against myelography and surgical outcomes. The study also compared the results of radiculograms with normal dye patterns observed in reference patients and cadaveric studies. Despite the diversity of disorders, selective nerve root blocks proved useful in identifying the pain source in most cases, which aligned with the abnormalities discovered during surgical repair. Furthermore, the technique was beneficial in restricting surgical decompression to the area of primary pain generation.

Table 1: Summary of the published articles

Reference	Study design	Sample size (n)	Intervention	Outcome	Findings
Anderberg *et al.,* [38], Sweden	Prospective-cohort	n= 20	Nerve block with MRI and surgical correlation in cervical radicular pain	VAS and surgical outcome	Out of 20 patients, 18 experienced significant relief after the nerve block and underwent surgery, with none reporting radicular pain post-surgery.
Dooley *et al.,* [31], Canada	Retrospective case.	n= 62 patients with radicular symptoms	Needle-based mechanical stimulation and SNRB were compared to surgery.	Comparison of the SNRB response with the surgical outcome	In 44 patients, positive SNRB results were confirmed by surgery, which identified local pathology in all cases.
Faraj and Mulholland, [22], UK	Prospective case series	n=96 patients with leg pain	Nerve root blocks were done with and without a stimulator, with an epidurogram obtained.	Comparison of SNRB response rates with and without a neurostimulator.	The response rate was 89%, with better outcomes for lateral canal stenosis and battered root syndrome compared to post-discectomy or disc prolapse pain. Pain relief was achieved in 96% of cases when NRI was guided by a neurostimulator, compared to 79% without its use.
Haueisen *et al.,* [30], United States	Retrospective study	n= 105 patients with sciatica	SNRB was performed post-laminectomy, followed by surgical re-exploration.	Comparison of surgical findings with SNRB versus myelogram.	Patients with a positive SNRB had confirmed positive surgical pathology.

Herron, [35] U.S.A.	Retrospective study	n= 215 patients with leg pain (78 underwent surgery)	SNRB before surgery	Comparison of surgical findings and outcomes	Out of 78 patients who underwent surgery, 53% had a good result, 23% had a fair result, and 24% had a poor result.
Shutz *et al.*, [27], Canada	Retrospective study	n=23 patients with sciatica	Selective nerve root blocks and surgery	Comparison of SNRB to surgical findings and outcomes	Of the 15 patients with positive test results who underwent surgery, surgical findings matched in 13 cases (87%). However, 18% of the tests failed due to the inability to stimulate the target nerve root.
Slipman *et al.*, [39] United States	Prospective study	n=87	Cervical nerve root mechanical stimulation	Pain mapping diagram	Dermatomal maps show sensory nerve areas, while dynatomal maps depict functional nerve aspects.
Tajima *et al.*, [29], Japan	Prospective case series	n= 106	Comparing mechanical stimulation with a needle and SNRB in surgical exploration	Comparison of SNRB response to imaging and surgical findings	In patients with a positive SNRB, imaging and surgical pathology were consistent.

DISCUSSION

This systematic review of literature on selective nerve root blocks indicates that the sensitivity and specificity of this technique vary widely, ranging from 45% to 100%. As a result, diagnostic selective nerve root blocks can be considered effective in evaluating patients with multilevel spinal pathology, helping to determine the precise source of pain. Additionally, they may be particularly useful when the location of symptoms does not align with abnormalities seen on imaging studies, aiding in more accurate diagnosis.

Selective nerve root block has been recognized as a valuable presurgical diagnostic tool for patients with uncertain anatomical findings. It has shown effectiveness in detecting previously unrecognized disc herniations, identifying the symptomatic level in cases of multilevel disc herniation, and determining the primary pain source in conditions such as spine-hip syndrome and root irritation from spondylolisthesis. Additionally, it helps assess symptomatic levels in multilevel stenosis and pinpoint the affected root in patients with postoperative fibrosis. A study reported that nerve root pain was present in 44% of patients with unexplained low back pain, even after thorough medical history, physical exams, radiographic, and electrophysiologic assessments [40].

Other studies [41] advise caution, highlighting that while the sensitivity of selective nerve root blocks is very high, their specificity is only moderate. In fact, the specificity of sciatic nerve block has been found to be comparable to that of selective nerve root block. However, the sensitivity of selective nerve root blocks was superior when compared to sciatic nerve blocks, posterior ramus blocks, and subcutaneous injections in a group of patients with sciatica [41].

Unlike facet joint blocks, which are confirmed through clinical results, diagnostic selective nerve root blocks are also validated by surgical examination. However, similar limitations apply to transforaminal epidural injections. Selective nerve root blocks lack a reliable methodology to prevent false positives, and using pain relief as the standard cannot definitively confirm or refute accuracy. Consequently, the true specificity and sensitivity of selective nerve root blocks, based on the pain-relief phenomenon, remain uncertain. These blocks are more akin to physical examinations than to most laboratory tests, which typically have a definitive gold standard for accuracy comparison.

Saal[5] explored the principles underlying diagnostic testing and assessed the effectiveness of existing diagnostic methods for lumbar spine disorders. Rather than suggesting that current diagnostic techniques are flawed or should be used less frequently, Saal proposed that their limitations should be acknowledged as part of the broader context of diagnostic medicine. He emphasized that all diagnostic tests have inherent inaccuracies, and this understanding should inform their interpretation. According to Saal [5], clinicians should not rely solely on diagnostic tests but should instead consider these results alongside other clinical data, including a detailed patient history, physical examination findings, and non-invasive imaging studies. By

integrating these diverse sources of information, healthcare providers can form a more comprehensive view of the patient's condition. This holistic approach enables clinicians to make more informed decisions regarding appropriate treatments and therapies. It allows for a more nuanced understanding of the patient's condition and helps in selecting interventions that are tailored to the specific needs of the patient, thus improving the overall management of painful spinal disorders [5,42,43].

No systematic reviews have directly compared our results with previous reviews. However, Boswell *et al.,* [1] while preparing guidelines for interventional techniques, evaluated the evidence for selective nerve root blocks. They found the evidence to be moderate for using selective nerve root blocks in the preoperative assessment of patients who have negative or inconclusive imaging studies but present with clinical signs of nerve root irritation.

Chronic spinal pain presents significant diagnostic challenges for physicians, especially when standard diagnostic methods such as physical examination, patient history, radiologic imaging, electrophysiologic tests, and psychological evaluations do not yield conclusive results. The complexity of spinal pain often requires multiple layers of assessment to pinpoint the underlying cause. When common sources like facet joint pain or discogenic pain are excluded, physicians may turn to diagnostic selective nerve root blocks as a potential solution.

A diagnostic selective nerve root block involves injecting a local anesthetic around a specific nerve root suspected of causing pain. If the patient's pain is relieved following the block, it suggests that the targeted nerve root is likely the pain generator. However, without clear indicators from prior diagnostic tests, this method becomes crucial yet still requires careful interpretation due to the potential for false positives or negatives. Using neurostimulation techniques alongside imaging studies, such as MRI or CT scans, can improve the accuracy of nerve root blocks by ensuring the correct nerve root is targeted. Neurostimulation helps identify the specific nerve root involved by stimulating it and reproducing the patient's symptoms, thus improving the likelihood that the block will provide meaningful diagnostic information. Additionally, performing a comprehensive evaluation with advanced imaging before the nerve block can provide a better understanding of the spinal pathology. This allows the physician to predict the patient's response to the block, tailoring the diagnostic approach more effectively. A combination of imaging and neurostimulation can help guide the procedure and increase the likelihood of an accurate diagnosis, leading to better treatment planning and patient outcomes.

Limitations

The current review of selective nerve root blocks (SNRBs) reveals several limitations. The existing literature is sparse and inconsistent, offering only limited support for their use as a diagnostic tool. There is no consensus on their role, and the quality of studies varies significantly, affecting the reliability of results. Most research focuses on short-term outcomes rather than long-term effectiveness. Additionally, there is a lack of comparative studies with other diagnostic tools such as MRI or CT scans, and SNRBs are known to have a low positive predictive value, though they are useful for ruling out conditions. The inclusion criteria restricted the review to studies written exclusively in English, thus excluding potentially valuable literature in other languages.

CONCLUSION

The present review, selected nerve root blocks (SNRBs) have been shown to be a useful diagnostic tool for spinal illnesses exhibiting characteristics of radicular pain, based on moderate evidence. The available research on this subject is few, but what is known is that SNRBs may be helpful in the diagnosis of radicular pain when other diagnostic techniques yield conflicting results. Particularly, in patients exhibiting ambiguous symptoms, selective nerve root blocks could be useful in identifying the pain-producing nerve root when conventional imaging or clinical evaluations might not be able to determine the source. However, additional research is necessary to comprehensively determine the diagnostic accuracy of selective nerve root blocks (SNRBs), especially in predicting outcomes for both surgical and non-surgical treatments. Comparative studies are essential to evaluate how SNRBs measure up against established diagnostic methods such as MRI, CT scans, and electrodiagnostic tools like electromyography (EMG) and nerve conduction studies. Through such comparative analyses, clinicians can better understand the role of SNRBs in diagnosing spinal disorders and refine treatment strategies for patients with radicular spinal pain. This will ensure that SNRBs are appropriately used, either as a complementary diagnostic tool or as part of a broader diagnostic algorithm, to improve patient outcomes and avoid unnecessary interventions.

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