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Systematic Review

An Updated (2026) Best-Evidence Synthesis Appraisal of the Diagnostic Accuracy and Utility of Facet (Zygapophysial) Joint Injections in Chronic Spinal Pain

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Background: Chronic axial spinal pain is one of the leading causes of disability. The literature demonstrates that expenditures for low back and neck pain continue to rise, not only in parallel with increasing disability, but also with escalating healthcare costs, accounting for the highest spending among multiple disease categories. Based on current evidence utilizing controlled diagnostic blocks, facet joints, nerve root dura, and sacroiliac joints have been identified as potential sources of spinal pain.

Study Design: A systematic review of the diagnostic accuracy of spinal facet joint nerve blocks.

Objective: To determine the diagnostic accuracy of spinal facet joint nerve blocks in chronic spinal pain.

Methods: Methodological quality of the included studies was assessed using the Quality Appraisal of Reliability Studies (QAREL) instrument. Only diagnostic accuracy studies meeting at least 50% of the predefined inclusion criteria were included in the analysis.

The strength of evidence was graded using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) criteria. Levels of evidence were classified using a modified best evidence synthesis, ranging from Level I to Level V.

Data sources included relevant literature identified through PubMed and other electronic searches published from 1966 through September 2025, Cochrane reviews, and manual searches of the bibliographies of primary and review articles.

Outcome Measures: Eligible studies were required to use placebo-controlled or comparative local anesthetic blocks. A positive diagnostic standard was defined as at least 50% pain relief from baseline scores along with the ability to perform previously painful movements.

Results: The available evidence demonstrated Level I for lumbar facet joint nerve blocks, based on 18 studies employing dual diagnostic blocks, demonstrating 75% to 80% pain relief, with an average prevalence of 16% to 45% and estimated or presumed false-positive rates of 25% to 50%.

Evidence for the diagnosis of cervical facet joint pain using cervical facet joint nerve blocks is Level II, derived from 12 controlled diagnostic accuracy studies, showing substantial heterogeneity and internal inconsistency. Reported prevalence ranged from 36% to 67% with ≥ 80% pain relief and estimated or presumed false-positive rates of 26% to 63%.

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The level of evidence for the diagnostic accuracy of thoracic facet joint nerve blocks is Level II, based on 3 studies using dual diagnostic blocks, demonstrating 80% or greater pain relief, with prevalence ranging from 34% to 48% and estimated or presumed false-positive rates ranging from 42% to 58%.

Limitations: Limitations of this systematic review include the limited number of studies involving the thoracic spine, ongoing debate regarding the appropriate reference standard, challenges in determining false-positive rates, concerns regarding the appropriateness of diagnostic blocks, the scarcity of recent publications, and issues related to clinical utility.

Conclusion: There is Level I evidence for the diagnostic accuracy of lumbar facet joint nerve blocks and Level II evidence for cervical and thoracic facet joint nerve blocks in the evaluation of chronic spinal pain.

Key words: Chronic spinal pain, lumbar facet or zygapophysial joint pain, cervical facet or zygapophysial joint pain, thoracic facet or zygapophysial joint pain, facet joint nerve blocks, medial branch blocks, controlled comparative local anesthetic blocks

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Chronic axial spinal pain, with or without extremity pain, chest wall pain, or headaches, is a major cause of disability and healthcare expenditures in the United States and worldwide (1-15). Multiple publications evaluating the status of health and disability in the United States (16), as well as spending on low back and neck pain and musculoskeletal disorders (17), have demonstrated escalating disability and rising costs associated with the management of low back and neck pain, accounting for the highest expenditures among major disease categories. Despite the availability of numerous treatment modalities, chronic persistent spinal pain is reported in 25% to 60% of patients for at least one year and often much longer following an initial episode (1,2,10-18).

Pain prevalence differs by spinal region, with the lumbar spine demonstrating the highest prevalence at 43%, followed by the cervical spine at 32% and the thoracic spine at 13% (19). Chronic spinal disorders are strongly associated with physical disability and a wide spectrum of psychological comorbidities, including depression, generalized anxiety disorder, cognitive impairment, and somatization (1,2,10-18,20). Furthermore, chronic spinal pain in parents has been associated with an increased likelihood of similar conditions in their children during adulthood (21).

Interventional approaches for the diagnosis and treatment of facet joint pain continue to generate considerable debate, despite advances in knowledge and multiple reports describing a deceleration in utilization growth patterns in the United States (22-28). Numerous publications addressing diagnostic accuracy and clinical utility have reported favorable outcomes (1-9,29-48).

Despite the exponential growth in available treatments, disability related to spinal pain continues to increase, driven by several factors, including the intrinsic difficulty of establishing an accurate diagnosis (1-18). An inaccurate or incomplete diagnosis may result in therapeutic failure, unnecessary diagnostic testing, and an artificial inflation of disease prevalence, leading to inappropriate healthcare expenditures and misallocation of resources (1,2,29-35). Diagnostic tests are fundamental to achieving accuracy in identifying the pain generator (1,2,29,32-35). Spinal pain without radiculitis is frequently encountered in both primary and tertiary care and establishing a definitive diagnosis in such cases remains challenging.

Based on the available literature, intervertebral discs, facet joints, nerve root dura, and sacroiliac joints have all been identified as potential sources of spinal and extremity pain (1,2,29). Controlled investigations have confirmed intervertebral discs, facet joints, and sacroiliac joints as sources of spinal pain (1,2,29,32-35). Nevertheless, despite recent advances and a substantial body of published work, facet joint pain is often not accurately diagnosed using conventional clinical and radiological methods (1,2,8,9,29,36-46). As a result, controlled diagnostic blocks have been advocated (1,2,29). Ongoing controversy, however, persists regarding the principles, accuracy, and appropriateness of diagnostic interventions and the treatments that follow.

According to Bogduk's postulates (47), spinal facet joints possess an extensive nerve supply (48-63), are

capable of generating persistent pain (64-79), and are affected by degenerative, inflammatory, and traumatic conditions including osteoarthritis, rheumatoid arthritis, and spondylitis, which lead to restricted motion and pain during movement (49,78,80-92). Using reliable and valid diagnostic techniques, these joints have been established as pain generators (1,2,29,41,93-104). Accordingly, controlled local anesthetic blocks of spinal facet joints or their medial branches are utilized for the diagnosis of facet joint pain.

The underlying rationale is that a painful joint will become asymptomatic for the duration of action of the local anesthetic, whereas blockade of a nonpainful joint will not modify the pain response. Repetition of the block with an anesthetic of different duration that reproduces the analgesic pattern increases the likelihood that the targeted joint is the true source of pain. Therefore, to ensure diagnostic validity and reliability, blocks must be controlled, verified for accurate delivery of the anesthetic, and designed to minimize placebo responses (1,2,29,48,94-98). A single facet joint injection is not recommended, as it does not adequately control for false-positive responses (1,2,29-35,94-102), although some have proposed therapeutic interventions without prior diagnostic blocks (103). The diagnostic accuracy of facet joint nerve blocks has been supported by studies with long-term follow-up (1-9,29-31,104). At the same time, numerous publications have both supported and questioned the validity of these diagnostic procedures (1,2,29-35,48,94,102-110).

Establishing a true placebo control for nerve blocks has proven extremely difficult, and to date, true placebo-controlled trials have not been conducted in the thoracic spine. Hancock et al (93) performed a systematic review of tests used to identify the disc, sacroiliac joint, or facet joint as sources of low back pain. Based on eight available studies at that time, they concluded that none of the tests for facet joint pain were informative. Subsequently, systematic reviews conducted for guideline development for the American Society of Interventional Pain Physicians (ASIPP) by Sehgal et al (109), Falco et al (95,96), and Atluri et al (97) were published. In 2007, Rubinstein and van Tulder (98) performed a best evidence review of diagnostic procedures for neck and low back pain, identifying 17 studies evaluating validity, prevalence, and false-positive rates of facet joint blocks, and concluded that strong evidence supported their diagnostic accuracy. In 2023, Hancock et al's review (93) was updated by Han et al (110), who reported that informative index tests could identify the facet joint, disc, and sacroiliac joint as sources of low back pain and challenged the prevailing notion that a pathoanatomical diagnosis is generally unattainable, thereby questioning the routine use of the label non-specific low back pain.

The systematic review conducted for ASIPP guideline developments by Manchikanti et al (1,2) demonstrated Level I evidence with moderate to strong strength of recommendation for the lumbar spine, showing 75% to ≥80% pain relief with controlled diagnostic blocks, a prevalence of 16% to 45%, and a presumed false-positive rate of 25% to 50%. For the cervical spine, the evidence was Level II with moderate strength of recommendation, ≥ 80% pain relief, prevalence ranging from 36% to 67%, and false-positive rates of 26% to 63%, with substantial variability. For the thoracic spine, the evidence was also Level II with moderate strength of recommendation, ≥ 80% pain relief, prevalence of 34% to 48%, and estimated false-positive rates between 42% and 58%.

Bogduk (32,33), in scholarly publications in 2022 and 2023, addressed the validity of diagnostic testing (32) and the validity and clinical utility of comparative local anesthetic blocks for the diagnosis of spinal pain (33), and together with Klessinger (34,35) introduced the concept of inconsistency rates related to false-positive responses in diagnostic medial branch blocks. In addition, Manchikanti et al (1,2,29) and other investigators have discussed numerous factors influencing diagnostic accuracy and clinical outcomes, including age, clinical assessment, psychological status, body mass index, prior surgery, smoking, sex, opioid exposure, sedation, and the effects of chronic pain on diagnostic interpretation. Manchikanti et al (30,31) further described the evolving role of diagnostic blocks in chronic low back and neck pain, noting a paradigm shift. Long-acting local anesthetics typically provide longer analgesia than short-acting agents. Studies in chronic pain models have shown that short-acting agents with effects lasting less than two hours and long-acting agents with effects lasting less than eight hours may be unreliable for diagnostic discrimination.

Consequently, an updated assessment has been undertaken to further evaluate the diagnostic accuracy of these interventions.

Methods

The methodology applied in this systematic review adhered to the review process derived from evidence-based systematic reviews and diagnostic accuracy studies (1,29,93,95-98,111-116)

Criteria for Considering Studies for This Review

Types of Studies

Diagnostic accuracy studies evaluating spinal facet joint pain involving the cervical, thoracic, and lumbar facet joints.

Types of Participants

Patients suffering from chronic neck pain, mid back pain, upper back pain, and low back pain.

Types of Interventions

Diagnostic cervical, thoracic, and lumbar facet joint injections.

Types of Outcome Measures

- The primary outcome parameter was pain relief.
- The secondary outcome measure was improvement in functional status.

Literature Search

All available trials in all languages and from all countries that provided appropriate management with outcome evaluations were considered for inclusion. Searches were conducted using the following sources without language restrictions:

1. PubMed from 1966
   www.ncbi.nlm.nih.gov/sites/entrez?db=pubmed
2. Cochrane Library
   www.thecochranelibrary.com/view/0/index.html
3. US National Guideline Clearinghouse (NGC)
   www.guideline.gov/
4. Previous systematic reviews and cross references
5. Clinical Trials
   www.clinicaltrials.gov/
6. All other sources including non-indexed journals and abstracts

The search period was from 1966 through November 2025.

Search Strategy

The search strategy focused on chronic cervical, mid back, and low back pain, facet or zygapophysial joint pain, cervical, thoracic, and lumbar facet injections, and cervical, thoracic, and lumbar facet joint nerve blocks.

The key words searched were: ((((((((((spinal pain, chronic low back pain) OR chronic back pain) OR chronic neck pain) OR facet joint pain) OR lumbosciatic pain) OR postlaminectomy) OR lumbar surgery syndrome) OR cervical post surgery syndrome OR spinal stenosis) OR zygapophysial)) AND ((((((facet joint) OR zygapophyseal) OR zygapophysial) OR medial branch block) OR diagnostic block) OR intraarticular).

This systematic review was limited to the evaluation of the diagnostic accuracy of facet joint injections. Only cervical, thoracic, and lumbar facet joint nerve blocks performed under fluoroscopic or computed tomography guidance were included. Studies in which blocks were performed using other imaging modalities or without image guidance were excluded. All investigations employing controlled diagnostic blocks, published in any language and from all sources, that reported appropriate outcome measures with valid statistical analyses were reviewed. Studies lacking appropriate diagnostic criteria, non-systematic reviews, book chapters, and case reports were excluded.

Data Collection and Analysis

The methodological quality for each included article was assessed using the Quality Appraisal of Reliability Studies (QAREL) checklist (Table 1) (111,115). This instrument has been validated and applied in multiple systematic reviews (1,2,29,95-97,103,116). The final set of selected studies underwent evaluation of quality and applicability using a 12-item checklist. The face validity of the checklist was confirmed by expert methodologists (111,115) and it was compared with other diagnostic reliability assessment tools used in systematic reviews (115-118). The checklist was developed in accordance with the Standards for Reporting Studies of Diagnostic Accuracy (STARD) (112) and the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) appraisal tool (114). Each item on the checklist was independently evaluated and graded as "yes," "no," "unclear," or "not applicable."

Inclusion and Exclusion Criteria

Only studies utilizing controlled diagnostic blocks, including placebo-controlled blocks, comparative local anesthetic blocks, or single blocks, with appropriate assessment and statistical evaluation were included. In addition, only studies scoring at least 4 of 12 on the Quality Appraisal Tool for Studies of Diagnostic Reliability (QAREL) were considered for diagnostic accuracy analysis (1,2,95-97,109,116).

Table 1. *Quality Appraisal of Diagnostic Reliability (QAREL) checklist.*

Item	Yes	No	Unclear	N/A
1. Was the test evaluated in a spectrum of subjects representative of patients who would normally receive the test in clinical practice?				
2. Was the test performed by examiners representative of those who would normally perform the test in practice?				
3. Were raters blinded to the reference standard for the target disorder being evaluated?				
4. Were raters blinded to the findings of other raters during the study?				
5. Were raters blinded to their own prior outcomes of the test under evaluation?				
6. Were raters blinded to clinical information that may have influenced the test outcome?				
7. Were raters blinded to additional cues, not intended to form part of the diagnostic test procedure?				
8. Was the order in which raters examined subjects varied?				
9. Were appropriate statistical measures of agreement used?				
10. Was the application and interpretation of the test appropriate?				
11. Was the time interval between measurements suitable in relation to the stability of the variable being measured?				
12. If there were dropouts from the study, was this less than 20% of the sample.				
TOTAL				

Source: Lucas NP, Macaskill P, Irwing L, Bogduk N. The development of a quality appraisal tool for studies of diagnostic reliability (QAREL). *J Clin Epidemiol* 2010; 63:854-861 (111).

Data Extraction and Management

Two review authors independently, in an unblinded and standardized manner, developed the search criteria, conducted the literature searches, selected eligible articles, and extracted data from the included studies. Disagreements were resolved through discussion between the two reviewers, and when necessary, a third author adjudicated unresolved differences.

Methodological Quality Assessment

Methodological quality was assessed by multiple reviewers, with pairs of authors each evaluating 4 to 6 articles. Assessments were performed independently in an unblinded standardized manner to determine methodological quality and internal validity of all studies considered for inclusion. Procedures were implemented to minimize discrepancies; when differences occurred, they were reviewed by a third evaluator and resolved by consensus. Persisting issues were discussed with the full author group and resolved collectively.

In the event of a conflict of interest, including situations in which a reviewer was assigned to assess an article he or she had authored, that reviewer was excluded from evaluating the methodological quality of the study.

The minimum acceptable pain relief threshold for a positive diagnostic block was defined as ≥ 50% relief during the performance of previously painful movements.

Assessment Utilizing Grading of Recommendations, Assessment, Development and Evaluation (GRADE) Criteria

Evidence grading was conducted using the GRADE system to determine overall strength and certainty of evidence (119,120). The GRADE assessment evaluated five domains, including methodological limitations, consistency of results, indirectness of evidence, imprecision, and publication bias. Each domain was rated as high, moderate, low, or very low, as summarized in Table 2. Based on the methodological quality of the included studies, the overall level of evidence could remain unchanged, be downgraded, or be upgraded.

The certainty of evidence was determined by assessing risk of bias, imprecision, inconsistency, indirectness, and publication bias, with corresponding adjustments made to the certainty rating, either upward or downward, as detailed in Table 3.

The methodological quality assessment and GRADE appraisal were independently performed by two authors (ADK, NNK) in an unblinded manner. Any disagreements were resolved in consultation with a third author (CGG). When a potential conflict of interest related to authorship was identified, the involved reviewers were excluded from the quality assessment of those studies.

Summary Measures

Summary measures included ≥ 50% and ≥ 80%

pain relief with the ability to perform previously painful movements, concordant with the duration of action of the local anesthetic, as well as pain relief following single blocks and dual blocks.

Analysis of Evidence

The analysis of the evidence was conducted using grading based on a best evidence synthesis, developed with modifications of multiple existing criteria, including those of the United States Preventive Services Task Force (USPSTF), as shown in Table 4 (121).

The analysis was performed using 5 levels of evidence, ranging from Level I to Level V.

At least 2 review authors independently, in an unblinded standardized manner, evaluated the evidence. Any disagreements were resolved by a third author and by consensus. In the presence of any conflicts of interest, including authorship, the affected reviewers were excluded from the assessment and analysis.

Table 2. *GRADE certainty ratings.*

Certainty	What it means
Very low	The true effect is probably markedly different from the estimated effect
Low	The true effect might be markedly different from the estimated effect
Moderate	The authors believe that the true effect is probably close to the estimated effect
High	The authors have a lot of confidence that the true effect is similar to the estimated effect

Source: BMJ Best Practice. Evidence-based medicine (EBM) toolkit. Learn EBM. What is GRADE? Accessed 1/27/2026. https://bestpractice-bmj-com.bibliotheek.ehb.be/info/evidence/learn-ebm/what-is-grade/ (120)

Table 3. *Reasons rate certainty in evidence up or down.*

Certainty can be rated down for:	Certainty can be rated up for:
• Risk of bias • Imprecision • Inconsistency • Indirectness • Publication bias	• Large magnitude of effect • Dose-response gradient • All residual confounding would decrease magnitude of effect (in situations with an effect)

Source: BMJ Best Practice. Evidence-based medicine (EBM) toolkit. Learn EBM. What is GRADE? Accessed 1/27/2026. https://bestpractice-bmj-com.bibliotheek.ehb.be/info/evidence/learn-ebm/what-is-grade/ (120)

Results

Study Selection

Figure 1, developed in accordance with the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (113), depicts the flow diagram of study selection using the PRISMA process. A large number of studies were initially considered for inclusion (30,31,99,102,122-166). Of these, 29 studies satisfied the inclusion criteria for evaluating the diagnostic accuracy and outcomes of facet joint injections (30,31,99,102,122-145). Among the included studies, 18 addressed lumbar facet joint pain (30,102,122-137), 12 evaluated cervical facet joint pain (31,99,134-136,138-144), and 3 examined thoracic facet joint pain (135,136,145). Two studies (135,136) evaluated prevalence and presumed false-positive rates across all three spinal regions.

Methodological Quality Assessment

Table 1 presents the QAREL criteria used to perform the methodological quality assessment of the included studies. Studies scoring at least 4 of 12 or higher were included. Scores of 8 of 12 or higher were classified as high quality, whereas scores of 4 to 7 were classified as moderate quality.

The results of the methodological quality assessment are summarized in Table 5 for the lumbar spine (30,102,122-137), Table 6 for the cervical spine (31,99,134-136,138-144), and Table 7 for the thoracic spine (135,136,145). In total, 29 studies meeting the inclusion criteria were evaluated (30,31,99,102,122-145).

Twenty-eight studies were rated as high quality (30,31,99,102,122-137,139-145), and one study was rated as moderate quality (138).

Table 4. *Modified grading of qualitative evidence with best evidence synthesis for diagnostic accuracy and therapeutic interventions.*

Level I	Evidence obtained from multiple high quality diagnostic accuracy studies
Level II	Evidence obtained from at least one high quality diagnostic accuracy study or multiple moderate or low quality diagnostic accuracy studies
Level III	Evidence obtained from at least one moderate quality diagnostic accuracy study in addition to low quality studies
Level IV	Evidence obtained from multiple relevant low quality diagnostic accuracy studies
Level V	Opinion or consensus of large group of clinicians and/or scientists.

Source: Manchikanti L, Falco FJE, Benyamin RM, Kaye AD, Boswell MV, Hirsch JA. A modified approach to grading of evidence. *Pain Physician* 2014; 17:E319-E325 (121).

Characteristics of Diagnostic Accuracy Studies

Table 8 presents the characteristics of diagnostic accuracy studies of lumbar facet joint nerve blocks (30,102,122-137). One placebo-controlled study (125) used ≥ 50% pain relief as the criterion standard. Only one study employed single blocks with ≥ 90% pain relief as the criterion standard (122). Two studies used controlled diagnostic blocks with ≥ 50% pain relief as the criterion standard (123,125). Six studies applied controlled diagnostic blocks with ≥ 75% pain relief as the criterion standard (126-131). In addition, eight studies used 80% or greater pain relief as the criterion standard (30,102,132-137).

Table 9 summarizes the characteristics of the diagnostic accuracy studies of cervical facet joint nerve blocks included in the review (31,99,134-136,138-144).

In the cervical spine, one placebo-controlled trial employed triple blocks with 100% pain relief as the criterion standard (143). Only one study (138) used ≥ 50% pain relief as the cutoff threshold for a positive block. One study evaluated controlled diagnostic blocks with ≥ 75% pain relief as the criterion standard (139). Four studies used controlled diagnostic blocks with ≥ 80% pain relief as the criterion standard (31,134-136). Six studies applied 100% pain relief as the criterion standard (99,140-144).

Table 10 describes the characteristics of diagnostic accuracy studies of thoracic facet joint nerve blocks considered for inclusion (135,136,145).

In the thoracic spine, no studies evaluated placebo-controlled blocks or single blocks. Three studies used controlled diagnostic blocks with ≥ 80% pain relief as the criterion standard (135,136,145).

Table 11 summarizes the GRADE assessment, applying 5 levels of evidence and evaluating 5 key domains, including methodological limitations, consistency, indirectness, imprecision, and publication bias. Each study was graded as high, moderate, low, or very low.

Based on the quality assessment and GRADE evaluation of the 18 lumbar spine studies, 9 were rated as high quality, 7 as moderate quality, and one as low quality. Given the predominance of high-quality evidence and the use of ≥ 80% pain relief as the criterion standard, the estimated prevalence ranged from 16% to 45%, with presumed or estimated false-positive rates of 25% to 50%.

Based on the quality assessment and GRADE evaluation of the 12 cervical spine studies, 7 were rated as high quality, 4 as moderate quality, and one as low quality. With the majority of studies demonstrating high-quality evidence and using ≥ 80% pain relief as the criterion standard, the estimated prevalence ranged

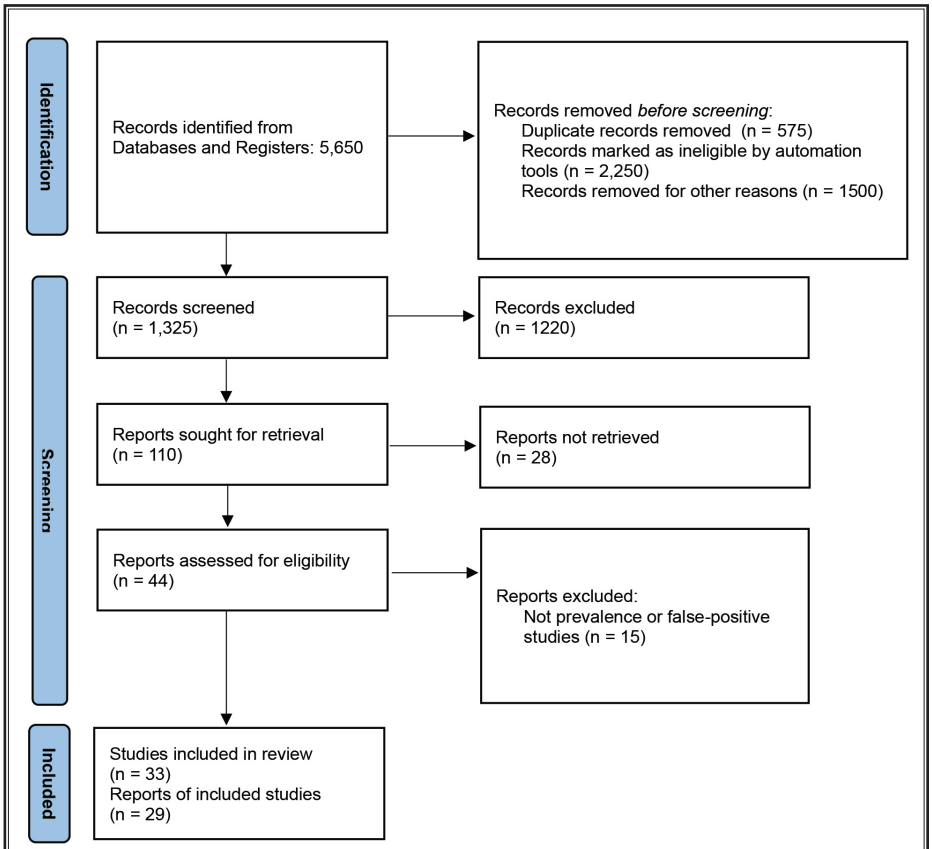


Fig. 1. *Flow diagram illustrating the literature based on 2020 PRISMA guidance used for evaluating diagnostic validity of facet joint nerve blocks in chronic spinal pain.*

Table 5. *Quality appraisal of the diagnostic accuracy of lumbar facet joint nerve block diagnostic studies.*

	Manchikanti et al (102)	Pang et al (122)	Schwarzer et al (123,124)	Schwarzer et al (125)	Manchikanti et al (126)	DePalma et al 2011 (127)	Manchikanti et al (128)	Manchikanti et al (129)	Manchikanti et al (130)	Manchikanti et al (131)	Manchikanti et al (132)
1. Was the test evaluated in a spectrum of subjects representative of patients who would normally receive the test in clinical practice?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Was the test performed by examiners representative of those who would normally perform the test in practice?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Were raters blinded to the reference standard for the target disorder being evaluated?	N	N	N	N	N	N	N	N	N	N	N
4. Were raters blinded to the findings of other raters during the study?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5. Were raters blinded to their own prior outcomes of the test under evaluation?	N	N	N	N	N	N	N	N	N	N	N
6. Were raters blinded to clinical information that may have influenced the test outcome?	N	N	N	N	N	N	N	N	N	N	N

Table 5 cont. *Quality appraisal of the diagnostic accuracy of lumbar facet joint nerve block diagnostic studies.*

	Manchikanti et al (102)	Pang et al (122)	Schwarzer et al (123,124)	Schwarzer et al (125)	Manchikanti et al (126)	DePalma et al 2011 (127)	Manchikanti et al (128)	Manchikanti et al (129)	Manchikanti et al (130)	Manchikanti et al (131)	Manchikanti et al (132)
7. Were raters blinded to additional cues, not intended to form part of the diagnostic test procedure?	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
8. Was the order in which raters examined subjects varied?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
9. Were appropriate statistical measures of agreement used?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
10. Was the application and interpretation of the test appropriate?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
11. Was the time interval between measurements suitable in relation to the stability of the variable being measured?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
12. If there were dropouts from the study, was this less than 20% of the sample.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TOTAL	9/12	8/12	9/12	9/12	9/12	9/12	9/12	9/12	9/12	9/12	9/12

Y=yes; N=no; U=unclear; N/A=not applicable

Source: Lucas NP, Macaskill P, Irwing L, Bogduk N. The development of a quality appraisal tool for studies of diagnostic reliability (QAREL). *J Clin Epidemiol* 2010; 63:854-861 (111).

Table 5 cont. *Quality appraisal of the diagnostic accuracy of lumbar facet joint nerve block diagnostic studies.*

	Manchikanti et al (133)	Manchikanti et al (134)	Manchikanti et al (135)	Manchukonda et al (136)	Manchikanti et al (137)	Manchikanti et al (30)
1. Was the test evaluated in a spectrum of subjects representative of patients who would normally receive the test in clinical practice?	Y	Y	Y	Y	Y	Y
2. Was the test performed by examiners representative of those who would normally perform the test in practice?	Y	Y	Y	Y	Y	Y
3. Were raters blinded to the reference standard for the target disorder being evaluated?	N	N	N	N	N	N
4. Were raters blinded to the findings of other raters during the study?	Y	Y	Y	Y	Y	Y
5. Were raters blinded to their own prior outcomes of the test under evaluation?	N	N	N	N	N	N
6. Were raters blinded to clinical information that may have influenced the test outcome?	N	N	N	N	N	N
7. Were raters blinded to additional cues, not intended to form part of the diagnostic test procedure?	Y	Y	Y	Y	Y	Y
8. Was the order in which raters examined subjects varied?	Y	Y	Y	Y	Y	Y
9. Were appropriate statistical measures of agreement used?	Y	Y	Y	Y	Y	Y
10. Was the application and interpretation of the test appropriate?	Y	Y	Y	Y	Y	Y
11. Was the time interval between measurements suitable in relation to the stability of the variable being measured?	Y	Y	Y	Y	Y	Y
12. If there were dropouts from the study, was this less than 20% of the sample.	Y	Y	Y	Y	Y	Y
TOTAL	9/12	9/12	9/12	9/12	9/12	9/12

Y=yes; N=no; U=unclear; N/A=not applicable

Source: Lucas NP, Macaskill P, Irwing L, Bogduk N. The development of a quality appraisal tool for studies of diagnostic reliability (QAREL). *J Clin Epidemiol* 2010; 63:854-861 (111).

from 36% to 67%, with presumed or estimated false-positive rates of 26% to 63%.

Based on the quality assessment and GRADE evaluation of the 3 thoracic spine studies, 2 were rated as high quality and one as moderate quality. With most studies of high-quality evidence and ≥ 80% pain relief as the criterion standard, the estimated prevalence ranged from 34% to 48%, with presumed or estimated false-positive rates of 42% to 58%.

Analysis of Evidence

The evidence analysis included evaluation of the prevalence and false-positive rates of facet joint pain using dual diagnostic blocks. The evidence was assessed separately by spinal region, including lumbar, cervical, and thoracic. Table 12 presents the prevalence and presumed false-positive rates of facet joint pain in the lumbar spine, Table 13 presents the prevalence and presumed false-positive rates based on diagnostic blocks in the cervical spine, and Table 14 presents the prevalence and false-positive rates based on diagnostic blocks in the thoracic spine.

Lumbar Facet Joint Pain

Table 12 presents the prevalence and false-positive rates of facet joint pain in the lumbar spine. Based on the methodological quality assessment using QAREL criteria, all 18 studies (30,102,122-137) were rated as high quality. However, according to GRADE criteria, 9 of the 18 studies were of high quality (30,102,123-127,133,135,136), 7 were of moderate quality (128-132,134,137), and one was of low quality (122). Nine studies met both high-quality QAREL and high-quality GRADE criteria (30,102,123-127,133,135,136), including a total of 2,069 patients. Seven studies met high-quality QAREL criteria and mod-

Table 6. *Quality appraisal of diagnostic accuracy of cervical facet joint nerve block diagnostic studies.*

	Aprill & Bogduk (138)	Manchikanti et al (139)	Manchikanti et al (134)	Manchukonda et al (136)	Manchikanti et al (135)	Barnsley et al (99)	Yin and Bogduk (140)	Speldewinde et al (141)	Barnsley et al (142)	Lord et al (143)	Barnsley et al (144)	Manchikanti et al (31)
1. Was the test evaluated in a spectrum of subjects representative of patients who would normally receive the test in clinical practice?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Was the test performed by examiners representative of those who would normally perform the test in practice?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Were raters blinded to the reference standard for the target disorder being evaluated?	N	N	N	N	N	N	N	N	N	N	N	N
4. Were raters blinded to the findings of other raters during the study?	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5. Were raters blinded to their own prior outcomes of the test under evaluation?	N	N	N	N	N	N	N	N	N	N	N	N
6. Were raters blinded to clinical information that may have influenced the test outcome?	N	N	N	N	N	N	N	N	N	N	N	N

Table 6 cont. *Quality appraisal of diagnostic accuracy of cervical facet joint nerve block diagnostic studies.*

	Aprill & Bogduk (138)	Manchikanti et al (139)	Manchikanti et al (134)	Manchukonda et al (136)	Manchikanti et al (135)	Barnsley et al (99)	Yin and Bogduk (140)	Speldewinde et al (141)	Barnsley et al (142)	Lord et al (143)	Barnsley et al (144)	Manchikanti et al (31)
7. Were raters blinded to additional cues, not intended to form part of the diagnostic test procedure?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
8. Was the order in which raters examined subjects varied?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
9. Were appropriate statistical measures of agreement used?	U	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
10. Was the application and interpretation of the test appropriate?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
11. Was the time interval between measurements suitable in relation to the stability of the variable being measured?	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
12. If there were dropouts from the study, was this less than 20% of the sample.	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TOTAL	5/12	9/12	9/12	9/12	9/12	9/12	9/12	9/12	9/12	9/12	9/12	9/12

Y = yes; N = no; U = unclear; N/A = not applicable

Source: Lucas NP, Macaskill P, Irwing L, Bogduk N. The development of a quality appraisal tool for studies of diagnostic reliability (QAREL). *J Clin Epidemiol* 2010; 63:854-861 (111).

Table 7. *Quality appraisal of diagnostic accuracy of thoracic facet joint nerve block diagnostic studies.*

	Manchikanti et al (135)	Manchikanti et al (145)	Manchukonda et al (136)
1. Was the test evaluated in a spectrum of subjects representative of patients who would normally receive the test in clinical practice?	Y	Y	Y
2. Was the test performed by examiners representative of those who would normally perform the test in practice?	Y	Y	Y
3. Were raters blinded to the reference standard for the target disorder being evaluated?	N	N	N
4. Were raters blinded to the findings of other raters during the study?	Y	Y	Y
5. Were raters blinded to their own prior outcomes of the test under evaluation?	N	N	N
6. Were raters blinded to clinical information that may have influenced the test outcome?	N	N	N
7. Were raters blinded to additional cues, not intended to form part of the diagnostic test procedure?	Y	Y	Y
8. Was the order in which raters examined subjects varied?	Y	Y	Y
9. Were appropriate statistical measures of agreement used?	Y	Y	Y
10. Was the application and interpretation of the test appropriate?	Y	Y	Y
11. Was the time interval between measurements suitable in relation to the stability of the variable being measured?	Y	Y	Y
12. If there were dropouts from the study, was this less than 20% of the sample.	Y	Y	Y
TOTAL	9/12	9/12	9/12

Y = yes; N = no; U = unclear; N/A = not applicable
Source: Lucas NP, Macaskill P, Irwing L, Bogduk N. The development of a quality appraisal tool for studies of diagnostic reliability (QAREL). *J Clin Epidemiol* 2010; 63:854-861 (111).

erate-quality GRADE criteria (128-132,134,137), with a total of 857 patients, and one study met high-quality QAREL and low-quality GRADE criteria (122), with 100 patients. Thus, a total of 3,026 patients were included. Only one study employed placebo control (125).

Since the publication of the previous systematic review in 2015 (29), a single additional study evaluating prevalence, false-positive rates, and introducing a paradigm shift from an acute to a chronic pain model for lumbar diagnostic facet joint nerve blocks was published by Manchikanti et al (30). This differed from earlier reviews in which the average duration of pain relief at 50% and 80% exceeded the expected pharmacological duration of the local anesthetics. In this chronic pain model, the prevalence of lumbar facet joint pain was 34.1% (95% CI, 28.8%, 39.8%) (30), with a presumed false-positive rate of 49.8% (95% CI, 42.7%, 56.8%). The average duration of > 80% pain relief was 6 days with lidocaine, with total relief > 50% lasting 32 days. With bupivacaine, the average duration of > 80% relief was 30 days, and total relief > 50% lasted 55 days.

Overall, 18 studies assessed the prevalence of lumbar facet joint pain, including one single-block study (122) and 16 dual-block studies (30,102,123-137). The single-block study (122), using ≥ 90% pain relief as the criterion standard, reported a prevalence of 48% in 100 patients.

Controlled diagnostic block studies employed ≥ 50%, ≥ 75%, or ≥ 80% pain relief as the criterion standard. Three high-quality studies using ≥ 50% pain relief (102,123,125), including more than 400 patients, demonstrated variable prevalence. Two early studies by Schwarzer et al (123,125) reported prevalence rates of 15% and 40% in Australian populations, with a false-positive rate of 38% reported in a related U.S. study (124). In contrast, a subsequent large study (102) reported a prevalence of 61% with a false-positive rate of 17%. Related to this internal inconsistency, the level of evidence for ≥ 50% pain relief as the criterion standard is Level II.

Six studies using ≥ 75% pain relief as the criterion standard (126-131) included 856 patients and showed prevalence rates ranging from 30% to 45%, with false-positive rates between 25% and 44%. Eight studies using ≥ 80% pain relief as the criterion standard (30,102,132-137), involving 2,147 patients, demonstrated prevalence ranging from 16% to 41% in heterogeneous populations. Subgroup analyses showed prevalence of 30% in patients younger than 65 years and 52% in those older than 65 years (128), 36% in

Table 8. *Characteristics of studies assessing the accuracy of diagnostic facet joint nerve blocks in lumbar spine with ≥ 50% pain relief.*

Study **Study Characteristics** **Methodological Quality Scoring**	**Participants**	**Intervention(s)** **Injectate Volume**	**Outcome Measures**	**Results**	**Conclusion(s)**
Schwarzer et al, 1995 (125) Randomized, impure placebo, controlled diagnostic blocks Quality Score: QAREL: 9/12	63 patients with low back pain lasting for longer than 3 months underwent computed tomography and blocks of the zygapophysial joints	A placebo injection followed by intraarticular zygapophysial joint injections with 1.5 mL of 0.5% bupivacaine. 1.5 mL	At least 50% reduction in pain maintained for minimum of 3 hours.	Prevalence = 40%	This study shows that computed tomography has no place in the diagnosis of lumbar zygapophysial joint pain, with an impure placebo design.
Schwarzer et al, 1994 (123,124) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	176 consecutive patients with chronic low back pain after some type of injury.	Zygapophysial joint nerve blocks or intraarticular injections were performed with either 2% lignocaine or 0.5% bupivacaine. 0.5 mL	At least 50% pain relief concordant with the duration of local anesthetic injected.	Prevalence = 15% False-positive rate = 38%	First study of evaluation of controlled prevalence and false-positive rates.
Pang et al, 1998 (122) Prospective, single block Quality Score: QAREL: 8/12	In a prospective evaluation, 100 consecutive adult patients with chronic low back pain with undetermined etiology were evaluated with spinal mapping.	Single block was performed by injecting 2% lidocaine into facet joints < 2 mL	Verbal analog scale Pain mapping 90% pain relief	Prevalence Only facet joint pain = 24% Lumbar nerve root and facet disease = 24% Total = 48%	This is the first study evaluating application of diagnostic blocks in the diagnosis of intractable low back pain of undetermined etiology with facet joint disease in potentially 48% of patients with a single block.
Manchikanti et al, 2010 (102) Retrospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	181 patients with at least 50% or 80% pain relief with concordant pain relief were evaluated with dual blocks.	Controlled diagnostic blocks of lumbar facet joint nerves with 1% preservative-free lidocaine or 0.25% preservative-free bupivacaine. 0.5 mL	At least 50% or 80% pain relief and ability to perform previously painful movements.	≥ 50% pain relief Prevalence = 61% Presumed False-positive rate = 17% ——————— ≥ 80% pain relief Prevalence = 31% Presumed False-positive rate = 42%	An unusually high proportion of positive rate for facet joint prevalence with single blocks and ≥ 50% pain relief as the criterion standard.
Manchikanti et al, 2000 (126) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	200 consecutive patients with chronic low back pain were evaluated.	Controlled diagnostic blocks with 1% lidocaine or 0.25% bupivacaine. 0.5 mL	75% pain relief with ability to perform previously painful movements.	Prevalence = 42% Presumed false-positive rate = 37%	The study showed that the clinical picture failed to diagnose facet joint pain.

Table 8 cont. *Characteristics of studies assessing the accuracy of diagnostic facet joint nerve blocks in lumbar spine with ≥ 50% pain relief.*

Study **Study Characteristics** **Methodological Quality Scoring**	**Participants**	**Intervention(s)** **Injectate Volume**	**Outcome Measures**	**Results**	**Conclusion(s)**
DePalma et al, 2011 (127) Retrospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	In a retrospective evaluation, a total of 156 patients with chronic low back pain were assessed for the source of chronic low back pain including discogenic pain, facet joint pain, and sacroiliac joint pain.	Controlled diagnostic blocks with 1% lidocaine or 0.5% bupivacaine. 0.5 mL	Concordant relief with 2 hours for lidocaine and 8 hours for bupivacaine with ≥ 75% pain relief as the criterion standard.	Prevalence = 31%	This is the third study evaluating various structures implicated in the cause of low back pain with controlled diagnostic blocks.
Manchikanti et al, 2001 (128) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	Controlled comparative prevalence study in 100 patients with 50 patients below age of 65 and 50 patients aged 65 or over.	Controlled diagnostic blocks with 1% lidocaine or 0.25% bupivacaine. 0.4 mL to 0.6 mL	75% pain relief with ability to perform previously painful movements was utilized as the criterion standard.	Prevalence: < 65 years = 30% > 65 years = 52% Presumed false-positive rate: < 65 years = 26% > 65 years = 33%	This study showed higher prevalence of facet joint pain in the elderly compared to the younger age group in contrast to the study by Manchikanti et al which showed no differences (181).
Manchikanti et al, 2001 (129) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	Authors evaluated 100 patients with low back pain. Patients were divided into 2 groups, Group I was normal weight and Group II was obese.	Diagnostic blocks with lidocaine 1% or bupivacaine 0.25%. 0.4 mL to 0.6 mL	A definite response was defined as relief of at least 75% in the symptomatic area.	Prevalence: Non-obese individuals = 36% Obese individuals = 40% Presumed false-positive rate: Non-obese individuals = 44% Obese individuals = 33%	This study showed no significant difference between obese and non-obese individuals either with prevalence or false-positive rate of diagnostic blocks in chronic facet joint pain.
Manchikanti et al, 2001 (132) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	120 patients were evaluated with a chief complaint of chronic low back pain to evaluate relative contributions of various structures in chronic low back pain. All 120 patients underwent facet joint nerve blocks.	Controlled diagnostic blocks with 1% lidocaine followed by 0.25% bupivacaine. 0.3 mL to 0.6 mL	80% pain relief with ability to perform previously painful movements	Prevalence = 40% Presumed false-positive rate = 47%	This study evaluated all the patients with low back pain, even with suspected discogenic pain.
Manchikanti et al, 1999 (130) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	120 patients with chronic low back pain after failure of conservative management were evaluated.	Controlled diagnostic blocks with 1% lidocaine followed by 0.25% bupivacaine. 0.4 mL to 0.6 mL	Concordant pain relief with 75% or greater criterion standard with ability to perform previously painful movements.	Prevalence = 45% Presumed false-positive rate = 41%	This was the first study performed in the United States in the heterogenous population as previous studies were performed in only post-injury patients.

Table 8 cont. *Characteristics of studies assessing the accuracy of diagnostic facet joint nerve blocks in lumbar spine with ≥ 50% pain relief.*

Study **Study Characteristics** **Methodological Quality Scoring**	**Participants**	**Intervention(s)** **Injectate Volume**	**Outcome Measures**	**Results**	**Conclusion(s)**
Manchikanti et al, 2000 (131) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	180 consecutive patients with chronic low back pain were evaluated after having failed conservative management	Controlled diagnostic blocks with lidocaine and 1% lidocaine and 0.25% bupivacaine with or without Sarapin and/or steroids 0.4 mL to 0.6 mL	75% pain relief with ability to perform previously painful movements	Prevalence = 36% Presumed false-positive rate = 25%	This study showed no significant difference if the steroids were used or not
Manchikanti et al, 2003 (133) Prospective, controlled diagnostic blocks QAREL: 9/12	At total of 300 patients with chronic low back pain were evaluated to assess the difference based on involvement of single or multiple spinal regions.	Controlled diagnostic blocks with 1% lidocaine followed by 0.25% bupivacaine. 0.5 mL	80% pain relief with ability to perform previously painful movements.	Single region: Prevalence = 21% Presumed false-positive rate = 17% Multiple regions: Prevalence = 41% Presumed false-positive rate = 27%	This study shows a higher prevalence when multiple regions are involved.
Manchikanti et al, 2002 (134) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	120 consecutive patients with chronic low back pain and neck pain were evaluated to assess involvement of facet joints as causative factors.	Controlled diagnostic blocks with 1% lidocaine followed by 0.25% bupivacaine. 0.5 mL	80% pain relief with ability to perform previously painful movements.	Prevalence = 40% Presumed false-positive = 30%	The results are similar to involvement of multiple regions with a prevalence of 40% as illustrated in another study.
Manchikanti et al, 2004 (135) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	500 consecutive patients with chronic, non-specific spinal pain were evaluated of which 397 patients suffered with chronic low back pain.	Controlled diagnostic blocks with 1% lidocaine followed by 0.25% bupivacaine. 0.5 mL	80% pain relief with ability to perform previously painful movements.	Prevalence = 31% Presumed false-positive rate = 27%	Largest study performed involving all regions of the spine.
Manchukonda et al, 2007 (136) Retrospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	500 consecutive patients with chronic spinal pain were evaluated, of which 303 patients were evaluated for chronic low back pain.	Controlled diagnostic blocks with 1% lidocaine followed by 0.25% bupivacaine. 0.5 mL	80% pain relief with ability to perform previously painful movements.	Prevalence = 27% Presumed false-positive rate = 45%	Second largest study performed involving all regions of the spine by the same group of authors (102).

Table 8 cont. *Characteristics of studies assessing the accuracy of diagnostic facet joint nerve blocks in lumbar spine with ≥ 50% pain relief.*

Study Study Characteristics Methodological Quality Scoring	Participants	Intervention(s) Injectate Volume	Outcome Measures	Results	Conclusion(s)
Manchikanti et al, 2007 (137) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	A total of 117 consecutive patients with chronic non-specific low back pain were evaluated, after lumbar surgical interventions, with post-surgery syndrome and continued axial low back pain with controlled, comparative local anesthetic blocks.	Controlled, comparative, local anesthetic blocks with 1% lidocaine and 0.25% bupivacaine. 0.5 mL	80% relief as the criterion standard	Prevalence = 16% Presumed false-positive rate = 49%	Lower prevalence of facet joint pain in post-surgery patients.
Manchikanti et al, 2020 (30) Retrospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	A total of 299 consecutive patients undergoing lumbar facet joint nerve blocks for chronic low back pain were included. Patients with axial low back pain with or without somatic radiation without radicular pattern for 6 months and have failed conservative management were included.	Controlled, comparative, local anesthetic blocks with 1% lidocaine and 0.25% bupivacaine. 0.5 mL	80% relief as the criterion standard	Prevalence = 34.1% Presumed false positive rate = 49.8% Duration of Relief: • ≥ 80% relief of 6 days with lidocaine, with total relief of over 50% of 32 days with lidocaine. • ≥ 80% relief of 30 days with bupivacaine, and total relief of ≥ 50% of 55 days	One of the more recent studies and the first one to study with a chronic pain model.

nonobese patients and 40% in obese patients (129), and 16% in post-surgical patients (137). Based on 7 studies using ≥ 80% relief and 6 studies using ≥ 75% relief as the criterion standard, the level of evidence for diagnosing lumbar facet joint pain with controlled diagnostic blocks is Level I.

Cervical Facet Joint Pain

Table 13 presents the prevalence and presumed false-positive rates of cervical facet joint nerve blocks. Using QAREL criteria, 11 of 12 studies were of high quality (31,99,134-136,139-144) and one was of moderate quality (138). Based on GRADE criteria, 7 studies were of high quality (31,99,135,136,142-144), 4 were of moderate quality (134,139-141), and one was of low quality (138). Seven studies met both high-quality QAREL and high-quality GRADE criteria (31,99,135,136,142-144), including 1,020 patients. Four studies met high-quality QAREL and moderate-quality GRADE criteria (134,139-141), with 466 patients, and one study met moderate-quality QAREL and low-quality GRADE criteria (138), with 318 patients. In total, 1,804 patients were included.

One placebo-controlled trial using triple blocks and 100% pain relief was reported (143). Since the previous systematic review (29), only one additional prevalence study was published, by Manchikanti et al (31), which applied a chronic pain model similar to that used in lumbar spine studies. This study reported a prevalence of 49.3% (95% CI, 43.6%, 55.0%) and a presumed false-positive rate of 25.6% (95% CI, 19.5%, 32.8%). The average duration of > 80% relief was 6 days with lidocaine and 12 days with bupivacaine, while total relief > 50% lasted 31 days with lidocaine and 55 days with bupivacaine. The single-block prevalence in this cohort was 66.3% (95% CI, 60.9%, 71.7%).

Overall, 12 studies (31,99,134-136,138-144) were included, one using a

Table 9. *Studies assessing the accuracy of diagnostic facet joint nerve blocks in cervical spine with ≥ 50% pain relief.*

Study **Study Characteristics** **Methodological Quality Scoring**	**Participants**	**Intervention(s)** **Injectate Volume**	**Outcome Measures**	**Results**	**Conclusion(s)**
Lord et al, 1996 (143) Randomized, double-blind, placebo controlled, comparative local anesthetic diagnostic blocks Quality Score: QAREL: 9/12	68 consecutive patients referred for chronic neck pain after whiplash were studied in a cervical spine research unit in Australia. The criteria for inclusion were 3 months duration of neck pain after a motor vehicle accident and evaluation by a consultant specialist before referral, and over 18 years of age.	Diagnostic blocks with placebo and 2% lidocaine or 0.5% bupivacaine. 0.5 mL	100% pain relief was the criterion standard.	Prevalence = 60%	The study was performed in a highly specialized academic research unit in Australia in patients after whiplash injury.
Aprill & Bogduk, 1992 (138) Prospective, single block Quality Score: QAREL: 5/12	The records were reviewed of 318 patients with chronic neck pain of at least 6 months without myelopathy from January 1989 to April 1990 in a radiology practice in New Orleans.	Intraarticular lidocaine injection after contrast injection with provocation with assessment of provocation and pain relief. 0.2 mL to 0.3 mL Iohexol 0.5 mL betamethasone	Provocation and pain relief ≥ 50%)	Approximate prevalence = 63%. A 25% positive rate with the possibility that an additional 38% suffered with zygapophysial joint pain.	The study was performed in a radiology setting and only with patients who were involved in a motor vehicle injury. Only a single block was performed.
Barnsley et al, 1993 (99) Randomized, double-blind, controlled diagnostic blocks Quality Score: QAREL: 9/12	47 consecutive patients with chronic neck pain following motor vehicle accidents.	Cervical medial branch blocks utilizing comparative local anesthetics with 2% lidocaine or 0.5% bupivacaine. 0.5 mL	Definite or complete relief of pain (100%) following the medial branch blocks.	Prevalence=60%	Comparative local anesthetic medial branch blocks were used in the diagnosis of cervical zygapophysial joint pain.
Yin and Bogduk, 2008 (140) Retrospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	143 patients with chronic neck pain of various origins of at least 3 months duration were included. A total of 84 patients underwent cervical medial branch blocks.	Cervical controlled, comparative local anesthetic medial branch blocks with either 4% lignocaine or 0.75% bupivacaine. 0.5 mL	Complete pain relief (100%)	Prevalence = 55% Positive responses were determined with duration of relief based on the local anesthetic with concordant response (i.e., patients were required to have long-lasting relief when 0.75% bupivacaine was administered and short-lasting relief when 4% lignocaine was administered).	In this evaluation a large proportion of patients (36%) did not pursue investigations, which diluted the crude prevalence of various conditions. A diagnosis remained elusive in 32% of those patients who completed investigations.

Table 9 cont. *Studies assessing the accuracy of diagnostic facet joint nerve blocks in cervical spine with ≥ 50% pain relief.*

Study **Study Characteristics** **Methodological Quality Scoring**	**Participants**	**Intervention(s)** **Injectate Volume**	**Outcome Measures**	**Results**	**Conclusion(s)**
Manchukonda et al, 2007 (136) Retrospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	A total of 251 consecutive patients receiving controlled, comparative local anesthetic blocks with chronic neck pain were included. Patients had pain for at least 6 months, which was nonspecific without a radicular component.	Controlled diagnostic medial branch blocks using 1% lidocaine or 0.25% bupivacaine. 0.5 mL	A positive response was considered at least 80% pain relief with the ability to perform previously painful movements. There were no withdrawals.	Prevalence = 39% Presumed false-positive rate = 45%	This is the second largest study following the previous one (135) with inclusion of the heterogenous population and 251 patients with neck pain yielding a moderate prevalence of 39% with a false-positive rate of 45%.
Manchikanti et al, 2004 (135) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	The study evaluated 255 consecutive patients presenting with chronic neck pain. Patients suffered with chronic neck pain without disc-related pain with radicular symptoms.	Controlled diagnostic medial branch blocks using 1% lidocaine or 0.25% bupivacaine. 0.5 mL	A positive response was considered at least 80% pain relief with the ability to perform previously painful movements. There were no withdrawals.	Prevalence = 55% Presumed false-positive rate = 63%	This is the largest study until 2004 with patients with neck pain, yielding a 55% prevalence rate in the cervical spine, with a false-positive rate of 63%.
Manchikanti et al, 2002 (134) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	120 consecutive patients presenting with complaints of chronic low back pain and neck pain, in a non-university setting, in one private comprehensive interventional pain management practice were evaluated.	Controlled diagnostic medial branch blocks using 1% lidocaine or 0.25% bupivacaine. 0.5 mL	A positive response was considered at least 80% pain relief with the ability to perform previously painful movements. There were no withdrawals.	Prevalence = 67% Presumed false-positive rate = 63%	Prevalence may have been higher due to the nature of the selection criteria. Authors utilized controlled, comparative local anesthetic blocks yielding high false-positive rates.
Manchikanti et al, 2002 (139) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	106 consecutive patients with chronic neck pain of various origins were included. Patients must have had pain for at least 6 months and also have failed conservative management without any evidence of radiculitis or disc herniation.	Controlled diagnostic medial branch blocks using 1% lidocaine or 0.25% bupivacaine. 0.5 mL	A positive response was considered at least 75% reduction of pain with the ability to perform previously painful movements. There were no withdrawals.	Prevalence = 60% Presumed false-positive rate = 40%	This is the only study outside the group of Australians evaluating the prevalence of cervical facet joint pain in chronic neck pain of heterogenous origin yielding a prevalence of 60% with controlled diagnostic blocks and a false-positive rate of 40%.
Speldewinde et al, 2001 (141) Retrospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	97 patients with chronic neck pain undergoing diagnostic cervical medial branch blocks from 1994 to 1997 were evaluated by 3 independent rehabilitation physicians.	Controlled, comparative local anesthetic blocks, 2% lignocaine or 0.5% bupivacaine. 0.5 mL	Complete pain relief (100%) was the criterion standard.	Prevalence = 36%	The authors utilized 100% pain relief as the criterion standard with controlled diagnostic blocks utilizing strict selection criteria in a heterogenous population in a private practice setting in a retrospective evaluation.

Table 9 cont. *Studies assessing the accuracy of diagnostic facet joint nerve blocks in cervical spine with ≥ 50% pain relief.*

Study **Study Characteristics** **Methodological Quality Scoring**	**Participants**	**Intervention(s)** **Injectate Volume**	**Outcome Measures**	**Results**	**Conclusion(s)**
Barnsley et al, 1995 (142) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	50 consecutive patients referred to the cervical spine research unit, a tertiary referral unit, in Australia were evaluated. The criteria for inclusion were neck pain of more than 3 months duration following and attributed to a motor vehicle accident, previous assessment.	Medial branch blocks with 2% lidocaine or 0.5% bupivacaine. 0.5 mL	Patients were classified as having a painful cervical zygapophysial joint only if they achieved definite or complete relief of pain (100%) with both anesthetics and a longer duration of pain relief after the use of bupivacaine.	Prevalence = 54%	The study was performed in a highly specialized academic research unit in Australia in patients after whiplash injury.
Barnsley et al, 1993 (144) Randomized, double-blind, controlled diagnostic blocks Quality Score: QAREL: 9/12	The study evaluated 55 consecutive patients with neck pain of greater than 3 months attributed to a motor vehicle accident, with random allocation.	Medial branch blocks with either 2% lignocaine or 0.5% bupivacaine. 0.5 mL	100% pain relief	Presumed false-positive rate = 27%	A well-performed study in a highly research-oriented center in patients after whiplash.
Manchikanti et al, 2020 (31) Retrospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	A total of 294 consecutive patients undergoing cervical facet joint nerve blocks for chronic neck pain were included. Patients with neck pain with or without somatic radiation without radicular pain pattern for 6 months and have failed conservative management were included.	Controlled, comparative, local anesthetic blocks with 1% lidocaine and 0.25% bupivacaine. 0.5 mL	80% relief as the criterion standard	Dual block prevalence = 49.3% Single block prevalence = 66.3% Presumed false positive rate = 25.6% Duration of Relief: • ≥ 80% relief of 6 days with lidocaine, with total relief of over 50% of 31 days with lidocaine. • ≥ 80% relief of 12 days with bupivacaine, and total relief of ≥ 50% of 55 days	One of the more recent studies and the first one to study with a chronic pain model.

single block (138) and 11 using controlled diagnostic blocks. Among controlled block studies, one used ≥ 75% pain relief as the criterion standard (139), four used ≥ 80% relief (31,134-136), and six used 100% relief (99,140-144). The single-block study (138) of moderate quality reported prevalence ranging from 25% to 63% in 318 patients.

The study using ≥ 75% relief (139) in 106 patients reported a prevalence of 60% with a false-positive rate of 40%. Four studies using ≥ 80% relief (31,134-136), including more than 920 patients, reported prevalence ranging from 39% to 67%, with false-positive rates between 26% and 63%. Of the six studies using 100% relief, only one was conducted in a heterogeneous U.S. population (140), reporting a prevalence of 55%. The remaining studies were from Australia, many involving whiplash populations, with prevalence ranging from 36% to 60% (99,141-144). The most recent large study (136) of 251 patients reported a prevalence of 39% with a false-positive rate of 45%, consistent with another Australian study of 97 patients reporting 36% prevalence (141).

Accordingly, the level of evidence for dual controlled diagnostic blocks in the cervical spine is Level II, reflecting substantial variability and internal inconsistency, with prevalence ranging from 36% to 67% and false-positive rates from 26% to 63%.

Thoracic Facet Joint Pain

Table 14 presents prevalence and false-positive rates of thoracic facet joint pain from three studies conducted by the same group (135,136,145), all using ≥ 80% pain relief as the criterion standard. These high-quality studies included

Table 10. *Studies assessing the accuracy of diagnostic facet joint nerve blocks in thoracic spine with ≥ 50% pain relief.*

Study **Study Characteristics** **Methodological Quality Scoring**	**Participants**	**Intervention(s)** **Injectate Volume**	**Outcome Measures**	**Results**	**Conclusion(s)**
Manchikanti et al, 2004 (135) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	500 consecutive patients with chronic, non-specific spine pain 72 patients with thoracic pain were evaluated.	Controlled comparative local anesthetic blocks with 1% lidocaine or 0.25% bupivacaine. 0.5 mL	80% pain relief with the ability to perform previously painful movements. The relief with bupivacaine to last longer than lidocaine.	The prevalence of facet joint pain in patients with chronic thoracic spine pain was 42% (95% CI, 30% – 53%). The presumed false-positive rate with single blocks with lidocaine was 55% (95% CI, 39% – 78%) in the thoracic spine.	Facet joints are clinically important spinal pain generators in a significant (42%) proportion of patients with chronic spinal pain, with a false-positive rate of 55%.
Manchikanti et al, 2002 (145) Prospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	46 consecutive patients with chronic midback and upper back pain	Diagnostic facet joint nerve blocks with lidocaine 1% or bupivacaine 0.25%. 0.5 mL	80% pain relief with the ability to perform previously painful movements. The relief with bupivacaine to last longer than lidocaine.	Prevalence = 48% Presumed false-positive rate = 58%	Comparative local anesthetic blocks showed the prevalence of facet joint pain to be 48%, with single blocks carrying a false-positive rate of 58%.
Manchukonda et al 2007 (136) Retrospective, controlled diagnostic blocks Quality Score: QAREL: 9/12	500 consecutive patients with chronic facet or zygapophysial joint pain. 65 patients with thoracic pain were evaluated.	Diagnostic blocks with 1% lidocaine or 0.25% bupivacaine. 0.5 mL	80% pain relief with the ability to perform previously painful movements. The relief with bupivacaine to last longer than lidocaine.	Prevalence of facet joint pain was 34% (95% CI, 22% - 47%) in patients with thoracic pain. The presumed False-positive rate with a single block in the thoracic region was 42%.	Significant prevalence of facet joint pain in chronic spinal pain, with 34% prevalence and 42% false-positive rate.

Table 11. *Evidence profile using randomized controlled trials of interventions for the same outcome and similar certainty of evidence.*

CERTAINTY ASSESSMENT							Number of Patients	Impact	Certainty
Study	**Study Design**	**Risk of Bias**	**Consistency**	**Indirectness**	**Imprecision**	**Publication Bias**			
Lumbar									
Schwarzer et al (125)	RA, PC, CDB	None	High	High	None	None	57 of 63	Prevalence: 40% (27% - 53%) Presumed False-Positive: NA	High
Schwarzer et al (123,124)	P, CDB	None	High	High	None	None	176	Prevalence: 15% (10% - 20%) Presumed False-Positive: 38% (95% CI, 30%-46%)	High
Pang et al (122)	P, SB	Moderate	Low	High	Moderate	Moderate	100	Prevalence: 48% Presumed False-Positive: NA	Low
Manchikanti et al (102)	RTR, CDB	Very low	Moderate	High	Very low	Very low	181	Prevalence: 61% (53% - 81%) 31% (26% - 35%) Presumed False-Positive: 17% (95% CI, 10%-24%) 42% (95% CI, 35%-50%)	High
Manchikanti et al (126)	P, CDB	Very low	Moderate	High	Very low	Very low	200	Prevalence: 42% (35% - 42%) Presumed False-Positive: 37% (95% CI, 32%-42%)	High
DePalma et al (127)	RTR, CDB	Very low	Moderate	High	Very low	Very low	156	Prevalence: 31% (24% - 38%) Presumed False-Positive: NA	High
Manchikanti et al (128)	P, CDB	Very low	Moderate	High	Very low	Very low	100 I: (<65 years) = 50 II:(>65 years) = 50	Prevalence: I: 30% (17% - 43%) II: 52% (38% - 66%) Presumed False-Positive: I: 26% (95% CI, 11%-40%) II: 33% (95% CI, 14%-35%)	Moderate

Table 11 cont. *Evidence profile using randomized controlled trials of interventions for the same outcome and similar certainty of evidence.*

CERTAINTY ASSESSMENT							Number of Patients	Impact	Certainty
Study	**Study Design**	**Risk of Bias**	**Consistency**	**Indirectness**	**Imprecision**	**Publication Bias**			
Manchikanti et al (129)	P, CDB	Very low	Moderate	High	Very low	Very low	100 I: (BMI<30) = 50 II: (BMI >30) = 50	Prevalence: I: 36% (22%, 50%) II: 40% (26%, 54%) Presumed False-Positive: I: 44% (95% CI, 26%-61%) II: 33% (95% CI, 16%-51%)	Moderate
Manchikanti et al (130)	P, CDB	Very low	Moderate	High	Very low	Very low	120	Prevalence: 45% (36% - 54%) Presumed False-Positive: 41% (95% CI, 29%-53%)	Moderate
Manchikanti et al (131)	P, CDB	Very low	Moderate	High	Very low	Very low	180	Prevalence: 36% (29% - 43%) Presumed False-Positive: 25% (95% CI, 21%-39%)	Moderate
Manchikanti et al (132)	P, CDB	Very low	Moderate	High	Very low	Very low	120	Prevalence: 40% (31%–49%) Presumed False-Positive: 47% (95% CI, 35%-59%)	Moderate
Manchikanti et al (133)	P, CDB	Very low	Moderate	High	Very low	Very low	300 I: Single region II: Multiple regions	Prevalence: I: 21% (14%-27%) II: 41% (33%-49%) Presumed False-Positive: I: 17% (95% CI, 10%-24%) II: 27% (95% CI, 18%-36%)	High
Manchikanti et al (134)	P, CDB	Very low	Moderate	High	Very low	Very low	120	Prevalence: 40% (31% - 49%) Presumed False-Positive: 30% (95% CI, 20%-40%)	Moderate
Manchikanti et al (135)	P, CDB	Very low	Moderate	High	Very low	Very low	397	Prevalence: 31% (27% - 36%) Presumed False-Positive: 27% (95% CI, 22%-32%)	High
Manchukonda et al (136)	RTR, CDB	Very low	Moderate	High	Very low	Very low	303	Prevalence: 27% (22% - 33%) Presumed False-Positive: 45% (95% CI, 36%-53%)	High

Table 11 cont. *Evidence profile using randomized controlled trials of interventions for the same outcome and similar certainty of evidence.*

CERTAINTY ASSESSMENT							Number of Patients	Impact	Certainty
Study	**Study Design**	**Risk of Bias**	**Consistency**	**Indirectness**	**Imprecision**	**Publication Bias**			
Manchikanti et al (137)	P, CDB	Very low	Moderate	High	Very low	Very low	117	Prevalence: 16% (9% – 23%) Presumed False-Positive: 49% (95% CI, 39%–59%)	Moderate
Manchikanti et al (30)	RTR, CDB	Very low	Moderate	High	Very low	Very low	299	Prevalence: 34.1% (95% CI, 28.8%, 39.8%) Presumed False-Positive: 49.8% (95% CI, 42.7%, 56.8%)	High
Cervical									
Lord et al (143)	RA, DB, PC, CDB	None	High	High	None	None	68	Prevalence: 60% (95% CI, 46%, 73%) Presumed False-Positive: NA	High
Aprill & Bogduk (138)	P, SB	Moderate	Low	High	Very low	Moderate	318	Prevalence: 25%-63% Presumed False-Positive: NA	Low
Manchikanti et al (139)	P, CDB	Very low	Moderate	High	Very low	Very low	106	Prevalence: 60% % (95% CI, 50%, 70%) Presumed False-Positive: 40% % (95% CI, 34%-46%)	Moderate
Manchukonda et al (136)	RTR, CDB	Very low	Moderate	High	Very low	Very low	251 of 500	Prevalence: 39% (95% CI, 32%, 45%) Presumed False-Positive: 45% (95% CI, 37%-52%)	High
Manchikanti et al (135)	P, CDB	Very low	Moderate	High	Very low	Very low	255 of 500	Prevalence: 55% (95% CI, 49%, 61%) Presumed False-Positive: 63% (95% CI, 54%-72%)	High
Manchikanti et al (134)	P, CDB	Very low	Moderate	High	Very low	Very low	120	Prevalence: 67% (95% CI 58% , 75%) Presumed False-Positive: 63% (95% CI, 48%-78%)	Moderate

Table 11 cont. *Evidence profile using randomized controlled trials of interventions for the same outcome and similar certainty of evidence.*

CERTAINTY ASSESSMENT							Number of Patients	Impact	Certainty
Study	**Study Design**	**Risk of Bias**	**Consistency**	**Indirectness**	**Imprecision**	**Publication Bias**			
Barnsley et al (99)	RA, DB, CDB	None	Moderate	High	None	None	47	Prevalence: 60% Presumed False-Positive: NA	High
Yin and Bogduk (140)	RTR, CDB	Very low	Moderate	High	Very low	Very low	143	Prevalence: 55% (95% CI, 38%, 62%) Presumed False-Positive: NA	Moderate
Speldewinde et al (141)	RTR, CDB	Very low	Moderate	High	Very low	Very low	97	Prevalence: 36% (95% CI, 27%, 45%) Presumed False-Positive: NA	Moderate
Barnsley et al (142)	P, CDB	None	High	High	None	None	50	Prevalence: 54% (95% CI, 40%, 68%) Presumed False-Positive: NA	High
Barnsley et al (144)	RA, DB, CDB	None	High	High	None	None	55	Prevalence: NA Presumed False-Positive: 27% (95% CI, 15%-38%)	High
Manchikanti et al (31)	RTR, CDB	Very low	Moderate	High	Very low	Very low	294	Prevalence: 49.3 (95% CI, 3.6%, 55%) Presumed False-Positive: 25.6% (95% CI, 19.5%, 32.8%)	High
Thoracic									
Manchikanti et al (145)	P, CDB	Very low	Moderate	High	Very low	Very low	46	Prevalence: 48% (95% CI; 34%-62%) Presumed False-Positive: 58% (95% CI, 38%-78%)	Moderate
Manchikanti et al (135)	P, CDB	Very low	Moderate	High	Very low	Very low	72	Prevalence: 42% (95% CI; 30%-53%) Presumed False-Positive: 55% (95% CI, 38%-78%)	High

Table 11 cont. *Evidence profile using randomized controlled trials of interventions for the same outcome and similar certainty of evidence.*

CERTAINTY ASSESSMENT							Number of Patients	Impact	Certainty
Study	Study Design	Risk of Bias	Consistency	Indirectness	Imprecision	Publication Bias			
Manchukonda et al (136)	RTR, CDB	Very low	Moderate	High	Very low	Very low	65	Prevalence: 34% (95% CI; 22%-47%) Presumed False-Positive: 42% (95% CI, 36%-53%)	High

RTR = retrospective; P = prospective; RA = randomized; CDB = controlled diagnostic blocks; PC = placebo controlled; SB = single block; DB = double-blind

183 patients and reported prevalence ranging from 34% to 48%, with false-positive rates between 42% and 58%.

Using QAREL criteria, all three studies (135,136,145) were of high quality. Based on GRADE criteria, two studies (135,136) were of high quality and one (145) was of moderate quality. Two studies met both high-quality QAREL and high-quality GRADE criteria, including 137 patients, and one study met high-quality QAREL and moderate-quality GRADE criteria, including 46 patients. In total, 183 patients were evaluated.

Based on these findings, the level of evidence for the diagnostic accuracy of thoracic facet joint nerve blocks is Level II, derived from three high-quality controlled diagnostic studies.

Discussion

This updated systematic review of the diagnostic accuracy of spinal facet joint nerve blocks in the evaluation of chronic spinal pain without evidence of disc herniation, radiculitis, or sacroiliac joint arthritis after failure of conservative management, utilizing various criteria for the diagnosis of facet joint pain with single blocks as well as controlled diagnostic blocks, shows varying results. The evidence is stronger for lumbar facet joint nerve blocks (Level I) compared to cervical and thoracic facet joint nerve blocks (Level II) in the diagnosis of chronic pain with the use of controlled diagnostic blocks with placebo or comparative local anesthetic blocks and a criterion standard of ≥ 75% or ≥ 80% pain relief in the lumbar spine and ≥ 80% in the cervical and thoracic spines, with the ability to perform previously painful maneuvers. Overall, there were 3 studies utilizing controlled blocks with ≥ 50% pain relief as the criterion standard (123-125), 6 studies (126-131) utilizing controlled blocks with at least 75% pain relief, and 8 studies (30,102,132-137) utilizing ≥ 80% pain relief as the criterion standard in the lumbar spine. Further, based on GRADE quality, 9 of the 18 studies were shown to be of high quality (30,102,123-127,133,135,136), 7 studies were of moderate quality (128-132,134,137), and one study was of low quality (122), yielding a prevalence rate of 16% to 45% with presumed false-positive rates of 25% to 50%. Similarly, of the 12 studies in the cervical spine, one study utilized ≥ 75% pain relief as the criterion standard (139) and 10 studies utilized ≥ 80% pain relief (31,99,134-136,140-144). Among the cervical studies, based on GRADE quality, 7 of the 12 studies were of high quality (31,99,135,136,142-144), 4 studies were of moderate quality (134,139-141), and one was of low quality (138), yielding a prevalence rate of 36% to 67% with an estimated presumed false-positive rate of 26% to 63%. In the thoracic spine, there were 3 studies with 80% pain relief as the criterion standard (135,136,145). Among the thoracic studies, based on GRADE quality, 2 of the 3 studies were of high quality (135,136) and one study was of moderate quality (145), yielding a prevalence ranging from 34% to 48% with presumed false-positive rates ranging from 42% to 58%. Significant homogeneity of prevalence in a heterogenous population was evident in the lumbar spine.

In the cervical spine, even though there were high quality studies with controlled diagnostic blocks and placebo control and many of them were pioneering studies establishing standards, there was a lack of significant homogeneity in the prevalence patterns in a heterogenous population with internal inconsistency, even though significant homogeneity was observed in patients with whiplash.

In the thoracic spine, there was significant homogeneity among the studies (135,136,145). In addition, a disadvantage of thoracic spine studies is that all of them were performed by one group of clinicians.

The evidence presented here with strict inclusion criteria and methodological quality assessment is similar to previous assessments (1,2,29,95-97).

In the cervical spine, there were 2 RCTs (142,143), with one utilizing placebo-controlled diagnostic blocks (143), showing a prevalence of 54% (142) and 60%

Table 12. *Data of prevalence and false-positive rate of facet joint pain by diagnostic blocks in the lumbar spine.*

Study	Methodological Criteria Score	GRADE Criteria and Scoring	Number of Patients	Criterion Standard of Percent Relief	Prevalence Estimates with 95% Confidence Intervals	Presumed False-Positive Rate with 95% Confidence Intervals
Single Blocks						
Pang et al (122)	High (8/12)	Low	100	90%	48%	NA
Controlled Blocks						
Schwarzer et al (125)	High (9/12)	High	57 of 63	Placebo control ≥ 50%	40% (27% - 53%)	NA
Schwarzer et al (123,124)	High (9/12)	High	176	≥ 50%	15% (10% - 20%)	38% (95% CI, 30%-46%)
Manchikanti et al (102)	High (9/12)	High	181	≥ 50% ≥ 80%	61% (53% - 81%) 31% (26% - 35%)	17% (95% CI, 10%-24%) 42% (95% CI, 35%-50%)
Manchikanti et al (126)	High (9/12)	High	200	≥ 75%	42% (35% - 42%)	37% (95% CI, 32%-42%)
DePalma et al (127)	High (9/12)	High	156	≥ 75%	31% (24% - 38%)	NA
Manchikanti et al (128)	High (9/12)	Moderate	100 I: (<65 years) = 50 II:(>65 years) = 50	≥ 75%	I: 30% (17% - 43%) II: 52% (38% - 66%)	I: 26% (95% CI, 11%-40%) II: 33% (95% CI, 14%-35%)
Manchikanti et al (129)	High (9/12)	Moderate	100 I: (BMI<30) = 50 II: (BMI >30) = 50	≥ 75%	I: 36% (22%, 50%) II: 40% (26%, 54%)	I: 44% (95% CI, 26%-61%) II: 33% (95% CI, 16%-51%)
Manchikanti et al (130)	High (9/12)	Moderate	120	≥ 75%	45% (36% - 54%)	41% (95% CI, 29%-53%)
Manchikanti et al (131)	High (9/12)	Moderate	180	≥ 75%	36% (29% - 43%)	25% (95% CI, 21%-39%)
Manchikanti et al (132)	High (9/12)	Moderate	120	≥ 80%	40% (31%–49%)	47% (95% CI, 35%-59%)
Manchikanti et al (133)	High (9/12)	High	300 I: Single region II: Multiple regions	≥80%	I: 21% (14%-27%) II: 41% (33%-49%)	I: 17% (95% CI, 10%-24%) II: 27% (95% CI, 18%-36%)
Manchikanti et al (134)	High (9/12)	Moderate	120	≥ 80%	40% (31% - 49%)	30% (95% CI, 20%-40%)
Manchikanti et al (135)	High (9/12)	High	397	≥ 80%	31% (27% - 36%)	27% (95% CI, 22%-32%)
Manchukonda et al (136)	High (9/12)	High	303	≥ 80%	27% (22% - 33%)	45% (95% CI, 36%-53%)
Manchikanti et al (137)	High (9/12)	Moderate	117	≥ 80%	16% (9% – 23%)	49% (95% CI, 39%–59%)
Manchikanti et al (30)	High (9/12)	High	299	≥ 80%	34.1% (95% CI, 28.8%, 39.8%)	49.8% (95% CI, 42.7%, 56.8%)

NA = not applicable; CI = confidence interval

Table 13. *Data of prevalence and false-positive rate of facet joint pain by diagnostic blocks in the cervical spine.*

Study	Methodological Criteria Score	GRADE Criteria and Scoring	Number of Patients	Criterion Standard of Percent Relief	Prevalence Estimates with 95% Confidence Intervals	Presumed False-Positive Rate with 95% Confidence Intervals
Single Blocks						
Aprill & Bogduk (138)	Moderate (5/12)	Low	318	≥ 50%	25%-63%	NA
Controlled Blocks						
Lord et al (143)	High (9/12)	High	68	Placebo control 100%	60% (95% CI, 46%, 73%)	NA
Manchikanti et al (139)	High (9/12)	Moderate	106	≥ 75%	60% % (95% CI, 50%, 70%)	40% % (95% CI, 34%-46%)
Manchukonda et al (136)	High (9/12)	High	251 of 500	≥ 80%	39% (95% CI, 32%, 45%)	45% (95% CI, 37%-52%)
Manchikanti et al (135)	High (9/12)	High	255 of 500	≥ 80%	55% (95% CI, 49%, 61%)	63% (95% CI, 54%-72%)
Manchikanti et al (134)	High (9/12)	Moderate	120	≥ 80%	67% (95% CI 58% , 75%)	63% (95% CI, 48%-78%)
Barnsley et al (99)	High (9/12)	High	47	100%	60%	NA
Yin and Bogduk (140)	High (9/12)	Moderate	143	100%	55% (95% CI, 38%, 62%)	NA
Speldewinde et al (141)	High (9/12)	Moderate	97	100%	36% (95% CI, 27%, 45%)	NA
Barnsley et al (142)	High (9/12)	High	50	100%	54% (95% CI, 40%, 68%)	NA
Barnsley et al (144)	High (9/12)	High	55	100%	NA	27% (95% CI, 15%-38%)
Manchikanti et al (31)	High (9/12)	High	294	≥ 80%	49.3 (95% CI, 3.6%, 55%)	25.6% (95% CI, 19.5%, 32.8%)

NA = not applicable; CI = confidence interval

Table 14. *Data of prevalence and false-positive rate of facet joint pain by diagnostic blocks in the thoracic spine.*

Study	Methodological Criteria Score	GRADE Criteria and Scoring	Number of Patients	Criterion Standard of Percent Relief	Prevalence Estimates with 95% Confidence Intervals	Presumed False-Positive Rate with 95% Confidence Intervals
Controlled Blocks						
Manchikanti et al (145)	High (9/12)	Moderate	46	≥ 80%	48% (95% CI; 34%-62%)	58% (95% CI, 38%-78%)
Manchikanti et al (135)	High (9/12)	High	72	≥ 80%	42% (95% CI; 30%-53%)	55% (95% CI, 38%-78%)
Manchukonda et al (136)	High (9/12)	High	65	≥ 80%	34% (95% CI; 22%-47%)	42% (95% CI, 36%-53%)

NA = Not Available or Not Applicable; CI = Confidence Interval

(143) in patients after whiplash. In a detailed study, the false-positive rate was also assessed and shown to be 27% by the same group of authors (144). These studies utilized samples ranging from 50 to 68 patients. Manchikanti et al (135), in a large study with 255 patients, showed a prevalence of 55%. In a later study including 251 patients, Manchukonda et al (136) showed a prevalence of 39%. Overall, Manchikanti et al's group performed 3 studies with large population samples (31,134-136,139), demonstrating prevalence ranging

from 39% to 67% with presumed false-positive rates ranging from 26% to 63%. The study by Yin and Bogduk (140) of 143 patients showed a prevalence of 55%. Similarly, Speldewinde et al (141) reported a prevalence of 36% in 97 patients.

In the lumbar spine, of 13 studies with a criterion standard of pain relief of 75% or more, 11 studies were performed by the same group of authors (30,102,128-137). These authors utilized large populations, with 300 patients in 4 studies and 100 or more patients in the remaining studies. Manchikanti et al (135) in 397 patients, Manchukonda et al (136) in 303 patients, Manchikanti et al (102) in 491 patients, and Manchikanti et al (30) in 299 patients showed overall prevalence rates of 27% to 34% in a heterogenous population with false-positive rates of 27%, 42%, 45%, and 50%, respectively, whereas in specific populations with post lumbar surgery syndrome, prevalence was 16% with a false-positive rate of 49%. In a comprehensive assessment, DePalma et al (127) studied 156 patients and showed a prevalence of 31% in a heterogenous population in the United States. There was one placebo-controlled randomized trial assessing the accuracy of facet joint injections in the lumbar spine. Schwarzer et al (125) injected sodium chloride into the joints, which may not be considered a pure placebo.

In the thoracic spine, there were 3 high quality studies, all performed by one group of authors (135,136,145), showing prevalence ranging from 34% to 48% and false-positive rates ranging from 42% to 58%. There were no randomized studies in the thoracic spine.

As described above, over the years, multiple articles have been published supporting and opposing the accuracy of diagnostic facet joint nerve blocks (64-74,76,99,101,103). In contrast to multiple diagnostic tests in medicine, which can be validated using conventional means by comparison with a criterion standard such as a blood test, biopsy, surgical observation, or imaging feature (112), diagnostic facet joint nerve blocks and pain-related assessments cannot be based on a physical standard, biopsy, or imaging modality. Engel et al (146) described that while diagnostic blocks cannot be validated by conventional means, the opposition is similar to that faced by other concepts, such as germ theory, which encountered philosophical objections that were overcome by establishing and satisfying multiple postulates. Similar issues have been encountered in occupational determinations of cause and effect, such as scrotal or pulmonary malignancy, which were initially rejected due to lack of proof. Proposals of multiple viewpoints of association should therefore be considered before causation is claimed, based on the criteria proposed by Bradford Hill (147) and Howick et al (148).

Engel et al (146) proposed a set of axiomatic criteria providing a philosophical basis for the validation of diagnostic blocks. These 8 criteria included plausibility, experiment, target-specificity, effect of the diagnostic blocks, duration of pain relief, consistency, establishment of controls, and replication. They classified essential criteria as target-specificity and duration, critical criteria as controls, relative criteria as effect and consistency, and academic criteria as plausibility, experiment, and replication. They also provided scoring for each criterion. However, some of the theories proposed by Engel et al (146) may be problematic, particularly regarding the requirement that duration of relief should not exceed the pharmacologic action of the local anesthetic and the requirement for placebo controls with randomization.

A true placebo control for nerve blocks has been extremely difficult to achieve, and true placebo-controlled trials of diagnostic accuracy have not been established. The role of placebo and nocebo effects has not been adequately assessed in interventional pain management in general and in diagnostic accuracy studies in particular (149). Placebo and nocebo effects may significantly influence diagnostic accuracy. Further, all reported studies used flawed designs, including intraarticular injection of sodium chloride, which is not a true placebo. However, appropriate placebo designs have been developed for the assessment of therapeutic interventions.

Bogduk (32,33) and Klessinger and Bogduk (34,35), in scholarly articles published in 2022 and 2023, described the validity and clinical utility of comparative local anesthetic blocks for the diagnosis of spinal pain and introduced the concept of inconsistency in false-positive rates of diagnostic medial branch blocks (34,35). Consequently, in this evaluation, the term presumed false-positive rate has been used, as the exact rate remains uncertain. It is also important to recognize the paradigm shift regarding longer-term relief following diagnostic blocks, as described in these evaluations.

The importance of diagnostic blocks was emphasized by Rubenstein and Van Tulder (98) in their 2007 best evidence review of diagnostic procedures for neck and low back pain. After identifying 17 studies, they concluded that there was strong evidence for the diag-

nostic accuracy of facet joint blocks in evaluating spinal pain. More recently, in 2023, Han et al (110), updating the work of Hancock et al (93), concluded that informative index tests exist to identify the facet joint, disc, and sacroiliac joint as sources of low back pain. They challenged the dominant view that a pathoanatomical diagnosis is usually not possible and that the label non-specific low back pain should be applied to most patients. In 2025, Abe et al (150) published expert consensus-based criteria for identifying lumbar facet joint pain in primary care. They extracted 77 diagnostic items from 8 articles and, through multiple Delphi rounds involving 39 orthopedic spine surgeons, established 4 diagnostic criteria: physical findings suggesting facet joint pain, neurological symptoms, imaging findings suggesting non-facet causes, and signs of discogenic low back pain. Diagnosis was considered confirmed if the first criterion was met and no more than one of the others was present. However, these criteria conflict with established standards, which emphasize the absence of neurological symptoms and discogenic signs. Diagnostic criteria in Medicare LCDs and other policies are consistent with ASIPP guidelines, requiring lack of radicular pain, tenderness over the facet joints, worsening with extension, and absence of imaging findings indicating disc herniation (1,151,152).

The diagnosis of cervical facet joint pain has been studied extensively (37-40). Schneider et al (38-40), in multiple publications, evaluated physical examination and clinical tests in patients with cervical facet joint pain. In screening patients for diagnostic cervical facet joint blocks and assessing the role of physiotherapists (38), they used a combination of physical, manual, and psychological findings, termed the clinical prediction guide (CPG), and concluded that patient history, self-report measures, and physical examination may assist in optimal diagnostic and therapeutic decision-making. In a subsequent study, Schneider et al (39) showed that a CPG incorporating manual spine examination (MSE), palpation for segmental tenderness (PST), and the extension-rotation (ER) test demonstrated a specificity of 84% and a positive likelihood ratio of 4.94. Sensitivities for PST and MSE were 94% and 92%, respectively, and negative PST findings were associated with a negative likelihood ratio of 0.08. They concluded that MSE, PST, and ER testing may be useful in identifying patients suitable for diagnostic facet joint blocks. In a third publication, Schneider et al (40) evaluated intrarater and interrater reliability of selected clinical tests in 56 patients referred for diagnostic cervical facet joint blocks and demonstrated moderate to substantial reliability, supporting their use in a clinical prediction model for screening prior to diagnostic blocks.

The philosophical approach with mathematical validation of controlled diagnostic blocks by Bogduk et al has been extensively studied (32,33), primarily in acute pain models (94,99,144,153). This philosophy is based on investigations and advocacy of comparative local anesthetic blocks as a substitute for placebo controls (154-161). The principle is that patients with genuine pain obtain short-lived relief with short-acting local anesthetics and longer relief with long-acting agents, a paradigm supported by double-blind, randomized, controlled studies demonstrating that bupivacaine has a significantly longer duration of action than lidocaine (154-161). Accordingly, controlled comparative local anesthetic blocks have been extensively validated (1,2,29,94,99,144,153). However, this model does not account for differences between acute and chronic pain. Bogduk et al (32,33,94,146,153) postulated that relief exceeding the expected pharmacologic duration, defined as ≤ 2 hours for short-acting and ≤ 8 hours for long-acting anesthetics, represents a false-positive or prolonged placebo response. For practical purposes, pharmacologic durations of 45 minutes for lidocaine and 90 minutes for bupivacaine have been used.

In contrast, chronic pain represents a complex biopsychosocial condition. Manchikanti and colleagues (30,31,101,102,131,162-168) have demonstrated a paradigm shift, showing that local anesthetics produce different and often prolonged effects in chronic pain compared to acute pain. Local anesthetics have been used in interventional pain management for over a century, particularly in epidural injections since 1901 and later with steroids after 1952, as well as in various nerve blocks (169,170). In chronic pain, prolonged relief may result from modulation of peripheral and central mechanisms, including reduction of noxious stimulation, decreased nociceptive input, attenuation of sensitization, and alterations in neurotransmitter release, leading to changes in central processing such as hyperalgesia, windup, nociceptive sensitization, and neural plasticity (169-171). Manchikanti et al (30,31) demonstrated these relief patterns using an ≥ 80% criterion standard. In the cervical spine (31), double-block positive patients receiving lidocaine experienced ≥ 80% relief for 6 days with total relief of 31 days, while bupivacaine produced ≥ 80% relief for 12 days with total relief of 55 days. In the lumbar spine (30), lidocaine produced ≥ 80% relief for 6 days with total relief of 32

days, whereas bupivacaine produced ≥ 80% relief for 11.86 days with total relief of 55 days (Tables 15 and 16).

Based on these findings, criticism has been advanced against multiple prior descriptions of the appropriateness of criteria for controlled comparative local anesthetic blocks, including 50%, 75%, 80%, or 100% pain relief criterion standards, along with the duration of relief with diagnostic blocks, the appropriateness of therapeutic facet joint nerve blocks, and multiple procedural aspects of radiofrequency neurotomy (1-7,29,101,103,105,131,162-176). Bogduk (94) categorized philosophical approaches into 3 groups. He described a purist approach by him and his colleagues (94,99,146), a second approach by Manchikanti et al without a particular name (101,102,168), and a pragmatic approach by Cohen et al (103,105,173). However, there are stark contrasts and differences among these approaches. It is also important to note that Bogduk believes lumbar facet joint pain is not that common; consequently, he asserts that the only way it can be diagnosed is by performing placebo-controlled blocks and he believes they are cost effective. Bogduk and colleagues and Cohen and colleagues continue to utilize an acute pain model, with one recommending placebo-controlled blocks with 100% pain relief, despite the fact that they utilized 50% or more relief as the criterion standard in the lumbar spine in their publications (123-125). In contrast, Manchikanti et al utilized a chronic pain model. Further, Cohen et al's patients were recruited from military personnel, whereas Bogduk and colleagues' patients were from Australia, with some patients from the United States, largely in a younger age group and often with motor vehicle injuries.

Understanding the multiple factors affecting diagnostic accuracy is crucial. Multiple articles have been published assessing factors influencing diagnostic accuracy and outcomes based on diagnostic accuracy. It is generally conceptualized that facet joint nerve blocks are inherently nonspecific, even when performed precisely with fluoroscopic guidance utilizing low volumes. Multiple confounding factors have been assessed in the literature in reference to spinal pain (101-103,128,129,137,151-160,162,177-179).

The influence of age was assessed in 3 studies (128,180,181), with only one utilizing patients suffering from cervical facet joint pain (180). Manchikanti et al (180), in assessing 424 patients suffering from either cervical or lumbar facet joint pain, showed the lowest prevalence (33%) in patients over 70 years old and the highest prevalence in patients aged 18 to 30 years. In contrast, they also showed that presumed false-positive rates for cervical facet joint nerve blocks were 39% in patients aged 41 to 50 years and 58% in patients aged 61 to 70 years, with an overall presumed false-positive rate of 45%. However, the results differed in the lumbar spine, with the lowest prevalence (18%) in patients aged 31 to 40 years and 44% in patients aged 51 to 60 years.

Two other studies also described age-related influence (128,181). In one study by DePalma et al (181), of 153 patients with controlled diagnostic blocks, the results showed that lumbar facet joint pain was the most likely source of chronic low back pain for men who were approximately 54 years of age, regardless of body mass index. However, for women who were 65 years old, facet joint pain was most likely. Manchikanti et al (128), in an earlier study of 100 patients, showed a significantly higher prevalence of facet joint pain in those over 65 years old.

The influence of psychological factors was assessed in 2 studies (182,183). Manchikanti et al (182) assessed 438 patients undergoing controlled comparative local anesthetic blocks for cervical, thoracic, and lumbar facet joint pain. They showed the prevalence of facet joint pain to range from 25% to 40% in those with no psychopathology, from 28% to 43% in those diagnosed with either major depression, generalized anxiety disorder, or somatization disorder, and from 23% to 39% in patients with a negative diagnosis. Regional facet joint pain prevalence and presumed false-positive rates were higher in the cervical region in patients with major depression. However, no differences were identified in the lumbar and thoracic regions. Wasan et al (183) also assessed the influence of psychological factors in lumbar and cervical facet joint pain; however, the sample size was only 86. The results showed that the low psychopathology group reported a mean 23% improvement in pain at one month, while the high psychopathology group reported worsening of pain. Further, 45% of the low group had at least 30% improvement in pain versus 10% in the high psychopathology group. In this poorly performed assessment with inappropriate methodology, the authors concluded that psychopathology influences the outcome of medial branch blocks.

The influence of body mass index was assessed in 2 studies (129,181). DePalma et al (181), in studying 153 patients with chronic low back pain, showed that there was a correlation between significant increases in facet joint pain prevalence and body mass index. However,

Table 15. *Duration of relief with controlled comparative local anesthetic blocks in the diagnosis of cervical facet joint pain.*

Outcome	n	1st Diagnostic Block			2nd Diagnostic Block		
		50-79%	≥ 80%	Total Relief	50-79%	≥ 80%	Total Relief
False positive	50	24.54	6.64	31.18	26.25	0.18	26.43
Negative	99	8.11	0.04	8.15	0.00	0.00	0.00
Positive	145	24.81	6.10	30.91	43.28	11.86	55.29
Total	294	19.14	4.15	23.29	38.71	8.82	47.64

Source: Manchikanti L, Kosanovic R, Cash KA, et al. Assessment of prevalence of cervical facet joint pain with diagnostic cervical medial branch blocks: Analysis based on chronic pain model. *Pain Physician* 2020; 23:531-540 (31).

Table 16. *Duration of relief with controlled comparative local anesthetic blocks in the diagnosis of lumbar facet joint pain.*

Outcome	N	1st Diagnostic Block			2nd Diagnostic Block		
		50-79%	>=80%	Total Relief	50-79%	>=80%	Total Relief
False positive	101	24.89	5.95	30.83	23.58	3.02	26.60
Negative	96	9.63	0.02	9.65	0.00	0.00	0.00
Positive	102	26.04	6.07	32.11	42.47	12.96	55.44
Total	299	20.38	4.09	24.47	33.07	8.02	41.09

Source: Manchikanti L, Kosanovic R, Pampati V, et al. Low back pain and diagnostic lumbar facet joint nerve blocks: Assessment of prevalence, false-positive rates, and a philosophical paradigm shift from an acute to a chronic pain model. *Pain Physician* 2020; 23:519-530 (30).

Manchikanti et al (129) showed a similar prevalence of 36% versus 40% in both groups.

The influence of surgery was assessed in 6 studies in the lumbar spine (137,184-188), one study in the cervical spine (187), and none in the thoracic spine. Overall, the prevalence of facet joint pain was shown to be lower in patients after surgical interventions in the lumbar spine, a uniform finding in the cervical spine studies. The prevalence in patients without surgery and post-surgery was similar as shown by Manchikanti et al (187).

An assessment of the influence of gender and smoking (181,189) showed that women patients may have a higher prevalence of facet joint pain in the lumbar spine. No studies were conducted in the other regions. However, no significant differences were observed based on history of smoking (181).

An assessment of the influence of sedation and opioid exposure yielded different results in the cervical and lumbar spine. Multiple studies were performed by Manchikanti et al (149,177,178,190,191). Overall, there was no significant difference in patients exposed to opioids prior to undergoing facet joint nerve blocks, with a prevalence of 33% and a presumed false-positive rate of 53% in patients without opioid exposure, and in those with heavy opioid use, prevalence ranged from 37% to 53% with a presumed false-positive rate of 38% (178). There was no significant influence of benzodiazepines such as midazolam or opioids when 80% pain relief was used as the criterion standard. However, when 50% relief was used as the criterion standard, fentanyl was a confounding factor in both the lumbar and cervical spines (177,190,191). Manchikanti et al (149) also showed placebo and nocebo effects not only with sodium chloride solution, but also with midazolam and fentanyl.

Finally, the influence of diagnostic blocks on therapeutic outcomes (101-103,162,163,165,166,192,194) showed variable results, with Pampati et al (101) and Manchikanti et al (102,162) demonstrating the importance of controlled diagnostic blocks with 80% pain relief as the criterion standard, with superior outcomes in the lumbar spine, whereas Cohen et al (103) provided contradictory results that we believe were based on flawed assessments. In contrast to Cohen et al (103), Patel et al (195), in a 2024 publication, evaluated the effect of sedation on diagnostic lumbar medial branch blocks for facet joint pain, including 95 patients undergoing facet joint nerve blocks and subsequent radiofrequency neurotomy. In this evaluation, they considered a false-positive result if a patient failed to respond with 50% pain relief from radiofrequency ablation after two successful dual medial branch blocks. The results showed no significant difference between the two groups. Overall, they concluded that Midazolam did not change patients' perceived intensity of pain follow-

ing medial branch blocks, nor did it change presumed false-positive rates after radiofrequency ablation. Even though in their study (103) patients receiving dual blocks showed superior outcomes, they concluded there was no significant difference. Finally, the volume of injectate was studied in the cervical spine by Cohen et al (179) in a small number of patients; however, the results were contradictory to the hypothesis, showing a higher prevalence of 55% of facet joint pain when low volume was utilized compared to a prevalence of 25% when a high volume was utilized.

Even though the exact source of pain in the facet joints can be complicated, it has been suggested for decades that arthrosis causes spinal pain, specifically low back pain. It has been postulated that facet joint degeneration, with alteration of motion associated with disc degeneration and arthritis, may be responsible for facet joint pain (196,197). Proposed pain mechanisms such as capsular stretch, entrapment of synovial villa between the articular surfaces, nerve impingement by osteophytes, and release of multiple inflammatory chemicals have been postulated as causes of facet joint pain (47,64-73). With abundant innervation of the facet joints, including free and encapsulated nerve endings and nerves containing substance P and calcitonin gene-related peptide (37,69,70,76,99,100,114-119,128), facet joint pain appears to be based on neuroanatomic, neurophysiologic, and biochemical processes. However, studies have repeatedly shown that facet joint arthritis is not required for facet joint pain (41,95-97). Further, there is evidence linking heavy work and occupational exposure to facet arthritis (85,198,199).

As described by Kuslich et al (200), discs, facet joints, and sacroiliac joints amenable to diagnostic blocks have been responsible for low back and lower extremity pain. Manchikanti et al (132) evaluated the relative contributions of various structures in chronic low back pain in 120 patients, diagnosing discogenic pain in 26%, facet joint pain in 40%, and sacroiliac joint pain in 2%. DePalma et al (127), assessing relative contributions in 156 patients, also showed similar findings, with internal disc disruption in 42%, facet joint pain in 31%, and sacroiliac joint pain in 18%. In a similar study, Pang et al (122) assessed 104 consecutive adult patients using what they described as spinal pain mapping with diagnostic blocks including provocation discography and other assessments. They reported internal disc disruption in 7% of patients, sacroiliac joint pain in 6%, lumbar nerve root pain in 20%, and facet joint pain in 24%, with combined lumbar nerve root and facet disease in 24%, combined facet and sacroiliac joint disease in 4%, and lumbar sympathetic dystrophy in 2% of patients. However, Pang et al (122) utilized a single block rather than dual blocks.

Despite these relative contribution studies, there remains a proportion of patients in whom a diagnosis cannot be established. Manchikanti et al (132) were unable to identify a diagnosis in 32% of patients without considering selective nerve root blocks as valid, whereas Pang et al (122) reported an unclassified diagnosis in 13% of patients, and DePalma et al (127) identified a diagnosis in all patients.

In the cervical spine, relative contributions were assessed by Yin and Bogduk (140) in the United States in 143 patients, showing a prevalence of zygapophysial joint pain in 55%, discogenic pain in 16%, and lateral atlanto-axial joint pain in 9%. Similar to the lumbar spine, a diagnosis remained elusive in 32% of patients who completed investigations.

Indirect measures are applied to assess diagnostic accuracy, with long-term follow-up used as the criterion standard, an approach accepted across multiple medical disciplines (162,201). Accordingly, the validity of controlled diagnostic facet joint nerve blocks has been established as a reference or gold standard for diagnosing facet joint pain (41,95-97,101,102,105,107,111,202-204). Consequently, controlled diagnostic facet joint nerve blocks, performed under fluoroscopy with utilization of local anesthetic of 0.5 mL or less per nerve, with 75% or greater relief in the lumbar spine and 80% or greater relief in the cervical and thoracic spines, along with the ability to perform previously painful movements, and with demonstrated efficacy in long-term follow-up, remain an appropriate criterion standard. With pain relief for one to 2 years with either radiofrequency neurotomy or therapeutic facet joint nerve blocks, the criterion standard of long-term follow-up appears appropriate (41,95-97,101,147,148,163,165,167,202,203).

A study conducted on the lumbar spine (101) also demonstrated sustained relief in only 51% of patients when 50% relief was considered the criterion standard for diagnostic accuracy at the end of 2 years. In addition, the flawed conclusions of Cohen et al (103) have been highlighted. Cohen et al (103) performed a randomized, multicenter study in 151 patients with suspected lumbar facet joint pain, comparing 3 treatment regimens in 3 groups receiving radiofrequency denervation either with no diagnostic blocks, one diagnostic block, or 2 diagnostic blocks. The reported success rate was 33% with no diagnostic blocks, 39% with a single

diagnostic block, and 64% with dual diagnostic blocks. Thus, the study essentially demonstrated that dual diagnostic blocks were more effective; however, they erroneously concluded that cost effectiveness favored no diagnostic blocks. In assessing cost effectiveness, they failed to consider the amount of relief patients received with diagnostic blocks and instead used only total cost without outcomes.

The rationale and validity of diagnostic facet joint nerve blocks have been well established. The anatomic characteristics of spinal facet joints allow anesthesia either via intraarticular injection of local anesthetic or by anesthetizing the medial branches of the dorsal rami that innervate the target joint (47,48,77,95-99,100,105-107,122,202,204). Controlled diagnostic blocks are performed either with placebo injections or comparative local anesthetic blocks. It is crucial to follow required steps to eliminate false-positive responses. The joint may be considered the source of pain if pain is relieved by joint blockade. True-positive responses can be obtained only by performing controlled blocks.

The rationale for facet joints as a pain source is supported by abundant innervation (48,53-59,61-63,95-97,205-216). The facet joints have been shown to cause axial spinal pain and referred pain in the extremities and chest wall (65-76,216). There is a demonstrated lack of correlation of facet joint pain with demographic features, pain characteristics, physical findings, and specific signs or symptoms (95-97). In addition, referral patterns for joints are variable (65-68,201), and a pain pattern similar to facet joint pain may be produced by multiple other spinal structures.

Further, most maneuvers used in physical examinations likely stress several structures simultaneously, including discs, muscles, and facet joints. Controlled local anesthetic facet joint blocks for diagnosing chronic axial spinal pain have been reviewed and validated (47,77,95-99,100,105-107,122,148,150). Thus, placebo-controlled blocks or comparative local anesthetic blocks using 2 different local anesthetics of differing duration of action on 2 separate occasions remain the only means of confirming the diagnosis of facet joint pain.

The face validity of intraarticular facet injections and medial branch blocks has been established by injecting small volumes of local anesthetic into the joint or onto the sensory nerves of the joint. The construct validity of facet joint blocks also has been established (47,77,95-99,100,105-107,122,148,150). The placebo effect of facet joint injections may be controlled by using strict criteria for determining a positive response to controlled anesthetic blocks. It has been proven that one approach to test placebo response is to administer lidocaine first and subsequently administer bupivacaine. Pain provocation response of facet joint injections has been shown to be unreliable (217). Further, false-positive rates for facet joint blockade have been reported to range from 17% to 49% (47,95-97). Finally, the false-negative rate for diagnostic facet joint blocks has been shown to be approximately 8% due to unrecognized intravascular injection of local anesthetic (218,219).

Systematic reviews are considered to occupy the highest level of hierarchy and provide the best evidence synthesis, with or without meta-analysis (201,220-233). Systematic reviews apply scientific strategies that limit bias, including systematic assembly, critical appraisal, and synthesis of all relevant studies on a specific topic, and may or may not include meta-analysis. Meta-analysis incorporates quantitative analysis following qualitative analysis in a systematic review; however, homogeneity of included studies is essential. In recent years, multiple authors have ignored appropriate assessment of homogeneity, including heterogenous studies in meta-analysis, and consequently provided inaccurate conclusions (221-242). Many of these authors have significant conflicts of interest and may lack expertise in clinical aspects of the diagnostic tests or treatments being studied. This lack of clinical expertise may lead to inaccurate conclusions and inappropriate application of results (221-223,236-242). However, in contrast to multiple prior systematic reviews and opinions of experts with substantial conflicts of interest, this systematic review minimizes bias through comprehensiveness and reproducibility of the search and selection of articles for review and through methodological quality assessment, reaching appropriate conclusions without meta-analysis.

Conclusion

This updated systematic review assessing the accuracy of diagnostic facet joint nerve blocks in chronic spinal pain showed Level I evidence for the diagnosis of chronic lumbar facet joint pain and Level II evidence for cervical and thoracic facet joint pain, based on multiple high-quality studies utilizing controlled diagnostic blocks.

Author Contributions

The article was designed by LM, VSP, MRS, and JH.

All authors contributed to the preparation of this article, reviewed and approved the content with the final version.

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Conflict of Interest:

Dr. Soin has several patents in non-opioid pain pharmaceuticals and neuromodulation (SCS and PNS) and artificial intelligence, has stock options with Neuros Medical, has received equipment, materials, drugs, medical writing, gifts or other services from Avanos for research, and has other financial or nonfinancial interests with Alyea Therapeutics, Neuros Medical, Neuronoff, and Avanos.

Dr. Navani is a board member and shareholder of Semnur Pharmaceutical.

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All other authors certify that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

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References

1. Manchikanti L, Sanapati MR, Albers SL, et al. Updated 2026 comprehensive evidence-based guidelines for facet joint interventions in the management of chronic spinal pain: American Society of Interventional Pain Physicians (ASIPP). *Pain Physician* 2026; 29:S1-S228.
2. Manchikanti L, Kaye AD, Soin A, et al. Comprehensive evidence-based guidelines for facet joint interventions in the management of chronic spinal pain: American Society of Interventional Pain Physicians (ASIPP) guidelines.*Pain Physician* 2020; 23:S1-S127.
3. Manchikanti L, Knezevic E, Knezevic NN, et al. Effectiveness of facet joint nerve blocks in managing chronic axial spinal pain of facet joint origin: A systematic review and meta-analysis. *Pain Physician* 2024; 27:E169-E206.
4. Manchikanti L, Knezevic E, Sic A, et al. A systematic review and meta-analysis of randomized trials of therapeutic intraarticular facet joint injections in chronic axial spinal pain. *Pain Physician* 2025; 28:261-286.
5. Manchikanti L, Knezevic E, Knezevic NN, et al. Effectiveness of radiofrequency ablation in managing chronic axial spinal pain of facet joint origin: A systematic review and meta-analysis of randomized controlled trials. *Pain Physician* 2026; 29:205-240.
6. Manchikanti L, Knezevic NN, Knezevic E, et al. A systematic review and meta-analysis of the effectiveness of radiofrequency neurotomy in managing chronic neck pain. *Pain Ther* 2023; 12:19-66.
7. Klessinger S, Casser HR, Gillner S, et al. Radiofrequency denervation of the spine and the sacroiliac joint: A systematic review based on the Grades of Recommendations, Assessment, Development, and Evaluation approach resulting in a German National Guideline. *Global Spine J* 2024; 14:2124-2154.
8. Cohen SP, Bhaskar A, Bhatia A, et al. Consensus practice guidelines on interventions for lumbar facet joint pain from a multispecialty, international working group. *Reg Anesth Pain Med* 2020; 45:424-467.
9. Hurley RW, Adams MCB, Barad M, et al. Consensus practice guidelines on interventions for cervical spine (facet) joint pain from a multispecialty international working group. *Reg Anesth Pain Med* 2022; 47:3-59.
10. Lucas JW, Sohi I. Chronic pain and high-impact chronic pain in U.S. adults, 2023. NCHS Data Brief, no. 518. Hyattsville, MD: National Center for Health Statistics. November 2024. Accessed 12/4/2024.
www.cdc.gov/nchs/data/databriefs/db518.pdf
11. Zajacova A, Grol-Prokopczyk H, Nahin RL. Pain among US adults before, during, and after the COVID-19 pandemic: A study using the 2019 to 2023 National Health Interview Survey. *Pain* 2026; 167:142-149.
12. Mullins PM, Gilligan CJ, Bhattacharyya N. The prevalence of opioid medication use among adults in the United States. *J Opioid Manag* 2022; 18:503-509.

13. Yong RJ, Mullins PM, Bhattacharyya N. Prevalence of chronic pain among adults in the United States. *Pain* 2022; 163:e328-e332.
14. US Pain Foundation. The Impact of Pain in America. August 25, 2023. Accessed 12/23/2025. https://uspainfoundation.org/news/the-impact-of-pain-in-america/
15. Mills SEE, Nicolson KP, Smith BH. Chronic pain: A review of its epidemiology and associated factors in population-based studies. *Br J Anaesth* 2019; 123:e273-e283.
16. US Burden of Disease Collaborators; Mokdad AH, Ballestros K, Echko M, et al. The state of US Health, 1990-2016: Burden of diseases, injuries, and risk factors among US states. *JAMA* 2018; 319: 1444-1472.
17. Dieleman JL, Cao J, Chapin A, et al. US health care spending by payer and health condition, 1996-2016. *JAMA* 2020; 323:863-884.
18. Fanuscu A, Meuwissen I, Meeus M. The past, present, and future of the biopsychosocial approach to nonspecific chronic low back pain in research and clinical practice based on a bibliometric analysis. *Pain Physician* 2025; 28:397-416.
19. Leboeuf-Yde C, Nielsen J, Kyvik KO, Fejer R, Hartvigsen J. Pain in the lumbar, thoracic or cervical regions: Do age or gender matter? A population-based study of 34,902 Danish twins 20–71 years of age. *BMC Musculoskelet Disord* 2009; 10:39.
20. Yang H, Haldeman S, Hurwitz EL, et al. Association of cognitive impairment and spinal pain in the older adult population in the United States: A cross-sectional study. *J Manipulative Physiol Ther* 2025: S0161-4754:00001-6.
21. Lier R, Nilsen TI, Vasseljen O, Mork PJ. Neck/upper back and low back pain in parents and their adult offspring: Family linkage data from the Norwegian HUNT Study. *Eur J Pain* 2015; 19:762-771.
22. Manchikanti L, Pampati V, Sanapati MR, et al. Exponential decline of 28.9% in utilization of interventional pain management techniques among Medicare beneficiaries from 2019 to 2022: Updated analysis on the ongoing effects of COVID-19, economic decline, the Affordable Care Act (ACA), and medical policies. *Pain Physician* 2024; 27:455-467.
23. Manchikanti L, Abd-Elsayed A, Kaye AD, et al. Escalating growth to rapid decline of utilization patterns of facet joint interventions in managing spinal pain in the Medicare population: Updated analysis of the effect of multiple factors from 2000 to 2022. *Pain Physician* 2024; 27:E969-E982.
24. Manchikanti L, Sanapati MR, Pampati V, et al. A 24% decline in the utilization of epidural procedure visits for chronic spinal pain management in the Medicare population from 2019 to 2022: Updated analysis of the effect of multiple factors. *Pain Physician* 2024; 27:E983-E994.
25. Manchikanti L, Pampati V, Kaye AD, et al. An updated review of utilization patterns of sacroiliac joint interventions in the fee-for-service (FFS) Medicare population from 2000-2022. *Curr Pain Headache Rep* 2026; 30:34.
26. Manchikanti L, Pampati V, Sanapati MR, et al. Updated analysis of decline of 16.8% in utilization of interventional pain management techniques among traditional (fee-for-service) Medicare beneficiaries from 2019 to 2024. *Pain Physician* 2025; 28:S121-S136.
27. Manchikanti L, Sanapati MR, Pampati V, et al. Updated analysis of declining utilization rate of 13% epidural procedures for chronic spinal pain management in the traditional Medicare population from 2019 to 2024. *Pain Physician* 2026; 29:1-16.
28. Manchikanti L, Abd-Elsayed A, Kaye AD, et al. Updated analysis of continued decline of utilization patterns of facet joint interventions in managing spinal pain in the traditional Medicare population: From 2000 to 2024. *Pain Physician* 2026; 26:E163-E181.
29. Boswell MV, Manchikanti L, Kaye AD, et al. A best-evidence systematic appraisal of the diagnostic accuracy and utility of facet (zygapophysial) joint injections in chronic spinal pain. *Pain Physician* 2015; 18:E497-E533.
30. Manchikanti L, Kosanovic R, Pampati V, et al. Low back pain and diagnostic lumbar facet joint nerve blocks: Assessment of prevalence, false-positive rates, and a philosophical paradigm shift from an acute to a chronic pain model. *Pain Physician* 2020; 23:519-530.
31. Manchikanti L, Kosanovic R, Cash KA, et al. Assessment of prevalence of cervical facet joint pain with diagnostic cervical medial branch blocks: Analysis based on chronic pain model. *Pain Physician* 2020; 23:531-540.
32. Bogduk N. On understanding the validity of diagnostic tests. Interv *Pain Med* 2022; 1:100127.
33. Bogduk N. On the validity and clinical utility of comparative local anesthetic blocks for the diagnosis of spine pain. *Interv Pain Med* 2023; 2:100257.
34. Klessinger S, Bogduk N. Are false-positive rates of diagnostic medial branch blocks correct? Introducing the inconsistency rate. *Interv Pain Med* 2023; 2:100298.
35. Klessinger S, Schuster N, MacVicar J, et al; International Pain and Spine Intervention Society. Safety practices for interventional pain procedures: Facet interventions. *Interv Pain Med* 2025; 4:100549.
36. King W, Lau P, Lees R, Bogduk N. The validity of manual examination in assessing patients with neck pain. *Spine J* 2007; 7:22-26.
37. Matar HE, Navalkissoor S, Berovic M, et al. Is hybrid imaging (SPECT/CT) a useful adjunct in the management of suspected facet joints arthropathy? *Int Orthop* 2013; 37:865-870.
38. Schneider GM, Jull G, Thomas K, Salo P. Screening of patients suitable for diagnostic cervical facet joint blocks--a role for physiotherapists. *Man Ther* 2012; 17:180-183.
39. Schneider GM, Jull G, Thomas K, et al. Derivation of a clinical decision guide in the diagnosis of cervical facet joint pain. *Arch Phys Med Rehabil* 2014; 95:1695-1701.
40. Schneider GM, Jull G, Thomas K, et al. Intrarater and interrater reliability of select clinical tests in patients referred for diagnostic facet joint blocks in the cervical spine. *Arch Phys Med Rehabil* 2013; 94:1628-1634.
41. Jull G, Bogduk N, Marsland A. The accuracy of manual diagnosis for cervical zygapophysial joint pain syndromes. *Med J Aust* 1988; 148:233-236.
42. Maas ET, Juch JN, Ostelo RW, et al. Systematic review of patient history and physical examination to diagnose chronic low back pain originating from the facet joints. *Eur J Pain* 2017; 21:403-414.
43. Manchikanti L, Kosanovic R, Pampati V, et al. Equivalent outcomes of lumbar therapeutic facet joint nerve blocks and radiofrequency neurotomy: Comparative evaluation of clinical outcomes and cost utility. *Pain Physician* 2022; 25:179-192.
44. Manchikanti L, Kosanovic R, Pampati V, Sanapati MR, Hirsch JA. Outcomes of cervical therapeutic medial branch blocks and radiofrequency neurotomy:

Clinical outcomes and cost utility are equivalent. *Pain Physician* 2022; 25:35-47.

45. Scholten P, Sheikh M, Atchison J, et al. Correlating SPECT-CT activity in cervical facet joints with positive response to cervical medial branch blocks. Interv *Pain Med* 2024; 3:100393.
46. Scholten P, Sheikh M, Atchison J, et al. Correlating SPECT-CT activity in lumbar facet joints with response to lumbar medial branch and L5 dorsal ramus blocks. *Interv Pain Med* 2024; 3:100387.
47. Bogduk N. Low back pain. *Clinical Anatomy of Lumbar Spine and Sacrum, 4th edition.* Churchill Livingstone, New York, 2005, pp 183-216.
48. Barnsley L, Bogduk N. Medial branch blocks are specific for the diagnosis of cervical zygapophyseal joint pain. *Reg Anesth* 1993; 18:343-350.
49. Schulte TL, Filler TJ, Struwe P, Liem D, Bullman V. Intra-articular meniscoid folds in thoracic zygapophysial joints. *Spine (Phila Pa 1976)* 2010; 35:E191-E197.
50. Suseki K, Takahashi Y, Takahashi K, Chiba T, Tanaka K, Morinaga T, Nakamura S, Moriya H. Innervation of the lumbar facet joints. Origins and functions. *Spine (Phila Pa 1976)* 1997; 22:477-485.
51. Cavanaugh JM, Lu Y, Chen C, Kallakuri S. Pain generation in lumbar and cervical facet joints. *J Bone Joint Surg Am* 2006; 88:63-67.
52. Cavanaugh JM, Ozaktay AC, Yamashita T, Avramov A, Getchell TV, King AI. Mechanisms of low back pain: A neurophysiologic and neuroanatomic study. *Clin Orthop Relat Res* 1997; 335:166-180.
53. Bogduk N, Wilson AS, Tynan W. The human lumbar dorsal rami. *J Anat* 1982; 134:383-397.
54. Bogduk N. The clinical anatomy of the cervical dorsal rami. *Spine (Phila Pa 1976)* 1982; 7:319-330.
55. Ohtori S, Takahashi K, Chiba T, Yamagata M, Sameda H, Moriya H. Sensory innervation of the cervical facet joints in rats. *Spine (Phila Pa 1976)* 2001; 26:147-150.
56. Zhang J, Tsuzuki N, Hirabayashi S, Saiki K, Fujita K. Surgical anatomy of the nerves and muscles in the posterior cervical spine. *Spine (Phila Pa 1976)* 2003; 28:1379-1384.
57. Kallakuri S, Li Y, Chen C, Cavanaugh JM. Innervation of cervical ventral facet joint capsule: Histological evidence. *World J Orthop* 2012; 3:10-14.
58. Ishikawa T, Miyagi M, Ohtori S, et al. Characteristics of sensory DRG neurons innervating the lumbar facet joints in rats. *Eur Spine J* 2005; 14:559-564.
59. Chua WH, Bogduk N. The surgical anatomy of thoracic facet denervation. *Acta Neurochir* 1995; 136:140-144.
60. Talsma JM, Maus TP, Chitneni A, Hao D. Investigation of the anatomical course of articular branches to the thoracic zygapophysial joints. *Interv Pain Med* 2024; 3:100399.
61. Stilwell DL. The nerve supply of the vertebral column and its associated structures in the monkey. *Anat Rec* 1956; 125:139-169.
62. Sato T, Koizumi M, Kim JH, et al. Fetal development of deep back muscles in the human thoracic region with a focus on transversospinalis muscles and the medial branch of the spinal nerve posterior ramus. *J Anat* 2011; 219:756-765.
63. Lau P, Mercer S, Govind J, Bogduk N. The surgical anatomy of lumbar medial branch neurotomy (facet denervation). *Pain Med* 2004; 5:289-298.
64. Jung JH, Kim HI, Shin DA, et al. Usefulness of pain distribution pattern assessment in decision-making for the patients with lumbar zygapophyseal and sacroiliac joint arthropathy. *J Korean Med Sci* 2007; 22:1048-1054.
65. Marks RC. Distribution of pain provoked from lumbar facet joints and related structures during diagnostic spinal infiltration. *Pain* 1989; 39:37-40.
66. Fukui S, Ohseto K, Shiotani M, Ohno K, Karasawa H, Naganuma Y. Distribution of referred pain from the lumbar zygapophyseal joints and dorsal rami. *Clin J Pain* 1997; 13:303-307.
67. Hirsch C, Ingelmark BE, Miller M. The anatomical basis for low back pain. Studies on the presence of sensory nerve endings in ligamentous, capsular and intervertebral disc structures in the human lumbar spine. *Acta Orthop Scand* 1963; 33:1-17.
68. Windsor RE, King FJ, Roman SJ, et al. Electrical stimulation induced lumbar medial branch referral patterns. *Pain Physician* 2002; 5:347-353.
69. Mooney V, Robertson J. The facet syndrome. *Clin Orthop Relat Res* 1976; 115:149-156.
70. McCall IW, Park WM, O'Brien JP. Induced pain referral from posterior lumbar elements in normal subjects. *Spine (Phila Pa 1976)* 1979; 4:441-446.
71. Dreyfuss P, Tibiletti C, Dreyer SJ. Thoracic zygapophyseal joint pain patterns: A study in normal volunteers. *Spine (Phila Pa 1976)* 1994; 19:807-811.
72. Fukui S, Ohseto K, Shiotani M. Patterns of pain induced by distending the thoracic zygapophyseal joints. *Reg Anesth* 1997; 22:332-336.
73. Dwyer A, Aprill C, Bogduk N. Cervical zygapophyseal joint pain patterns: A study in normal volunteers. *Spine (Phila Pa 1976)* 1990; 15:453-457.
74. Aprill C, Dwyer A, Bogduk N. The prevalence of cervical zygapophyseal joint pain patterns II: A clinical evaluation. *Spine (Phila Pa 1976)* 1990; 15:458-461.
75. Fukui S, Ohseto K, Shiotani M, et al. Referred pain distribution of the cervical zygapophyseal joints and cervical dorsal rami. *Pain* 1996; 68:79-83.
76. Windsor RE, Nagula D, Storm S. Electrical stimulation induced cervical medial branch referral patterns. *Pain Physician* 2003; 6:411-418.
77. Watson DH, Drummond PD. Head pain referral during examination of the neck in migraine and tension-type headache. *Headache* 2012; 52:1226-1235
78. Kalichman L, Li L, Kim DH, et al. Facet joint osteoarthritis and low back pain in the community-based population. *Spine (Phila Pa 1976)* 2008; 33:2560-2565.
79. Jin Q, Chang Y, Lu C, Chen L, Wang Y. Referred pain: characteristics, possible mechanisms, and clinical management. *Front Neurol* 2023; 14:1104817.
80. Bykowski JL, Wong WH. Role of facet joints in spine pain and image-guided treatment: A review. *AJNR Am J Neuroradiol* 2012; 33:1419-1426.
81. Kras JV, Dong L, Winkelstein BA. Increased interleukin-1α and prostaglandin E2 expression in the spinal cord at 1 day after painful facet joint injury: Evidence of early spinal inflammation. *Spine (Phila Pa 1976)* 2014; 39:207-212.
82. Anderst WJ, Donaldson WF 3rd, Lee JY, Kang JD. In vivo cervical facet joint capsule deformation during flexion extension. *Spine (Phila Pa 1976)* 2014; 39:E514-E520.
83. Gellhorn AC, Katz JN, Suri P. Osteoarthritis of the spine: The facet joints. *Nat Rev Rheumatol* 2013; 9:216-224.
84. Oppenheimer A. Diseases of the apophyseal (intervertebral) articulations. *J Bone Joint Surg* 1938; 20:285-313.
85. Lewin T. Osteoarthritis in lumbar synovial joints. A morphologic study.

Acta Orthop Scand 1964; 73:1-112.

86. Igarashi A, Kikuchi S, Konno S, Olmarker K. Inflammatory cytokines released from the facet joint tissue in degenerative lumbar spinal disorders. *Spine (Phila Pa 1976)* 2004; 29:2091-2095.
87. Kim JS, Kroin JS, Buvanendran A, et al. Characterization of a new animal model for evaluation and treatment of back pain due to lumbar facet joint osteoarthritis. *Arthritis Rheum* 2011; 63:2966-2973.
88. Shuang F, Zhu J, Song K, et al. Establishment of a rat model of adjuvant-induced osteoarthritis of the lumbar facet joint. *Cell Biochem Biophys* 2014; 70:1545-1551.
89. Ko S, Vaccaro AR, Lee S, Lee J, Chang H. The prevalence of lumbar spine facet joint osteoarthritis and its association with low back pain in selected Korean populations. *Clin Orthop Surg* 2014; 6:385-391.
90. Sagar DR, Ashraf S, Xu L, et al. Osteoprotegerin reduces the development of pain behaviour and joint pathology in a model of osteoarthritis. *Ann Rheum Dis* 2014; 73:1558-1565.
91. Linov L, Klindukhov A, Li L, Kalichman L. Lumbar facet joint orientation and osteoarthritis: A cross-sectional study. *J Back Musculoskelet Rehabil* 2013; 26:421-426.
92. Quinn KP, Winkelstein BA. Detection of altered collagen fiber alignment in the cervical facet capsule after whiplash-like joint retraction. *Ann Biomed Eng* 2011; 39:2163-2173.
93. Hancock MJ, Maher CG, Latimer J, et al. Systematic review of tests to identify the disc, SIJ or facet joint as the source of low back pain. *Eur Spine J* 2007; 16:1539-1550.
94. Bogduk N. On diagnostic blocks for lumbar zygapophysial joint pain. *F1000 Med Rep* 2010; 2:57.
95. Falco FJE, Manchikanti L, Datta S, et al. An update of the systematic assessment of the diagnostic accuracy of lumbar facet joint nerve blocks. *Pain Physician* 2012; 15:E869-E907
96. Falco FJE, Datta S, Manchikanti L, et al. An updated review of diagnostic utility of cervical facet joint injections. *Pain Physician* 2012; 15:E807-E838.
97. Atluri S, Singh V, Datta S, Geffert S, Sehgal N, Falco FJE. Diagnostic accuracy of thoracic facet joint nerve blocks: An update of the assessment of evidence. *Pain Physician* 2012; 15:E483-E496.
98. Rubinstein SM, van Tulder M. A best-evidence review of diagnostic procedures for neck and low-back pain. *Best Pract Res Clin Rheumatol* 2008; 22:471-482.
99. Barnsley L, Lord S, Bogduk N. Comparative local anesthetic blocks in the diagnosis of cervical zygapophysial joints pain. *Pain* 1993; 55:99-106.
100. Lord SM, Barnsley L, Bogduk N. The utility of comparative local anesthetic blocks versus placebo-controlled blocks for the diagnosis of cervical zygapophysial joint pain. *Clin J Pain* 1995; 11:208-213.
101. Pampati S, Cash KA, Manchikanti L. Accuracy of diagnostic lumbar facet joint nerve blocks: A 2-year follow-up of 152 patients diagnosed with controlled diagnostic blocks. *Pain Physician* 2009; 12:855-866.
102. Manchikanti L, Pampati S, Cash KA. Making sense of the accuracy of diagnostic lumbar facet joint nerve blocks: An assessment of implications of 50% relief, 80% relief, single block or controlled diagnostic blocks. *Pain Physician* 2010; 13:133-143.
103. Cohen SP, Williams KA, Kurihara C, et al. Multicenter, randomized, comparative cost-effectiveness study comparing 0, 1, and 2 diagnostic medial branch (facet joint nerve) block treatment paradigms before lumbar facet radiofrequency denervation. *Anesthesiology* 2010; 113:395-405
104. Derby R, Melnik I, Lee JE, Lee SH. Correlation of lumbar medial branch neurotomy results with diagnostic medial branch block cutoff values to optimize therapeutic outcome. *Pain Med* 2012; 13:1533-1546.
105. Cohen SP, Doshi TL, Constantinescu OC, et al. Effectiveness of lumbar facet joint blocks and predictive value before radiofrequency denervation: The facet treatment study (FACTS), A randomized, controlled clinical trial. *Anesthesiology* 2018; 129:517-535.
106. Revel ME, Listrat VM, Chevalier XJ, et al. Facet joint block for low back pain: Identifying predictors of a good response. *Arch Phys Med Rehabil* 1992; 73:824-828.
107. Revel ME, Poiraudeau S, Auleley GR, et al. Capacity of the clinical picture to characterize low back pain relieved by facet joint anesthesia. Proposed criteria to identify patients with painful facet joints. *Spine (Phila Pa 1976)* 1998; 23:1972-1976.
108. Carragee EJ, Haldeman S, Hurwitz E. The pyrite standard: The Midas touch in the diagnosis of axial pain syndromes. *Spine J* 2006; 7:27-31.
109. Sehgal N, Dunbar EE, Shah RV, Colson J. Systematic review of diagnostic utility of facet (zygapophysial) joint injections in chronic spinal pain: an update. *Pain Physician* 2007; 10:213-228.
110. Han CS, Hancock MJ, Sharma S, et al. Low back pain of disc, sacroiliac joint, or facet joint origin: a diagnostic accuracy systematic review. *EClinicalMedicine* 2023; 59:101960.
111. Lucas NP, Macaskill P, Irwing L, Bogduk N. The development of a quality appraisal tool for studies of diagnostic reliability (QAREL). *J Clin Epidemiol* 2010; 63:854-861.
112. Bossuyt PM, Reitsma JB, Bruns DE, et al; STARD Group. Towards complete and accurate reporting of studies of diagnostic accuracy: The STARD Initiative. *Ann Intern Med* 2003; 138:40-44.
113. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ* 2021; 372:n71.
114. Whiting PF, Rutjes AW, Westwood ME, et al; QUADAS-2 Group. QUADAS-2: A revised tool for the quality assessment of diagnostic accuracy studies. *Ann Intern Med* 2011; 155:529-536.
115. Lucas N, Macaskill P, Irwig L, et al. The reliability of a quality appraisal tool for studies of diagnostic reliability (QAREL). *BMC Med Res Methodol* 2013; 13:111.
116. Gemmell H, Miller P. Interexaminer reliability of multidimensional examination regimens used for detecting spinal manipulable lesions: A systematic review. *Clin Chiropractic* 2005; 8:199-204.
117. May S, Littlewook C, Bishop A. Reliability of procedures used in the physical examination of non-specific low back pain: A systematic review. *Aust J Physiother* 2006; 52:91-102.
118. Stochkendahl MJ, Christensen HW, Hartvigsen J, et al. Manual examination of the spine: A systematic critical literature review of reproducibility. *J Manipulative Physiol Ther* 2006; 29:475-485, 485.e1-10.
119. Cuello-Garcia CA, Santesso N, Morgan RL, et al. GRADE guidance 24 optimizing the integration of randomized and non-randomized studies of interventions in evidence syntheses and health guidelines. *J Clin Epidemiol* 2022; 142:200-208.
120. BMJ Best Practice. Evidence-based

medicine (EBM) toolkit. Learn EBM. What is GRADE? Accessed 1/27/2026. https://bestpractice-bmj-com.bibliotheek.ehb.be/info/evidence/learn-ebm/what-is-grade/

121. Manchikanti L, Falco FJE, Benyamin RM, Kaye AD, Boswell MV, Hirsch JA. A modified approach to grading of evidence. *Pain Physician* 2014; 17:E319-E32.
122. Pang WW, Mok MS, Lin ML, Chang DP, Hwang MH. Application of spinal pain mapping in the diagnosis of low back pain--analysis of 104 cases. *Acta Anaesthesiol Sin* 1998; 36:71-74.
123. Schwarzer AC, Aprill C, Derby R, Fortin J, Kine G, Bogduk N. Clinical features of patients with pain stemming from the lumbar zygapophyseal joints. Is the lumbar facet syndrome a clinical entity? *Spine (Phila Pa 1976)* 1994; 10:1132-1137.
124. Schwarzer AC, Aprill CN, Derby R, Fortin J, Kine G, Bogduk N. The false-positive rate of uncontrolled diagnostic blocks of the lumbar zygapophysial joints. *Pain* 1994; 58:195-200.
125. Schwarzer AC, Wang S, Bogduk N, McNaught PJ, Laurent R. Prevalence and clinical features of lumbar zygapophysial joint pain: A study in an Australian population with chronic low back pain. *Ann Rheum Dis* 1995; 54:100-106.
126. Manchikanti L, Pampati V, Fellows B, Baha GA. The inability of the clinical picture to characterize pain from facet joints. *Pain Physician* 2000; 3:158-166.
127. DePalma MJ, Ketchum JM, Saullo T. What is the source of chronic low back pain and does age play a role? *Pain Med* 2011; 12:224-233.
128. Manchikanti L, Pampati V, Rivera JJ, Fellows B, Beyer CD, Damron KS. Role of facet joints in chronic low back pain in the elderly: A controlled comparative prevalence study. *Pain Practice* 2001; 1:332-337.
129. Manchikanti L, Pampati V, Singh V, Beyer C, Damron K, Fellows B. Evaluation of role of facet joints in persistent low back pain in obesity: A controlled, prospective, comparative evaluation. *Pain Physician* 2001; 4:266-272.
130. Manchikanti L, Pampati V, Fellows B, Bakhit CE. Prevalence of lumbar facet joint pain in chronic low back pain. *Pain Physician* 1999; 2:59-64.
131. Manchikanti L, Pampati V, Fellows B, Bakhit CE. The diagnostic validity and therapeutic value of medial branch blocks with or without adjuvants. *Curr Rev Pain* 2000; 4:337-344.
132. Manchikanti L, Singh V, Pampati V, et al. Evaluation of the relative contributions of various structures in chronic low back pain. *Pain Physician* 2001; 4:308-316.
133. Manchikanti L, Hirsch JA, Pampati V. Chronic low back pain of facet (zygapophysial) joint origin: Is there a difference based on involvement of single or multiple spinal regions? *Pain Physician* 2003; 6:399-405.
134. Manchikanti L, Singh V, Pampati V, Damron KS, Beyer CD, Barnhill RC. Is there correlation of facet joint pain in lumbar and cervical spine? An evaluation of prevalence in combined chronic low back and neck pain. *Pain Physician* 2002; 5:365-371.
135. Manchikanti L, Boswell MV, Singh V, Pampati V, Damron KS, Beyer CD. Prevalence of facet joint pain in chronic spinal pain of cervical, thoracic, and lumbar regions. *BMC Musuloskeletal Disord* 2004; 5:15.
136. Manchukonda R, Manchikanti KN, Cash KA, Pampati V, Manchikanti L. Facet joint pain in chronic spinal pain: An evaluation of prevalence and false-positive rate of diagnostic blocks. *J Spinal Disord Tech* 2007; 20:539-545.
137. Manchikanti L, Manchukonda R, Pampati V, Damron KS, McManus CD. Prevalence of facet joint pain in chronic low back pain in postsurgical patients by controlled comparative local anesthetic blocks. *Arch Phys Med Rehabil* 2007; 88:449-455.
138. Aprill C, Bogduk N. The prevalence of cervical zygapophyseal joint pain. A first approximation. *Spine (Phila Pa 1976)* 1992; 17:744-747.
139. Manchikanti L, Singh V, Rivera J, Pampati V. Prevalence of cervical facet joint pain in chronic neck pain. *Pain Physician* 2002; 5:243-249.
140. Yin W, Bogduk N. The nature of neck pain in a private pain clinic in the United States. *Pain Med* 2008; 9:196-203.
141. Speldewinde G, Bashford G, Davidson I. Diagnostic cervical zygapophyseal joint blocks for chronic cervical pain. *Med J Aust* 2001; 174:174-176.
142. Barnsley L, Lord SM, Wallis BJ, Bogduk N. The prevalence of chronic cervical zygapophyseal joint pain after whiplash. *Spine (Phila Pa 1976)* 1995; 20:20-26.
143. Lord SM, Barnsley L, Wallis BJ, Bogduk N. Chronic cervical zygapophysial joint pain with whiplash: A placebo-controlled prevalence study. *Spine (Phila Pa 1976)* 1996; 21:1737-1744.
144. Barnsley L, Lord S, Wallis B, Bogduk N. False-positive rates of cervical zygapophysial joint blocks. *Clin J Pain* 1993; 9:124-130.
145. Manchikanti L, Singh V, Pampati VS, Beyer CD, Damron KS. Evaluation of the prevalence of facet joint pain in chronic thoracic pain. *Pain Physician* 2002; 5:354-359.
146. Engel A, MacVicar J, Bogduk N. A philosophical foundation for diagnostic blocks, with criteria for their validation. *Pain Med* 2014; 15:998-1006.
147. Bradford Hill A. The environment and disease: Association or causation? *Proc Roy Soc Med* 1965; 58:295-300.
148. Howick J, Glasziou P, Aronson JK. The evolution of evidence hierarchies: What can Bradford Hill's "guidelines for causation" contribute? *J R Soc Med* 2009; 102:186-194.
149. Manchikanti L, Pampati V, Damron KS. The role of placebo and nocebo effects of perioperative administration of sedatives and opioids in interventional pain management. *Pain Physician* 2005; 8:349-355.
150. Abe H, Kato S, Takami H, et al. Expert Consensus-based criteria for identifying lumbar facet joint pain in primary care: Development using factor analysis and a modified Delphi method. *Pain Ther* 2025, Nov 13. Epub ahead of print.
151. CGS Administrators, LLC. Local Coverage Determination (LCD). Peripheral Nerve Blocks and Procedures for Chronic Pain (DL40261). Proposed LCD Posting Date: 09/25/2025.
152. CGS Administrators, LLC. Local Coverage Determination (LCD). Facet Joint Interventions for Pain Management (L38773). Revision Effective Date 07/07/2024.
153. Curatolo M, Bogduk N. Diagnostic blocks for chronic pain. *Scand J Pain* 2010; 1:186-192.
154. Bonica JJ. Local anaesthesia and regional blocks. In: Wall PD, Melzack R (eds.) *Textbook of Pain*, 2nd ed. Churchill Livingstone, Edinburgh, 1989, pp 724-743.
155. Bonica JJ, Buckley FP. Regional analgesia with local anesthetics. In: Bonica JJ (ed.) *The Management of Pain, Vol. II*. Lea and Febiger, Philadelphia, PA, 1990, pp 1883-1966.
156. RA Boas. Nerve blocks in the diagnosis of low back pain, Neurosurg. *Clin N Am* 1991; 2:807-816.
157. Cousins MJ, Mather LE. Clinical

pharmacology of local anaesthetics. *Anaesth Intensive Care* 1980; 8:257-277.

158. Moore DC, Bridenbaugh LD, Bridenbaugh PO, Tucker GT. Bupivacaine. A review of 2,077 cases. *JAMA* 1970; 214:713-718.
159. Moore DC, Bridenbaugh LD, Bridenbaugh PO, Tucker GT. Bupivacaine for peripheral nerve block: A comparison with mepivacaine, lidocaine, and tetracaine. *Anesthesiology* 1970; 32:460-463.
160. Watt MJ, Ross DM, Atkinson RS. A double-blind trial of bupivacaine and lignocaine. Latency and duration in extradural blockade. *Anaesthesia* 1968; 23:331-337.
161. Rubin AP, Lawson DI. A controlled trial of bupivacaine. A comparison with lignocaine. *Anaesthesia* 1968; 23:327-330.
162. Manchikanti L, Singh V, Pampati V. Are diagnostic lumbar medial branch blocks valid? Results of 2-year follow-up. *Pain Physician* 2003; 6:147-153.
163. Manchikanti L, Singh V, Falco FJE, Cash KA, Pampati V. Evaluation of lumbar facet joint nerve blocks in managing chronic low back pain: A randomized, double-blind, controlled trial with a 2-year follow-up. *Int J Med Sci* 2010; 7:124-135.
164. Manchikanti L, Pampati V, Bakhit C, et al. Effectiveness of lumbar facet joint nerve blocks in chronic low back pain: A randomized clinical trial. *Pain Physician* 2001; 4:101-117.
165. Manchikanti L, Singh V, Falco FJE, Cash KA, Pampati V, Fellows B. The role of thoracic medial branch blocks in managing chronic mid and upper back pain: A randomized, double blind, active control trial with a 2-year follow-up. *Anesthesiol Res Pract* 2012; 2012:585806.
166. Manchikanti L, Manchikanti KN, Manchukonda R, Pampati V, Cash KA. Evaluation of therapeutic thoracic medial branch block effectiveness in chronic thoracic pain: A prospective outcome study with minimum 1-year follow up. *Pain Physician* 2006; 9:97-105.
167. Manchikanti L, Singh V, Falco FJE, Cash KA, Fellows B. Comparative outcomes of a 2-year follow-up of cervical medial branch blocks in management of chronic neck pain: A randomized, double-blind controlled trial. *Pain Physician* 2010; 13:437-450.
168. Manchikanti L, Manchikanti K, Damron K, Pampati V. Effectiveness of cervical medial branch blocks in chronic neck pain: A prospective outcome study. *Pain Physician* 2004; 7:195-201.
169. Manchikanti L, Knezevic NN, Parr A, Kaye AD, Sanapati M, Hirsch JA. Does epidural bupivacaine with or without steroids provide long-term relief? A systematic review and meta-analysis. *Curr Pain Headache Rep* 2020; 24:26.
170. Shanthanna H, Busse J, Wang L, et al. Addition of corticosteroids to local anaesthetics for chronic non-cancer pain injections: A systematic review and meta-analysis of randomised controlled trials. *Br J Anaesth* 2020; 125:779-801.
171. Hamaya C, Barr T, Strichartz GR. Multiple inhibitory mechanisms of lidocaine on bradykinin receptor activity in model sensory neurons. *Reg Anesth Pain Med* 2018; 43:605-612.
172. Cohen SP, Moon JY, Brummett CM, White RL, Larkin TM. Medial Branch Blocks or Intra-articular injections as a prognostic tool before lumbar facet radiofrequency denervation: A multicenter, case-control study. *Reg Anesth Pain Med* 2015; 40:376-383.
173. Cohen SP, Strassels SA, Kurihara C, et al. Establishing an optimal "cutoff" threshold for diagnostic lumbar facet blocks: A prospective correlational study. *Clin J Pain* 2013; 29:382-391.
174. Derby R, Melnik I, Choi J, Lee JE. Indications for repeat diagnostic medial branch nerve blocks following a failed first medial branch nerve block. *Pain Physician* 2013; 16:479-488.
175. Engel A, Rappard G, King W, Kennedy DJ; Standards Division of the International Spine Intervention Society. The effectiveness and risks of fluoroscopically-guided cervical medial branch thermal radiofrequency neurotomy: A systematic review with comprehensive analysis of the published data. *Pain Med* 2016; 17:658-669.
176. Schneider BJ, Doan L, Maes MK, Martinez KR, Gonzalez Cota A, Bogduk N; Standards Division of the Spine Intervention Society. Systematic review of the effectiveness of lumbar medial branch thermal radiofrequency neurotomy, stratified for diagnostic methods and procedural technique. *Pain Med* 2020; 21:1122-1141.
177. Manchikanti L, Pampati V, Damron KS, et al. A randomized, prospective, double-blind, placebo-controlled evaluation of the effect of sedation on diagnostic validity of cervical facet joint pain. *Pain Physician* 2004; 7:301-309.
178. Manchikanti L, Boswell MV, Manchukonda R, Cash KA, Giordano J. Influence of prior opioid exposure on diagnostic facet joint nerve blocks. *J Opioid Manage* 2008; 4:351-360.
179. Cohen SP, Strassels SA, Kurihara C, et al. Randomized study assessing the accuracy of cervical facet joint nerve (medial branch) blocks using different injectate volumes. *Anesthesiology* 2010; 112:144-152.
180. Manchikanti L, Manchikanti K, Cash KA, Singh V, Giordano J. Age-related prevalence of facet joint involvement in chronic neck and low back pain. *Pain Physician* 2008; 11:67-75.
181. DePalma MJ, Ketchum JM, Saullo TR. Multivariable analyses of the relationships between age, gender, and body mass index and the source of chronic low back pain. *Pain Med* 2012; 13:498-506.
182. Manchikanti L, Cash KA, Pampati V, Fellows B. Influence of psychological variables on the diagnosis of facet joint involvement in chronic spinal pain. *Pain Physician* 2008; 11:145-160.
183. Wasan AD, Jamison RN, Pham L, Tipirneni N, Nedeljkovic SS, Katz JN. Psychopathology predicts the outcome of medial branch blocks with corticosteroid for chronic axial low back or cervical pain: A prospective cohort study. *BMC Musculoskelet Disord* 2009; 10:22.
184. DePalma MJ, Ketchum JM, Saullo TR. Etiology of chronic low back pain in patients having undergone lumbar fusion. *Pain Med* 2011; 12:732-739.
185. DePalma MJ, Ketchum JM, Saulio TR, Laplante BL. Is the history of a surgical discectomy related to the source of chronic low back pain? *Pain Physician* 2012; 15:E1-E6.
186. Manchikanti L, Pampati V, Baha A, Fellows B, Damron KS, Barnhill RC. Contribution of facet joints to chronic low back pain in postlumbar laminectomy syndrome: A controlled comparative prevalence evaluation. *Pain Physician* 2001; 4:175-180.
187. Manchikanti L, Manchikanti K, Pampati V, Brandon D, Giordano J. The prevalence of facet joint-related chronic neck pain in postsurgical and non-postsurgical patients: A comparative evaluation. *Pain Pract* 2008; 8:5-10.
188. Klessinger S. Zygapophysial joint pain in post lumbar surgery syndrome. The efficacy of medial branch blocks and radiofrequency neurotomy. *Pain Med* 2013; 14:374-377.
189. Manchikanti L, Singh V, Fellows B, Pampati V. Evaluation of influence

of gender, occupational injury, and smoking on chronic low back pain of facet joint origin: A subgroup analysis. *Pain Physician* 2002; 5:30-35.

190. Manchikanti L, Damron KS, Rivera J, et al. Evaluation of effect of sedation as a confounding factor in the diagnostic validity of lumbar facet joint pain: A prospective, randomized, double blind, placebo-controlled evaluation. *Pain Physician* 2004; 7:411-417.
191. Manchikanti L, Pampati V, Damron KS, et al. The effect of sedation on diagnostic validity of facet joint nerve blocks: An evaluation to assess similarities in population with involvement in cervical and lumbar regions (ISRCTNo: 76376497). *Pain Physician* 2006; 9:47-52.
192. Lord SM, Barnsley L, Wallis BJ, McDonald GJ, Bogduk N. Percutaneous radio-frequency neurotomy for chronic cervical zygapophyseal-joint pain. *N Engl J Med* 1996; 335:1721-1726.
193. Civelek E, Cansever T, Kabatas S, et al. Comparison of effectiveness of facet joint injection and radiofrequency denervation in chronic low back pain. *Turk Neurosurg* 2012; 22:200-206.
194. Nath S, Nath CA, Pettersson K. Percutaneous lumbar zygapophysial (facet) joint neurotomy using radiofrequency current, in the management of chronic low back pain. A randomized double-blind trial. *Spine (Phila Pa 1976)* 2008; 33:1291-1297.
195. Patel N, Nowak K, Vaidyanathan A, et al. The effect of sedation on diagnostic lumbar medial branch blocks for facetogenic low back pain: An observational study. *Pain Physician* 2024; 27:E407-E418.
196. Dong L, Odeleye AO, Jordan-Sciutto KL, Winkelstein BA. Painful facet joint injury induces neuronal stress activation in the DRG: implications for cellular mechanisms of pain. *Neurosci Lett* 2008; 443:90-94.
197. Dong L, Winkelstein BA. Simulated whiplash modulates expression of the glutamatergic system in the spinal cord suggesting spinal plasticity is associated with painful dynamic cervical facet loading. *J Neurotrauma* 2010; 27:163-174.
198. Eubanks JD, Lee MJ, Cassinelli E, Ahn NU. Prevalence of lumbar facet arthrosis and its relationship to age, sex, and race: An anatomic study of cadaveric specimens. *Spine (Phila Pa 1976)* 2007; 32:2058-2062.
199. Fujiwara A, Tamai K, Yamato M, An HS, Yoshida H, Saotome K, Kurihashi A. The relationship between facet joint osteoarthritis and disc degeneration of the lumbar spine: An MRI study. *Eur Spine J* 1999; 8:396-401.
200. Kuslich SD, Ulstrom CL, Michael CJ. The tissue origin of low back pain and sciatica: A report of pain response to tissue stimulation during operation on the lumbar spine using local anesthesia. *Orthop Clin North Am* 1991; 22:181-187.
201. Saal JS. General principles of diagnostic testing as related to painful lumbar spine disorders: A critical appraisal of current diagnostic techniques. *Spine (Phila Pa 1976)* 2002; 27:2538-2545.
202. Cohen SP, Hameed H, Kurihara C, Pasquina PF, Patel AM, Babade M, Griffith SR, Erdek ME, Jamison DE, Hurley RW. The effect of sedation on the accuracy and treatment outcomes for diagnostic injections: A randomized, controlled, crossover study. *Pain Med* 2014; 15:588-602.
203. Laslett M, Oberg B, Aprill CN, McDonald B. Zygapophysial joint blocks in chronic low back pain: A test of Revel's model as a screening test. *BMC Musuloskeletal Disord* 2004; 5:43-48.
204. Mainka T, Lemburg SP, Heyer CM, Altenscheidt J, Nicolas V, Maier C. Association between clinical signs assessed by manual segmental examination and findings of the lumbar facet joints on magnetic resonance scans in subjects with and without current low back pain: A prospective, single-blind study. *Pain* 2013; 154:1886-1895.
205. Schwarzer AC, Wang SC, O'Driscoll D, Harrington T, Bogduk N, Laurent R. The ability of computed tomography to identify a painful zygapophysial joint in patients with chronic low back pain. *Spine (Phila Pa 1976)* 1995; 20:907-912.
206. Laslett M, McDonald B, Aprill CN, Tropp H, Oberg B. Clinical predictors of screening lumbar zygapophyseal joint blocks: Development of clinical prediction rules. *Spine J* 2006; 6:370-379.
207. Miyagi M, Ohtori S, Ishikawa T, Aoki Y, Ozawa T, Doya H, Saito T, Moriya H, Takahashi K. Up-regulation of TNFalpha in DRG satellite cells following lumbar facet joint injury in rats. *Eur Spine J* 2006; 15:953-958.
208. Dong L, Smith JR, Winkelstein BA. Ketorolac reduces spinal astrocytic activation and PAR1 expression associated with attenuation of pain after facet joint injury. *J Neurotrauma* 2013; 30:818-825.
209. Kras JV, Tanaka K, Gilliland TM, Winkelstein BA. An anatomical and immunohistochemical characterization of afferents innervating the C6-C7 facet joint after painful joint loading in the rat. *Spine (Phila Pa 1976)* 2013; 38:E325-E331.
210. Ohtori S, Takahashi K, Chiba T, Yamagata M, Sameda H, Moriya H. Substance P and calcitonin gene-related peptide immunoreactive sensory DRG neurons innervating the lumbar facet joints in rats. *Auton Neurosci* 2000; 86:13-17.
211. Suseki K, Takahashi Y, Takahashi K, Chiba T, Tanaka K, Moriya H. CGRP-immunoreactive nerve fibers projecting to lumbar facet joints through the paravertebral sympathetic trunk in rats. *Neurosci Lett* 1996; 221:41-44.
212. Ohtori S, Takahashi K, Chiba T, Yamagata M, Sameda H, Moriya H. Brain-derived neurotrophic factor and vanilloid receptor subtype 1 immunoreactive sensory DRG neurons innervating the lumbar facet joints in rats. *Auton Neurosci* 2001; 94:132-135.
213. Yamashita T, Cavanaugh J, el-Bohy AA, Getchell TV, King AI. Mechanosensitive afferent units in the lumbar facet joint. *J Bone Joint Surg Am* 1990; 72:865-870.
214. Yamashita T, Cavanaugh JM, Ozaktay AC, Avramov AI, Getchell TV, King AI. Effect of substance P on mechanosensitive units of tissues around and in the lumbar facet joint. *J Orthop Res* 1993; 11:205-214.
215. Beaman DN, Graziano GP, Glover RA, Wojtys EM, Chang V. Substance P innervation of lumbar spine facet joints. *Spine (Phila Pa 1976)* 1993; 18:1044-1049.
216. Lu Y, Chen C, Kallakuri S. Patwardhan A, Cavanaugh JM. Neurophysiological and biomechanical characterization of goat cervical facet joint capsules. *J Orthop Res* 2005; 30:779-787.
217. Inami S, Shiga T, Tsujino A, Yabuki T, Okado N, Ochiai N. Immunohistochemical demonstration of nerve fibers in the synovial fold of the human cervical facet joint. *J Orthop Res* 2001; 19:593-596.
218. Chen C, Lu Y, Kallakuri S, Patwardhan A, Cavanaugh JM. Distribution of A-delta and C-fiber receptors in the cervical facet joint capsule and their response to stretch. *J Bone Joint Surg Am* 2006; 88:1087-1816.
219. Kallakuri S, Singh A, Chen C, Cavanaugh JM. Demonstration of substance P, calcitonin gene-related peptide, and protein gene product 9.5 containing nerve fibers in human cervical facet joint capsules. *Spine (Phila Pa 1976)* 2004; 29:1182-1186.

220. McLain RF. Mechanoreceptors ending in human cervical facets joints. *Spine (Phila Pa 1976)* 1994; 5:495-501.
221. Schwarzer AC, Derby R, Aprill CN, Fortin J, Kine G, Bogduk N. The value of the provocation response in lumbar zygapophysial joint injections. *Clin J Pain* 1994; 10:309-313.
222. Kaplan M, Dreyfuss P, Halbrook B, Bogduk N. The ability of lumbar medial branch blocks to anesthetize the zygapophysial joint. *Spine (Phila Pa 1976)* 1998; 23:1847-1852.
223. Dreyfuss P, Schwarzer AC, Lau P, Bogduk N. Specificity of lumbar medial branch and L5 dorsal ramus blocks. A computed tomography study. *Spine (Phila Pa 1976)* 1997; 22:895-902.
224. Eden J, Levit L, Berg A, Morton S (eds); Committee on Standards for Systematic Reviews of Comparative Effectiveness Research; Institute of Medicine. Finding What Works in Health Care. Standards for Systematic Reviews. The National Academies Press, Washington, DC, 2011.
225. Pinto RZ, Maher CG, Ferreira ML, et al. Epidural corticosteroid injections in the management of sciatica: A systematic review and meta-analysis. *Ann Intern Med* 2012; 157:865-877.
226. Chou R, Hashimoto R, Friedly J, et al. Pain Management Injection Therapies for Low Back Pain. Technology Assessment Report ESIB0813. (Prepared by the Pacific Northwest Evidence-based Practice Center under Contract No. HHSA 290-2012-00014-I.) Rockville, MD: Agency for Healthcare Research and Quality; March 20, 2015. www.cms.gov/Medicare/Coverage/DeterminationProcess/Downloads/id98TA.pdf
227. Health Technology Assessment, Washington State Health Care Authority. Spinal Injections, Updated Final Evidence Report. Spectrum Research, Inc., March 10, 2011. https://www.hca.wa.gov/assets/program/spinal_injection_final_report%5B1%5D.pdf
228. Manchikanti L, Sanapati MR, Soin A, et al. Comprehensive evidence-based guidelines for implantable peripheral nerve stimulation (PNS) in the management of chronic pain: From the American Society of Interventional Pain Physicians (ASIPP). *Pain Physician* 2024; 27:S115-S191.
229. Manchikanti L, Khaira MB, Soin A, et al. Effectiveness of peripheral nerve stimulation in managing chronic pain: A systematic review and meta-analysis of randomized controlled trials. *Pain Physician* 2025; 28:E481-E507.
230. Manchikanti L, Navani R, Navani A, et al. Comprehensive evidence-based guidelines for regenerative therapies in the management of chronic low back pain: 2025 update from the American Society of Interventional Pain Physicians (ASIPP). *Pain Physician* 2025; 28:S1-S119.
231. Manchikanti L, Atluri S, Boswell MV, et al. Methodology for evidence synthesis and development of comprehensive evidence-based guidelines for interventional techniques in chronic spinal pain. *Pain Physician* 2021; 24:S1-S26.
232. Manchikanti L, Abd-Elsayed A, Jin MY, et al. A systematic review and meta-analysis of randomized controlled trials of epidural regenerative medicine therapies in managing spinal pain. *Curr Pain Headache Rep* 2026; 30:83.
233. Manchikanti L, Knezevic E, Knezevic NN, et al. Epidural injections for lumbar radiculopathy or sciatica: A comparative systematic review and meta-analysis of Cochrane review. *Pain Physician* 2021; 24:E539-E554.
234. Manchikanti L, Knezevic NN, Sanapati J, Kaye AD, Sanapati MR, Hirsch JA. Is epidural injection of sodium chloride solution a true placebo or an active control agent? A systematic review and meta-analysis. *Pain Physician* 2021; 24:41-59.
235. Wang X, Martin G, Sadeghirad B, et al. Common interventional procedures for chronic non-cancer spine pain: A systematic review and network meta-analysis of randomised trials. *BMJ* 2025; 388:e079971.
236. Busse JW, Genevay S, Agarwal A, et al. Commonly used interventional procedures for non-cancer chronic spine pain: A clinical practice guideline. *BMJ* 2025; 388:e079970.
237. Manchikanti L, Sanapati M, Soin A, et al. BMJ publications on interventional techniques do not meet appropriateness criteria of conducting a rapid review: A comprehensive review. *Pain Physician* 2025; 28:E467-E479.
238. Manchikanti L, Kaye AD, Abd-Elsayed A, et al. A systematic review of sacroiliac joint injections of platelet-rich plasma (PRP) and stem cells. *Curr Pain Headache Rep* 2025; 29:63.
239. Manchikanti L, Abd-Elsayed A, Kaye AD, et al. A systematic review of regenerative medicine therapies for axial spinal pain of facet joint origin. *Curr Pain Headache Rep* 2025; 29:61.
240. Kaye AD, Brouillette AE, Howe CA, et al. Efficacy of steroid facet joint injections for axial spinal pain and post radiofrequency ablation neuritis: A systematic review. *Curr Pain Headache Rep* 2025; 29:53.
241. Manchikanti L, Knezevic E, Knezevic NN, et al. Effectiveness of intradiscal regenerative medicine therapies for long-term relief of chronic low back pain: A systematic review and meta-analysis. *Pain Physician* 2024; 27:E995-E1032.
242. Janapala RN, Knezevic E, Knezevic NN, et al. Systematic review and meta-analysis of the effectiveness of radiofrequency ablation of the sacroiliac joint. *Curr Pain Headache Rep* 2024; 28:335-372.