

Systematic Review

e An Update of the Systematic Assessment of the Diagnostic Accuracy of Lumbar Facet Joint Nerve Blocks

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Background: Lumbar facet joints are a well recognized source of low back pain and referred pain in the lower extremity in patients with chronic low back pain. Conventional clinical features and other non-invasive diagnostic modalities are unreliable in diagnosing lumbar zygapophysial joint pain. Controlled diagnostic studies with at least 80% pain relief as the criterion standard have shown the prevalence of lumbar facet joint pain to be 16% to 41% of patients with chronic low back pain without disc displacement or radiculitis, with a false-positive rate of 17% to 49% with a single diagnostic block.

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

Objective: To determine and update the diagnostic accuracy of lumbar facet joint nerve blocks in the assessment of chronic low back pain.

Methods: A methodological quality assessment of included studies was performed using Quality Appraisal of Reliability Studies (QAREL). Only diagnostic accuracy studies meeting at least 50% of the designated inclusion criteria were utilized for analysis. Studies scoring less than 50% are presented descriptively and analyzed critically.

The level of evidence was classified as good, fair, and limited or poor based on the quality of evidence developed by the United States Preventive Services Task Force (USPSTF).

Data sources included relevant literature identified through searches of PubMed and EMBASE from 1966 to June 2012, and manual searches of the bibliographies of known primary and review articles.

Outcome Measures: Studies must have been performed utilizing controlled local anesthetic blocks. Pain relief was categorized as at least 50% pain relief from baseline pain and the ability to perform previously painful movements.

Results: A total of 25 diagnostic accuracy studies were included. Of these, one study evaluated 50% to 74% relief as criterion standard with a single block with prevalence of 48%, 4 studies evaluated 75% to 100% relief as the criterion standard with a single block with a prevalence of 31% to 61%, 5 studies evaluated 50% to 74% relief as the criterion standard with controlled blocks with a prevalence of 15% to 61%, and 13 studies evaluated 75% to 100% relief as the criterion standard with controlled blocks with a prevalence of 25% to 45% in heterogenous populations. False-positive rates ranged from 17% to 66% in the 50% to 74% pain relief group and 27% to 49% with at least 75% relief as the criterion standard. Based on this evaluation, the evidence showed that there is good evidence for diagnostic facet joint nerve blocks with 75% to 100% pain relief as the criterion standard with dual blocks and fair evidence with 50% to 74% pain relief as the criterion standard with controlled diagnostic blocks; however, the evidence is poor with single diagnostic blocks of 50% to 74%, and limited for 75% or more pain relief as the criterion standard.

Limitations: The shortcomings of this systematic review of the accuracy of diagnostic lumbar facet joint nerve blocks include a paucity of literature and continued debate on an appropriate gold standard.

Conclusion: There is good evidence for diagnostic facet joint nerve blocks with 75% to 100% pain relief as the criterion standard with dual blocks, with fair evidence with 50% to 74% pain relief.

Key words: Chronic low back pain, lumbar facet or zygapophysial joint pain, facet joint nerve blocks, medial branch blocks, controlled comparative local anesthetic blocks

Chronic low back pain, with or without lower extremity pain of spinal origin constitutes a major portion of chronic pain (1-11). Thus, the numerous modalities of treatments for managing chronic low back pain and the growing social and economic costs continue to influence medical decision-making (1,2,5,12-37). Even though low back pain is a common complaint in primary care and tertiary care, it is often difficult to reach a definitive diagnosis (2,27,38-41). Controlled studies have established intervertebral discs, facet joints, and sacroiliac joints as potential sources of low back and lower extremity pain (2,27,38-47). Thus, lumbar facet joints are a well-recognized source of low back and referred pain in the lower extremity in patients with chronic low back pain (2,41-54). Facet joints are well innervated by the medial branches of the dorsal rami (55-62). Neuroanatomic, neurophysiologic, and biomechanical studies have demonstrated free and encapsulated nerve endings in lumbar facet joints, as well as nerves containing substance *P* and calcitonin gene-related peptide (63-73).

The exponential growth in treatment modalities and subsequent rise in health care costs are the result of multiple factors, including the inherent difficulty in obtaining an accurate diagnosis (1-5,14-37,74-84). An inaccurate or incorrect diagnosis may lead not only to treatment failure, but also results in wasted health care dollars, diverting essential health care resources. Fundamental to an accurate diagnosis is the reliability of the test used to make the diagnosis (2,38,41,46,47,85-90). Attempts have been made to improve the accuracy of diagnostic lumbar facet joint pain by multiple means, including physical examination, imaging techniques, and controlled local anesthetic blocks (2,38,41-47,91-149).

There is, however, no universally accepted gold standard for the diagnosis of low back pain, regardless of whether the suspected source is the facet joint(s), intervertebral disc(s), or sacroiliac joint(s). The recom-

mended reference standards typically involve anesthetic or provocative injections. Multiple arguments have been made in favor of and against the diagnostic accuracy of controlled local anesthetic blocks, but controlled local anesthetic blocks continue to be the best available tool to identify intervertebral disc(s), facet joint(s), or sacroiliac joint(s) as the source of low back pain. Yet, these reference standards are invasive, expensive, and often difficult to interpret, and therefore may not be suitable for routine clinical use as a primary diagnostic modality.

The published radiological investigations report no correlation between the clinical symptoms of low back pain and degenerative spinal changes observed on radiologic imaging studies, including radiographs, magnetic resonance imaging (MRI), computed tomography (CT) scanning, single photon emission computed tomography (SPECT), and radionuclide bone scanning (2,41,106-135). Specifically, the association between degenerative changes in the lumbar facet joints and symptomatic low back pain remains unclear and is a subject of ongoing debate.

Conventional clinical features are unreliable in diagnosing lumbar zygapophysial (facet) joint pain. Hancock et al (47) performed a systematic review of tests to identify the disc, sacroiliac joint, and facet joint as the source of low back pain. They found that none of the tests for facet joint pain were found to be informative. Consequently, controlled local anesthetic blocks of the facet joint or its nerve supply are routinely employed to diagnose facet joint pain. The rationale for controlled diagnostic blocks is that an anesthetic blockade of a painful joint will abolish pain arising from that joint for the duration of the anesthetic effect, while an anesthetic blockade of a non-painful joint will not alter the pain report. The probability that the blocked joint is the actual source of pain is increased if repeating the block with an anesthetic agent that has a different duration of action reproduces the analgesic response (33). To

ensure accuracy and validity, these blocks must be controlled and verified for the delivery of a local anesthetic agent and placebo response. Fluoroscopic guidance and controlled dual blocks eliminate or greatly reduce placebo responses. Single facet joint injections are not recommended, as they do not control for a false-positive response (42,43,75,96,98,136-149). Rubinstein and van Tulder (46) also provided a best-evidence review of diagnostic procedures for neck and low back pain. They commented that it is quite remarkable that while many named orthopedic tests of the neck and low back are often illustrated in orthopedic textbooks, there is little evidence to support their diagnostic accuracy, and therefore their use in clinical practice. Consistent with clinical experience, many studies have demonstrated that the physical examination serves primarily to confirm suspicions that arise during the history. The placebo-controlled technique is considered the gold standard, but has limited clinical utility due to cost implications and to the ethical and logistical issues of designing a true placebo. Controlled comparative blocks with short- and long-acting local anesthetics are an acceptable alternative strategy (38,39,41,150-153).

The accuracy and validity of controlled comparative blocks have been criticized, and the precision of these diagnostic techniques questioned (2,22,27,154-166). Although these tests control and verify the location of local anesthetic delivery, they are faulted for assuming that reports and documentation of the magnitude and quality of pain relief are accurate. Because these tests employ subjective criteria, i.e., rely on a patient's report of the presence or absence of pain following a block and their ability to isolate different painful areas or differentiate between significant and insignificant pain relief (when pain relief is incomplete), they promote doubt about the accuracy of these procedures.

Multiple systematic reviews have concluded that evidence for the diagnostic accuracy of lumbar facet joint nerve blocks is strong (27,41,46,47,160). Rubinstein and van Tulder (46), who have performed multiple Cochrane reviews, also concluded that there was strong evidence for the diagnostic accuracy of facet joint blocks in evaluating spinal pain.

Kalichman et al (126) evaluated facet joint osteoarthritis and low back pain in the community-based Framingham Heart Study. They concluded that there is a high prevalence of facet joint osteoarthritis in the community-based population with a prevalence of 59.6% in males and 66.7% in females. The prevalence of facet joint osteoarthritis increased with age

and reached 89.2% in individuals 60 to 69 years old with the highest prevalence of facet joint osteoarthritis found at the L4/5 spinal level. Furthermore, they showed that individuals with facet joint osteoarthritis identified by a CT scan at any spinal level showed no association with low back pain. Eubanks et al (167) in a study of 647 cadaveric lumbar spines found that facet joint osteoarthritis is a universal finding. Characteristic features of osteoarthritis emerge early on in the life cycle, with more than half of adults younger than 30 years demonstrating arthritic changes in the facets, with the most common arthritic level being L4/5. The relationship between lumbar facet joint osteoarthritis and back pain is not clear. Gong et al (168) explored a rat model of lumbar facet joint osteoarthritis associated with facet-mediated mechanical hyperalgesia induced by an intraarticular injection of monosodium iodoacetate (MIA). The results showed that progressive cartilage degeneration and changes in subchondral bone were observed after injection. A biphasic pattern of mechanical hyperalgesia was noted in the hind paw. They concluded that with the establishment of an experimental lumbar facet joint osteoarthritis model associated with facet-mediated mechanical hyperalgesia with an intraarticular injection of MIA, this model might provide a useful tool for further study to ascertain the complex mechanism of facet joint pain.

Henry et al (64) with the objective of developing a novel animal model of persisting lumbar facet joint pain showed that in a rat model, lumbar facet joint compressive injury induces lasting changes in local structure, nociceptive scores, and inflammatory mediators. They concluded that the compression of a facet joint induces a novel model of local cartilage loss accompanied by increased sensitivity to mechanical stimuli and increases in inflammatory mediators. The results of this study showed a site-specific loss of cartilage, tactile hypersensitivity, and increases in pro-inflammatory cytokines.

The latest review of the diagnostic accuracy of lumbar facet joint nerve blocks was published in August 2009 (41). However, the value of systematic reviews continues to deteriorate with time (169,170). Thus, frequent updates of systematic reviews have been recommended for evolving subjects. This systematic review has been undertaken in order to assess the current evidence and also to update the previous systematic review (41) on the accuracy of lumbar facet joint nerve blocks in the diagnosis of chronic low back pain.

1.0 METHODS

The methodology utilized in this systematic review followed the review process derived from evidence-based systematic reviews and meta-analysis of diagnostic accuracy studies (22,46,47,85-90,171,172).

1.1 Criteria for Considering Studies for This Review

1.1.1 Types of Studies

Diagnostic accuracy studies evaluating lumbar facet joint pain.

1.1.2 Types of Participants

Participants of interest were adults aged at least 18 years with chronic low back pain of at least 3 months duration.

Participants must have failed previous pharmacotherapy, exercise therapy, etc., prior to starting diagnostic interventional pain management techniques.

1.1.3 Types of Interventions

The interventions were lumbar facet joint nerve blocks appropriately performed with proper technique under fluoroscopic or CT guidance.

1.1.4 Types of Outcome Measures

- ◆ The primary outcome parameter was pain relief concordant with the type of controlled diagnostic blocks performed.
- ◆ The secondary outcome measure was the ability to perform previously painful movements without significant pain or complications.
- ◆ At least 2 of the review authors independently, in an unblinded standardized manner, assessed the outcomes measures. Any disagreements between reviewers were resolved by a third author and consensus.

1.2 Literature Search

Searches were performed from the following sources without language restrictions:

1. PubMed from 1966
www.ncbi.nlm.nih.gov/sites/entrez?db=pubmed
2. EMBASE from 1980
www.embase.com
3. Cochrane Library
www.thecochranelibrary.com/view/0/index.html
4. U.S. National Guideline Clearinghouse (NGC)
www.guideline.gov

5. Previous systematic reviews and cross references
6. Clinical Trials
clinicaltrials.gov

The search period was from 1966 through June 2012.

1.3 Search Strategy

The search strategy emphasized chronic low back pain, facet or zygapophysial joint pain, lumbar facet injections, and lumbar facet joint nerve blocks.

This systematic review focused only on diagnostic studies, including invasive and noninvasive techniques and reports of complications. Only lumbar facet joint nerve blocks performed under fluoroscopy or CT imaging techniques were evaluated. Interventional techniques performed blindly or using other identification modalities were excluded. All studies describing appropriate outcome evaluations with proper statistical evaluations were reviewed. Reports without appropriate diagnosis, nonsystematic reviews, book chapters, and case reports were excluded.

At least 2 of the review authors independently, in an unblinded standardized manner, performed each search. A statistician confirmed accuracy. All searches were combined to obtain a unified search strategy. Any disagreements between reviewers were resolved by a third author and consensus.

1.4 Data Collection and Analysis

The quality of each individual article used in this assessment was based on the Quality Appraisal of Reliability Studies (QAREL) checklist (Table 1) (85). This checklist has been validated and utilized in multiple systematic reviews (86). Each study in the final sample of eligible manuscripts was assessed using a 12-item appraisal checklist designed to assess the quality and applicability of studies. The face validity of these checklists was established by consultation with methodology experts (85) and comparison with quality appraisal checklists used in other systematic reviews examining diagnostic reliability (173-177). This checklist was also developed in accordance to the Standards for Reporting Studies of Diagnostic Accuracy (STARD) (89), and the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) (90) appraisal tool. Studies were not given an overall numeric quality score; instead, each item was considered separately and graded as "yes," "no," "unclear," or "not applicable."

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				

Lucas N, et al. Reliability of physical examination for diagnosis of myofascial trigger points. *Clin J Pain* 2009; 25:80-89 (85).

1.4.1 Selection of Studies

- ◆ In an unblinded standardized manner, 2 review authors screened the abstracts of all identified studies against the inclusion criteria.
- ◆ All articles with possible relevance were then retrieved in full text for a comprehensive assessment of internal validity, quality, and adherence to inclusion criteria.

1.4.2 Inclusion and Exclusion Criteria

The following are the inclusion and exclusion criteria.

1. Are the patients described in sufficient detail to allow one to decide whether they are comparable to those who are treated in interventional pain management clinical practices?
 - A. Setting – office, hospital, outpatient, inpatient
 - B. Physician – interventional pain physician, general physician, anesthesiologist, physiatrist, neurologist, rheumatologist, orthopedic surgeon, neurosurgeon, etc.
 - C. Patient characteristics - duration of pain
 - D. Noninterventional techniques or surgical intervention in the past
2. Is the intervention described in sufficient detail to enable one to apply its use to patients in interventional pain management settings?

- A. Nature of intervention
- B. Frequency of intervention
- C. Duration of intervention
3. Were clinically relevant outcomes measured?
 - A. Proportion of pain relief
 - B. Disorder/specific disability
 - C. Functional improvement
 - D. Allocation of eligible and noneligible patients to return to work
 - E. Ability to work

1.4.3 Clinical Relevance

The clinical relevance of the included studies was evaluated according to 5 questions recommended by the Cochrane Back Review Group (Table 2) (178,179). Each question was scored as positive (+) if the clinical relevance item was met, negative (-) if the item was not met, and unclear (?) if data were not available to answer the question.

1.4.4 Methodological Quality or Validity Assessment

Each study was evaluated by at least 2 authors for stated criteria and any disagreements were discussed with a third reviewer. Authors with a perceived conflict of interest for any manuscript were recused from reviewing the manuscript.

Table 2. *Clinical relevance questions.*

	P (+)	N (-)	U (unclear)
A) Are the patients described in detail so that one can decide whether they are comparable to those who are treated in practice?			
B) Are the interventions and treatment settings described in sufficient detail to apply its use in clinical practice?			
C) Were clinically relevant outcomes measured and reported?			
D) Is the size of the effect clinically meaningful?			
E) Do the likely treatment benefits outweigh the potential harms?			

Scoring adapted and modified from Staal JB, et al. Injection therapy for subacute and chronic low-back pain. *Cochrane Database Syst Rev* 2008; 3:CD001824 (179).

Table 3. *Method for grading the overall strength of the evidence for an intervention.*

Grade	Definition
Good	Evidence includes consistent results from well-designed, well-conducted studies in representative populations that directly assess effects on health outcomes (at least 2 consistent, higher-quality RCTs or studies of diagnostic test accuracy).
Fair	Evidence is sufficient to determine effects on health outcomes, but the strength of the evidence is limited by the number, quality, size, or consistency of included studies; generalizability to routine practice; or indirect nature of the evidence on health outcomes (at least one higher-quality trial or study of diagnostic test accuracy of sufficient sample size; 2 or more higher-quality trials or studies of diagnostic test accuracy with some inconsistency; at least 2 consistent, lower-quality trials or studies of diagnostic test accuracy, or multiple consistent observational studies with no significant methodological flaws).
Limited or Poor	Evidence is insufficient to assess effects on health outcomes because of limited number or power of studies, large and unexplained inconsistency between higher-quality trials, important flaws in trial design or conduct, gaps in the chain of evidence, or lack of information on important health outcomes.

Adapted and modified from methods developed by U.S. Preventive Services Task Force (22,23,181-183).

Only diagnostic accuracy studies meeting at least 50% of applicable inclusion criteria were included for analysis. Studies scoring less than 50% are reported descriptively with critical analysis.

1.4.5 Data Extraction and Management

Two review authors independently, in an unblinded standardized manner, extracted the data from the included studies. Disagreements were resolved by discussion between the 2 reviewers; if no consensus could be reached, a third author was called in to break the impasse.

1.4.6 Assessment of Heterogeneity

Whenever meta-analyses were conducted, the I-squared (I²) index was used to identify heterogeneity (180). Combined results with I² > 50% were considered substantially heterogenous.

Analysis of the evidence was based on diagnostic criteria as follows: 1) blocks in which the reference standard for diagnosis was between 50% to 74% pain relief with a single block; 2) blocks in which the reference standard for diagnosis was between 50% to 74% pain relief with dual blocks; 3) blocks in which the reference standard for diagnosis was between 75% to 100% pain relief with a single block; and 4) blocks in which the reference

standard for diagnosis was between 75% to 100% pain relief with dual blocks, to reduce clinical heterogeneity.

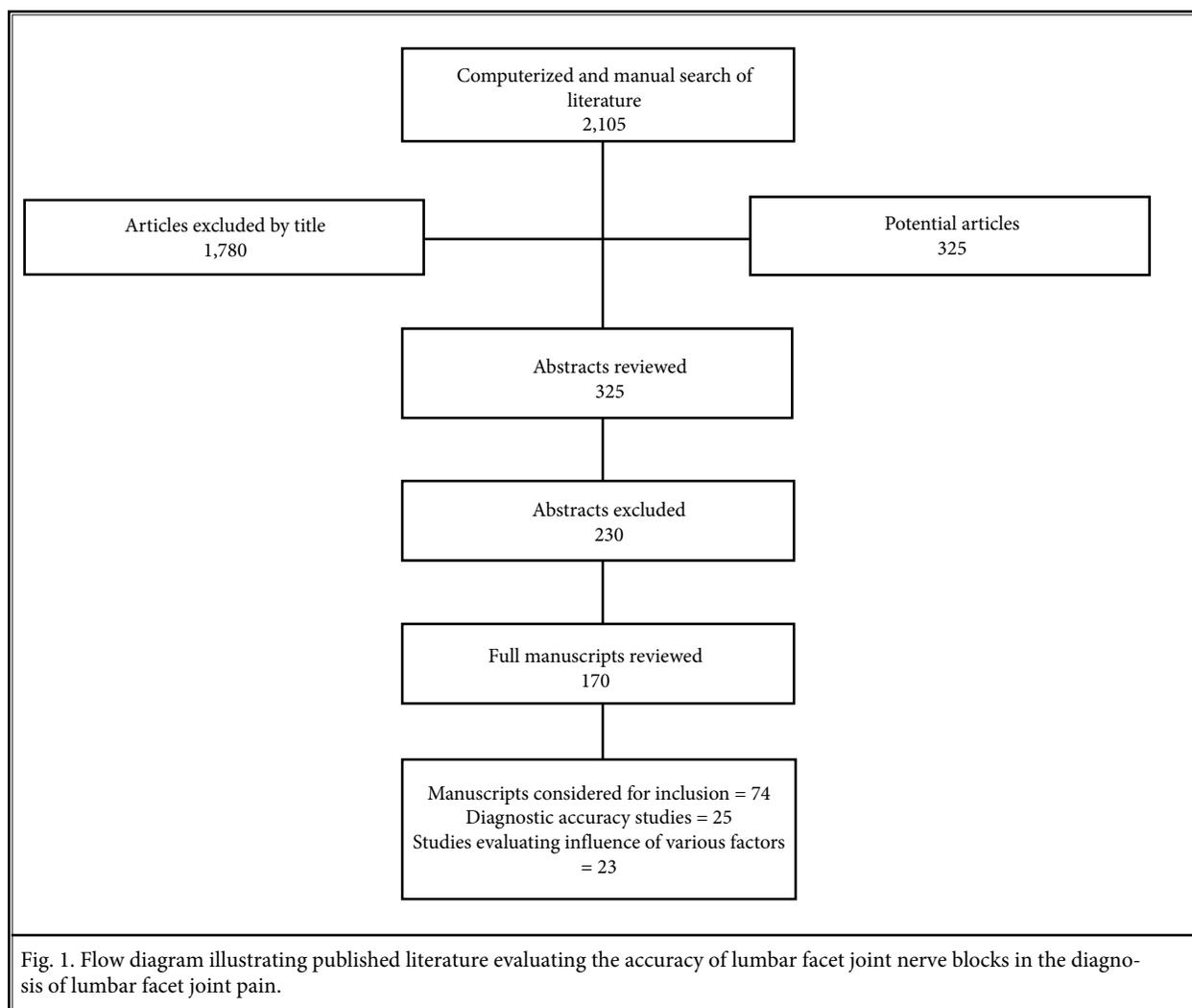
1.4.7 Measurement of Treatment Effect in Data Synthesis (Meta-Analysis)

Data was separately summarized using meta-analysis when at least 5 studies per type of diagnostic criteria were available that met the inclusion criteria (e.g., single block, double blocks, and 50% to 74% relief).

The minimum acceptable relief was considered to be 50%; however, data were sub-analyzed for ≥ 80% and 50% to 74% relief as the cutoff threshold for a positive block during the performance of previously painful movements. Four separate diagnostic categories were evaluated (i.e., 50% to 74% relief as the cutoff threshold with single and dual blocks; and 75% to 100% relief as the cutoff threshold with single or dual blocks). For dual blocks, there had to have been a concordant response with short-acting and long-acting local anesthetics, or placebo.

1.4.8 Integration of Heterogeneity

A meta-analysis was performed only if there were at least 5 studies meeting inclusion criteria for each variable.



Statistical heterogeneity was explored using univariate meta-regression (180).

1.5 Summary Measures

Summary measures included 50% to 74% or 75% to 100% pain relief with the ability to perform previously painful movements concordant with the duration of local anesthetic.

1.6 Analysis of Evidence

The analysis of the evidence was performed based on United States Preventive Services Task Force (USPSTF) criteria (181) as illustrated in Table 3, which has been utilized by multiple authors (22,23,27,28,182,183).

The analysis was conducted using 3 levels of evidence: good, fair, and limited or poor (22,23,181-183).

At least 2 of the review authors independently, in an unblinded standardized manner, analyzed the evidence. Any disagreements between reviewers were resolved by a third author and consensus. If there were any conflicts of interest (e.g., authorship), those reviewers were recused from assessment and analysis.

1.7 Outcome of the Studies

Outcomes included the prevalence of lumbar facet joint pain and false-positive rate. Based on the above parameters, the reliability of the data derived from each study was assessed.

2.0 RESULTS

Figure 1 shows a flow diagram of study selection. There were 74 studies considered for inclusion

(43,44,49-54,95-102,136-149,157,163-166,184-222) Among these, 25 evaluated diagnostic facet joint injections of accuracy and outcomes (43,44,95,98-102,136-140,142-146,149,166,184,192,200,205,217), with 3 duplicate publications (95,137,217). In addition, 21 studies evaluated various factors influencing the diagnostic accuracy (141,147-149,163-166,187-189,194,195,200-203,205,206,212,218). Tables 4 and 5 show diagnostic accuracy studies evaluating prevalence and false-positive rates, and studies assessing various factors. Multiple studies evaluating the role of ultrasound guidance, reviews, therapeutic evaluations, studies focusing on radiographic evaluation, non-invasive studies, and studies focusing on other aspects of facet joint pain were excluded from assessment in this evaluation. Table 6 shows reasons for exclusion of select studies.

2.1 Diagnostic Accuracy Studies

Table 4 shows the characteristics of studies considered for inclusion. There was one study utilizing single blocks with 50% to 74% relief (44), and 4 studies utilizing single blocks with 75% to 100% relief (99,100,102,166). There were 5 studies utilizing 50% to 74% relief with controlled blocks (98,136,140,166,192) and one publication with false-positive rates (146), with one duplicate publication (137), and 13 studies utilizing 75% to 100% relief with controlled blocks (43,101,138,139,142-145,149,166,184,200,205) with one duplicate publication (95).

2.2 Studies of Factors Influencing Diagnosis

Table 5 shows the characteristics of relevant studies. There were 3 studies assessing the influence of age (147,189,200), 2 studies assessing psychological variables (148,194), 2 studies assessing the influence of body mass index (189,205), 5 studies assessing the influence of surgery (149,187,188,206,218), 2 studies assessing gender/smoking related factors (189,201), 3 studies assessing the influence of sedation (163,202,203), and 5 studies assessing the influence of diagnostic blocks on therapeutic outcomes (164-166,195,212).

2.3 Methodological Quality Assessment

A methodological quality assessment of diagnostic accuracy studies meeting inclusion criteria was carried out utilizing QAREL criteria as shown in Table 7. Studies achieving 50% or higher scores were included. Scores of 67% or higher were considered to be high quality, 50% were considered to be moderate quality, and stud-

ies scoring less than 50% were considered to be of poor quality and excluded.

There were 22 studies evaluating diagnostic accuracy (43,44,98-102,136,138-140,142-146,149,166,184,192,200,205), after the exclusion of 3 duplicate publications (95,137,217). All were considered to be high quality.

2.4 Clinical Relevance

An assessment of clinical relevance of included studies of diagnostic accuracy with lumbar facet joint nerve blocks was included. Among the 22 studies assessed for clinical relevance (43,44,98-102,136,138-140,142-146,149,166,184,192,200,205), and after the elimination of 3 duplicate publications (95,137,217), all studies met the criteria with a score of 3 of 5 or greater. Table 8 illustrates the assessment of clinical relevance.

2.5 Meta-Analysis

As shown in Table 4, all of the diagnostic accuracy studies were evaluated for homogeneity for inclusion in the meta-analysis.

There were 4 studies utilizing placebo control (99,100,140,192). There was one study utilizing single blocks with 50% to 74% relief (44). In the group with single blocks where there was greater than 75% pain relief, there were 4 studies (99,100,102,166). In the group with 50% to 74% relief with controlled blocks, there were 5 studies (98,136,140,146,166,192), without homogeneity among 5 studies. Two of the studies were published by Schwarzer et al (136,140), 2 were published by Manchikanti et al (98,166), and one was published by Schütz et al (192), all with varying methodology and heterogenous patient populations. Among the studies utilizing 75% or higher relief with controlled blocks, there were 13 studies after the exclusion of duplicates (43,101,138,139,142-145,149,166,184,200,205). However, 11 of these were published by a single group, Manchikanti et al (43,138,139,142-145,149,166,200,205), in different populations with assessment of various factors. There were only 2 homogenous studies (144,145). Meta-analysis was not feasible in any of the categories.

2.6 Analysis of Evidence

The evidence was synthesized based on the relief criteria when lumbar facet joint nerve blocks were performed. Tables 4 and 5 describe the study characteristics. Table 9 illustrates data of the prevalence of lumbar facet joint pain by diagnostic blocks.

Table 4. Studies assessing the accuracy of diagnostic blocks.

Study/Methods	Participants	Intervention(s)	Outcome Measures	Results	Conclusion(s)
Single Blocks With 50%-74% Relief					
Pang et al, 1998 (44)	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	Visual analog scale	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.
Single Blocks With ≥75%-100% Relief					
Revel et al, 1992 (99)	51 patients with chronic low back pain were evaluated to identify predictors of good response in a preliminary evaluation.	Intraarticular injection of 1 mL of 2% lidocaine or 1 mL of sodium chloride solution was injected in a randomized fashion.	90% pain relief	Prevalence = 33%	This is a preliminary study and was also was not a prevalence study.
Revel et al, 1998 (100)	80 patients underwent diagnostic facet joint injections meeting the criteria to identify patients with painful facet joints with chronic low back pain.	Intraarticular injection of 1 mL of 2% lidocaine or 1 mL of sodium chloride solution was injected in a randomized fashion.	75% pain relief	Prevalence = 31%	This was not a prevalence study and authors evaluated capacity of the clinical picture to characterize low back pain relieved by facet joint anesthesia to identify the proposed criteria.
Young et al, 2003 (102)	102 patients with chronic low back pain were evaluated with 21 exclusions to correlate clinical examination characteristics with 3 sources of chronic low back pain.	Single diagnostic block with 2% lidocaine with less than 1.5 mL.	80% or greater pain relief for 30 to 60 minutes after the injection.	Prevalence = 61%	High proportion of patients showing positive results in a non-prevalence study conducted to correlate clinical examination characteristics with 3 sources of chronic low back pain in highly select population.
Manchikanti et al, 2010 (166)	491 patients with chronic low back pain undergoing evaluation for facet joint pain.	Controlled diagnostic blocks of lumbar facet joint nerves with 1% preservative-free lidocaine and 0.25% preservative-free bupivacaine 1 mL.	At least 80% pain relief with the ability to perform previously painful movements.	Prevalence = 53%	Higher prevalence than with 50% pain relief, but still higher than double block algorithmic approach.
Controlled Blocks With 50%-74% Relief					
Schwarzer et al, 1994 (136,146,217)	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.	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.
Schwarzer et al, 1995 (137,140)	63 patients with low back pain lasting for longer than 3 months underwent computed tomography and blocks of the zygapophysial joints	Patients underwent a placebo injection followed by intraarticular zygapophysial joint injections with 1.5 mL of 0.5% bupivacaine.	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.
Manchikanti et al, 2000 (98)	200 consecutive patients with chronic low back pain were evaluated.	Controlled diagnostic blocks with 1% lidocaine and 0.25% bupivacaine were injected over facet joint nerves with 0.4 to 0.6 mL.	75% pain relief with ability to perform previously painful movements.	Prevalence = 42% False-positive rate = 37%	The study showed that the clinical picture failed to diagnose facet joint pain.

Table 4 (cont). *Studies assessing the accuracy of diagnostic blocks.*

Study/Methods	Participants	Intervention(s)	Outcome Measures	Results	Conclusion(s)
Manchikanti et al, 2010 (166)	181 patients with at least 50% pain relief with concordant pain relief were evaluated with dual blocks.	Controlled diagnostic blocks of lumbar facet joint nerves with 1% preservative-free lidocaine and 0.25% preservative-free bupivacaine 1 mL.	At least 50% pain relief and ability to perform previously painful movements.	Prevalence = 61% False-positive rate = 17%	An unusually high proportion of positive rate for facet joint prevalence.
Schütz et al, 2011 (192)	60 consecutive patients with chronic low back pain were identified in a complicated prospective, randomized, single blinded, simple cross-over study with 6 parallel groups.	There were 6 parallel groups with Group 1 receiving a sham + placebo + local anesthetic injection, Group 2 receiving sham + local anesthetic + placebo, Group 3 receiving placebo + sham + local anesthetic, Group 4 receiving placebo + local anesthetic + sham, Group 5 receiving local anesthetic + placebo + sham, and Group 6 receiving local anesthetic + sham + placebo.	At least 50% pain relief	False-positive rate = 66%	Authors recommended abandoning single diagnostic blocks prior to invasive therapies, comparative facet joint blocks with local anesthetics and placebo controls also have to be interpreted carefully.
Controlled Blocks With ≥75%-100% Relief					
Manchikanti et al, 2001 (43)	120 patients were evaluated with 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.	80% pain relief with ability to perform previously painful movements	Prevalence = 40% False-positive rate = 47%	This study evaluated all the patients with low back pain, even with suspected discogenic pain.
Manchikanti et al, 1999 (138)	120 patients with chronic low back pain after radiographic conservative management were evaluated.	Controlled diagnostic blocks with 1% lidocaine followed by 0.25% bupivacaine.	Concordant pain relief with 75% or greater criterion standard with ability to perform previously painful movements.	Prevalence = 45% 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.
Manchikanti et al, 2000 (139)	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	75% pain relief with ability to perform previously painful movements	Prevalence = 36% False-positive rate = 25%	This study showed no significant difference if the steroids were used or not
Laslett et al 2004, 2006 (95,101)	151 patients with chronic low back pain were assessed for clinical predictors with screening by lumbar zygapophysial joint blocks. 120 patients were included in the study.	Either intraarticular or facet joint nerve block with 0.5 mL of 2% lidocaine or 0.5% bupivacaine if the response was positive with the first block	75% through 95% or more pain reduction	Prevalence = 24.2%	The prevalence reduced from 24.2% at 75% relief to 20.8% at 80% relief, 18.3% at 85%, 14.2% at 90%, and 10.8% and 95%; however, this was not a prevalence study.

Diagnostic Accuracy of Lumbar Facet Joint Nerve Blocks

Table 4 (cont). *Studies assessing the accuracy of diagnostic blocks.*

Study/Methods	Participants	Intervention(s)	Outcome Measures	Results	Conclusion(s)
Manchikanti et al, 2003 (142)	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.	80% pain relief with ability to perform previously painful movements.	Single Region: Prevalence = 21% False-positive rate = 17% Multiple Regions: Prevalence = 41% False-positive rate = 27%	This study shows a higher prevalence when multiple regions are involved.
Manchikanti et al, 2002, (143)	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.	80% pain relief with ability to perform previously painful movements.	Prevalence = 40% 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 (144)	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.	80% pain relief with ability to perform previously painful movements.	Prevalence = 31% False-positive rate = 27%	Largest study performed involving all regions of the spine.
Manchukonda et al, 2007 (145)	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.	80% pain relief with ability to perform previously painful movements.	Prevalence = 27% False-positive rate = 45%	Second largest study performed involving all regions of the spine by the same group of authors (144).
Manchikanti et al, 2007 (149)	A total of 117 consecutive patients with chronic non-specific low back pain were evaluated, after lumbar surgical interventions, with postsurgery 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.	80% relief as the criterion standard	Prevalence = 16% False-positive rate = 49%	Lower prevalence
Manchikanti et al, 2010 (166)	491 patients with chronic low back pain undergoing evaluation for facet joint pain.	Controlled diagnostic blocks of lumbar facet joint nerves with 1% preservative-free lidocaine and 0.25% preservative-free bupivacaine 1 mL.	At least 80% pain relief with ability to perform previously painful movements.	Prevalence = 31% False-positive rate = 42%	Much lower prevalence with stricter criteria compared to 50% pain relief.
DePalma et al, 2011 (184)	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.	Dual controlled diagnostic blocks with 1% lidocaine for the first block with 0.5% bupivacaine for the second.	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 (43,44).

Table 4 (cont). Studies assessing the accuracy of diagnostic blocks.

Study/Methods	Participants	Intervention(s)	Outcome Measures	Results	Conclusion(s)
Manchikanti et al, 2001 (200)	Controlled comparative prevalence study in 100 patients with 50 patients below age of 65 and 50 patients aged 65 or over was assessed.	Controlled diagnostic blocks	75% pain relief with ability to perform previously painful movements was utilized as the criterion standard.	Prevalence: < 65 years = 30% > 65 years = 52% 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 latest study by Manchikanti et al which showed no differences (147).
Manchikanti et al, 2001 (205)	Authors evaluated 100 patients with low back pain. Patients were divided into 2 groups, Group I was normal weight and Group II was obese.	Facet joints were investigated with diagnostic blocks using lidocaine 1% initially followed by bupivacaine 0.25%, at least 2 weeks apart.	A definite response was defined as relief of at least 75% in the symptomatic area.	Prevalence: Non-obese individuals = 36% Obese individuals = 40% 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.

2.6.1 Single Block with 50% to 74% Pain Relief

There was one study (44) evaluating the prevalence of facet joint pain utilizing the single block paradigm with 50% to 74% relief, yielding a prevalence of 48% with poor evidence.

2.6.2 Single Block with 75% to 100% Relief

There were a total of 4 studies meeting the inclusion criteria evaluating facet joint pain using a cutoff threshold between 75% and 100% relief following a single block (99,100,102,166). Two of the 4 studies showed a prevalence of 31% and 33% (99,100) whereas the other 2 studies showed 53% and 61% prevalence (102,166). It appears that a high proportion of patients will yield positive evidence and undergo unnecessary therapeutic facet joint modalities. Consequently, the evidence is limited.

2.6.3 Dual Blocks with 50% to 74% Pain Relief

There were 5 studies after the exclusion of duplicate publications evaluating the role of 50% to 74% relief with controlled diagnostic blocks in assessing the prevalence and false-positive rates (98,136,140,166,192).

Of these, 2 studies evaluated false-positive rates only (146,192). Among the 3 remaining studies, the most widely quoted studies by Schwarzer et al (136,140) yielded a prevalence of 15% and 40%, whereas the 2 studies by Manchikanti et al (98,166) yielded 42% and 61% prevalence. The 2 studies evaluating false-positive rates yielded a false-positive rate of 38% by Schwarzer et al (146), whereas Schütz et al (192) yielded a false-positive rate of 66%. Manchikanti et al (98,166) showed a false-positive rate variable of either 17% or 37%.

Thus, the prevalence has been shown to be variable from 15% to 61% with a false-positive rate of 17% to 66%, with the evidence, which is fair, utilizing 50% to 74% relief as the criterion standard.

2.6.4 Dual Blocks with 75% to 100% Relief

This is the category most widely studied. After the exclusion of duplicate publications, there were 13 studies (43,101,138,139,142-145,149,166,184,200,205) utilizing greater than 75% relief as the criterion standard with controlled diagnostic blocks. The prevalence in these studies ranged from 25% to 45% with false-positive rates demonstrated from 25% to 49% in heterogeneous populations. However, in post-laminectomy syndrome, the prevalence was less with 16%. In the elderly, prevalence rates were higher, whereas with obesity, there was no significant difference.

Table 5. Assessment of factors influencing prevalence and false-positive rates of facet joint pain.

Study	Methods And Assessment Criteria	Results	Comments
Influence of Age Manchikanti et al, 2008 (147) Age related prevalence of facet joint involvement and chronic low back pain was evaluated in a retrospective assessment.	A total of 303 patients were assessed divided into 6 groups with Group I aged 18-30 years, Group II aged 31-40 years, Group III aged 41-50 years, Group IV aged 51-60 years, Group V aged 61-70 years, Group VI over 70 years. Controlled comparative local anesthetic blocks with 80% pain relief and the ability to perform previously painful movements was utilized as the criterion standard.	The prevalence was 28% in Group I, 18% in Group II, 28% in Group III, 44% in Group IV, 21% in Group V, and 26% in Group VI with overall prevalence of 27%. The false-positive rates were 40%, 50%, 45%, 30%, 64%, and 43% respectively, with overall false-positive rate of 45%.	Age-related prevalence ranged from a low of 18% to a high of 44% with overall prevalence of 27%. Similarly, false-positive rates also changed. Overall it appears that there is not a substantial difference based on the age, especially the elderly, even though Group V with age of 61 to 70 years showed 21% prevalence which is less than Group VI of over 70 years with 26% prevalence and significantly different from Group IV, 51 to 60 year group of 44%.
DePalma et al, 2012 (189) Assessment of relationships between age, gender, and body mass index and source of chronic low back pain	153 patients with chronic low back pain were evaluated in a retrospective evaluation with dual diagnostic blocks with 1% lidocaine and 0.5% bupivacaine with concordant relief of 75% of the criterion standard.	Body mass index was associated with significant increases in the prevalence of facet joint pain. Facet joint pain was the most likely source of chronic low back pain for male patients who were approximately 54 years of age (30%-54%), regardless of body mass index, whereas, for female patients who were 65 years facet joint pain was most likely (46%-57%).	Based on this study it appears that female, elderly, obese patients may have higher prevalence of facet joint pain.
Manchikanti et al, 2001 (200) Assessment of the role of facet joints in chronic low back pain in the elderly	Controlled comparative prevalence study in 100 patients, in which 50 patients below age of 65 and 50 patients aged 65 or over were assessed. Controlled diagnostic blocks were performed with 75% pain relief with ability to perform previously painful movements utilized as the criterion standard.	The prevalence of facet joint pain was determined as 30% in the adults below the age of 65 and 52% in the elderly above the age of 65 with false-positive rates of 26% and 33%, respectively.	This study showed higher prevalence of facet joint pain in the elderly compared to the younger age group in contrast to the latest study by Manchikanti et al which showed no differences (147).
Influence Of Psychological Factors Manchikanti et al, 2008 (148) Assessment of influence of psychological variables on the diagnosis of facet joint involvement in chronic low back pain.	A total of 303 patients were evaluated with chronic low back pain. Patients were allocated into no psychopathology group, major depression, generalized anxiety disorder, and somatization disorder. Controlled comparative local anesthetic blocks with 80% pain relief and the ability to perform previously painful movements was utilized as the criterion standard.	The prevalence of lumbar facet joint pain was 28% in no psychopathology group compared to 43% in patients with major depression, 42% in patients with generalized anxiety disorder, and 38% in patients with somatization disorder with false-positive rates of 58%, 39%, 40%, and 42%, respectively.	The study illustrates no significant difference in patients with or without psychopathology.
Wasan et al, 2009 (194) Evaluation of influence of psychopathology to predict the outcome of medial branch blocks with corticosteroid injection for chronic axial low back pain in	86 patients for chronic axial low back or cervical pain in a prospective cohort study were classified into low psychopathology group, moderate psychopathology group, or high psychopathology group. Diagnostic blocks were performed utilizing facet joint nerve blocks with methylprednisolone 20 to 30 mg and 0.25% bupivacaine with a total volume of 1 to 1.25 mL injection per level.	The low psychopathology group reported a mean of 23% improvement in pain at one month while the high psychopathology group reported a mean worsening of 0.58% in pain. 45% of low group had a least 30% improvement in pain versus 10% in the high group.	This is poorly performed flawed evaluation with inappropriate methodology.

Table 5 (cont). Assessment of factors influencing prevalence and false-positive rates of facet joint pain.

Study	Methods And Assessment Criteria	Results	Comments
Influence Of Body Mass Index			
Manchikanti et al, 2001 (205) Assessment of the role of obesity in chronic low back pain.	Authors evaluated 100 patients with low back pain. Patients were divided into 2 groups, Group I was normal weight and Group II was obese. Facet joints were investigated with diagnostic blocks using lidocaine 1% initially followed by bupivacaine 0.25% at least 2 weeks apart. A definite response was defined as relief of at least 75% in the symptomatic area.	The results showed that the prevalence rate of facet joint pain in chronic low back pain in Group I or non-obese patients was 36%, in contrast to 40% in Group II, or the obese patient group, with no significant differences among the 2 groups. The study also showed a false-positive rate of 39% in the total sample, or 44% in Group I non-obese patients and 33% in Group II, or obese patients.	This study showed the prevalence of lumbar facet joint pain of 40% in obese patients and 36% in patients of normal weight with a false-positive rate of 33% in obese patients and 44% in non-obese patients is similar to the results of multiple previous studies concluding that facet joint pain is a common occurrence in obese patients; however, the incidence of facet joint mediated pain is similar in obese patients and non-obese patients.
DePalma et al, 2012 (189) Assessment of relationships between age, gender, and body mass index and source of chronic low back pain	153 patients with chronic low back pain were evaluated in a retrospective evaluation with dual diagnostic blocks with 1% lidocaine and 0.5% bupivacaine with concordant relief of 75% of the criterion standard.	Body mass index was associated with significant increases in the prevalence of facet joint pain. Facet joint pain was the most likely source of chronic low back pain for male patients who were approximately 54 years of age (30%-54%), regardless of BMI, whereas, for female patients who were 65 years facet joint pain was most likely 46%-57%.	Based on this study it appears that female, elderly, obese patients may have higher prevalence of facet joint pain.
Influence of Surgery			
Manchikanti et al, 2007 (149) Assessment of facet joint pain in post-surgery syndrome	A total of 117 consecutive patients with chronic, nonspecific low back pain, after lumbar surgical intervention(s) were evaluated with controlled, comparative local anesthetic blocks.	The prevalence of lumbar facet joint pain in patients with recurrent pain after various surgical intervention(s) was 16% (95% confidence interval, 9%-23%). The false-positive rate with a single block with lidocaine was 49%.	This study showed prevalence of lumbar facet joint pain in patients after surgical interventions of 16% with a false-positive rate of 49% with a single block.
DePalma et al, 2011 (187) Evaluation of etiology of chronic low back pain in patients having undergone lumbar fusion	A total of 28 fusion cases identified from 170 low back pain patients undergoing diagnostic procedures were assessed. Controlled diagnostic blocks were performed.	After 28 fusion cases, 5 patients were identified with zygapophysial pain with a prevalence of facet joint pain of approximately 18%.	The results showed that patients even after lumbar fusion have persistent low back pain secondary to facet joint involvement in approximately 18% of the patients. This is similar to other reports (149).
DePalma et al, 2012 (188) Evaluation of the source of chronic low back pain based on the history of surgical discectomy.	158 patients underwent dual diagnostic blocks with 1% lidocaine and 0.5% bupivacaine with concordant relief of 75% of the criterion standard. A total of 158 patients were evaluated.	The study showed facet joint pain in 18.2% of the patients whereas it was 32.6% of the patients in patients without surgical intervention. However, there were only 2 patients positive in patients with surgical discectomy.	Results show lower prevalence in patients with surgical discectomy; however, the sample size was extremely small.
Manchikanti et al, 2001 (218) Assessment of the role of facet joint pain in post-surgery syndrome	This prospective, randomized, controlled comparative evaluation was performed to determine the prevalence of facet joint pain in persistent low back pain in postlumbar laminectomy patients with a comparative non-surgical group. 100 patients with 50 patients in each group were randomly assigned with group I consisting of 50 patients without history of previous surgery and group II consisting of 50 patients with history of previous surgery.	Results showed that the prevalence of facet joint mediated pain in non-surgical patients was 44% compared to 32% in post surgical patients determined by comparative controlled local anesthetic blocks utilizing lidocaine and bupivacaine. This study also showed a false positive rate of 36% in the non-surgical group and 24% in the post-surgical group. In conclusion, this study shows that facet joint mediated symptomatology in chronic low back pain is prevalent, both in non-surgical as well as post-surgical patients even though the prevalence was somewhat higher in the non-surgical group compared to post-surgical group.	There was a lower prevalence of facet joint pain in patients after surgical interventions.

Table 5 (cont). Assessment of factors influencing prevalence and false-positive rates of facet joint pain.

Study	Methods And Assessment Criteria	Results	Comments
Bokov et al, 2011 (206) Assessment of facet joint pain in patients after nerve root decompression	138 consecutive patients with radicular pain syndromes in Group I underwent microdiscectomy with pathology being disc extrusion or sequestration, Group II underwent nucleoplasty for nerve root compression caused by contained disc herniation - disc protrusion, and Group III with a nerve root compression caused by uncontained disc herniation/disc extrusion treated by nucleoplasty.	The failure rate of surgery with continued pain problems were present in 44.7% in Group I, 47.8% in Group II, and 85.2% in Group III. Facet joint pain was identified in 23.1% in Group I (15 of 65 patients), 16.9% in Group II (11 of 46 patients), and 22.2% in Group III (6 of 27 patients).	Authors once again show that facet joint pain is present in patients who have undergone disc decompression either by microdecompression or nucleoplasty.
INFLUENCE OF GENDER/SMOKING			
DePalma et al, 2012 (189) Assessment of relationships between age, gender, and body mass index and source of chronic low back pain	153 patients with chronic low back pain were evaluated in a retrospective evaluation with dual diagnostic blocks with 1% lidocaine and 0.5% bupivacaine with concordant relief of 75% of the criterion standard.	Body mass index was associated with significant increases in the prevalence of facet joint pain. Facet joint pain was the most likely source of chronic low back pain for male patients who were approximately 54 years of age (30%-54%), regardless of BMI, whereas, for female patients who were 65 years facet joint pain was most likely 46%-57%.	Based on this study it appears that female, elderly, obese patients may have higher prevalence of facet joint pain.
Manchikanti et al, 2002 (201) Evaluation of the influence of gender, occupational injury, and smoking on prevalence of facet joint pain	320 patients were evaluated with controlled diagnostic blocks performed with 75% pain relief with the ability to perform previously painful movements utilized as the criterion standard.	Facet joint pain was present in 38% of men compared to 43% of women. Smokers had prevalence of 43% compared to nonsmokers of 41% in heavy smokers. Patients with occupational injury reported 28% of prevalence of facet joint pain compared to 44% with patients with gradual onset without injury. False-positive rates varied from 28% to 46%.	The study showed the prevalence of facet joint pain to be less in male patients and occupational injury patients. , There were no differences based on smoking.
INFLUENCE OF SEDATION			
Manchikanti et al, 2004 (202) Assessment of the effect of sedation as a confounding factor in the diagnostic validity of lumbar facet joint pain	180 patients with confirmed diagnosis of facet joint pain following controlled comparative local anesthetic blocks were injected intravenously with sodium chloride solution, midazolam, or fentanyl.	Pain relief of 80% was noted in 2% of the patients in sodium chloride group, 5% of the patients in midazolam group, and 7% of the patients receiving fentanyl. However, pain relief of 50% or greater was noted in 7% of the patients in sodium chloride group, 5% of the patients in midazolam group, and 13% of the patients receiving fentanyl.	Overall there was no significant difference with placebo response with either sodium chloride solution, midazolam, or fentanyl intravenous injections. The administration of sedation with midazolam or fentanyl may be a confounding factor, specifically if 50% relief is used as a criterion standard.
Manchikanti et al, 2006 (203) Evaluation of the effect of sedation on diagnostic validity of facet joint nerve blocks	Evaluation of 60 patients with 20 patients in each group with chronic low back pain. Diagnosis was established with controlled comparative local anesthetic blocks. Patients received either sodium chloride solution, midazolam, or fentanyl.	As many as 10% of the patients reported significant relief ($\geq 80\%$) with the ability to perform prior painful movements. Pain relief of 50% or greater was illustrated in 5% of the patients in sodium chloride group, 5% in patients receiving midazolam, and 10% in patients receiving fentanyl. However 80% or greater relief was observed in 5% of patients in sodium chloride group and also midazolam group, and 0% in fentanyl group.	This study also demonstrates, similar to previous studies, that there is no significant difference when sedation was used with potential false-positive rates.

Table 5 (cont). Assessment of factors influencing prevalence and false-positive rates of facet joint pain.

Study	Methods And Assessment Criteria	Results	Comments
<p>Manchikanti et al, 2005 (163) Effect of placebo and nocebo</p>	<p>This study evaluated the role of placebo and nocebo effects of perioperative administration of sedatives and opioids in interventional pain management in 360 patients, 180 patients with chronic low back pain, in a placebo controlled randomized, double-blind evaluation.</p>	<p>Between 13% and 30% of all patients across all 3 groups of the study, rated their pain relief following injection as better than their previous experience. A small proportion, 3% to 8% of patients in all 3 groups rated their experience following injection as worse than their previous experience.</p>	<p>This study shows it is not only placebo effect that influences the patients experience, but also the nocebo effect even when opioid and benzodiazepine are used.</p>
Influence of Diagnostic Blocks on Therapeutic Outcomes			
<p>Pampati et al, 2009 (165) Diagnostic validity</p>	<p>Authors evaluated 152 patients diagnosed with lumbar facet joint pain utilizing controlled comparative local anesthetic blocks, with lidocaine 1% or bupivacaine 0.25% with concordant relief with criterion standard of 80%, the accuracy of diagnostic lumbar facet joint nerve blocks. Assessment was carried out at a 2 year follow-up.</p>	<p>At the end one year, 93% of the patients and at the end of 2 years 89.5% of the patients were considered to have lumbar facet joint pain.</p>	<p>Controlled comparative local anesthetic blocks with 80% pain relief showed validity.</p>
<p>Cohen et al, 2010 (164) Evaluation of the role of diagnostic blocks without any diagnostic blocks, with a single diagnostic block, or dual diagnostic block</p>	<p>Authors evaluated 151 patients with suspected lumbar facet joint pain for radiofrequency neurotomy. Group I was treated with radiofrequency denervation without diagnostic blocks, Group II with a positive response for a single diagnostic block with 50% relief, and Group III underwent radiofrequency neurotomy in patients who were positive with controlled comparative local anesthetic blocks with a 50% relief of criterion standard.</p>	<p>In "0" group, 17 patients (33%) obtained a successful outcome at 3 months versus eight patients (16%) in "1" and "2" group (22%) patients in group "2". Denervation success rates in groups 0, 1, and 2 were 33, 39, and 64%, respectively.</p>	<p>This study showed clearly that dual diagnostic blocks were superior to either no diagnostic block or a single diagnostic block, despite miscalculation of cost effectiveness.</p>
<p>Manchikanti et al, 2010 (166) Assessment of the accuracy of diagnostic lumbar facet joint nerve blocks with either 50% relief or 80% relief as the criterion standard with controlled comparative local anesthetic blocks</p>	<p>Controlled comparative local anesthetic blocks were performed WITH lidocaine, bupivacaine, with either 50% to 79% relief or over 80% relief as the criterion standard with ability to perform previously painful movements.</p>	<p>At the end of one year, the diagnosis was confirmed in 75% of the group with 50% relief, whereas it was 93% in the group with 80% relief. At the end of 2-year follow-up, the diagnosis of lumbar facet joint pain was sustained in 51% of the patients in the group with 50% relief, whereas it was sustained in 89.5% of the patients with 80% relief.</p>	<p>Application of 80% relief with controlled comparative local anesthetic blocks provides a robust diagnostic criteria.</p>
<p>Manchikanti et al, 2003 (195) Evaluation of the accuracy of diagnostic facet joint nerve blocks with a long-term follow-up</p>	<p>The diagnosis was established with dual blocks with 80% pain relief with ability to perform previously painful movements.</p>	<p>85% of the patients available for follow-up withstood the diagnosis of facet joint pain at the end of 2 years, whereas this proportion decreased to 75% if all the patients in the study were included in the intent-to-treat analysis.</p>	<p>The study shows that diagnostic lumbar medial branch blocks are valid and the diagnosis of facet joint pain is sustainable after 2 years.</p>
<p>Cohen et al, 2008 (212) Assessment of the factors contributing to success of radiofrequency denervation based on diagnostic medial branch blocks</p>	<p>Authors evaluated, in a multicenter analysis, the factors contributing to success of radiofrequency denervation based on diagnostic medial branch blocks and their relief in 262 patients from 3 centers. The relief criteria used was with a single block with bupivacaine of medial branches with either 50% to 79% pain relief or 80% or greater.</p>	<p>In the greater than or equal to 50% group, success rates were 52% and 67% based on pain relief and global perceived effect respectively. Among patients who experienced greater than 80% relief from diagnostic blocks, 56% obtained greater than or equal to 50% relief from radiofrequency denervation and 66% had a positive global perceived effect.</p>	<p>Based on a single diagnostic block there was no difference in improvement related to radiofrequency neurotomy, either with a criterion standard of 50% or 80% with a single block.</p>

Table 6. List of excluded studies.

Manuscript Author(s)	Reason for Exclusion
Pneumaticos et al, 2006 (97)	This was a prospective evaluation of use of bone scintigraphy with single photon emission computed tomography (SPECT) for identification of patients with low back pain who would benefit from facet joint injections, rather than diagnostic accuracy study.
Ackerman & Ahmad, 2008 (127)	Authors evaluated therapeutic effect of intraarticular or medial branch nerve blocks without diagnostic blocks and without evaluation of prevalence and false-positive rates.
Ackerman et al, 2004 (157)	Authors evaluated if diagnostic lumbar facet joint injections are influenced by pain of muscular origin rather than accuracy, prevalence, or false-positive rates.
Chua et al 2011, (186)	This study describes if diagnostic blocks have any beneficial effects on pain processing. It is not a prevalence, diagnostic accuracy, or false-positive rate study.
Holm et al 2000, (193)	This study evaluated influence of facet joint anesthesia on isokinetic muscle performance in patients with chronic degenerative low back disorders rather than diagnostic accuracy, prevalence, or false-positive rates.
Mayer et al 2004, (196)	Authors evaluated corticosteroid joint injections in 70 patients with segmental rigidity. They concluded that 17% of the patients with lumbar segmental rigidity met criteria for the facet syndrome.
Birkenmaier et al, 2007 (197)	This study used uncontrolled blocks comparing pericapsular blocks in evaluating cryo-denervation. The injection was also of high volumes with 0.5% bupivacaine.
Marks et al, 1992 (198)	Authors compared facet joint nerve blocks and intraarticular injections with high volume injections with very short-term follow-up in a randomized trial. No prevalence or false-positive rate data were available.
Nash, 1990 (199)	Authors compared the effectiveness of intraarticular injections with medial branch blocks on a short-term basis with no controlled local anesthetic blocks or false-positive rate evaluation.
Bokov et al, 2010 (207)	Authors evaluated difference in treatment of nerve root compression pain caused by lumbar disc herniation applying nucleoplasty.
Steib et al, 2012 (208)	Authors evaluated predictors of facet joint syndrome after lumbar disc surgery.
Senoglu et al, 2010 (209)	Authors described morphological evaluation of cervical and lumbar facet joints with consideration of intraarticular facet joint injections.
Miyakoshi et al, 2007 (211)	In this manuscript total dorsal ramus block for the treatment of chronic low back pain was described as a preliminary study.
Schwarzer et al, 1994 (217)	Authors evaluated combination of discogenic and facet joint pain in the same patients utilized in other studies.
Jackson et al, 1988 (219)	This study with intraarticular injections showed mean relief of 29%. Authors evaluated multiple factors. Authors concluded that facet joint was not commonly the single or primary cause of pain in the great majority of low back pain patients.
Selby & Paris, 1981 (220)	Anatomic correlation of the facet joints was evaluated.
Raymond & Dumas, 1989 (221)	Twenty-five patients were evaluated with intraarticular facet blocks with discussions about if intraarticular injection is diagnostic or therapeutic procedure.
Schwarzer et al, 1994 (222)	Authors evaluated the value of provocation response in lumbar zygapophysial joint injections showing that the study called into the question the validity of pain provocation alone as a criterion standard in patients undergoing diagnostic lumbar zygapophysial joint blocks.

The level of evidence is good for dual blocks with 75% to 100% relief.

2.7 Analysis of Confounding Factors

Prevalence and false-positive rates were evaluated for age, psychological factors, weight/obesity, surgery, gender/smoking, sedation, and other confounding factors.

2.7.1 Influence of Age

There were 3 studies evaluating the influence of age on the prevalence and false-positive rate of facet joint injections (147,189,200). Manchikanti et al (147,200) evaluated the influence of age. In the first evaluation (200), they showed a significant difference with a prevalence of 30% in those who were aged less than 65 years old, and 52% in those aged 65 or older,

Table 7. Quality appraisal of the diagnostic reliability of lumbar facet joint diagnostic studies.

	Manchikanti et al (43)	Pang et al (44)	Schwarzer et al (136,146,217)	Schwarzer et al (137,140)	Manchikanti et al (138)	Manchikanti et al (139)	Laslett et al (95,101)	Manchikanti et al (98)	Revel et al (99)	Revel et al (100)	Young et al (102)
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?	+	+	+	+	+	+	+	+	NA	NA	+
5. Were raters blinded to their own prior outcomes of the test under evaluation?	+	+	+	+	+	+	+	+	NA	NA	+
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	11/12	9/12	11/12	12/12	11/12	12/12	12/12	12/12	8/10	8/10	11/12

Y=yes; N=no; U=undear; N/A=not applicable
 Lucas N, et al. Reliability of physical examination for diagnosis of myofascial trigger points. Clin J Pain 2009; 25:80-89 (85).

Table 7 (cont.). *Quality appraisal of diagnostic reliability of lumbar facet joint diagnostic studies.*

	Manchikanti et al (142)	Manchikanti et al (143)	Manchikanti et al (144)	Manchukonda et al (145)	Manchikanti et al (149)	Manchikanti et al (166)	DePalma et al 2011 (184)	Schütz et al (192)	Manchikanti et al (200)	Manchikanti et al (205)
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	11/12	11/12	11/12	11/12	11/12	11/12	11/12	11/12	11/12	11/12

Y=yes; N=no; U=unclear; N/A=not applicable
 Lucas N, et al. Reliability of physical examination for diagnosis of myofascial trigger points. Clin J Pain 2009; 25:80-89 (85).

Table 8. *Clinical relevance of included studies.*

Manuscript Author(s)	A) Patient description	B) Description of interventions and treatment settings	C) Clinically relevant outcomes	D) Clinical importance	E) Benefits versus potential harms	Total Criteria Met
Manchikanti et al 2001 (43)	+	+	+	+	+	5/5
Pang et al, 1998 (44)	+	+	-	+	+	4/5
Schwarzer et al, 1994 (136,146,217)	+	+	+	+	+	5/5
Schwarzer et al, 1995 (137,140)	+	+	+	+	+	5/5
Manchikanti et al, 1999 (138)	+	+	+	+	+	5/5
Manchikanti et al, 2000 (139)	+	+	+	+	+	5/5
Laslett et al, 2004, 2006 (95,101)	+	+	+	+	+	5/5
Manchikanti et al, 2000 (98)	+	+	+	+	+	5/5
Revel et al, 1992 (99)	+	+	-	+	+	4/5
Revel et al, 1998 (100)	+	+	-	+	+	4/5
Young et al, 2003 (102)	+	+	-	+	+	4/5
Manchikanti et al, 2003 (142)	+	+	-	+	+	4/5
Manchikanti et al, 2002, (143)	+	+	+	+	+	5/5
Manchikanti et al, 2004 (144)	+	+	+	+	+	5/5
Manchukonda et al, 2007 (145)	+	+	+	+	+	5/5
Manchikanti et al, 2007 (149)	+	+	+	+	+	5/5
Manchikanti et al, 2010 (166)	+	+	+	+	+	5/5
DePalma et al, 2011 (184)	+	+	+	+	+	5/5
Schütz et al, 2011 (192)	+	+	+	+	+	5/5
Manchikanti et al, 2001 (200)	+	+	+	+	+	5/5
Manchikanti et al, 2001 (205)	+	+	+	+	+	5/5

+ = positive; - = negative

Scoring adapted from Staal JB, et al. Injection therapy for subacute and chronic low back pain. *Cochrane Database Syst Rev* 2008; 3:CD001824 (179).

with a false-positive rate of 26% and 33%, respectively. In the second study (147), they categorized the patients into various groups and found that age-related prevalence ranged from a low of 18% to a high of 44% with an overall prevalence of 27%. False-positive rates were also variable from 30% to 64%. In fact, in elderly patients 61 to 70 years of age, the prevalence was 21%, which was less than patients older than 70 years with 26%. In contrast, DePalma et al (189) in their assessment found that chronic low back pain of facet joint origin was most commonly seen in male patients of 54 years of age regardless of body mass index, whereas for female patients who were 65 years facet joint pain was most likely.

2.7.2 Influence of Psychological Factors

Psychological factors were studied by 2 groups of authors, Manchikanti et al (148) and Wasan et al (194). The study by Wasan et al (194) was very poorly performed with multiple evaluations and flaws with inappropriate methodology. The study by Manchikanti et al (148) showed overall prevalence of facet joint pain in 28% in patients without any psychopathology compared to 43% in patients with major depression. Overall the study illustrated no significant difference in patients with or without psychopathology including depression, generalized anxiety disorder, and somatization disorder.

Diagnostic Accuracy of Lumbar Facet Joint Nerve Blocks

Table 9. Data of prevalence of lumbar facet joint pain by diagnostic blocks.

Study	Methodological Criteria Score	Number of Subjects	Prevalence Estimates with 95% Confidence Intervals	False-Positive Rate with 95% Confidence Intervals
Single Blocks With 50%-74% Relief				
Pang et al, 1998 (44)	9/12	100	Prevalence 48%	NA
Single Blocks With ≥75%-100% Relief				
Revel et al, 1992 (99)	8/10	51	33%	NA
Revel et al, 1998 (100)	8/10	80	31%	NA
Young et al, 2003 (102)	11/12	102	61%	NA
Manchikanti et al, 2010 (166)	11/12	491	53% (67%-80%)	NA
Controlled Blocks With 50%-74% Relief				
Schwarzer et al, 1994 (136,146,217)	11/12	176	15%	38% (30% - 46%)
Schwarzer et al, 1995 (137,140)	12/12	57 of 63	40% (27% - 53%)	NA
Manchikanti et al, 2000 (98)	12/12	200	42% (35% - 42%)	37% (32% - 42%)
Manchikanti et al, 2010 (166)	11/12	181	61% (53% - 81%)	17% (10% - 24%)
Schütz et al, 2011 (192)	11/12	60	NA	66%
Controlled Blocks With ≥75%-100% Relief				
Manchikanti et al, 2001 (43)	11/12	120	40% (31%-49%)	47% (35% - 59%)
Manchikanti et al, 1999 (138)	11/12	120	45% (36% - 54%)	41% (29% - 53%)
Manchikanti et al, 2000 (139)	12/12	180	36% (29% - 43%)	25% (21% - 39%)
Laslett et al 2004, 2006 (95,101)	12/12	151	24.2%	NA
Manchikanti et al, 2003 (142)	11/12	300 I: Single region II: Multiple regions	I: 21% (14%-27%) II: 41% (33%-49%)	I: 17% (10% - 24%) II: 27% (18% - 36%)
Manchikanti et al, 2002, (143)	11/12	120	40% (31% - 49%)	30% (20% - 40%)
Manchikanti et al, 2004 (144)	11/12	397	31% (27% - 36%)	27% (22% - 32%)
Manchukonda et al, 2007 (145)	11/12	303	27% (22% - 33%)	45% (36% - 53%)
Manchikanti et al, 2007 (149)	11/12	117	16% (9% - 23%)	49% (39% - 59%)
Manchikanti et al, 2010 (166)	11/12	491	31% (26% - 35%)	42% (35% - 50%)
DePalma et al, 2011 (184)	11/12	156	31% (24% - 38%)	NA
Manchikanti et al, 2001 (200)	11/12	100 I: (<65 years) = 50 II: (>65 years) = 50	I: 30% (17% - 43%) II: 52% (38% - 66%)	I: 26% (11%-40%) II: 33% (14%-35%)
Manchikanti et al, 2001 (205)	11/12	100 I: (BMI<30) = 50 II: (BMI >30) = 50	I: 36% (22%, 50%) II: 40% (26%, 54%)	I: 44% (26%, 61%) II: 33% (16%, 51%)

NA = Not available

2.7.3 Influence of Body Mass Index

Two studies evaluated the influence of body mass index on prevalence of facet joint pain and chronic low back pain (189,205). DePalma et al (189) showed that female patients with obesity were most likely to have facet joint pain. In contrast, Manchikanti et al (205) showed no significant difference between obese and

non-obese patients with a prevalence of 36% versus 40% with a false-positive rate of 44% versus 33%.

2.7.4 Influence of Surgery

The influence of post-laminectomy syndrome, post-surgery syndrome or post-fusion was evaluated in 5 studies (149,187,188,206,218). Manchikanti et al (149,218) evaluated post-surgery in 2 separate studies.

The recent study (149) showed a prevalence of 16% with a false-positive rate of 49%. In this evaluation, there was no comparison group. In the first study from 2001 (218), evaluating obese and non-obese individuals, the authors showed both post-surgery patients and those patients who had not undergone surgical interventions. The authors showed a prevalence of 44% in nonsurgical patients and 32% in post-surgical patients with a false-positive rate of 36% and 24%. Overall both studies showed a lower prevalence of facet joint pain after surgery even though the rates were significantly different. DePalma et al (187,188) assessed the etiology of chronic low back pain in those who had a surgical discectomy and those who had undergone lumbar fusion; however, there were very few patients included in this assessment. In patients who had a previous surgical discectomy (188), the prevalence was 18.2%, compared to those without surgical intervention of 32.6% in patients with post fusion (187) prevalence was 18%. Another study by Bokov et al (206) showed the prevalence of facet joint pain of 16.9% to 23.1% based on the type of intervention they underwent for nerve root decompression.

2.7.5 Influence of Gender/Smoking

Two studies evaluated the influence of gender and smoking (189,201). DePalma et al (189) showed that elderly females with obesity might have higher prevalence of facet joint pain. Manchikanti et al (201) in a 2002 evaluation showed a lesser prevalence of facet joint pain in male patients and occupational injury patients, although they were unable to detect any difference based on smoking.

2.7.6 Influence of Sedation

Manchikanti et al assessed the influence of sedation in 3 different studies (163,202,203). In the first 2 studies, evaluating the influence of sedation on the diagnostic validity of facet joint blocks (202,203), the authors showed that the influence was minimal either with midazolam or fentanyl when 80% relief was used as the criterion standard; however, there was a significant difference in pain relief in patients when 50% relief was used as the criterion standard indicating that a criterion standard of 80% pain relief seems to have higher accuracy compared to 50% pain relief. Manchikanti et al (163) also evaluated the effect of placebo and nocebo showing that approximately 13% to 30% of all patients across all 3 groups of the study rated their pain relief following injection as better than their previous

experience with sodium chloride solution, midazolam, or fentanyl. However, a small proportion, 3% to 8% of patients in all 3 groups rated their experience following injection as worse than their previous experience. This study essentially shows that even though midazolam and fentanyl were administered, patients felt worse.

2.7.7 Influence of Diagnostic Blocks on Therapeutic Outcomes

Multiple evaluations were performed in this arena. Pampati et al (165) showed controlled comparative local anesthetic blocks with 80% relief with high validity with 93% of patients with facet joint pain at the end of one year and approximately 90% of patients with a sustained diagnosis of facet joint pain at 2 years. Manchikanti et al (195) in a study in 2003 also showed the sustainability of diagnosis at 85% at the end of 2 years when diagnostic blocks were performed with 80% pain relief with controlled diagnostic blocks. In another study, Manchikanti et al (166) assessed the accuracy of diagnostic lumbar facet joint nerve blocks with either 50% relief or 80% relief as the criterion standard with controlled comparative local anesthetic blocks. In this study they showed that at the end of one year the diagnosis was confirmed in 75% of the group with 50% relief, whereas it was 93% in the group with 80% relief. At the end of the 2 year follow-up, the diagnosis of lumbar facet joint pain was sustained in 51% of patients in the group with 50% relief, whereas it was sustained in 90% of patients with 80% relief. Cohen et al (212) assessed, in a multicenter analysis, the factors contributing to the success of radiofrequency denervation. Based on a single block they showed no significant difference with a criterion standard of either 50% or 80%. Cohen et al (164) also evaluated the role of diagnostic blocks without any diagnostic blocks, with a single diagnostic block, or dual diagnostic block. This study clearly showed that dual diagnostic blocks were superior to either no diagnostic block or a single diagnostic block, despite the miscalculation of cost effectiveness.

3.0 COMPLICATIONS

Complications from facet joint nerve blocks, intraarticular injections, or radiofrequency neurolysis in the lumbar spine are exceedingly rare (1,41,43,44,75,76,79-83,98,106,127,130,136,140,142,144,164,189,191,195-305). The most common complications of lumbar facet joint interventions are twofold: Complications related to the placement of the needle and those related to the administration of various drugs. Most problems such as

local swelling, pain at the site of the needle insertion, and pain in the low back are short-lived and self-limited.

More serious complications may include dural puncture, spinal cord trauma, subdural injection, neural trauma, injection into the intervertebral foramen, and hematoma formation; infectious complications including epidural abscess and bacterial meningitis; and side effects related to the administration of steroids, local anesthetics, and other drugs.

Other minor complications include lightheadedness, flushing, sweating, nausea, hypotension, syncope, pain at the injection site as described earlier, and non-postural headaches.

Side effects related to the administration of steroids are generally attributed to the chemistry or to the pharmacology of the steroids (282). The major theoretical complications of corticosteroid administration include suppression of pituitary-adrenal axis, hyperadrenocorticism, Cushing's syndrome, osteoporosis, avascular necrosis of bone, steroid myopathy, epidural lipomatosis, weight gain, fluid retention, and hyperglycemia.

The evaluation of the effect of neuraxial steroids on weight and bone mass density showed no significant differences in patients undergoing various types of interventional techniques with or without steroids (283), multiple other studies have echoed the same (284-286). Brill et al (285) also evaluated the effect of 3 consecutive epidural steroid injections with 40 mg methylprednisolone acetate once monthly for 3 months on weight gain and found no significant change in weight after administration. However, Lee et al (286) in a systematic review of the effects of low-dose corticosteroids on bone mineral density of rheumatoid arthritis patients, which included 7 studies on lumbar bone mineral density meta-analysis and 6 studies on femur bone mineral density meta-analysis, showed that corticosteroids resulted in a moderate worsening in lumbar bone mineral density compared with controls, whereas the femoral bone mineral density differences were not significant. They showed bone mineral density loss after low-dose corticosteroid treatment in patients with rheumatoid arthritis with practical implications for the long-term management of patients with rheumatoid arthritis on low-dose corticosteroids. Similarly, Korczowska et al (284), assessing low-dose and short-term glucocorticoid treatment and the risk of osteoporosis in rheumatoid arthritis in female patients, concluded that there was anti-inflammatory effect of low-dose glucocorticoid therapy in rheumatoid arthritis patients; however, in patients who previously used glucocorticoids on a long-

term basis, the benefits are questionable. Multiple other studies evaluating epidural injections showed no significant difference whether steroids were used or not (291-298).

A study by Manchikanti et al (240) included over 7,500 episodes or 43,000 facet joint nerve blocks performed under fluoroscopic guidance in an ambulatory surgery center by one of 3 physicians. The complications encountered during the procedure and postoperatively were prospectively evaluated. The results showed no major complications. Multiple side effects and complications observed in lumbar facet joint nerve blocks included intravascular penetration in 4%, local bleeding in 73% of episodes, oozing in 10% of encounters, with local hematoma seen only in 0.1% of the encounters with profuse bleeding, bruising, soreness, nerve root irritation, and all other effects such as vasovagal reactions observed in 1% or less of the episodes.

4.0 Discussion

This systematic review of the diagnostic accuracy of lumbar facet joint nerve blocks in evaluation of chronic low back pain without indications of disc herniation or radiculitis after failure of conservative management shows varying results. The evidence is good for utilization of 75% to 100% pain relief with controlled diagnostic blocks as the criterion standard with a prevalence of 25% to 45% with false-positive rates of 25% to 49% in heterogenous population (43,101,138,139,142-145,149,166,184,200,205). The evidence is fair for controlled diagnostic blocks utilizing 50% to 74% relief as the criterion standard with a prevalence of 15% to 61% with a false-positive rate of 17% to 66% in heterogenous population (98,136,140,146,166,192). The evidence is poor utilizing 50% to 74% or 75% and limited for greater pain relief with a single diagnostic block with prevalence ranging from 33% to 61% (44,99,100,102,166).

Facet arthrosis has been suggested as a cause of low back pain for decades (126,167). However, the exact source of pain in the facet joints is ambiguous. Theories on the generation of pain range from mechanical alterations to vascular changes and molecular signaling. While disc degeneration can clearly cause low back pain, some patients may not experience pain until degenerative changes in the facet joints alter mechanical alignment sufficiently to produce "articular" low back pain (306). Eubanks et al (167) and others (307,308) concluded that evidence of facet arthrosis appears early and can be linked to the amount of heavy work done

before age 20. Indeed, it appears that facet arthrosis starts early, with nearly 60% of adults showing some signs of degenerative changes by the time they reach age 30. After this early rise in arthritic changes, subsequent degeneration appears to steadily increase until the seventh decade when the evidence of arthrosis becomes ubiquitous (167).

A systematic review is defined as, "the application of scientific strategies that limit bias by the systematic assembly, critical appraisal, and synthesis of all relevant studies on a specific topic" (309,310). Systematic reviews are labor intensive and require expertise in both the subject matter and review methods. Thus, expertise in one or the other area is not enough and may lead to inaccurate conclusions in turn leading to inappropriate application of the results (78,228-231). Thus, this systematic review has provided not only expertise in the subject matter which is crucial, but also knowledge in review methodology. A systematic review differs from a narrative review because a systematic review attempts to minimize bias by the comprehensiveness and reproducibility of the search and selection of articles for review and provides assessment of the methodological quality of the studies (78,228-231). In this systematic review, we attempted to answer specific narrow clinical questions in depth – the diagnostic accuracy and validity of facet joint blocks and the level of evidence with recommendation for diagnostic facet joint injections. A systematic searching, selecting, appraising, interpreting, and summarizing of data from original studies was performed. The study summaries were qualitative and quantitative.

In this review we have also searched for other types of integrative evidence including other systematic reviews and cost effectiveness studies. Further, recent evaluations in reference to guideline warfare, evidence-based medicine, comparative effectiveness research, have been extensively discussed (27,28,36,37,161,162,311-313).

The IOM standards for systematic reviews (314) described 4 major standards: 1) standards for initiating the systematic review, 2) standards for finding and assessing individual studies, 3) standards for synthesizing the body of evidence, and 4) standards for reporting systematic reviews. Each one of the standards describe in detail multiple aspects.

Further, the IOM also described multiple challenges and guidance in developing guidelines (315). The IOM states that the literature assessing the best methods for guideline development have evolved dramatically in

the 20 years since the IOM's first report on the subject (316). The new definition from IOM for guidelines is as follows (315):

Clinical practice guidelines are statements that include recommendations intended to optimize patient care that are informed by a systematic review of evidence and an assessment of the benefits and harms of alternative care options.

The outcomes of facet joint interventions to a great extent may depend on the diagnosis. Multiple authors have evaluated the factors related to accuracy of the diagnosis and its influence on the outcomes. It is well known that facet joint nerve blocks are inherently non-specific, even when low volumes are injected under fluoroscopic guidance. Thus, a strong case can be made for increasing the criteria to a more stringent 75% pain relief. A study by Dreyfuss et al (317) found that using 0.5 mL low volume facet joint nerve block using conventional landmarks resulted in contrast spread into the epidural space or intervertebral foramen in 16% of cases, and between the cleavage plain of the multifidus and longissimus muscles in all injections. Kaplan et al (318) also demonstrated the ability of lumbar medial branch blocks to anesthetize the zygapophysial joint. Consequently, 75% or higher relief with controlled diagnostic blocks has been recommended. The rationale behind using 50% relief as criteria to proceed to a therapeutic radiofrequency neurotomy was outlined by Schwarzer et al (136) who cite the high evidence of concurrent spinal pathology occurring with lumbar facet joint degeneration as the primary reason. Further, Fujiwara et al (307) found that even though lumbar degenerative disc disease frequently occurs in absence of lumbar facet joint degeneration, patients with severe lumbar facet joint arthritis virtually always have radiologic evidence of degenerative disc disease and/or other spinal pathology. The role of 50% or 75% relief on the diagnostic accuracy has been evaluated (165,166). In these studies, it was illustrated that the prevalence specifically with a and a single block with 50% criterion standard is inordinately high (73%), along with proof that diagnosis was sustained in 50% of patients at the end of 2 years when it was made by controlled diagnostic blocks with 50% minimum relief criteria. In contrast, when the diagnosis was made by 80%, the diagnosis of facet joint pain was sustained in 89.5% of patients at the end of 2 years (166). In addition, 80% pain relief also has shown lack of confounding when sedation was administered, either with midazolam or fentanyl (202,203). Even though, dual blocks with 80% relief as a

criterion standard appears to be the best, some have argued that there is no difference between the outcome, specifically with radiofrequency neurotomy (319). In fact, the results were also significant when patients were selected without any diagnostic blocks, in a study by Civelek et al (241), even though the study by Cohen et al (164) showed inferior results.

Cohen et al (212) emphasized that one reason that double blocks were not used for their study on the success of lumbar zygapophysial joint radiofrequency denervation as a function of diagnostic block relief was that the use of controlled blocks was not cost-effective. Manchikanti and Singh (320) commented that the whole concept of single blocks resulting with 50% or more relief followed by radiofrequency denervation creates many questions regarding the reliability of diagnostic blockade, increased health care costs, and coverage for facet joint nerve blocks and radiofrequency neurotomy. Schwarzer et al (136) using 50% relief of pain as a standard showed the prevalence of lumbar zygapophysial joint pain in 15% of patients. They (140) also showed a 40% prevalence in another study with 90% pain relief as the criterion standard with placebo control. They also showed a false-positive response in 38% of the patients (146). Most publications agree that 2 diagnostic blocks must be performed before radiofrequency denervation and many payers are requiring 80% or more pain relief. Further, Cohen et al (164) in a randomized controlled trial investigated costs and outcomes of radiofrequency treatment using 3 different medial branch blocks treatment paradigms including radiofrequency without the use of a screening block, radiofrequency if the patient obtained significant relief after a single diagnostic block with 50% relief, and radiofrequency denervation only if a patient has an appropriate response with a positive response of 50% or more relief with 2 confirmatory blocks. By 3 months after radiofrequency treatment, the proportion of successful outcomes of each individual cohort was highest in the group where patients received radiofrequency treatment after 2 diagnostic blocks with 64% of the patients reporting relief. However, by utilizing the total number of patients, Cohen et al (164) confused the entire data and misinterpreted the results, concluding that it was more cost-effective to perform radiofrequency neurotomy without any type of diagnostic blocks. This misinformation and inappropriate evaluation only lead to unnecessary radiofrequency neurotomy, increasing health care costs (39,162). Consequently, a single block will definitely increase the costs of care

as the single diagnostic block will lead to an increase in the number of radiofrequency denervations, which are more expensive and time consuming. The cost effectiveness of controlled, comparative, local anesthetic facet joint nerve blocks has been evaluated and found to be superior to an algorithmic approach starting with discography in axial pain (43).

Manchikanti and coauthors in multiple publications (143-145) evaluated the prevalence and false-positive rates of diagnostic blocks. In all included studies they utilized a criterion standard of 80% pain relief with the ability to perform previously painful movements without pain utilizing 1% lidocaine. In a large study of 500 patients in which prevalence of facet joint pain in chronic spinal pain of cervical, thoracic, and lumbar regions were evaluated (144), 397 patients were evaluated for low back pain showing a prevalence of 31% (95% CI, 27%, 36%) with a false-positive rate with single blocks with lidocaine of 27% (95% CI, 22%, 32%). The second large study by Manchukonda et al (145) evaluated 438 patients with 303 patients with lumbar pain. The prevalence of lumbar facet joint pain was determined as being 27% (95% CI, 22%, 33%), with a false-positive rate of single blocks in the lumbar region of 45% (95% CI, 36%, 53%).

Manchikanti et al (43) also have evaluated relative contributions of various structures in chronic low back pain in 120 patients yielding similar results in terms of prevalence and false-positive rates. They also evaluated prevalence based on involvement of multiple regions with a lower prevalence in patients with involvement of only lumbar spine versus multiple regions (21% versus 41%) (142). They also have evaluated facet joint pain in post-surgery syndrome yielding 16% prevalence and false-positive rate (149) with no significant difference between age, gender, smoking, or obesity (201,205). In their evaluation of confounding factors (202,203), they showed significant accuracy in patients receiving sedation with midazolam or fentanyl, compared with sodium chloride solution when 80% relief was used as the criterion standard instead of 50% which confounded the results.

In recent years DePalma et al (184) have assessed the prevalence of facet joint pain. They also published multiple manuscripts with subgroup analysis (185,187-190). Their study (184) with 156 subjects showed that the prevalence of internal disc disruption, facet joint pain, and sacroiliac joint pain was 42%, 31%, and 18%, respectively. Patients with internal disc disruption were significantly younger than those with facet joint pain

or sacroiliac joint pain. Increased age was associated with a decreased probability of internal disc disruption and increased probabilities of facet joint pain and sacroiliac joint pain as the source of low back pain until approximately age 70. They concluded that their data confirmed the intervertebral disc as the most common etiology of chronic low back pain in adults, and the younger the patient, the more likely low back pain is discogenic in origin. Facetogenic or sacroiliac joint pain is more likely in older patients.

No tissue diagnosis (biopsy or autopsy) techniques are available to diagnose facet joint pain and confirm specificity and sensitivity of facet joint nerve blocks. However, pain relief and stability of the diagnosis with long-term follow-up are employed as the criterion standards and are accepted across different medical disciplines (41,156,195). Thus, the validity of controlled facet joint nerve blocks as a gold standard or reference standard in the diagnosis of lumbar facet joint pain has been established (165,166). Reference standards are established in surgical situations via biopsy or autopsy. However, these are difficult to apply in the diagnosis of chronic spinal pain of facet joint origin. Thus, the long-term or dedicated clinical follow-up of the subjects appears to be the only solution in establishing a reference standard with controlled facet joint nerve blocks (156). Based on the criterion standard of long-term follow-up, controlled diagnostic lumbar facet joint nerve blocks have been shown to be valid utilizing the criteria of 80% pain relief and the ability to perform previously painful movements, with a sustained diagnosis of lumbar facet joint pain in at least 89.5% of patients at the end of 2-year follow-up (165). However, the diagnosis was sustained in only 51% of the patients with 50% relief at the end of 2 years (165). Thus, the controlled diagnostic blocks utilized in this study appear to be reliable.

Multiple evaluations have been performed assessing the role of confounding factors in the diagnosis of facet joint pain and its prevalence (147-149,163-166,185,187-190,194,195,200-203,205,206,212,217,218). There were 3 studies evaluating the influence of age on prevalence and false-positive rates of facet joint injections (147,189,200), with only limited evidence showing that the prevalence of facet joint pain is higher in the elderly. Two studies assessing the influence of psychological factors (148,194) showed no significant correlation with psychopathology and prevalence of facet joint pain or false-positive rate. Body mass index showed limited evidence that obese patients may have a higher preva-

lence of facet joint pain (189,205). In patients with post-laminectomy syndrome and fusion, the prevalence of facet joint pain has been shown to be lower than in non-surgical patients (149,187,188,206,218). In reference to smoking there has not been any significant difference noted, while in reference to gender it appears that the prevalence of facet joint pain may be higher in women (189,201). The influence of sedation was also evaluated in 3 different studies (163,202,203) on the diagnostic accuracy, although these studies were by the same group of authors.

The literature shows differing effects with injections of various solutions such as local anesthetic, normal saline, or dextrose and also shows differing effects by injection into the disc, facet joint, or multifidus muscle (321-327). It has been shown that a small volume of local anesthetic or normal saline abolishes muscle twitch induced by a low current (0.5 mA) during electrode location (321-324). Furthermore, there is direct evidence for spinal cord involvement in placebo analgesia (325). It also has been shown that epidurally administered sodium chloride solution provides significant improvement in the pain and function (328-330).

Consequently, multiple misunderstandings abound regarding the role of placebo control. Placebo control in neural blockade is not only a difficult task, but also adds ethical issues and difficulty with recruitment in the United States. The majority of investigations performed in interventional pain management with descriptions of placebo control have been met with design flaws (27,28,36,37,161,162,331-333). In the interventional pain management literature, the effect of any solution injected into a closed space, such as intraarticular space or epidural space, or over a nerve continues to be an enigma. Carrette et al (234,334) in their widely acclaimed studies, showed that patients responded similarly to an intraarticular injection or epidural injection, whether it contained a sodium chloride solution or steroid with a low response in both groups, leading to inappropriate conclusions, that the treatments do not work. In fact, Birkenmaier et al (197) utilizing either pericapsular injections or medial branch blocks for diagnostic purposes, went on to perform cryoneurolysis and showed that results were superior in patients who were diagnosed using medial branch blocks than in patients diagnosed using a pericapsular injection of local anesthetic. These misconceptions have led to many experts (22) to discard the value of diagnostic lumbar facet joint nerve blocks. Even though the limitations of lack of placebo is most likely underestimated, it should

also not be overestimated, specifically in diagnostic interventions. It is essential to design a proper placebo prior to discarding their role.

In addition, multiple reviewers have considered a local anesthetic injection also as a placebo leading to inaccurate conclusions. The mechanism of local anesthetics in providing longer than duration of its action in chronic pain is a complex phenomenon, similar to the effectiveness of steroids beyond the widely acclaimed anti-inflammatory effect. In fact, it has been shown that there is no additional effect with either local anesthetics alone or local anesthetics with steroids providing similar effect. The literature is replete with descriptions of epidural corticosteroids providing a certain level of efficacy by their anti-inflammatory, immunosuppressive, anti-edema effects, and inhibition of neural transmission within C fibers, which is claimed to explain the effectiveness of steroids for the proponents (78,291-296,334-364), even though opponents of steroids continue to debate and deny such a role. Similarly, even though more debatable, local anesthetics also have been described to provide long-term symptomatic relief. It has been postulated that local anesthetics provide relief by suppression of nociceptive discharge (352), the blockade of axonal transport (353,354), the blockade of the sympathetic reflex arc, sensitization (355,356), and anti-inflammatory effects (357). However, multiple studies have shown the long-term effectiveness of local anesthetics in a host of studies following local anesthetic nerve blocks or epidural injections in direct comparison with local anesthetics with steroids (234,334,345-351). Thus, a large number of experimental and clinical studies have shown a lack of significant difference with local anesthetic alone, compared to combination of local anesthetic with steroids (76,78,98,138,139,142-145, 147, 148, 149, 163, 165, 166, 195, 200-205,218,238,246,350-364).

In conclusion, there is good evidence for diagnostic facet joint nerve blocks with 75% to 100% pain relief as the criterion standard with dual blocks, whereas there is fair evidence with 50% to 74% criterion standard with controlled diagnostic blocks.

5.0 CONCLUSION

There is good evidence for diagnostic facet joint nerve blocks with 75% to 100% pain relief as the criterion standard with dual blocks, whereas there is fair evidence with 50% to 74% criterion standard with controlled diagnostic blocks. However, the evidence is limited with single diagnostic blocks of either 50% to 74%

or 75% to 100% pain relief as the criterion standard.

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CONFLICT OF INTEREST

Dr. Falco is a consultant for St. Jude Medical Inc. and Joimax Inc.

Dr. Datta receives research support from Sucampo Pharmaceuticals and an honorarium from Smith and Nephew.

Dr. Benyamin is a consultant with Bioness and Nevro, serves on the advisory boards of Vertos Medical and Nuvo Pharma, teaches/lectures for Vertos Medical, Boston Scientific, Neurotherm, and Bioness, and receives research/grants from Alfred Mann Foundation, Teknon Foundation, Spinal Restoration, Inc., Bioness, Boston Scientific, Vertos Medical, Medtronic, Kimberly Clarke, Epimed, BioDelivery Sciences International, Inc., Theravance, Mundipharma Research, Cephalon/Teva, AstraZeneca, and Purdue Pharma, LP.

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Dr. Hirsch has received fees from CareFusion in the past 12 months. He participated in an Aetrium focus group and received compensation.

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