Systematic Review

A Systematic Review and Best Evidence Synthesis of Effectiveness of Therapeutic Facet Joint Interventions in Managing Chronic Spinal Pain

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Background: The therapeutic spinal facet joint interventions generally used for the treatment of axial spinal pain of facet joint origin are intraarticular facet joint injections, facet joint nerve blocks, and radiofrequency neurotomy. Despite interventional procedures being common as treatment strategies for facet joint pathology, there is a paucity of literature investigating these therapeutic approaches.

Systematic reviews assessing the effectiveness of various therapeutic facet joint interventions have shown there to be variable evidence based on the region and the modality of treatment utilized. Overall, the evidence ranges from limited to moderate.

Objective: To evaluate and update the clinical utility of therapeutic lumbar, cervical, and thoracic facet joint interventions in managing chronic spinal pain.

Study Design: A systematic review of therapeutic lumbar, cervical, and thoracic facet joint interventions for the treatment of chronic spinal pain.

Methods: The available literature on lumbar, cervical, and thoracic facet joint interventions in managing chronic spinal pain was reviewed. The quality assessment criteria utilized were the Cochrane Musculoskeletal Review Group criteria and Interventional Pain Management Techniques – Quality Appraisal of Reliability and Risk of Bias Assessment (IPM – QRB) for randomized trials and Interventional Pain Management Techniques – Quality Appraisal of Reliability and Risk of Bias Assessment for Nonrandomized Studies (IPM – QRBNR) for observational studies.

The level of evidence was classified at 5 levels from Level I to Level V.

Data sources included relevant literature identified through searches on PubMed and EMBASE from 1966 through March 2015, and manual searches of the bibliographies of known primary and review articles.

Outcome Measures: The primary outcome measure was pain relief (short-term relief = up to 6 months and long-term > 6 months). Secondary outcome measures were improvement in functional status, psychological status, return to work, and reduction in opioid intake consumption.

Results: A total of 21 randomized controlled trials meeting appropriate inclusion criteria were assessed in this evaluation. A total of 5 observational studies were assessed.

In the lumbar spine, for long-term effectiveness, there is Level II evidence for radiofrequency neurotomy and lumbar facet joint nerve blocks, whereas the evidence is Level III for lumbosacral intraarticular injections.

In the cervical spine, for long-term improvement, there is Level II evidence for cervical radiofrequency neurotomy and cervical facet joint nerve blocks, and Level IV evidence for cervical intraarticular injections.

In the thoracic spine there is Level II evidence for thoracic facet joint nerve blocks and Level IV evidence for radiofrequency neurotomy for long-term improvement.

Limitations: The limitations of this systematic review include an overall paucity of high quality studies and more specifically the lack of investigations related to thoracic facet joint injections.

Conclusion: Based on the present assessment for the management of spinal facet joint pain, the evidence for long-term improvement is Level II for lumbar and cervical radiofrequency neurotomy, and therapeutic facet joint nerve blocks in the cervical, thoracic, and lumbar spine; Level III for lumbar intraarticular injections; and Level IV for cervical intraarticular injections and thoracic radiofrequency neurotomy.

Key Words: Spinal pain, chronic low back pain, chronic neck pain, chronic thoracic pain, intraarticular facet joint blocks, facet joint nerve blocks, conventional radiofrequency neurotomy, pulsed radiofrequency neurolysis

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Chronic spinal pain with or without extremity pain, chest wall pain, or headaches is commonly encountered in modern day health care, at a time when health care costs and disability are exploding with a corresponding exponential increase in treatment modalities (1-15). Controlled studies have previously established intervertebral discs, facet joints, and sacroiliac joints as potential sources of spinal and extremity pain (10,16-20). It has been described that facet joint degeneration can result from abnormal motion associated with disc degeneration, as well as arthritis, similar to that seen in other synovial joints (21-24). In addition, multiple mechanisms have been postulated as being responsible for modulation of spinal pain related to the facet joints, including capsular stretch, entrapment of synovial villi between the articular surfaces, nerve impingement by osteophytes, and release of inflammatory substances (25-29). The spinal facet joints have been shown to have an abundant nerve supply (30-41); they can cause pain much like what has been reported in normal volunteers who have persistent spinal pain and referred pain into the extremities, chest wall, or head (42-53); are known to be susceptible to arthritic changes, degenerative changes, inflammation, and injury, all of which can lead to a restriction in range of motion and pain upon movement (21-29). By using accepted and proven diagnostic techniques, facet joints have been shown to be a pain generator with subsequent therapeutic application of modalities with significant improvement in pain and disability directed at facet joint innervation (10,16-19,54). Thus, facet joint pain may be diagnosed with reliability based on established controlled diagnostic blocks and may be managed with therapeutic interventions including intraarticular injections, facet joint nerve blocks, or facet joint neurolytic procedures (10,55-57). The diagnostic accuracy and reliability of facet joint nerve blocks for chronic spinal pain have shown that with controlled diagnostic blocks, there is a prevalence of 27% to 41% in the low back with a false-positive rate of 25% to 44%, a prevalence of 36% to 67% and a false-positive rate of 27% to 63% in the cervical spine, and finally, in the thoracic spine a prevalence rate of 34% to 48% with a false-positive rate of 42% to 48% (19).

The accurate selection of patients for therapeutic modalities and diagnostic accuracy is crucial, since interventional techniques, specifically facet joint interventions, have shown overall increases of 293% or 11.1% per year per 100,000 fee-for-service Medicare population from 2000 to 2013, compared to 14% of US population and 64% of Medicare beneficiaries (13-15). In fact, lumbar facet joint nerve blocks have increased at a rate of 213%, cervical/thoracic facet joint nerve blocks have increased at a rate of 350%, and radiofrequency neurotomy have increased even more at a rate of 522% for lumbar facet joint radiofrequency neurotomy and 845% for cervical facet joint radiofrequency neurotomy from 2000 to 2013 in the fee-for-service Medicare population (13-15). Based on the selection criteria of appropriate diagnosis with controlled diagnostic blocks, multiple therapeutic interventions have been assessed in multiple reviews (10,55-61). These systematic reviews demonstrated variable evidence for facet joint neurotomy, facet joint nerve blocks, and intraarticular injections (55-61).

Thus, the debate over the appropriateness of these procedures, continues often with contradictory evidence based on personal and/or professional bias, conservatism, and policy implementations, but not grounded in an appropriate synthesis of the literature (7,58-68). Multiple systematic reviews have been performed based on methodologic assessment but we believe that they display significant bias and have made methodologic errors.

The objective of this systematic review is to assess

the effectiveness of therapeutic facet joint interventions with appropriate methodology.

1.0 Methods

The methodology utilized in this systematic review followed the review process derived from evidence-based systematic reviews and meta-analyses of randomized trials and observational studies (69-73).

1.1 Criteria for Considering Studies for This Review

1.1.1 Types of Studies

Randomized controlled trials
Observational studies

1.1.2 Types of Participants

Patients suffering with chronic neck pain, mid back pain, upper back pain or low back pain of at least 3 months duration.

Patients with acute trauma, fractures, malignancies, and inflammatory diseases were excluded.

1.1.3 Types of Interventions

Cervical, thoracic, and lumbar facet joint interventions appropriately performed with proper technique under image guidance (fluoroscopy, computed tomography [CT], or magnetic resonance imaging [MRI]) were included. Blind and ultrasound-guided interventions were excluded.

1.1.4 Types of Outcome Measures

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

1.2 Literature Search

All of the available trials in all languages from all countries providing appropriate management with outcome evaluations were considered for inclusion. Searches were performed from the following sources without language restrictions:

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

The search period was from 1966 through March 2015.

1.3 Search Strategy

The search strategy emphasized chronic spinal pain treated with facet joint interventions. The search terms included: cervical, mid back, and low back pain, facet or zygapophysial joint pain, cervical, thoracic, and lumbar facet injections; cervical, thoracic, and lumbar facet joint nerve blocks; and cervical, thoracic, and lumbar radiofrequency thermoneurolysis.

Search criteria were as follows:

((((((((((((((((((chronic low back pain) OR chronic back pain) OR chronic neck pain) OR disc herniation) OR discogenic pain) OR facet joint pain) OR herniated lumbar discs) OR nerve root compression) OR lumbosciatic pain) OR postlaminectomy) OR lumbar surgery syndrome) OR radicular pain) OR radiculitis) OR sciatica) OR spinal fibrosis) OR spinal stenosis) OR zygapophysial)) AND (((((((facet joint) OR zygapophyseal) OR zygapophysial) OR medial branch block) OR diagnostic block) OR radiofrequency) OR intraarticular)

1.4 Data Collection and Analysis

The review focused on randomized trials for efficacy. If there were not at least 5 randomized trials, observational studies were utilized. Those patients being studied were those who had been suffering with chronic pain for 3 months or longer. Only facet joint interventions were evaluated. All of the available studies, in all languages, from all countries providing appropriate management and with outcome evaluations of 3 months or longer and statistical evaluations were reviewed. Reports without an appropriate diagnosis, nonsystematic reviews, nonrandomized studies¸ book chapters, and case reports were excluded.

1.4.1 Inclusion and Exclusion Criteria

Randomized trials with at least 3 months of follow-up and with at least 25 patients in each group or with appropriate sample size determination were included. Observational studies of at least 50 patients with a minimum 6 month follow-up were included when needed (fewer than 5 randomized trials available in any category).

1.4.2 Methodological Quality or Validity Assessment

The quality of each individual article used in this analysis was assessed by Cochrane review criteria (Table 1) (70), Interventional Pain Management techniques – Quality Appraisal of Reliability and Risk of Bias Assessment (IPM – QRB) for randomized trials (Table 2) (72), and for observational studies: Interventional Pain Management Techniques – Quality Appraisal of Reliability and Risk of Bias Assessment for Nonrandomized Studies (IPM – QRBNR) (Table 3) (73).

Utilizing Cochrane review criteria, studies meeting the inclusion criteria with a score of at least 8 of 12 were considered high quality and 4 to 7 were considered moderate quality. Those with a score of less than 4 were considered low quality and were excluded.

Based on IPM-QRB criteria for randomized trials, the trials meeting the inclusion criteria that scored less than 16 were considered as low quality and were excluded, those scoring 16 to 31 were considered moderate quality, and those scoring 32 to 48 were considered high quality.

Based on IPM-QRBNR criteria for observational studies, manuscripts meeting the inclusion criteria scoring less than 16 were considered low quality and were excluded, manuscripts scoring 16 to 31 were considered moderate quality, and manuscripts scoring 32 to 48 were considered high quality.

1.4.3 Data Extraction and Management

Working independently and in an unblinded, standardized way, 2 review authors established the search criteria, searched for relevant literature, selected the manuscripts, and extracted the data from the included studies. Any disagreement between the 2 reviewers were discussed and debated. If no compromise was reached, another author would review the disagreement and cast the deciding opinion.

Methodological quality assessment was performed by multiple review authors with groups of 2 authors reviewing 4 to 6 manuscripts. The assessment was carried out independently in an unblinded standardized manner to assess the methodological quality and internal validity of all the studies considered for inclusion. The methodological quality assessment was performed in such a way to prevent discrepancies from occurring; if they did occur, a third reviewer was called in and the discrepancy decided by consensus. Continued issues were also discussed with the entire group and resolved.

If there was a conflict of interest with a reviewed manuscript (concerning authorship), if the reviewer was also one of the authors or there was any type of conflict, the involved authors did not review the manuscript for methodological quality assessment.

Table 1. *Sources of risk of bias and Cochrane Review rating system.*

A	1. Was the method of randomization adequate?	Yes/No/Unsure
B	2. Was the treatment allocation concealed?	Yes/No/Unsure
C	Was knowledge of the allocated interventions adequately prevented during the study?	
	3. Was the patient blinded to the intervention?	Yes/No/Unsure
	4. Was the care provider blinded to the intervention?	Yes/No/Unsure
	5. Was the outcome assessor blinded to the intervention?	Yes/No/Unsure
D	Were incomplete outcome data adequately addressed?	
	6. Was the drop-out rate described and acceptable?	Yes/No/Unsure
	7. Were all randomized participants analysed in the group to which they were allocated?	Yes/No/Unsure
E	8. Are reports of the study free of suggestion of selective outcome reporting?	Yes/No/Unsure
F	Other sources of potential bias:	
	9. Were the groups similar at baseline regarding the most important prognostic indicators?	Yes/No/Unsure
	10. Were co-interventions avoided or similar?	Yes/No/Unsure
	11. Was the compliance acceptable in all groups?	Yes/No/Unsure
	12. Was the timing of the outcome assessment similar in all groups?	Yes/No/Unsure

Source: Furlan AD, Pennick V, Bombardier C, van Tulder M; Editorial Board, Cochrane Back Review Group. 2009 updated method guidelines for systematic reviews in the Cochrane Back Review Group. *Spine (Phila Pa 1976)* 2009; 34:1929-1941 (70).

Table 2. *Item checklist for assessment of randomized controlled trials of IPM techniques utilizing IPM – QRB.*

		Scoring
I.	TRIAL DESIGN AND GUIDANCE REPORTING	
1.	CONSORT or SPIRIT	
	Trial designed and reported without any guidance	0
	Trial designed and reported utilizing minimum criteria other than CONSORT or SPIRIT criteria or trial was conducted prior to 2005	1
	Trial implies it was based on CONSORT or SPIRIT without clear description with moderately significant criteria for randomized trials or the trial was conducted before 2005	2
	Explicit use of CONSORT or SPIRIT with identification of criteria or trial conducted with high level reporting and criteria or conducted before 2005	3
II.	DESIGN FACTORS	
2.	Type and Design of Trial	
	Poorly designed control group (quasi selection, convenient sampling)	0
	Proper active-control or sham procedure with injection of active agent	2
	Proper placebo control (no active solutions into active structures)	3
3.	Setting/Physician	
	General setting with no specialty affiliation and general physician	0
	Specialty of anesthesia/PMR/neurology/radiology/ortho, etc.	1
	Interventional pain management with interventional pain management physician	2
4.	Imaging	
	Blind procedures	0
	Ultrasound	1
	CT	2
	Fluoro	3
5.	Sample Size	
	Less than 50 participants in the study without appropriate sample size determination	0
	Sample size calculation with less than 25 patients in each group	1
	Appropriate sample size calculation with at least 25 patients in each group	2
	Appropriate sample size calculation with 50 patients in each group	3
6.	Statistical Methodology	
	None or inappropriate	0
	Appropriate	1
III.	PATIENT FACTORS	
7.	Inclusiveness of Population	
7a.	For epidural procedures:	
	Poorly identified mixed population	0
	Clearly identified mixed population	1
	Disorders specific trials (i.e. well defined spinal stenosis and disc herniation, disorder specific, disc herniation or spinal stenosis or post surgery syndrome)	2
7b.	For facet or sacroiliac joint interventions:	
	No diagnostic blocks	0
	Selection with single diagnostic blocks	1
	Selection with placebo or dual diagnostic blocks	2
8.	Duration of Pain	
	Less than 3 months	0
	3 to 6 months	1
	> 6 months	2

Table 2 (cont.). *Item checklist for assessment of randomized controlled trials of IPM techniques utilizing IPM – QRB.*

		Scoring
9.	Previous Treatments	
	Conservative management including drug therapy, exercise therapy, physical therapy, etc.	
	Were not utilized	0
	Were utilized sporadically in some patients	1
	Were utilized in all patients	2
10.	Duration of Follow-up with Appropriate Interventions	
	Less than 3 months or 12 weeks for epidural or facet joint procedures, etc., and 6 months for intradiscal procedures and implantables	0
	3 to 6 months for epidural or facet joint procedures, etc., or 1 year for intradiscal procedures or implantables	1
	6 months to 17 months for epidurals or facet joint procedures, etc., and 2 years or longer for discal procedures and implantables	2
	18 months or longer for epidurals and facet joint procedures, etc., or 5 years or longer for discal procedures and implantables	3
IV.	OUTCOMES	
11.	Outcomes Assessment Criteria for Significant Improvement	
	No descriptions of outcomes OR < 20% change in pain rating or functional status	0
	Pain rating with a decrease of 2 or more points or more than 20% reduction OR functional status improvement of more than 20%	1
	Pain rating with decrease of ≥ 2 points AND ≥ 20% change or functional status improvement of ≥ 20%	2
	Pain rating with a decrease of 3 or more points or more than 50% reduction OR functional status improvement with a 50% or 40% reduction in disability score	2
	Significant improvement with pain and function ≥ 50% or 3 points and 40% reduction in disability scores	4
12.	Analysis of All Randomized Participants in the Groups	
	Not performed	0
	Performed without intent-to-treat analysis without inclusion of all randomized participants	1
	All participants included with or without intent-to-treat analysis	2
13.	Description of Drop Out Rate	
	No description of dropouts, despite reporting of incomplete data or ≥ 20% withdrawal	0
	Less than 20% withdrawal in one year in any group	1
	Less than 30% withdrawal at 2 years in any group	2
14.	Similarity of Groups at Baseline for Important Prognostic Indicators	
	Groups dissimilar with significant influence on outcomes with or without appropriate randomization and allocation	0
	Groups dissimilar without influence on outcomes despite appropriate randomization and allocation	1
	Groups similar with appropriate randomization and allocation	2
15.	Role of Co-Interventions	
	Co-interventions were provided but were not similar in the majority of participants	0
	No co-interventions or similar co-interventions were provided in the majority of the participants	1
V.	RANDOMIZATION	
16.	Method of Randomization	
	Quasi randomized or poorly randomized or not described	0
	Adequate randomization (coin toss, drawing of balls of different colors, drawing of ballots)	1

Table 2 (cont.). *Item checklist for assessment of randomized controlled trials of IPM techniques utilizing IPM – QRB.*

	High quality randomization (computer generated random sequence, pre-ordered sealed envelopes, sequentially ordered vials, telephone call, pre-ordered list of treatment assignments, etc.)	2
VI.	ALLOCATION CONCEALMENT	
17.	Concealed Treatment Allocation	
	Poor concealment of allocation (open enrollment) or inadequate description of concealment	0
	Concealment of allocation with borderline or good description of the process with probability of failure of concealment	1
	High quality concealment with strict controls (independent assignment without influence on the assignment sequence)	2
VII.	BLINDING	
18.	Patient Blinding	
	Patients not blinded	0
	Patients blinded adequately	1
19.	Care Provider Blinding	
	Care provider not blinded	0
	Care provider blinded adequately	1
20.	Outcome Assessor Blinding	
	Outcome assessor not blinded or was able to identify the groups	0
	Performed by a blinded independent assessor with inability to identify the assignment-based provider intervention (i.e., subcutaneous injection, intramuscular distant injection, difference in preparation or equipment use, numbness and weakness, etc.)	1
VIII.	CONFLICTS OF INTEREST	
21.	Funding and Sponsorship	
	Trial included industry employees	-3
	Industry employees involved; high levels of funding with remunerations by industry or an organization funded with conflicts	-3
	Industry or organizational funding with reimbursement of expenses with some involvement	0
	Industry or organization funding of expenses without involvement	1
	Funding by internal resources only with supporting entity unrelated to industry	2
	Governmental funding without conflict such as NIH, NHS, AHRQ	3
22.	Conflicts of Interest	
	None disclosed with potential implied conflict	0
	Marginally disclosed with potential conflict	1
	Well disclosed with minor conflicts	2
	Well disclosed with no conflicts	3
	Hidden conflicts with poor disclosure	–1
	Misleading disclosure with conflicts	–2
	Major impact related to conflicts	–3
	TOTAL MAXIMUM	48

Source: Manchikanti L, Hirsch JA, Cohen SP, Heavner JE, Falco FJE, Diwan S, Boswell MV, Candido KD, Onyewu O, Zhu J, Sehgal N, Kaye AD, Benyamin RM, Helm II S, Singh V, Datta S, Abdi S, Christo PJ, Hameed H, Hameed M, Vallejo R, Pampati V, Racz GB, Raj PP. Assessment of methodologic quality of randomized trials of interventional techniques: Development of interventional pain management specific instrument. Pain Physician 2014; 17:E263-E290 (72).

Table 3. *IPM checklist for assessment of nonrandomized or observational studies of IPM techniques utilizing IPM-QRBNR.*

I.	STUDY DESIGN AND GUIDANCE REPORTING	Scoring
1.	STROBE or TREND Guidance	
	Case Report/Case Series	0
	Study designed without any guidance	1
	Study designed with minimal criteria and reporting with or without guidance	2
	Study designed with moderately significant criteria or implies it was based on STROBE or TREND without clear description or the study was conducted before 2011 or similar criteria utilized with study conducted before 2011	3
	Designed with high level criteria or explicitly uses STROBE or TREND with identification of criteria or conducted prior to 2011	4
II.	DESIGN FACTORS	
2.	Study Design and Type	
	Case report or series (uncontrolled – longitudinal)	0
	Retrospective cohort or cross-sectional study	1
	Prospective cohort case-control study	2
	Prospective case control study	3
	Prospective, controlled, nonrandomized	4
3.	Setting/Physician	
	General setting with no specialty affiliation and general physician	0
	Specialty of anesthesia/PMR/neurology, etc.	1
	Interventional pain management with interventional pain management physician	2
4.	Imaging	
	Blind procedures	0
	Ultrasound	1
	CT	2
	Fluoro	3
5.	Sample Size	
	Less than 100 participants without appropriate sample size determination	0
	At least 100 participants in the study without appropriate sample size determination	1
	Sample size calculation with less than 50 patients in each group	2
	Appropriate sample size calculation with at least 50 patients in each group	3
	Appropriate sample size calculation with 100 patients in each group	4
6.	Statistical Methodology	
	None	0
	Some statistics	1
	Appropriate	2
III.	PATIENT FACTORS	
7.	Inclusiveness of Population	
7a.	For epidural procedures:	
	Poorly identified mixed population	1
	Poorly identified mixed population with large sample (≥ 200)	2
	Clearly identified mixed population	3
	Disorders specific trials (i.e. well defined spinal stenosis and disc herniation, disorder specific, disc herniation or spinal stenosis or post surgery syndrome)	4
7b.	For facet or sacroiliac joint interventions:	
	No specific selection criteria	1
	No diagnostic blocks based on clinical symptomatology	2

Table 3 (cont.) . *IPM checklist for assessment of nonrandomized or observational studies of IPM techniques utilizing IPM-QRBNR.*

	Selection with single diagnostic blocks	3
	Selection with placebo or dual diagnostic blocks	4
8.	Duration of Pain	
	Less than 3 months	0
	3 to 6 months	1
	> 6 months	2
9.	Previous Treatments	
	Conservative management including drug therapy, exercise therapy, physical therapy, etc.	
	Were not utilized	0
	Were utilized sporadically in some patients	1
	Were utilized in all patients	2
10.	Duration of Follow-up with Appropriate Interventions	
	Less than 3 months or less for epidural or facet joint procedures, etc., and 6 months for intradiscal procedures and implantables	1
	3-6 months for epidural or facet joint procedures, etc., or one year for intradiscal procedures or implantables	2
	6-12 months for epidurals or facet joint procedures, etc., and 2 years or longer for discal procedures and implantables	3
	18 months or longer for epidurals and facet joint procedures, etc., or 5 years or longer for discal procedures and implantables	4
IV.	OUTCOMES	
11.	Outcomes Assessment Criteria for Significant Improvement	
	No descriptions of outcomes OR < 20% change in pain rating or functional status	0
	Pain rating with a decrease of 2 or more points or more than 20% reduction OR functional status improvement of more than 20%	1
	Pain rating with decrease of ≥ 2 points AND ≥ 20% change or functional status improvement of ≥ 20%	2
	Pain rating with a decrease of 3 or more points or more than 50% reduction OR functional status improvement with a 50% or 40% reduction in disability score	2
	Significant improvement with pain and function ≥ 50% or 3 points and 40% reduction in disability scores	4
12.	Description of Drop Out Rate	
	No description despite reporting of incomplete data or more than 30% withdrawal	0
	Less than 30% withdrawal in one year in any group	1
	Less than 40% withdrawal at 2 years in any group	2
13.	Similarity of Groups at Baseline for Important Prognostic Indicators	
	No groups or groups dissimilar with significant influence on outcomes	0
	Groups dissimilar without significant influence on outcomes	1
	Groups similar	2
14.	Role of Co-Interventions	
	Dissimilar co-interventions or similar co-interventions in some of the participants	1
	No co-interventions or similar co-interventions in majority of the participants	2
V.	ASSIGNMENT	
15.	Method of Assignment of Participants	
	Case report/case series or selective assignment based on outcomes or retrospective evaluation based on clinical criteria	1
	Prospective study with inclusion without specific criteria	2

Table 3 (cont.) . *IPM checklist for assessment of nonrandomized or observational studies of IPM techniques utilizing IPM-QRBNR.*

	Retrospective method with inclusion of all participants or random selection of retrospective data	3
	Prospective, well-defined assignment of methodology and inclusion criteria (quasi randomization, matching, stratification, etc.)	4
VI.	CONFLICTS OF INTEREST	
16.	Funding and Sponsorship	
	Trial included industry employees with or without proper disclosure	-3
	Industry employees involved; high levels of funding with remunerations by industry or an organization funded with conflicts	-3
	Industry or organizational funding with reimbursement of expenses with some involvement or no information available	0
	Industry or organization funding of expenses without involvement	1
	Funding by internal resources only	2
	Governmental funding without conflict such as NIH, NHS, AHRQ	3
	TOTAL MAXIMUM	48

Source: Manchikanti L, Hirsch JA, Heavner JE, Cohen SP, Benyamin RM, Sehgal N, Falco FJE, Vallejo R, Onyewu O, Zhu J, Kaye AD, Boswell MV, Helm II S, Candido KD, Diwan S, Simopoulos TT, Singh V, Pampati V, Racz GB, Raj PP. Development of an interventional pain management specific instrument for methodologic quality assessment of nonrandomized studies of interventional techniques. Pain Physician 2014; 17:E291-E317 (73).

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

If the literature search provided at least 3 randomized trials meeting the inclusion criteria and they are clinically homogenous for each modality and region evaluated, a meta-analysis was performed.

Data were summarized using a meta-analysis when at least 3 trials per type of modality were available that met the inclusion criteria (e.g., intraarticular injections, facet joint nerve blocks, and radiofrequency thermoneurolysis) of clinical and statistical homogeneity.

Qualitative (the direction of a treatment effect) and quantitative (the magnitude of a treatment effect) conclusions were evaluated. A random-effects meta-analysis to pool data was also used. For placebo-controlled trials, the net effect between 2 treatments was utilized. However, for active-controlled trials, the differences between baseline and follow-up period were utilized.

1.5 Outcome of the Studies

According to reports from trials that studied general chronic pain, a clinically meaningful pain score change is considered to be, at a minimum, a 2-point change on a 0 to 10 scale (or 20 percentage points) (74), chronic musculoskeletal pain (75), and chronic low back pain (71-73,75,76), which have been commonly utilized. Traditional criteria of minimum or meaningful improvements have been criticized as clinically irrelevant (71-73,77-81). Thus, recent descriptions of clinically meaningful improvement considered more robust outcomes with either pain relief and functional status improvement of 50% (82-97). The following outcomes were considered clinically meaningful or significant: a 3-point or greater change on an 11-point pain scale (0-10), or a 50% pain improvement from baseline and a 40% or greater improvement in functional status.

A trial was judged to be positive if the facet joint intervention was clinically relevant and effective, either with a placebo control or active control. This indicates that the difference in the effect for the primary outcome measure was statistically significant on the conventional 5% level. Negative studies were those where the study treatments showed no difference or there was no improvement from baseline. Outcomes were reported at one, 3, 6, and 12 months. For observational studies, appropriate outcomes were reported with positive or negative results at 3 months, 6 months, and one-year or longer with effectiveness demonstrated when a study was judged to be positive. If a lack of effectiveness was identified in the study, it was judged to be negative.

1.6 Summary Measures

Summary measures included a 50% or more reduction of pain in at least 50% of the patients, or at least a 3-point decrease in pain scores and a relative risk of adverse events, including side effects.

1.7 Analysis of Evidence

The analysis of the evidence was performed based on best evidence synthesis developed from modifica-

Table 4. *Qualitative modified approach to grading of evidence.*

Level I	Evidence obtained from multiple relevant high quality randomized controlled trials
Level II	Evidence obtained from at least one relevant high quality randomized controlled trial or multiple relevant moderate or low quality randomized controlled trials
Level III	Evidence obtained from at least one relevant moderate or low quality randomized controlled trial with multiple relevant observational studies or Evidence obtained from at least one relevant high quality nonrandomized trial or observational study with multiple moderate or low quality observational studies
Level IV	Evidence obtained from multiple moderate or low quality relevant observational studies
Level V	Opinion or consensus of large group of clinicians and/or scientists

Source: Manchikanti L, Falco FJE, Benyamin RM, Kaye AD, Boswell MV, Hirsch JA. A modified approach to grading of evidence. Pain Physician 2014; 17:E319-E325 (105).

tion of multiple available criteria including those of the United States Preventive Services Task Force (USPSTF) and Cochrane review criteria as illustrated in Table 4 (98-104).

The analysis was conducted utilizing best evidence synthesis using 5 levels of evidence ranging from strong to opinion- or consensus-based (105).

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 for the study in question.

2.0 Results

Figure 1 shows a flow diagram of the study selection of therapeutic intervention trials and studies.

Based on comprehensive search criteria there were multiple studies considered for inclusion (82-84,106-164).

Multiple randomized trials, duplicates, and all nonrandomized trials were excluded. Table 5 is a partial list of excluded trials that did not meet inclusion criteria. Subsequently, 21 randomized trials (82-84,108,110,112-124,128,129) and 5 observational studies were included (152,159-162).

There were 3 trials (82,112,117) that evaluated therapeutic lumbar facet joint nerve blocks, 9 trials (108,113-118,122,123) that evaluated lumbar facet joint radiofrequency neurolysis, and 5 trials (110,111,121,123,124) that evaluated lumbar intraarticular injections that met the inclusion criteria. Even though there were only 3 randomized controlled trials, there were no observational therapeutic facet joint nerve block studies available for inclusion.

There was one trial (128) that evaluated the efficacy of cervical facet joint nerve radiofrequency thermoneurolysis, one trial (83) that evaluated the efficacy of cervical facet joint nerve blocks, and 2 trials (119,129) that evaluated cervical intraarticular injections that met inclusion criteria. Thus, 3 observational studies assessing radiofrequency neurotomy of the cervical spine (159-161) were included in the assessment of radiofrequency neurotomy. In addition, one prospective evaluation of cervical facet joint nerve blocks was also included (152).

There was one trial (84) that evaluated therapeutic thoracic facet joint nerve blocks and one trial (120) that evaluated thoracic facet joint radiofrequency neurolysis that met the inclusion criteria. Thus, one study of thoracic facet joint nerve blocks (162) was included. There were no other studies meeting inclusion criteria.

2.1 Methodological Quality Assessment

A methodological quality assessment of the randomized controlled trials meeting inclusion criteria was carried out utilizing Cochrane review criteria and IPM-QRB criteria for randomized trials as shown in Tables 6 and 7 and IPM – QRBNR for nonrandomized studies as shown in Table 8.

Utilizing Cochrane review criteria, studies meeting the inclusion criteria with at least a score of 8 of 12 were considered high quality and a score of 4 to 7 were considered moderate quality. A score lower than 4 was considered low quality and those studies were excluded.

Based on IPM-QRB criteria for randomized trials and IPM-QRBNR for observational studies, the trials meeting the inclusion criteria with scores of less than 16 were considered low quality and were excluded, manuscripts with scores of 16 to 31 were considered moderate quality, and scores of 32 to 48 or higher were considered as high quality trials.

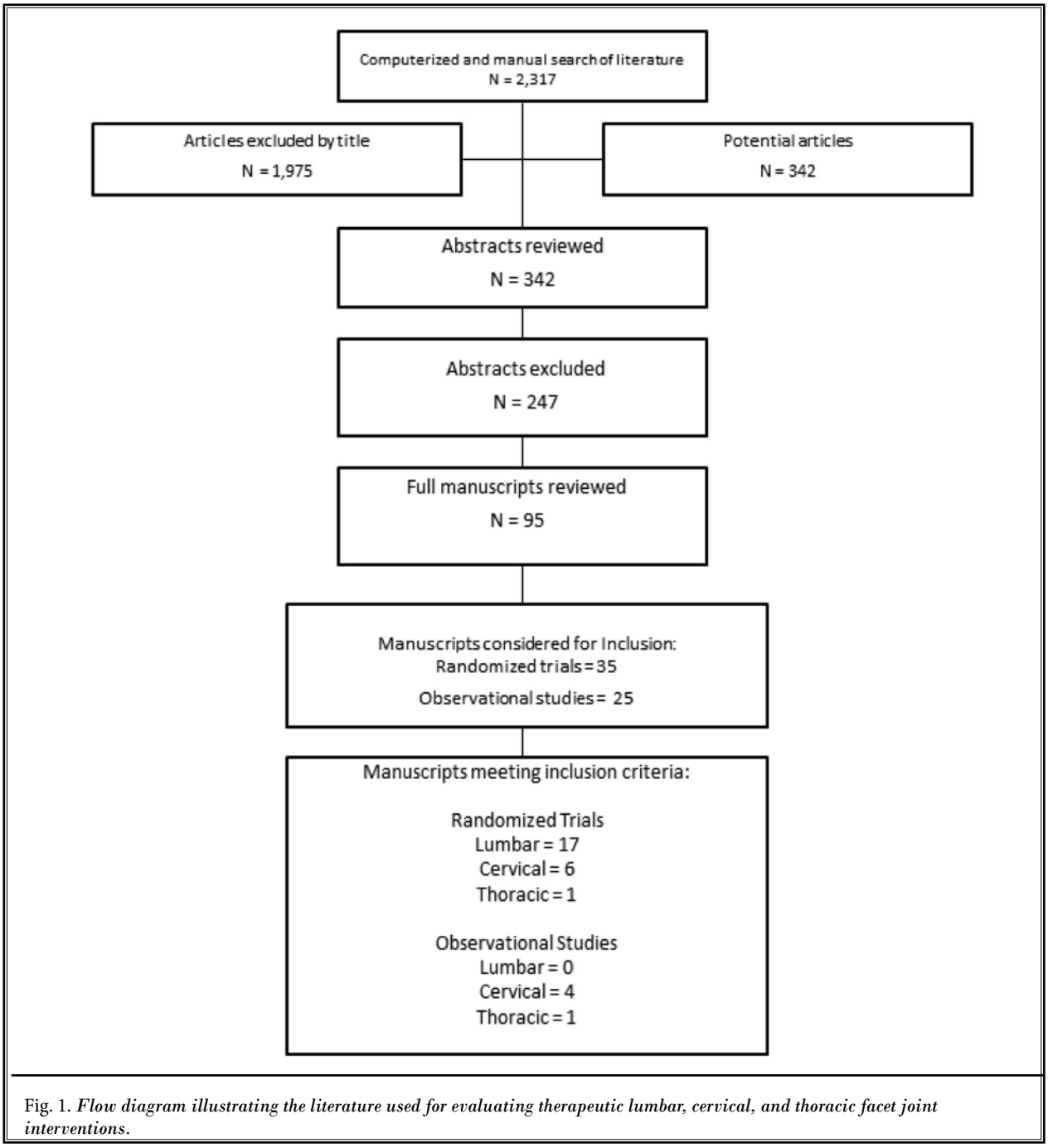

Fig. 1. *Flow diagram illustrating the literature used for evaluating therapeutic lumbar, cervical, and thoracic facet joint interventions.*

2.2 Meta-Analysis

If there were more than 2 trials meeting clinical homogeneity criteria, they were further assessed for homogeneity, and a meta-analysis was performed. There were 9 trials assessing lumbar radiofrequency neurotomy (108,113-118,122,123), 5 trials assessing lumbar intraarticular injection therapy (110,111,121,123,124), and 3 trials assessing lumbar facet joint nerve blocks (82,112,117). However, all modalities in the cervical spine and the thoracic spine had 2 or fewer. An assessment of clinical and methodological homogeneity

Table 5. *List of excluded randomized trials with brief explanation.*

Study	Condition Studied	Number of Patients	Reason for Exclusion	
			Followup Period	Other Reason(s)
LUMBAR FACET JOINT INTERVENTIONS				
Lilius et al (131) Randomized	Chronic low back pain	109	3 months	Study with short-term follow-up along with lack of diagnostic blocks and comparison of intraarticular or extraarticular injections with a large volume of injection. At best, this study may be appropriate for a diagnostic study with a single block.
Marks et al (132) Randomized	Chronic low back pain	86	3 months	The authors compared facet joint nerve blocks and intraarticular injections with high volume injections with very short-term follow-up in a randomized trial as diagnostic blocks.
Nash (133) Randomized	Chronic low back pain	67	3 months	The authors compared the effectiveness of intraarticular injections with medial branch blocks on a short-term basis with no controlled local anesthetic blocks, and with lack of long-term follow-up and outcomes
Leclaire et al (134) Randomized, Placebo-Controlled	Chronic low back pain	70	12 weeks	Relatively small study; however, technique and the diagnostic evaluation with intraarticular injections were inappropriate. The authors have admitted that the results might not be applicable in clinical practice.
Gallagher et al (135) Randomized	Chronic low back pain	41	One month and 6 months	Authors evaluated 60 patients with a single block and randomized them into 2 groups with 41 patients testing positive. The study showed improvement at one month and 6 months; however, the inclusion criteria, the technical considerations, and statistical analysis were considered as flawed.
Kroll et al (136) Randomized	Acute low back pain	50	3 months	Conventional and pulsed radiofrequency neurotomy were studied in acute low back pain.
Kader et al (140) Randomized	Chronic nonspecific low back pain with or without leg pain	63	10 weeks	Patients were randomized into 3 groups with back education and standard physiotherapy for 10 weeks, back education and gym ball exercise for 10 weeks, or perifacet injection into the lumbar multifidus muscle with methylprednisolone. Since there was no facet joint injection, the study failed to meet the criteria for inclusion.
Wen et al (126) Randomized	Low back pain	20	6 weeks	Twenty with 10 patients in each group receiving facet joint blocks either blindly or guided by ultrasound; however, the needle tip was confirmed by CT in both groups. Small sample size with short-term follow-up of 6 weeks utilizing either a blind technique or ultrasound-guided lumbar facet joint injections.
CERVICAL FACET JOINT INTERVENTIONS				
Obernauer et al (125) Randomized	Subacute chronic facet-joint-associated neck pain of the middle or lower cervical spine	40	4 weeks	Injection of local anesthetic and steroids into cervical facet joints either under CT scanning or ultrasonography. The short-term follow-up in patients with subacute pain was done without diagnostic blocks.
Slappendel et al (148) Randomized	Cervicobrachialgia	61	3 months	The authors evaluated the efficacy of radiofrequency lesioning of the cervical dorsal root ganglion.
Haspeslagh et al (149) Randomized	Cervicogenic headache	30	48 weeks	In this study, 30 patients with cervicogenic headache were evaluated. This study was problematic, not only in the diagnosis but also in the application of technique. The authors claim that they developed a sequence of various cervical radiofrequency neurotomies that proved successful in a prospective pilot trial with 15 chronic headache patients. Their diagnosis was not established by controlled diagnostic blocks; and the treatments targeted toward different structures: cervical facet joints and dorsal root ganglia compared to occipital nerves.

Table 6. *Methodological quality assessment of randomized trials of lumbar, cervical and thoracic facet joint interventions utilizing Cochrane review criteria.*

	Manchikanti et al (82)	Carette et al (110)	Fuchs et al (111)	Nath et al (113)	van Wijk et al (114)	van Kleef et al (115)	Tekin et al (116)	Civelek et al (117)	Dobrogowski et al (118)	Cohen et al (108)	Barnsley et al (119)
Randomization adequate	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Concealed treatment allocation	Y	Y	N	Y	Y	Y	Y	Y	U	N	Y
Patient blinded	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y
Care provider blinded	Y	Y	N	Y	Y	Y	Y	N	Y	U	Y
Outcome assessor blinded	N	Y	Y	Y	Y	Y	Y	U	U	U	Y
Drop-out rate described	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
All randomized participants analyzed in the group	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Reports of the study free of suggestion of selective outcome reporting	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Groups similar at baseline regarding most important prognostic indicators	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Co-intervention avoided or similar in all groups	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
Compliance acceptable in all groups	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Time of outcome assessment in all groups similar	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SCORE	11/12	11/12	8/12	12/12	12/12	12/12	12/12	9/12	10/12	8/12	12/12

	Manchikanti et al (83)	Lord et al (128)	Park & Kim (129)	Manchikanti et al (84)	Joo et al (120)	Ribeiro et al (121)	Moon et al (122)	Lakemeier et al (123)	Yun et al (124)	Manchikanti et al (112)
Randomization adequate	Y	Y	N	Y	Y	Y	Y	Y	Y	N N
Concealed treatment allocation	Y	Y	N	Y	Y	Y	Y	Y	Y	
Patient blinded	Y	Y	N	Y	Y	Y	Y	Y	N	Y
Care provider blinded	Y	Y	N	Y	N	N	Y	N	N	Y
Outcome assessor blinded	N	Y	N	N	N	N	Y	N	N	N
Drop-out rate described	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
All randomized participants analyzed in the group	Y	Y	Y	Y	Y	Y	N	Y	Y	N
Reports of the study free of suggestion of selective outcome reporting	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Groups similar at baseline regarding most important prognostic indicators	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Co-intervention avoided or similar in all groups	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Compliance acceptable in all groups	Y	Y	N	Y	Y	Y	N	N	Y	N
Time of outcome assessment in all groups similar	Y	N	Y	Y	Y	Y	N	Y	Y	Y
SCORE	11/12	11/12	6/12	10/12	10/12	10/12	9/12	9/12	9/12	6/12

Source: Furlan AD, Pennick V, Bombardier C, van Tulder M; Editorial Board, Cochrane Back Review Group. 2009 updated method guidelines for systematic reviews in the Cochrane Back Review Group. *Spine (Phila Pa 1976)* 2009; 34:1929-1941 (70).

Table 7. *Methodologic quality assessment of randomized trials of lumbar, cervical and thoracic facet joint interventions utilizing IPM – QRB criteria.*

		Manchikanti et al (82)	Carette et al (110)	Fuchs et al (111)	Nath et al (113)	van Wijk et al (114)	van Kleef et al (115)	Tekin et al (116)	Civelek et al (117)	Dobrogowski et al (118)	Cohen et al (108)
I.	Trial design and guidance reporting										
1.	Consort or spirit	3	3	3	3	2	2	2	2	2	3
II.	Design factors										
2.	Type and design of trial	2	3	2	3	3	3	3	2	2	2
3.	Setting/physician	2	1	1	3	3	3	2	2	2	2
4.	Imaging	3	3	2	3	3	3	3	3	2	3
5.	Sample size	3	2	2	1	1	1	1	1	1	3
6.	Statistical methodology	1	1	1	1	1	1	1	1	1	1
III.	Patient factors										
7.	Inclusiveness of population										
	• For facet or sacroiliac joint interventions:	2	1	0	2	1	1	1	0	1	1
8.	Duration of pain	2	2	1	2	2	3	2	0	2	0
9.	Previous treatments	2	0	0	0	0	0	1	2	0	0
10.	Duration of follow-up with appropriate interventions	3	2	1	2	2	2	2	2	1	0
IV.	Outcomes										
11.	Outcomes assessment criteria for significant improvement	4	4	2	4	4	2	2	2	2	0
12.	Analysis of all randomized participants in the groups	2	2	2	2	2	2	2	2	2	2
13.	Description of drop out rate	2	1	2	2	2	2	2	2	2	2
14.	Similarity of groups at baseline for important prognostic indicators	2	2	2	2	2	2	2	2	2	2
15.	Role of co-interventions	1	0	0	1	1	1	1	1	1	1
V.	Randomization										
16.	Method of randomization	2	2	2	2	2	2	2	2	2	2
VI.	Allocation concealment										
17.	Concealed treatment allocation	2	2	1	2	2	2	2	2	2	0
VII.	Blinding										
18.	Patient blinding	1	1	0	1	1	1	1	0	1	0
19.	Care provider blinding	1	1	0	1	1	1	1	0	1	0
20.	Outcome assessor blinding	0	1	0	0	1	0	0	0	0	0
VIII.	Conflicts of interest										
21.	Funding and sponsorship	2	3	1	2	0	3	2	0	0	2
22.	Conflicts of interest	3	3	1	3	0	3	2	0	0	2
TOTAL		45	40	26	42	36	40	37	28	29	28

Source: Manchikanti L, Hirsch JA, Cohen SP, Heavner JE, Falco FJE, Diwan S, Boswell MV, Candido KD, Onyewu O, Zhu J, Sehgal N, Kaye AD, Benyamin RM, Helm II S, Singh V, Datta S, Abdi S, Christo PJ, Hameed H, Hameed M, Vallejo R, Pampati V, Racz GB, Raj PP. Assessment of methodologic quality of randomized trials of interventional techniques: Development of an interventional pain management specific instrument. Pain Physician 2014; 17:E263-E290 (72).

Table 7 (cont.). Methodologic quality assessment of randomized trials of lumbar, cervical and thoracic facet joint interventions utilizing IPM – QRB criteria.

		Barnsley et al (119)	Manchikanti et al (83)	Lord et al (128)	Park & Kim (129)	Manchikanti et al (84)	Joo et al (120)	Ribeiro et al (121)	Moon et al (122)	Lakemeier et al (123)	Yun et al (124)	Manchikanti et al (112)
I.	Trial design and guidance reporting											
1.	Consort or spirit	2	3	3	2	3	2	2	2	2	2	2
II.	Design factors											
2.	Type and design of trial	2	2	3	2	2	2	2	2	2	2	2
3.	Setting/physician	2	2	2	2	2	2	2	2	1	1	3
4.	Imaging	3	3	3	3	3	3	3	3	3	3	3
5.	Sample size	1	3	1	3	3	1	2	2	2	2	2
6.	Statistical methodology	1	1	1	1	1	1	1	1	1	1	1
III.	Patient factors											
7.	Inclusiveness of population											
	• For facet or sacroiliac joint interventions:	2	2	2	2	2	2	0	2	1	0	2
8.	Duration of pain	2	2	2	2	2	2	0	2	2	0	2
9.	Previous treatments	0	2	2	2	2	2	0	2	2	1	2
10.	Duration of follow-up with appropriate interventions	1	3	2	2	3	2	1	1	2	1	3
IV.	Outcomes											
11.	Outcomes assessment criteria for significant improvement	2	4	4	2	4	2	2	2	2	1	2
12.	Analysis of all randomized participants in the groups	2	2	2	2	2	2	2	0	2	2	0
13.	Description of drop out rate	1	2	2	2	2	2	2	2	2	2	0
14.	Similarity of groups at baseline for important prognostic indicators	2	2	2	2	2	2	2	2	2	2	2
15.	Role of co-interventions	0	1	1	0	1	1	1	1	1	1	1
V.	Randomization											
16.	Method of randomization	2	2	2	2	2	2	2	2	2	2	0
VI.	Allocation concealment											
17.	Concealed treatment allocation	2	2	2	0	2	2	2	2	2	2	0
VII.	Blinding											
18.	Patient blinding	1	1	1	0	1	1	1	1	1	0	1
19.	Care provider blinding	1	1	1	0	1	0	0	1	0	0	1

Table 7 (cont.). Methodologic quality assessment of randomized trials of lumbar, cervical and thoracic facet joint interventions utilizing IPM – QRB criteria.

		Barnsley et al (119)	Manchikanti et al (83)	Lord et al (128)	Park & Kim (129)	Manchikanti et al (84)	Joo et al (120)	Ribeiro et al (121)	Moon et al (122)	Lakemeier et al (123)	Yun et al (124)	Manchikanti et al (112)
20.	Outcome assessor blinding	1	0	1	0	0	0	0	1	0	0	0
VIII.	Conflicts of interest											
21.	Funding and sponsorship	3	2	3	2	2	2	2	2	2	1	2
22.	Conflicts of interest	3	3	3	2	3	3	3	3	3	0	3
TOTAL		36	45	45	35	45	38	32	38	37	26	34

Source: Manchikanti L, Hirsch JA, Cohen SP, Heavner JE, Falco FJE, Diwan S, Boswell MV, Candido KD, Onyewu O, Zhu J, Sehgal N, Kaye AD, Benyamin RM, Helm II S, Singh V, Datta S, Abdi S, Christo PJ, Hameed H, Hameed M, Vallejo R, Pampati V, Racz GB, Raj PP. Assessment of methodologic quality of randomized trials of interventional techniques: Development of an interventional pain management specific instrument. Pain Physician 2014; 17:E263-E290 (72).

Table 8. *IPM checklist for assessment of nonrandomized or observational studies of lumbar, cervical and thoracic facet joint interventions of IPM techniques utilizing IPM-QRBNR.*

		Sapir & Gorup (159)	MacVicar et al (160)	Speldewinde GC (161)	Manchikanti et al (152)	Manchikanti et al (162)
I.	Study design and guidance reporting					
1.	Strobe or trend guidance	3	3	3	3	3
II.	Design factors					
2.	Study design and type	4	4	4	4	4
3.	Setting/physician	2	2	2	2	2
4.	Imaging	3	3	3	3	3
5.	Sample size	2	1	1	1	1
6.	Statistical methodology	2	2	2	2	2
III.	Patient factors					
7.	Inclusiveness of population					
	• For facet or sacroiliac joint interventions:	4	4	4	4	4
8.	Duration of pain	2	2	2	2	2
9.	Previous treatments	2	2	2	2	2
10.	Duration of follow-up with appropriate interventions	3	3	3	3	3
IV.	Outcomes					
11.	Outcomes assessment criteria for significant improvement	2	4	4	4	4
12.	Description of drop out rate	1	1	1	1	1
13.	Similarity of groups at baseline for important prognostic indicators	2	0	0	0	0
14.	Role of co-interventions	2	2	2	2	2
V.	Assignment					
15.	Method of assignment of participants	4	4	4	2	2
VI.	Conflicts of interest					
16.	Funding and sponsorship	2	1	2	2	2
TOTAL		40	38	39	37	37

Source: Manchikanti L, Hirsch JA, Heavner JE, Cohen SP, Benyamin RM, Sehgal N, Falco FJE, Vallejo R, Onyewu O, Zhu J, Kaye AD, Boswell MV, Helm II S, Candido KD, Diwan S, Simopoulos TT, Singh V, Pampati V, Racz GB, Raj PP. Development of an interventional pain management specific instrument for methodologic quality assessment of nonrandomized studies of interventional techniques. Pain Physician 2014; 17:E291-E317 (73).

among various studies of the 11 trials of radiofrequency neurotomy was performed. None of the 3 trials were homogeneous either for selection criteria, outcome measures, or design of the trial. Among the 5 lumbar intraarticular injections and 3 facet joint nerve blocks there was no clinical homogeneity in any of the 2 or more trials. Thus, a meta-analysis was not feasible; consequently it was not performed.

2.3 Study Characteristics

Tables 9 and 10 illustrate the study characteristics of the included studies for randomized trials and observational studies evaluating facet joint interventions.

2.4 Analysis of Evidence

The evidence was synthesized based on the modality of treatment for each region. Tables 11 and 12 illustrate the results of therapeutic studies.

A total of 21 randomized trials met inclusion criteria with 9 trials (108,113-118,122,123) evaluating lumbar radiofrequency neurotomy, one trial evaluating cervical radiofrequency neurotomy (128), and one trial evaluating thoracic radiofrequency neurotomy (120); with 3 trials (82,112,117) evaluating therapeutic lumbar facet joint nerve blocks, one trial evaluating therapeutic cervical facet joint nerve blocks (83), and one trial evaluating therapeutic thoracic facet joint nerve blocks (84); and 5 trials evaluating lumbar intraarticular injections (110,111,121,123,124) and 2 trials evaluating cervical intraarticular injections (119,129). In addition, one additional therapeutic thoracic facet joint nerve blocks study (162), one additional therapeutic cervical facet joint nerve block study (152), and 3 additional cervical radiofrequency neurotomy studies (159-161) were also included.

The evidence for radiofrequency neurotomy in the lumbar, cervical, and thoracic spines is variable. The evidence is Level I for short-term effectiveness of radiofrequency neurotomy of less than 6 months and Level II for long-term relief of longer than 6 months based on 8 moderate to high quality randomized controlled trials of radiofrequency neurotomy (108 ,113,115,116,117,118,122,123) showing short-term effectiveness of radiofrequency neurotomy, lack of response shown in one moderate to high quality trial of radiofrequency neurotomy (114), long-term relief based on 3 high quality randomized controlled trials showing effectiveness (115-117), lack of effectiveness demonstrated in one trial (114). In the cervical spine, the evidence is Level II based on one high quality randomized controlled trial (128) for short-term and long-term effectiveness; whereas, in the thoracic spine the evidence is Level III based on one randomized, double-blind, active control trial (120) for short-term and long-term effectiveness.

The evidence for therapeutic facet joint nerve blocks is Level II in the cervical, thoracic, and lumbar regions for short-term and long-term improvement based on 2 high quality randomized controlled trials (82,117) and one moderate (6/12 Cochrane criteria) to high quality (34/48 IPM-QRB criteria) randomized controlled trial (112) of facet joint nerve blocks in the lumbar spine with long-term follow-up (82,117). In the cervical spine, the evidence is Level II based on one high quality randomized controlled trial (83) and the evidence is Level II in the thoracic spine based on one high quality randomized controlled trial (84).

The evidence for intraarticular facet joint injections is variable between the lumbar and cervical spines. There is no evidence available for thoracic intraarticular injections. The evidence for lumbar intraarticular injections of steroids is Level III, based on 3 high quality randomized controlled trials (121,123,124) showing effectiveness with short-term follow-up of less than 6 months and 2 moderate to high quality randomized controlled trials (110,111) showing a lack of effectiveness with a follow-up shorter than 6 months for short-term pain relief. The evidence for cervical intraarticular injections is Level IV based on one high quality randomized controlled trial (119) showing a lack of effectiveness and one moderate quality randomized controlled trial (129) demonstrating indeterminate results.

3.0 Discussion

The systematic review of randomized trials of efficacy of the spinal facet joint interventions in the lumbar, cervical and thoracic regions, with intraarticular injections, facet joint nerve blocks, and radiofrequency neurotomy, revealed variable results. A total of 20 randomized trials were assessed with moderate to high methodologic quality criteria.

Based on the available evidence, there is Level II evidence for lumbar radiofrequency neurotomy, Level II evidence for cervical radiofrequency neurotomy, and Level III evidence for thoracic radiofrequency neurotomy for long-term effectiveness. The evidence is Level II for lumbar, cervical, and thoracic facet joint nerve blocks for long-term effectiveness. For intraarticular injections, the evidence is Level III for lumbar intraarticular injections and Level IV for cervical intraarticular injections;

Table 9. *Study characteristics of randomized controlled trials and observational studies assessing lumbar radiofrequency neurotomy, facet joint nerve blocks, and intraarticular injections.*

Study Study Characteristic Methodological Quality Scoring	Number of Patients & Selection Criteria	Control	Interventions	Outcome Measures	Time of Measurement	Results	Strengths	Weaknesses	Conclusions
RADIOFREQUENCY NEUROTOMY									
Civelek et al, 2012 (117) Randomized, active-control trial Quality Scores: Cochrane = 9/12 IPM-QRB = 28/48	100 patients with chronic low back pain with failed conservative therapy and strict selection criteria; however, without diagnostic blocks.	Facet joint nerve block with local anesthetic and steroids in 50 patients.	Conventional radiofrequency neurotomy at 80°C for 120 seconds in combination with high dose local anesthetic and steroids, in 50 patients.	Visual Numeric Pain Scale, North American Spine Society patient satisfaction questionnaire, Euro-Qol in 5 dimensions and ≥ 50% relief	One month, 6 months, 12 months	At one year, 90% of patients in the radiofrequency group and 69% of the patients in the facet joint nerve block group showed significant improvement compared to 92% and 75% at 6-month follow-up.	Randomized relatively large number of patients with 50 in each group.	No diagnostic blocks were performed. High dose steroids and local anesthetics were utilized in both groups.	Efficacy was shown even without diagnostic blocks, both for facet joint nerve blocks and radiofrequency neurotomy.
Cohen et al, 2010 (108) Randomized, double-blind, active control trial Quality Scores: Cochrane = 8/12 IPM-QRB = 28/48	151 chronic low back pain 51 patients with no diagnostic block 50 patients a single diagnostic block 50 patients in double diagnostic block.	Radiofrequency neurotomy in patients without diagnostic blocks.	Conventional radiofrequency neurotomy at 80° C for 90 seconds in all patients; however, in 2 groups with either a single block paradigm or a double block paradigm testing for positive results.	Greater than 50% pain relief coupled with a positive global perceived effect persisting for 3 months.	3 months	Denervation success rates in Groups 0, 1, and 2 were 33%, 39%, and 64% respectively.	Multicenter, randomized controlled trial with or without diagnostic blocks	Authors misinterpreted cost-effectiveness without consideration of many factors reported.	Results showed efficacy when double diagnostic blocks were utilized.
Nath et al, 2008 (113) Randomized, double-blind, sham control trial Quality Scores: Cochrane = 12/12 IPM-QRB = 42/48	40 patients with chronic low back pain for at least 2 years with 80% relief of low back pain after controlled medial branch blocks. The patients were randomized into an active and a control group.	Sham control with placement of the needles with injection of local anesthetic without radiofrequency neurotomy.	The 20 patients in the active group received conventional lumbar facet joint radiofrequency neurolysis at 85°C for 60 seconds. The 20 patients in the control group received sham treatment without radiofrequency neurolysis of the lumbar facet joints.	Numeric Rating Scale, global functional improvement, reduced opioid intake, employment status.	6 months	Significant reduction not only in back, and leg pain; functional improvement; opioid reduction; and employment status in the active group compared to the control group.	Randomized, double-blind trial after the diagnosis of facet joint pain with triple diagnostic blocks	Short-term follow-up with small number of patients	Efficacy of radiofreqency neurotomy was shown compared to local anesthetic injection and sham lesioning.
Tekin et al, 2007 (116) Randomized, active and sham, double-blind controlled trial Quality Scores: Cochrane = 12/12 IPM-QRB = 37/48	60 patients with chronic low back pain randomized into 3 groups with 20 patients in each group. Single diagnostic block of facet joint nerves with 0.3 mL of lidocaine 2% with 50% or greater relief.	Sham control with local anesthetic injection	Either pulsed radiofrequency (42°C for 4 minutes) or conventional radiofrequency neurotomy (80°C for 90 seconds) in 20 patients in each group.	Visual analog scale and Oswestry Disability Index	3, 6, and 12 months	Visual analog scale and Oswestry Disability Index scores decreased in all groups from 3 procedural levels. Decrease in pain scores was maintained in the conventional radiofrequency group at 6 months and one year. However, in pulsed radiofrequency group, the improvement was significant only at 6 months, but not one year.	Randomized, double-blind, controlled trial comparing control, pulsed radiofrequency, and conventional radiofreqency neurotomy. Authors also utilized a parallel needle placement approach	Small sample size with a single block and 50% relief as inclusion criteria. Authors did not report significant improvement percentages.	Efficacy with conventional radiofreqency neurotomy up to one year, whereas efficacy with local anesthetic block with sham control radiofrequency neurotomy and pulsed radiofrequency neurotomy at 6 months only.

Table 9 (cont.). *Study characteristics of randomized controlled trials and observational studies assessing lumbar radiofrequency neurotomy, facet joint nerve blocks, and intraarticular injections.*

Study Study Characteristic Methodological Quality Scoring	Number of Patients & Selection Criteria	Control	Interventions	Outcome Measures	Time of Measurement	Results	Strengths	Weaknesses	Conclusions
van Wijk et al, 2005 (114) Randomized, double-blind, sham control trial Quality Scores: Cochrane = 12/12 IPM-QRB = 36/48	81 patients with chronic low back pain were evaluated with radiofreqency neurotomy with 41 patients in the control group with at least 50% relief for 30 minutes with a single block with intraarticular injection of 0.5 mL lidocaine 2%.	Sham lesion procedure after local anesthetic injection	40 patients received conventional radiofrequency lesioning at 80°C for 60 seconds and 41 patients received sham lesioning.	Pain relief, physical activities, analgesic intake, global perceived effect, Short-form-36, quality of life measures	3 months	Global perceived effect improved after radiofrequency facet joint denervation. The visual analog scale in both groups improved. The combined outcome measures showed no difference between radiofreqency facet joint denervation (27.5% vs. 29.3% success rate).	Double-blind, sham control, randomized trial	Poor selection with a single diagnostic block of 50% pain reduction even though 17.5% of the patients were tested positive. Further, authors described that the needle was positioned parallel; however, the radiographic figures illustrate the needle was being positioned perpendicularly rather than parallel to the nerve.	Lack of efficacy with methodologic deficiencies and a short-term follow-up.
Dobrogowski et al, 2005 (118) Randomized, active control trial Quality Scores: Cochrane = 10/12 IPM-QRB = 29/48	45 consecutive patients with chronic low back pain judged to be positive with significant relief with 2 controlled diagnostic blocks	Injection of saline in patients after conventional radiofrequency (85° for 60 seconds) neurotomy to evaluate postoperative pain	Conventional radiofrequency neurotomy at 85°C for 60 seconds, followed by injection of either methylprednisolone or pentoxifylline	Visual analog scale, minimum of 50% reduction of pain intensity, patient satisfaction score	One, 3, 6, and 12 months	Greater than 50% reduction of pain intensity was observed in 66% of the patients 12 months later. There was no difference in the long-term outcomes.	Randomized, active control trial	Very small study with highly defined inclusion criteria evaluating effectiveness of radiofrequency neurotomy and postoperative pain.	Radiofrequency neurotomy effective with or without steroid injection after neurolysis.
Van Kleef et al, 1999 (115) Randomized, double-blind, sham control trial Quality Scores: Cochrane = 12/12 IPM-QRB = 40/48	31 patients with a history of at least one year of chronic low back pain randomly assigned to one of 2 treatment groups. Single diagnostic block with 50% relief.	Sham control of radiofrequency after local anesthetic injection in 16 patients	The 15 patients in the conventional radiofrequency treatment group received an 80° C radiofrequency lesion for 60 seconds.	Visual analog scale, pain scores, global perceived effect, Oswestry Disability Index	3, 6, and 12 months	After 3, 6, and 12 months, the number of successes in the lesion and sham groups was 9 of 15 (60%) and 4 of 16 (25%), 7 of 15 (47%) and 3 of 16 (19%), and 7 of 15 (47%) and 2 of 16 (13%) respectively. There was a statistically significant difference.	Double-blind, randomized, sham controlled trial	A single block with a small sample with inclusion criteria of 50% pain relief to enter the study. The study has been criticized that electrodes were placed at an angle to the target nerve, instead of parallel.	Efficacy shown in a small sample with a single diagnostic block

Table 9 (cont.). *Study characteristics of randomized controlled trials and observational studies assessing lumbar radiofrequency neurotomy, facet joint nerve blocks, and intraarticular injections.*

Study Study Characteristic Methodological Quality Scoring	Number of Patients & Selection Criteria	Control	Interventions	Outcome Measures	Time of Measurement	Results	Strengths	Weaknesses	Conclusions
Moon et al, 2013 (122) Prospective, randomized, active control, comparative analysis Quality Scores: Cochrane = 9/12 IPM-QRB = 38/48	82 patients were included with low back pain with 41 patients in each group either with a parallel placement of the needle or perpendicular placement of the needle. Concordant pain relief of >50% after a comparative local anesthetic block.	An active control trial with needle placement with perpendicular approach.	41 patients in each group were treated with radiofrequency (80°C for 90 seconds) after appropriate diagnosis of facet joint pain with dual diagnostic blocks with 50% relief as the criterion standard. The needle was positioned either utilizing a discal or perpendicular approach or utilizing a tunnel vision approach with parallel placement of the needle.	Numeric Rating Scale, Oswestry Disability Index	One month and 6 months	Patients in both groups showed a statistically significant reduction in NRS and Oswestry disability index scores from baseline to that of the scores at one and 6 months (all $P < 0.0001$, Bonferroni corrected).	Randomized, double-blind, controlled trial. The major strength is that authors have proven that parallel approach may not be the best as has been described. Diagnosis of facet joint pain by dual blocks.	Active controlled trial without placebo group. Short-term follow-up.	Positive results in an active controlled trial, in a relatively short-term follow-up of 6 months, with positioning of the needle either with distal approach (perpendicular placement or tunnel vision) with parallel placement of the needle with some superiority with perpendicular approach. This trial abates any criticism of needle positioning one way or the other and the traditional needle positioning appears to be superior to parallel needle placement.
Lakemeier et al, 2013 (123) Randomized, double-blind, active controlled trial Quality Scores: Cochrane = 9/12 IPM-QRB = 37/48	56 patients were randomized into 2 groups with 29 patients receiving intraarticular steroid injections and 27 patients receiving radiofrequency denervation after the diagnosis was made with intraarticular injection of local anesthetic with a single block with pain reduction of at least 50%.	Intraarticular injection of local anesthetic and steroid	Radiofrequency neurotomy for 90 seconds at 80°C	Roland-Morris questionnaire, visual analog scale, Oswestry Disability Index, analgesic intake	6 months	Pain relief and functional improvement were observed in both groups. There were no significant differences between the 2 groups for pain relief and functional status improvement.	Lack of placebo group. Relatively short-term follow-up.	Randomized, double-blind trial with single diagnostic block with intraarticular injection	Both groups showed improvement. Effectiveness at 6 months in both groups with intraarticular injection or radiofrequency neurotomy.

Table 9 (cont.). *Study characteristics of randomized controlled trials and observational studies assessing lumbar radiofrequency neurotomy, facet joint nerve blocks, and intraarticular injections.*

Study Study Characteristic Methodological Quality Scoring	Number of Patients & Selection Criteria	Control	Interventions	Outcome Measures	Time of Measurement	Results	Strengths	Weaknesses	Conclusions
LUMBAR FACET JOINT NERVE BLOCKS									
Civelek et al, 2012 (117) Randomized, active-control trial Quality Scores: Cochrane = 9/12 IPM-QRB = 28/48	100 patients with chronic low back pain with failed conservative therapy and strict selection criteria; however, without diagnostic blocks.	Blocks of facet joint nerves with local anesthetic and steroids.	Conventional radiofrequency neurotomy at 80°C for 120 seconds in combination with high dose local anesthetic and steroids.	Visual Numeric Pain Scale, North American Spine Society patient satisfaction questionnaire, Euro-Qol in 5 dimensions and ≥ 50% relief	One month, 6 months, 12 months	At the end of one year, 90% of patients in the radiofrequency group and 69% of the patients in the facet joint nerve block group showed significant improvement vs. 92% and 75% at 6-month follow-up.	Randomized active-control trial with relatively large number of patients with 50 in each group.	No diagnostic blocks were performed. High dose steroids and local anesthetics were provided in both groups.	Results showed efficacy even without diagnostic blocks, both for facet joint nerve blocks and radiofrequency neurotomy.
Manchikanti et al, 2010 (82) Randomized, double blind, active control trial Quality Scores: Cochrane = 11/12 IPM-QRB = 45/48	120 patients with chronic low back pain of facet joint origin treated with therapeutic lumbar facet joint nerve blocks. Double diagnostic blocks with 80% relief.	Local anesthetic only	Total of 120 patients with 60 patients in each group with local anesthetic alone or local anesthetic and steroids. Both groups were also divided into 2 categories each with the addition of Sarapin.	Numeric Rating Scale, Oswestry Disability Index, employment status, and opioid intake.	3, 6, 12, 18, and 24 months	Significant pain relief was shown in 85% in local anesthetic group and 90% in local anesthetic with steroids group at the end of the 2 year study period in both groups, with an average of 5-6 total treatments.	Randomized trial with relatively large proportion of patients with 2-year follow-up, with inclusion of patients diagnosed with controlled diagnostic blocks	Lack of placebo group	Effectiveness demonstrated with facet joint nerve blocks with local anesthetic with or without steroids.
Manchikanti et al, 2001 (112) Randomized, active control trial Quality Scores: Cochrane = 6/12 IPM-QRB = 34/48	73 patients with chronic low back pain diagnosed with dual diagnostic blocks were selected	Active control with local anesthetic and Sarapin	Facet joint nerve blocks with local anesthetic and Sarapin or with local anesthetic, Sarapin, and methylprednisolone	Numeric pain rating scale, functional status, opioid intake, employment status	2 ½ years	Results showed significant improvement in patients in both groups. Significant relief was seen in 100% of patients up to 3 months, 75% in Group I and 80% in Group II at 6 months and 12 months.	Moderate quality randomized trial with long-term follow-up	Appropriate randomization and allocation concealment were lacking.	Positive results with cost utility
LUMBAR INTRAARTICULAR INJECTIONS									
Carette et al, 1991 (110) Randomized, double blind, impure placebo or active-control trial Quality Scores: Cochrane = 11/12 IPM-QRB = 40/48	Patients with chronic low back pain who reported immediate relief of their pain after injection of local anesthetic into the facet joints. Single diagnostic blocks with 50% relief were randomly assigned to receive injections under fluoroscopic guidance.	Intraarticular injection of isotonic saline	Injection of either sodium chloride or methylprednisolone into the facet joints (49 for isotonic saline and 48 for sodium chloride). Only one injection was provided.	Visual Analog Scale, McGill Pain Questionnaire, mean sickness impact profile.	One, 3, and 6 months	After one month, 42% of the patients in the methylprednisolone group and 33% in the sodium chloride group reported marked or very marked improvement. At the 6 month evaluation, 46% in the methylprednisolone group and 15% in the placebo group showed sustained relief. . Revised statistics showed 22% improvement in active group and 10% in control group.	Well-performed randomized, double-blind controlled trial	Only single block was applied and patients were treated with steroids without local anesthetic with only one treatment and expected 6 months of relief.	The authors concluded that results were negative in an active-control trial with injection of either sodium chloride solution or steroid into the facet joints after diagnosis with a single block.

Table 9 (cont.). *Study characteristics of randomized controlled trials and observational studies assessing lumbar radiofrequency neurotomy, facet joint nerve blocks, and intraarticular injections.*

Study Study Characteristic Methodological Quality Scoring	Number of Patients & Selection Criteria	Control	Interventions	Outcome Measures	Time of Measurement	Results	Strengths	Weaknesses	Conclusions
Fuchs et al, 2005 (111) Randomized, double-blind, active-control trial Quality Scores: Cochrane = 8/12 IPM-QRB = 26/48	60 patients with chronic low back pain were included with patients randomly assigned into 2 groups. No diagnostic blocks	Active-control study with no control group	Intraarticular injection of hyaluronic acid versus glucocorticoid injection.	Visual Analog Scale, Rowland-Morris Questionnaire, Oswestry Disability Index, low back outcomes score, Short Form-36	3 months and 6 months	Patients reported lasting pain relief, better function, and improved quality of life with both treatments.	Randomized, active-control, double-blind study	Relatively small sample of patients with 6 month follow-up without a placebo group, without diagnostic blocks.	Undetermined (clinically inapplicable) results with high number of injections during a 6-month period.
Ribeiro et al, 2013 (121) Randomized, double-blind, active control Quality Scores: Cochrane = 10/12 IPM-QRB = 32/48	60 patients with a diagnosis of facet joint syndrome randomized into experimental and control groups.	Triamcinolone acetonide intramuscular injection of 6 lumbar paravertebral points	Intraarticular injection of 6 lumbar facet joints with triamcinolone hexacetonide	Pain visual analog scale, pain visual analog scale during extension of the spine, Likert scale, improvement percentage scale, Roland-Morris, 36-Item Short Form Health Survey, and accountability of medications taken.	One, 4, 12, and 24 weeks	Improvement "percentage" analysis at each time point, showed significant differences between the groups at week 7 and week 12. Improvement percentage was > 50% at all times in the experimental group with intraarticular steroids; however, significant difference was noted at 24 weeks only.	Randomized, double-blind controlled trial	Diagnostic blocks were not employed, thus, many patients without facet joint pain may have been included in this trial.	Overall intraarticular steroids showed positive effective for 24 weeks compared to intramuscular steroids provided in a double-blind manner.
Lakemeier et al, 2013 (123) Randomized, double-blind, active controlled trial Quality Scores: Cochrane = 9/12 IPM-QRB = 37/48	56 patients were randomized into 2 groups receiving intraarticular steroid injections or radiofrequency denervation after the diagnosis was made with intraarticular injection of local anesthetic with a single block.	Intraarticular injection of local anesthetic and steroid in 29 patients	Radiofrequency neurotomy for 90 seconds at 80°C in 27 patients	Roland-Morris questionnaire, Visual Analog Scale, Oswestry Disability Index, analgesic intake	6 months	Pain relief and functional improvement were observed in both groups. There were no significant differences between the 2 groups for pain relief and functional status improvement.	Lack of placebo group. Relatively short-term follow-up.	Randomized, double-blind trial with single diagnostic block with intraarticular injection	Both groups showed improvement. Effectiveness of both modalities at 6 months in both groups.

Table 9 (cont.). *Study characteristics of randomized controlled trials and observational studies assessing lumbar radiofrequency neurotomy, facet joint nerve blocks, and intraarticular injections.*

Study Characteristic Methodological Quality Scoring	Number of Patients & Selection Criteria	Control	Interventions	Outcome Measures	Time of Measurement	Results	Strengths	Weaknesses	Conclusions
Yun et al, 2012 (124) Randomized, active controlled trial Quality Scores: Cochrane = 9/12 IPM-QRB = 26/48	57 patients with facet syndrome were assigned to 2 groups with 32 patients in the fluoroscopy group and 25 patients in the under ultrasonography group without diagnostic blocks	Intraarticular injection of lidocaine and triamcinolone under fluoroscopic guidance	Intraarticular injection of lidocaine and triamcinolone under ultrasonic guidance	Visual Analog Scale, physician's and patient's global assessment (PhyGA, PaGA), modified Oswestry Disability Index	One week, one and 3 months	Each group showed significant improvement from the facet joint injections. However at one week, one month, and 3 months after injections, no significant differences were observed between the groups.	Randomized trial	Short-term follow-up with no diagnostic blocks, thus increasing the potential for inclusion of patients without facet joint pain. The aim of study mainly was to confirm if ultrasonic imaging was appropriate.	The study showed positive results in both groups with intraarticular steroid injections with a short-term follow-up whether performed under ultrasonic guidance or fluoroscopy.

there were no trials available for thoracic intraarticular injection therapy.

The evidence for lumbar facet joint neurotomy is Level I for short-term effectiveness (< 6 months) and Level II for long-term effectiveness of 6 months or longer based on 8 moderate to high quality trials showing effectiveness (108,113,115,116,117,118,122,123), and one moderate to high quality trial (114) showed a lack of effectiveness. These results are in agreement with previously published systematic reviews (55-61). With recent publications, significant evidence has been demonstrated for lumbar radiofrequency neurotomy; however, multiple studies continue to include a small number of patients often with short-term follow-up. Among the long-term trials with effectiveness assessed at least at one year, Civelek et al (117) included 50 patients. Tekin et al (116) included 20 patients in the conventional radiofrequency neurotomy group; whereas, van Kleef et al (115) included only 15 patients in the radiofrequency neurotomy group showing positive results with a total number of 85 patients included. In contrast, van Wijk et al (114) showed a lack of effectiveness in 40 patients undergoing radiofrequency neurotomy.

The other studies by Cohen et al (108) included 14 patients with dual blocks; Nath et al (113) included 20 patients; Dobrogowski (118) included 45 patients; Moon et al (122) included 82 patients utilizing 2 different types of techniques; and Lakemeier et al (123) included 27 patients. Even though meta-analysis was not feasible based on a lack of homogeneity, others have attempted meta-analysis (59). Overall, other studies also showed similar results. Poetscher et al (59) and Leggett et al (58) showed positive results including the same studies included in this systematic review with best evidence synthesis. Both systematic reviews concluded that radiofrequency neurotomy has significant efficacy; however, others have showed a lack of efficacy (66,67). Overall, multiple deficiencies in these systematic reviews have been pointed out, including the small sample size of patients and the lack of homogeneity. Saltychev and Laimi (156) criticized the systematic review by Poetscher et al (59) for its lack of homogeneity. They noted that all conclusions were drawn from 2 studies (114,116), which were responsible for 85% of the entire synthesis. Further, the trial by Leclaire et al (165) was utilized in all recent systematic reviews (58,59,66,67), which has been considered as inappropriate and was excluded from this systematic review since the authors themselves have acknowledged multiple

Table 10. *Study characteristics of randomized trials and observation studies assessing cervical and thoracic radiofrequency neurotomy, facet joint nerve blocks, and intraarticular injections.*

Study **Study Characteristic** **Methodological Quality Scoring**	**Number of Patients & Selection Criteria**	**Control**	**Interventions**	**Outcome Measures**	**Time of Measurement**	**Results**	**Strengths**	**Weaknesses**	**Conclusions**
CERVICAL RADIOFREQUENCY									
Lord et al, 1996 (128) Randomized, sham control, double-blind Quality Scores: Cochrane = 11/12 IPM-QRB = 45/48	24 patients selected in a specialty cervical spine research unit in Australia suffering with chronic pain of cervical facet joint origin after whiplash injury and have failed conservative management. The diagnosis was confirmed with the use of double-blind, placebo-controlled local anesthetics with complete pain relief.	Sham control with placement of the needles with injection of local anesthetic without radiofrequency neurotomy.	Radiofrequency group 90 second lesion at 80°C of medial branch; control group received sham treatment with electrode insertion. Even though this is described as a placebo-control treatment, maybe it is better to be called sham control since each patient received local anesthetic block which has been shown to be effective in itself (83). Authors also produced multiple lesions at each level.	0 to 5 of 100 on visual analog scale; word count 3 or less on McGill Pain questionnaire.	3, 6, and 12 month follow-up	Median time to return of pain in treatment group was 263 days; 8 days in control group; 10 patients underwent second procedures with varying results.	Highly controlled design with meticulous diagnostic techniques and radiofrequency neurotomy.	Small group size and has been criticized for creative statistical analysis.	Efficacy was shown even though the study has been criticized for small group size and variations with creative statistical analysis. This study continues to be the landmark evaluation to show efficacy of radiofrequency neurotomy in the cervical spine.
Sapir & Gorup, 2001 (159) Prospective Quality Score: IPM-QRBNR = 40/48	32 litigants and 18 non-litigants underwent radiofrequency neurotomy. Patients with cervical whiplash who remained symptomatic after 20 weeks of conservative management were included. Inclusion criteria were 80% reduction in pain with controlled comparative local anesthetic blocks. 50 patients underwent radiofrequency neurotomy and 46 patients completed the study.	No control available.	The details for radiofreqency neurotomy were not provided.	Visual analog scale and self-report of improvement.		66% of the patients in the litigation group and 71% of the patients in the non-litigation group reported relief for more than one year. Time to recurrence defined as 50% return of pain was 8.0 ± 2.0 months. The frequency of recurrence of pain was similar in both groups.	Appropriate selection criteria with outcomes assessment in a prospective study.	Nonrandomized study with rather small number of patients.	The results were positive in this study in both litigants and non-litigants; however, there were only 32 litigants and 18 non-litigants undergoing radiofrequency neurotomy. Further, the difference between groups in the degree of symptomatology or response to treatment did not reach significance.

Table 10 (cont.). *Study characteristics of randomized trials and observation studies assessing cervical and thoracic radiofrequency neurotomy, facet joint nerve blocks, and intraarticular injections.*

Study **Study Characteristic** **Methodological Quality Scoring**	**Number of Patients & Selection Criteria**	**Control**	**Interventions**	**Outcome Measures**	**Time of Measurement**	**Results**	**Strengths**	**Weaknesses**	**Conclusions**
MacVicar et al, 2012 (160) Prospective Quality Score: IPM-QRBNR =38/48	A total of 104 patients selected on the basis of complete relief of pain following controlled, diagnostic, medial branch blocks were treated with radiofrequency neurotomy. The study was performed at 2 centers in New Zealand. A heterogenous group of patients were included with suspicion of cervical zygapophysial joint pain. Patients were selected following the controlled comparative local anesthetic blocks with 100% pain relief concordant with duration of local anesthetic.	No control available.	Radiofreqency neurotomy was performed by placing the needles parallel to medial branches, with creation of sufficient lesions in the sagittal and in an oblique plain, with 16-gauge 10 cm electrodes with 5 mm exposed tips. Radiofrequency was performed at 80°C or 85°C for 90 seconds for each lesion.	Successful outcome was defined as complete relief of pain, or at least 80% relief, for at least 6 months, with complete restoration of activities of daily living, no need for any further health care, and return to work.		In the 2 practices, 74% and 61% of the patients achieved a successful outcome. Relief lasted 17 to 20 months from the first radiofrequency neurotomy and 15 months for repeat treatments. Patients maintained relief for a median duration of 20 to 26 months, with 60% still having relief at follow-up.	The rigorous study was performed utilizing a rigorous criteria in a practical setting in New Zealand with impressive results.	Observational study performed in 2 different practices.	Positive results in a long-term follow-up with strict inclusion criteria with a meticulous technique with impressive results.
Speldewinde, 2011 (161) Prospective Quality Score: IPM-QRBNR = 39/48	A total 151 procedures were performed in the cervical spine on 130 patients. During the period from 2001 to 2010, patients were selected for radiofrequency thermal neurotomy in whom a diagnosis of cervical zygapophysial joint pain had been established with at least 2 fluoroscopically guided diagnostic medial branch nerve or intraarticular injections providing at least 80% relief in the index pain for the duration of action of local anesthetic used.	No control available.	Radiofrequency was performed at 80°C for 90 seconds for medial branches.	Numeric Rating Scale, Functional Rating Index, Activities of Daily Living, General Health Questionnaire, psychiatric morbidity		Cervical radiofrequency neurotomy was successful in 76% of the patients. The outcomes were similar in all 3 regions. A significant proportion of patients had relief for longer than one year. Average pain relief was 12 months in the cervical spine with average of 88% pain relief.	Even though study was prospective, design was appropriate and strict inclusion criteria with meticulous technique were utilized. Excellent outcome measures	Observational study.	Positive results. The study was performed in a community setting giving more of a practical setting in Australia.

Table 10 (cont.). *Study characteristics of randomized trials and observation studies assessing cervical and thoracic radiofrequency neurotomy, facet joint nerve blocks, and intraarticular injections.*

Study **Study Characteristic** **Methodological Quality Scoring**	**Number of Patients & Selection Criteria**	**Control**	**Interventions**	**Outcome Measures**	**Time of Measurement**	**Results**	**Strengths**	**Weaknesses**	**Conclusions**
CERVICAL FACET JOINT NERVE BLOCKS									
Manchikanti et al, 2010 (83) Randomized, double-blind, active-control Quality Scores: Cochrane = 11/12 IPM-QRB = 45/48	120 patients were recruited from consecutive new patients presenting to an interventional pain management practice with neck pain without suspected disc herniation or radiculitis. All the patients had conservative management and were judged to be positive for facet joint pain utilizing controlled comparative local anesthetic blocks with 80% pain relief and ability to perform previously painful movements. 60 patients received local anesthetic with steroid and another 60 patients received local anesthetics alone. 30 patients in each group also received Sarapin with local anesthetic and steroids.	Active control with local anesthetic and Sarapin	Cervical medial branch nerve blocks with fluoroscopy were performed utilizing local anesthetic with or without Sarapin or steroid.	Measured numeric pain scores, Neck Pain index, opioid intake, and employment status at baseline. The procedures were repeated upon the return of pain and deterioration in functional status to less than 50%.	3, 6, 12, 18, and 24 months	85% of the patients with local anesthetic only and 92% of the patients with steroid reported significant pain relief at 12 months, whereas the statistics were 85% in local anesthetic group and 93% in local anesthetic with steroid group at the end of 2 years. Functional status improvement of 50% or more by Neck Disability Index was seen in 63% and 68% at 12 months and 70% and 75% at 24 months in local anesthetic group and local anesthetic with steroid group.	Randomized trial with relatively large proportion of patients with 2-year follow-up, with inclusion of patients diagnosed with controlled diagnostic blocks.	Lack of placebo group	This is the first study conducted evaluating therapeutic medial branch blocks in a randomized double-blind fashion, with effectiveness of facet joint nerve blocks with or without steroids.
Manchikanti et al, 2004 (152) Prospective Quality Score: IPM-QRBNR = 37/48	100 consecutive patients meeting the diagnostic criteria of facet joint pain by means of comparative, controlled diagnostic blocks, with disabling chronic neck pain of various origins of at least 6 months duration and have failed conservative management were included.	No control available.	Medial branch blocks with fluoroscopy with bupivacaine with or without methylprednisolone. Patients had repeat blocks as clinically indicated.	Pain relief, Oswestry Disability Index, psychological status, work status	Timing: 3 months, 6 months, and 12 months	Significant pain relief at 3, 6, and 12 months, compared to baseline measurements. There was also significant improvement in disability status, psychological status, and return to work. Significant pain relief was observed at 92% at 3 months, 82% at 6 months, and 56% at 12 months.	First trial available	Non-randomized	Positive This was the first evaluation ever published in the cervical spine evaluating the role of therapeutic cervical medial branch blocks.

Table 10 (cont.). *Study characteristics of randomized trials and observation studies assessing cervical and thoracic radiofrequency neurotomy, facet joint nerve blocks, and intraarticular injections.*

Study **Study Characteristic** **Methodological Quality Scoring**	**Number of Patients & Selection Criteria**	**Control**	**Interventions**	**Outcome Measures**	**Time of Measurement**	**Results**	**Strengths**	**Weaknesses**	**Conclusions**
CERVICAL INTRAARTICULAR INJECTIONS									
Barnsley et al, 1994 (119) Randomized, double-blind, active-control Quality Scores: Cochrane = 12/12 IPM-QRB = 36/48	41 patients with involvement of one or more cervical zygapophysial joints after automobile accidents with median duration of pain of 39 months were randomly assigned into 2 groups.	Active control trial with injection of intraarticular local anesthetic.	Intraarticular injection of 5.7 mg betamethasone or 1 mL intraarticular bupivacaine	Pain relief		No significant difference in duration of pain relief. Median duration of time to return of pain to 50% was 3 days in the steroid group and 3.5 days in the local anesthetic group.	Randomized controlled trial.	Small sample size, extremely short follow-up period.	Lack of effectiveness. Authors injected local anesthetic or steroid into the joint, thus this is not placebo controlled, it is rather an active-control trial.
Park & Kim, 2012 (129) Randomized, active control Quality Scores: Cochrane = 6/12 IPM-QRB = 35/48	200 patients were studied in each group either with intraarticular injections or conservative management. Patients were selected for therapeutic intraarticular injections if they were positive for facet joint pain utilizing dual diagnostic blocks with concordant 80% pain relief.	Conservative management controlled trial.	Intraarticular injections were performed with 0.5 mL of 1% lidocaine and 5 mg of triamcinolone and 187.5 international units of hyaluronidase. Patients also received either onabotulinumtoxinA or trigger point injections if they required; however, these were of a small number.	Cervical range of motion, numeric rating scale for pain, comorbid tension type headache		Patients receiving intraarticular injections on one occasion showed increased cervical range of motion, increased mean numeric rating scale pain reduction, and decreased incidence of combined tension-type headache compared with control group receiving conservative management during follow-up.	Randomized controlled trial in a large proportion of patients.	Intraarticular injections were compared with conservative management. The study was also confounded with multiple deficiencies including trigger point injections and Botox injections in some patients with greater than 20% withdrawal rate.	Undetermined This study showed effectiveness of intraarticular injections.

Table 10 (cont.). *Study characteristics of randomized trials and observation studies assessing cervical and thoracic radiofrequency neurotomy, facet joint nerve blocks, and intraarticular injections.*

Study **Study Characteristic** **Methodological Quality Scoring**	**Number of Patients & Selection Criteria**	**Control**	**Interventions**	**Outcome Measures**	**Time of Measurement**	**Results**	**Strengths**	**Weaknesses**	**Conclusions**
THORACIC RADIOFREQUENCY									
Joo et al, 2013 (120) Randomized, double-blind, active control Quality Scores: Cochrane = 10/12 IPM-QRB = 38/48	40 patients with recurrent thoracolumbar facet joint pain after successful thermal radiofrequency ablation (RFA) defined as a numeric rating scale (NRS) score of 7 or a revised Oswestry disability index (ODI) of 22% were randomly allocated to 2 groups receiving either the same repeated RFA (n = 20) or alcohol ablation (AA) (n = 20).	Active control with alcohol.	Patients were provided with similar interventions with placement of radiofrequency needles, electric stimulation, contrast medium injection, local anesthetic injection followed by either radiofrequency thermoneurolysis for 90 seconds at 90°C or injection of 1 mL volume over a period of 15 seconds.	The recurrence rate was assessed with NRS and ODI and adverse events		After RFA and AA, one and 17 patients, respectively, were without recurring thoracolumbar facet joint pain. The median effective periods in the RFA and AA groups were 10.7 (range 5.4–24) and 24 (range 16.8–24) months, respectively (P = 0.000).	Randomized, double-blind, active control trial with appropriate outcomes assessment.	Small sample size. Selection criteria which included only the patients who required repeat thoracolumbar facet joint neurotomy after prior successful procedure.	This trial is the first of its nature for the thoracic spine in a randomized fashion with active control design. Specific importance is that they selected only the patients who had responded successfully with the first radiofrequency treatment for at least 6 months and then randomized them to assess the differences between alcohol injection and radiofrequency neurotomy. Alcohol treatment was superior to radiofrequency for recurrent pain; however, this also shows effectiveness of radiofrequency neurotomy though inferior to alcohol with long-term follow-up of 24 months.

Table 10 (cont.). *Study characteristics of randomized trials and observation studies assessing cervical and thoracic radiofrequency neurotomy, facet joint nerve blocks, and intraarticular injections.*

Study Study Characteristic Methodological Quality Scoring	Number of Patients & Selection Criteria	Control	Interventions	Outcome Measures	Time of Measurement	Results	Strengths	Weaknesses	Conclusions
THORACIC FACET JOINT NERVE BLOCKS									
Manchikanti et al, 2012 (84) Randomized, double-blind, active controlled trial Quality Scores: Cochrane = 10/12 IPM-QRB = 45/48	100 patients were included with 50 patients in each of the local anesthetic and steroid groups. Selection was with controlled diagnostic blocks with criterion standard of 80% concordant pain relief.	Local anesthetic only.	Local anesthetic patients received thoracic medial branch blocks with bupivacaine. Local anesthetic with steroid patients received thoracic medial branch blocks with bupivacaine and non-particulate betamethasone.	Numeric pain scores, Oswestry Disability Index, opioid intake, and return to work status. Significant pain relief was defined as > 50% relief. Significant functional improvement was > 40% reduction of Oswestry Disability Index.	All outcomes were assessed at baseline, 6 months, 12 months, and 24 months.	In local anesthetic group, 80% of patients showed significant pain relief and functional improvement at 12 and 24 months. In local anesthetic with steroid group, 84% of patients showed significant pain relief and functional improvement at 12 months and 24 months. The majority of patients experienced significant pain relief for 46 to 47 weeks, requiring approximately 3 to 4 treatments with an average relief of 14 to 16 weeks per episode of a treatment.	Significant pain relief was shown in 85% in local anesthetic group and 90% in local anesthetic with steroids group at the end of the 2 year study period an average of 5 - 6 total treatments in both groups.	Randomized trial with relatively large proportion of patients with 2-year follow-up, with inclusion of patients diagnosed with controlled diagnostic blocks	The majority of patients in both groups experienced significant pain relief and improvement in functional status. Therapeutic thoracic medial branch blocks, with or without steroid.
Manchikanti et al, 2006 (162) Prospective outcome study Quality Score: IPM-QRBNR = 37/48	55 consecutive patients, all meeting diagnostic criteria for thoracic facet joint pain	None	Thoracic facet joint nerve blocks performed using bupivacaine with or without Sarapin and depomethylprednisolone	Measured numeric pain scores, Oswestry Disability Index, employment status, and Pain Patient Profile.	3, 6, 12, 24, and 36 months.	Significant (≥ 50%), was observed in 71% of the patients at 3 months and 6 months, 76% at 12 months, 71% at 24 months, and 69% at 36 months.			Therapeutic thoracic medial branch blocks were an effective modality of treatment in managing chronic thoracic pain secondary to facet joint involvement confirmed by controlled, comparative local anesthetic blocks. Positive short-term and long-term relief.

Table 11. *Efficacy of lumbar radiofrequency, facet joint nerve blocks, and intraarticular injections.*

Study Study Characteristic Methodological Quality Scoring	Patients	Interventions	Pain Relief and Function			Results			Comments
			3 mos.	6 mos.	12 mos.	Short-Term ≤ 6 mos.	Long-Term		
							> 6 mos.	≥ 1 year	
LUMBAR RADIOFREQUENCY NEUROTOMY									
Civelek et al, 2012 (117) RA, AC Quality Scores: Cochrane = 9/12 IPM-QRB = 28/48	100	CRF = 50 Facet joint nerve blocks = 50	NA	92% vs. 75%	90% vs. 69%	NA	P	P	Effective for short and long-term
Cohen et al, 2010 (108) RA, DB Quality Scores: Cochrane = 8/12 IPM-QRB = 28/48	"0" block = 51 One block = 20 Two blocks = 14	CRF	"0" group = 33% One block = 39% Two blocks = 64%	NA	NA	P in dual block group	NA	NA	Effective in short-term results with application of dual blocks Not effective with no or single diagnostic blocks.
Nath et al, 2008 (113) RA, DB, Sham control Quality Scores: Cochrane = 12/12 IPM-QRB = 42/48	40	Radiofrequency = 20 Sham = 20	NA	Significant proportion of patients in interventional group	NA	P for radiofrequency N for sham or active	P for radiofrequency N for sham or active	NA	Effective for short and long-term
Tekin et al, 2007 (116) RA, AC and sham, DB Quality Scores: Cochrane = 12/12 IPM-QRB = 37/48	60	CRF = 20 PRF = 20 Control = 20	NA	SI with CRF	SI with CRF	NA	P for radiofrequency N for sham	P for radiofrequency N for sham	Effective in long-term
van Wijk et al, 2005 (114) RA, DB, Sham control Quality Scores: Cochrane = 12/12 IPM-QRB = 36/48	81	Radiofrequency = 40 Sham = 41	27.5% vs. 29.3%	27.5% vs. 29.3%	27.5% vs. 29.3%	N	N	N	Lack of effectiveness with short- and long-term

Table 11 (cont.). *Efficacy of lumbar radiofrequency, facet joint nerve blocks, and intraarticular injections.*

Study **Study Characteristic** **Methodological Quality Scoring**	**Patients**	**Interventions**	**Pain Relief and Function**			**Results**			**Comments**
			3 mos.	**6 mos.**	**12 mos.**	**Short-Term ≤ 6 mos.**	**Long-Term**		
							> 6 mos.	**≥ 1 year**	
Dobrogowski et al, 2005 (118) RA, AC Quality Scores: Cochrane = 10/12 IPM-QRB = 29/48	45	CRF	NA	60%	NA	NA	P	NA	Short- and long-term effectiveness
van Kleef et al, 1999 (115) RA, DB, sham control Quality Scores: Cochrane = 12/12 IPM-QRB = 40/48	31	Radiofrequency = 15 Sham = 16	60% vs. 25%	47% vs. 19%	47% vs. 13%	P for radiofrequency N for sham or active	P for radiofrequency N for sham	P for radiofrequency N for sham	Effectiveness with short- and long-term
Moon et al, 2013 (122) Prospective, RA, comparative study Quality Scores: Cochrane = 9/12 IPM-QRB = 38/48	Total = 82 Tunnel vision approach group – 41 patients included and 34 patients analyzed.	Radiofrequency neurotomy distal approach	SI in both groups	SI in both groups	NA	P	P	NA	Short- and long-term effectiveness
Lakemeier et al (123) RA, DB Quality Scores: Cochrane = 9/12 IPM-QRB = 37/48	Total = 56 Steroid group = 29 patients Radiofrequency group = 27 patients	Intraarticular lumbar facet joint steroid injections compared to lumbar facet joint radiofrequency denervation	NA	SI in both groups	NA	P	P	NA	Short- and long-term effectiveness
LUMBAR FACET JOINT NERVE BLOCKS									
Civelek et al, 2012 (117) RA, AC Quality Scores: Cochrane = 9/12 IPM-QRB = 28/48	100	LA with steroid = 50 CRF = 50	NA	75% vs. 92%	69% vs. 90%	NA	P	P	Long-term effectiveness

Table 11 (cont.). *Efficacy of lumbar radiofrequency, facet joint nerve blocks, and intraarticular injections.*

Study Study Characteristic Methodological Quality Scoring	Patients	Interventions	Pain Relief and Function			Results			Comments
			3 mos.	6 mos.	12 mos.	Short-Term ≤ 6 mos.	Long-Term		
							> 6 mos.	≥ 1 year	
Manchikanti et al, 2010 (82) RA, DB, AC Quality Scores: Cochrane = 11/12 IPM-QRB = 45/48	120	LA with steroid = 60 LA = 60	82% vs. 83%	93% vs. 83%	85% vs. 84%	P	P	P	Short- and long-term effectiveness
Manchikanti et al, 2001 (112) RA, AC Quality Scores: Cochrane = 6/12 IPM-QRB = 34/48	73	LA with steroid = 41 LA = 32	100% vs 100%	75% vs 80%	75% vs 80%	P	P	P	Positive short and long-term results
LUMBAR INTRAARTICULAR INJECTIONS									
Carette et al, 1991 (110) RA, DB, PC or AC Quality Scores: Cochrane = 11/12 IPM-QRB = 40/48	97	Methylprednisolone acetate =49 Isotonic saline =48 patients	33% vs. 42%	22% vs. 10%	NA	N	N	NA	Lack of effectiveness
Fuchs et al, 2005 (111) R, DB, AC Quality Scores: Cochrane = 8/12 IPM-QRB = 26/48	60	Hyaluronic acid versus glucocorticoid with 6 injections.	Significant proportion of patients	Significant proportion of patients	NA	U	U	NA	Effectiveness undetermined
Ribeiro et al, 2013 (121) RA, DB, AC Quality Scores: Cochrane = 10/12 IPM-QRB = 32/48	60	Intraarticular injection group = 31 Intramuscular steroid injection group = 29	52% vs 45%	55% vs 38%	NA	P	P	NA	Short- and long-term effectiveness

Table 11 (cont.). *Efficacy of lumbar radiofrequency, facet joint nerve blocks, and intraarticular injections.*

Study Study Characteristic Methodological Quality Scoring	Patients	Interventions	Pain Relief and Function			Results			Comments
			3 mos.	6 mos.	12 mos.	Short-Term ≤ 6 mos.	Long-Term		
							> 6 mos.	≥ 1 year	
Yun et al, 2012 (124) RA Quality Scores: Cochrane = 9/12 IPM-QRB = 26/48	Total = 57 Fluoroscopy group = 32 Ultrasonography group = 25	Intraarticular injection of local anesthetic and steroid	SI in both groups	NA	NA	*P*	NA	NA	Short-term effectiveness
Lakemeier et al, 2013 (123) RA, DB Quality Scores: Cochrane = 9/12 IPM-QRB = 37/48	Total = 56 Steroid group = 29 patients Radiofrequency group = 27 patients	Intraarticular lumbar facet joint steroid injections compared to lumbar facet joint radiofrequency denervation	NA	SI in both groups	NA	P	P	NA	Short-and long-term effectiveness

RA = randomized; DB = double-blind; AC = active control; ST = steroid; LA = local anesthetic; SAL = saline; SI = significant improvement; P = positive; N = negative; NA = not applicable

flaws in performing their trial. Further, multiple issues related to radiofrequency neurotomy and exclusion of studies is based on an author's own criteria such, as by Leclaire et al (165).

The evidence for cervical radiofrequency neurotomy was derived from only one high quality randomized controlled trial with an extremely small sample size of patients (128). There were no other trials; consequently, it appears that the level of evidence of II or III may be appropriate. Since there was only one randomized double-blind controlled trial, it may be worthwhile to look at the evidence from nonrandomized prospective trials. The randomized trial by Lord et al (128) included 24 patients and compared percutaneous radiofrequency neurotomy to a sham procedure. Thus, the technique of radiofrequency thermoneurolysis was the same, but radiofrequency lesioning was not performed in the sham control group.

The inclusion criteria were rather strict with comparative local anesthetic blocks with 100% concordant pain relief. The post-treatment assessment was carried out with the Visual Analog Scale and the McGill Pain Questionnaire. The results showed one patient in the sham control group and 7 patients in the active treatment group were pain-free at the 27-week follow-up. Their results also showed that the median time for return of pain to at least 50% of the preoperative level was 263 days in the active treatment groups; whereas it was 8 days in the sham control group. The authors concluded that this trial proved that radiofrequency neurotomy is capable of giving pain relief for up to and over a year. Even though this study was meticulously performed in an academic setting, it only included a small number of patients with whiplash injury and the technique with multiple lesions is not commonly utilized in the United States. This trial also faced significant criticism by Carragee et al (157) for multiple aspects that have not been widely recognized and criticized in the past, which included the differences in baseline characteristics of patients among both groups and the nature of blinding. In fact, Carragee et al (157) reported that the integrity of the blinding was in doubt related to the fact that 42% of the active group developed long-term anesthetic or dysesthetic areas of the skin, whereas none of the patients in the sham control group developed changes. Thus, Carragee et al (157) felt that there was no significant blinding technique applied with ability of the participants to recognize their group assignment. In addition, litigation also had no significant difference in the outcomes. Overall, the

Table 12. *Results of randomized trials of cervical and thoracic radiofreqency neurotomy, facet joint, nerve blocks and intraarticular injections.*

Study **Study Characteristic** **Methodological Quality Scoring**	**Patients**	**Interventions**	**Pain Relief and Function**			**Results**			**Comments**
			3 mos.	**6 mos.**	**12 mos.**	**Short-Term ≤ 6 mos.**	**Long-Term**		
							> 6 mos.	**≥ 1 year**	
CERVICAL RADIOFREQUENCY									
Lord et al, 1996 (128) RA, sham control, DB Quality Scores: Cochrane = 11/12 IPM-QRB = 45/48	24	Conventional RFTN 80°C, 90 seconds Sham = 12 Intervention = 12	NA	One of sham 7 of active	58% in active treatment group	P	P	P	Short- and long-term effectiveness
Sapir & Gorup, 2001 (159) Prospective Quality Score: IPM-QRBNR = 40/48	50	Conventional RFTN 80°C, 90 seconds Litigants = 32 Non-litigants = 18	NA	NA	66% litigant 71% non-litigant	NA	NA	P	Long-term effectiveness
MacVicar et al, 2012 (160) Prospective Quality Score: IPM-QRBNR =38/48	104	Conventional RFTN 80°C, 90 seconds 2 practices	NA	NA	74% vs 61%	NA	NA	P	Long-term effectiveness
Speldewinde, 2011 (161) Prospective Quality Score: IPM-QRBNR = 39/48	130	Conventional RFTN 80°C, 90 seconds	NA	NA	76%	NA	NA	P	Long-term effectiveness
CERVICAL FACET JOINT NERVE BLOCKS									
Manchikanti et al, 2010 (83) RA, DB, AC Quality Scores: Cochrane = 11/12 IPM-QRB = 45/48	120	Local anesthetic = 60 Local anesthetic with steroid = 60	83% versus 85%	87% versus 95%	85% versus 92%	P	P	P	Short- and long-term effectiveness
Manchikanti et al, 2004 (152) Prospective Quality Score: IPM-QRBNR = 37/48	100	Therapeutic medical branch blocks	92%	82%	56%	P	P	P	Long-term effectiveness
CERVICAL INTRAARTICULAR INJECTIONS									
Barnsley et al, 1994 (119) RA, DB, AC Quality Scores: Cochrane = 12/12 IPM-QRB = 36/48	41	LA = 20 Steroid = 21	20%	20%	20%	N	N	N	Lack of effectiveness

Table 12 (cont.). *Results of randomized trials of cervical and thoracic radiofreqency neurotomy, facet joint, nerve blocks and intraarticular injections.*

Study Study Characteristic Methodological Quality Scoring	Patients	Interventions	Pain Relief and Function			Results			Comments
			3 mos.	6 mos.	12 mos.	Short-Term ≤ 6 mos.	Long-Term		
							> 6 mos.	≥ 1 year	
Park & Kim, 2012 (129) RA, AC Quality Scores: Cochrane = 6/12 IPM-QRB = 35/48	306	Non-injection group = 151 Nerve blocks = 155	U	U	U	U	U	U	Unable to determine effectiveness
THORACIC RADIOFREQUENCY									
Joo et al, 2013 (120) Quality Scores: Cochrane = 10/12 IPM-QRB = 38/48	40	Radiofrequency neurotomy = 20 Alcohol injection = 20	SI in both groups	SI in both groups	SI in both groups	P	P	P	Short- and long-term effectiveness of radiofrequency neurotomy in alcohol injection group.
THORACIC FACET JOINT NERVE BLOCKS									
Manchikanti et al, 2012 (84) RA, DB Quality Scores: Cochrane = 10/12 IPM-QRB = 45/48	100	Local anesthetic = 50 Local anesthetic with steroid = 50	79% vs 83%	79% vs 81%	80% vs 83%	P	P	P	Short- and long-term effectiveness

RA = randomized; DB = double-blind; P = prospective; R = retrospective; vs = versus; *P* = positive

results showed that in the sham control group 58% of the patients and in the active treatment group 25% of the patients had their pain come back immediately after the procedure at the 3-month follow-up. Lord et al (128) were obviously unable to avoid this issue of different return of pain in 2 different groups and this is a problem with any of the interventional techniques. In contrast to the criticism of Carragee et al (157), Dreyfuss and Baker (158) supported Lord et al's manuscript (128) for maintaining appropriate blinding of patients based on the fact that it was very difficult to maintain a lack of anesthetic effect and also the numerous difficulties encountered in performing such studies, which is evidenced by the lack of such studies thus far in the cervical spine.

The remaining radiofrequency neurotomy studies were observational in nature. Sapir and Gorup (159), in a 2001 study evaluated the effectiveness of radiofrequency medial branch neurotomy of cervical facet joints after whiplash injury with chronic neck pain in a design which compared litigants to nonlitigants. The inclusion criteria included involvement in a motor vehicle accident at least 20 weeks prior to the study, failure to respond to conservative treatment, and a positive response to controlled, comparative, local anesthetic blocks. They included 50 patients who met inclusion criteria with at least 80% pain relief from comparative local anesthetic blocks and subsequently underwent radiofrequency neurotomy. However, only 46 of the patients completed the study with 29 in the litigation group (63%) and 17 in the nonlitigation group (37%). Subsequent to radiofrequency neurotomy, 21 patients, 14 patients in the litigation group and 7 in the nonlitigation group, experienced recurrence of pain within one year, whereas, 25 patients, 15 in the litigation group and 20 in the nonlitigation group, remained asymptomatic at the end of the one-year follow-up period. They showed that the return of pain, which they defined as 50% of pain returning, was approximately 8.3 ± 2.3 months in the 21 patients whose pain returned within one year. There were no significant differences in relation to the outcomes between the litigant and nonlitigant groups. Overall the authors concluded that cervical radiofrequency neurotomy of facet joints in

chronic neck pain secondary to whiplash injury was an effective modality independent of litigation.

In another study by MacVicar (160), which was derived from 2 practices in New Zealand, a successful outcome was reported in 74% and 61% of patients with long-lasting relief of 17 to 20 months from the first radiofrequency neurotomy, and 15 months for repeat radiofrequency neurotomy. Considering the need for repeat treatments, which were provided appropriately, overall the patients maintained relief for a median duration of 20 to 26 months, with 60% continuing to have relief with one radiofrequency neurotomy procedure. The authors concluded that radiofrequency neurotomy is an effective technique when performed in a rigorous manner with appropriate selection of patients and consideration of the procedural requirements in chronic neck pain secondary to cervical facet joint involvement temporarily, but completely, relieved of pain, restoring patients to desired activities of daily living. In another study by Speldewinde (161), with 379 procedures, 272 or 72% of the procedures were considered successful by the patients, irrespective of the region treated. He showed a large effect size with significant improvement. He also showed that repetition of the procedure was highly successful. He concluded that radiofrequency neurotomy of not only the cervical facet joints, but also thoracic and lumbar facets and sacroiliac joints were uniformly successful with 72% of recipients obtaining an average of 86% reduction in pain for a period of 12 months. Other studies by McDonald et al (163) and Barnsley et al (164) also demonstrated significant progress on a long-term basis. McDonald et al (163), in an assessment of long-term follow-up of patients, performed cervical radiofrequency neurotomy for chronic neck pain and showed successful results with complete pain relief in 71% of the patients after an initial procedure; however, the pain returned after 290 days when failures were included. Otherwise, they reported 422 days of relief with all successful cases. The major deficiency was that it included only 28 patients, which appears to have been replicating the results of the randomized controlled trial (128) with very similar outcomes. Barnsley et al (164) also assessed percutaneous radiofrequency neurotomy for chronic neck pain in 35 patients with 47 procedures. The results showed patients receiving 36 procedures achieved 80% significant pain relief with a mean duration of pain relief of 36 weeks, with repeat procedures usually achieving reproducible pain relief.

For thoracic radiofrequency neurotomy the level of evidence is Level III based on one high quality randomized controlled trial (120).

The level of evidence for facet joint nerve blocks is Level II in the lumbar, cervical, and thoracic regions based on 4 high quality randomized controlled trials (82-84,117) and one moderate to high quality randomized controlled trial (112). Further, there were no trials showing a lack of effectiveness.

Therapeutic facet joint nerve blocks were studied in all 3 regions with 2 high quality randomized controlled trials (82,117) in the lumbosacral region, and one moderate to high quality randomized controlled trial (112). One high quality randomized controlled trial in the thoracic (84) and cervical region (83). Four of the 5 manuscripts were from the same group of authors (82-84,112). In 2 manuscripts (82,83), 120 patients were included in each of the studies of lumbar and cervical facet joint pain (82,83); in studying thoracic facet joint pain (84) 100 patients were included; whereas, in one lumbar trial (112) 73 patients were included. The patients were all drawn from an interventional pain management practice. They had all failed conservative management and were judged to be positive for facet joint pain utilizing controlled comparative local anesthetic blocks with 80% pain relief as the criterion standard with ability to perform previously painful movements. In each group, an equal number of patients were allocated to receive either local anesthetic alone or local anesthetic with steroid. Outcome parameters included pain relief criteria and disability criteria with follow-ups at 3, 6, 12, 18, and 24 months. Significant pain relief was defined as greater than 50% relief with significant improvement in functional status of greater than 40%. In the lumbar region (82), the results showed significant pain relief in 85% of the patients receiving local anesthetic and 90% of the patients receiving local anesthetic with steroids at the end of the 2 year study period with an average of 5 to 6 total treatments. In the cervical spine (83), 85% of the patients in the local anesthetic only group and 93% of the patients in the steroid and local anesthetic group had significant improvement with a total of 5 to 6 procedures over a period of 2 years.

In the thoracic spine, the results were similar to the cervical and lumbar spines with 80% of the patients in the local anesthetic group and 84% of the patients in the local anesthetic and steroid group showing significant improvement at the end of 2 years with a total of 5 to 6 procedures. The fourth study, by Civelek et al (117), studied 100 patients with chronic low back pain who

failed conservative therapy and implemented strict selection criteria even though no diagnostic blocks were utilized. They used lumbosacral facet joint nerve blocks as the control group, whereas, the second group received conventional radiofrequency neurotomy. They followed the patients for 6 months and 12 months. At the end of one-year, 69% of the patients in the facet joint nerve block group showed significant improvement compared to 90% in the radiofrequency neurotomy group. Overall it showed the effectiveness of lumbar facet joint nerve blocks even though they were inferior to radiofrequency neurotomy. The final moderate to high quality study by Manchikanti et al (112), included 73 patients and compared a combination of bupivacaine with Sarapin and bupivacaine with Sarapin with the addition of steroids and showed positive results on a long-term basis.

These results are similar to some previously published systematic reviews (55-57); however, there were no other systematic reviews which appropriately studied the role of facet joint nerve blocks.

The evidence for the lumbar intraarticular injection of steroids is Level III, based on 3 high quality randomized controlled trials, showed effectiveness with short-term follow-up of less than 6 months (121,123,124); however, the results were also opposed by 2 moderate to high quality randomized controlled trials showing a lack of effectiveness (110,111). This level of evidence is similar to other published systematic reviews. In the cervical spine there were 2 randomized controlled trials of intraarticular injections (119,129) yielding evidence of Level III with one trial showing a lack of effectiveness and the second one showing undetermined results. These results are also similar to previous systematic reviews. There were no studies on intraarticular injections in the thoracic spine.

The disadvantages of this systematic review include the lack of metaanalysis; however, there was no clinical homogeneity among the trials. Further, it would be inappropriate to perform a systematic review based on some hypothetical principle if the trials are not clinically homogenous. Consequently, a best evidence synthesis appears to be the most appropriate in this setting. Other disadvantages include the continued paucity of literature about facet joint nerve blocks in all 3 regions and radiofrequency neurotomy in the cervical and thoracic regions as well as intraarticular injections in the cervical and thoracic regions. Future trials must be of appropriate size, draw from a population from practical settings, with a minimum long-term follow-up of one-year. Multiple other issues related to facet joint interventions include placebo response, nocebo response, the role of sham procedures, technical aspects in performing a procedure, and finally the role of local anesthetic alone compared to steroids with sodium chloride solution or steroids with local anesthetic (165-224). Based on the present evidence, there is no additional effectiveness beyond the relief provided by local anesthetic blocks with the addition of steroids, bupivacaine specifically, in facet joint nerve blocks (82-84,112,152,162,180).

The rationale for intraarticular injections comes from steroids being used for treating inflammation. The literature abounds with reports that epidural corticosteroid injections have significant efficacy for their anti-inflammatory, immuno-suppressive, anti-edema effects and inhibition of neurotransmission within the C fibers (185-198). The same is supported with facet joint nerve blocks; with long-term symptomatic improvement very similar to the addition of steroids and even better than with steroids (82-84,112,152,162,180,189,190,225-234). The experimental evidence also shows a lack of effectiveness of adding steroids (189,190).

It has been postulated that local anesthetics provide relief by suppressing nociceptive discharge (190), blocking axonal transport (191,192), blocking the sympathetic reflex arc, blocking sensitization (193,194), and by their anti-inflammatory effects (195). Local anesthetics have been reported to have long-term effectiveness following local anesthetic nerve blocks or epidural injections (82-84,110,112,152,180,206-208,225-234).

The lack of placebo in active control trials is a major misunderstanding and a limitation. However, placebo control has been misunderstood in many cases. The reviewers have considered a local anesthetic injection as a placebo control. It is a well known fact that placebo control in any neural blockade is a difficult task. Further, it also adds ethical issues and difficulty with recruitment in the United States. However, multiple investigations performed in interventional pain management with descriptions of placebo control have design flaws (62,65,180,199-204). A solution's effect when injected into a closed space has been inappropriately appraised. Carrette et al (110,196) reported that the response is similar whether an injectate has a sodium chloride solution or a local anesthetic with a steroid. The response to both injections in both the intraarticular and epidural space was low. Thus, their study (110) shows that sodium chloride solution injected into an intraarticular space has similar effects as local anesthetic with a steroid; the conclusion is that intraarticular steroids are

not an effective therapy. The issue is also exemplified by Birkenmaier et al (205), utilizing either pericapsular injections or medial branch blocks, who then went on to perform cryoneurolysis. Not surprisingly, the results were superior in patients who were diagnosed using medial branch blocks rather than pericapsular injections of local anesthetic. This study was the basis for Chou and Huffman (7) to reject diagnostic lumbar facet joint never blocks as having value. Also, there are reports of different effects from different solutions such as local anesthetic, normal saline, and dextrose; the same is true when a solution is injected into the disc, facet joint, or multifidus muscle (206-213). 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 (206-209). Further, there is direct evidence for spinal cord involvement in placebo analgesia (210). It also has been shown that epidurally administered sodium chloride solution provides significant improvement in pain and function (196,214-217). Therefore, it can be concluded that local anesthetic's effect on cervical facet joint nerve blocks is not due to the placebo effect, even though some have mistakenly misinterpreted this to be the case (200,201,217,218).

Placebo effects are not expected to be seen in a high proportion of patients, nor are they expected to be long lasting with repeat interventions over a period of 2 years. However, the limitations of the lack of placebo must not be underestimated. If feasible, a placebo-controlled study with appropriate design that includes not injecting the placebo solution over the facet joint nerves, and subsequent results, would be highly valid and provide conclusive knowledge on the issue of placebo-controlled blocks. The issues related to placebo have been discussed extensively in recent years ultimately leading to the opinion that the placebo effect is an inconsistent measure in clinical studies, unless it is designed appropriately (166,167,169,170,219-224).

Another issue is related to the reliability of controlled, comparative local anesthetic blocks, which have been criticized, and their validity as precision diagnostic techniques has been questioned and debated (7,10,16-19,62,199,235-239). The issues related to the accuracy of diagnostic facet joint nerve blocks include the reference standard, prior exposure to opioids, sedation, systemic local anesthetic effect, and non-specific effect resulting in positive results (7,10,16-19,56,62,209,240-249). 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 (248,249). A reference standard is 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 patients appears to be the only solution in establishing a reference standard with controlled facet joint nerve blocks (250). 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 the patients at the end of 2-year follow-up (248). However, the diagnosis was sustained in only 51% of the patients with 50% relief at the end of 2 years (248). Thus, the controlled diagnostic blocks utilized in this study appear to be reliable.

4.0 Conclusion

This systematic review shows Level II evidence for long-term effectiveness of radiofrequency neurotomy in the lumbar and cervical spines, for facet joint nerve blocks in the cervical, thoracic, and lumbar spine, and Level III evidence for thoracic radiofrequency neurotomy, lumbar intraarticular injections and cervical intraarticular injections. This systematic review was performed utilizing strict inclusion criteria and methodological quality assessment criteria. Overall, the results appear to be somewhat superior in patients who receive conventional radiofrequency neurotomy after undergoing controlled diagnostic blocks.

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Conflict of interest:

Dr. Manchikanti has provided limited consulting services to Semnur Pharmaceuticals, Incorporated, which is developing nonparticulate steroids.

Dr. Kaye is a speaker for Depomed, Inc.

Dr. Gupta has been paid honorarium for presenting at meetings and teaching on the interventional pain medicine cadaver courses and by pharmaceutical companies for presenting to health care professionals. Pharmaceutical companies and companies that manufacture equipments used in pain medicine have supported meetings organized by Dr S Gupta

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Dr. Hirsch is a consultant for Medtronic.

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