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Systematic Review & Meta-Analysis

Effectiveness of Radiofrequency Ablation in Managing Chronic Axial Spinal Pain of Facet Joint Origin: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

Laxmaiah Manchikanti, MD[1], Emilija Knezevic[2], Nebojsa Nick Knezevic, MD, PhD[3], Mahendra R. Sanapati, MD[4], Alan D. Kaye, MD, PhD[5], Vinita Singh, MD[6], Ramarao Pasupuleti, MD[7], Mittal S. Prajapati, MD[8], Navneet Boddu, MD[9], and Joshua A. Hirsch, MD[10]

From: [1]Pain Management Centers of America, Paducah, KY, & Evansville, IN; [2]Advocate Illinois Masonic Medical Center, Chicago, IL; [3]Advocate Illinois Masonic Medical Center and College of Medicine, University of Illinois, Chicago, IL; [4]University of Louisville School of Medicine, Louisville, KY, and Indiana University School of Medicine, Evansville, IN; [5]Louisiana State University Health Sciences Center at Shreveport, Shreveport, LA, Tulane School of Medicine and LSU School of Medicine, New Orleans, LA, USA; [6]Emory University, School of Medicine, Atlanta, GA; [7]Center for Pain Management, Bowling Green, KY; [8]Harvard Medical School, Beth Israel Deaconess Medical, Boston, MA; [9]Advanced Pain & Regenerative Specialists, Oceanside CA; and [10]Massachusetts General Hospital and Harvard Medical School, Boston, MA

Address Correspondence:
Laxmaiah Manchikanti, MD
67 Lakeview Drive
Paducah, Kentucky 42001
E-mail: drlm@thepainmd.com

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Background: Chronic axial spinal pain is a major cause of disability. The literature shows that expenditures related to low back and neck pain and other musculoskeletal disorders continue to rise, not only due to disability but also due to increasing healthcare costs, accounting for the highest expenditure among various disease categories. Based on current evidence utilizing controlled diagnostic blocks, facet joints, nerve root dura, and sacroiliac joints have been identified as potential sources of spinal pain. Therapeutic facet joint interventional modalities for axial spinal pain include radiofrequency ablation, therapeutic facet joint nerve blocks, and therapeutic intraarticular injections.

Objective: The objective of this systematic review and meta-analysis is to evaluate the effectiveness of radiofrequency ablation as a therapeutic modality in managing chronic axial spinal pain of facet joint origin.

Study Design: A systematic review and meta-analysis of randomized controlled trials (RCTs) utilizing the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist.

Methods: The available literature on radiofrequency ablation in axial spinal pain was reviewed. The quality assessment criteria utilized included the Cochrane review criteria to assess risk of bias and the Interventional Pain Management Techniques – Quality Appraisal of Reliability and Risk of Bias Assessment (IPM-QRB) for randomized therapeutic trials. The evidence was graded according to the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) criteria. The level of evidence was determined based on best evidence synthesis with modified grading of qualitative evidence from Level I to Level V.

A comprehensive literature search of multiple databases from 1966 to June 2025, including manual searches of the bibliographies of relevant review articles, was performed. Quality assessment of the included studies and best evidence synthesis were incorporated into both qualitative and quantitative analyses.

Outcome Measures: The primary outcome measure was the proportion of patients achieving significant pain relief and functional improvement of greater than 50% for at least 6 months. Duration of relief was categorized as short-term (less than 6 months) and long-term (greater than 6 months).

Results: This assessment identified 17 RCTs, including 14 high-quality and 3 moderate-quality studies based on Cochrane criteria, and 11 high-quality and 6 moderate-quality studies based on IPM-QRB criteria. Based on the GRADE assessment, 8 trials demonstrated at least moderate levels of impact and certainty, whereas 7 trials showed low impact with low certainty, and 2 trials demonstrated very low impact and certainty.

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Limitations: Despite the availability of multiple studies, the relative paucity of high-quality literature remains a major limitation.

Conclusion: Based on this systematic review and meta-analysis of 17 RCTs, the evidence is Level II with moderate certainty and a moderate strength of recommendation for the use of radiofrequency ablation in managing chronic axial spinal pain of facet joint origin.

Key words: Facet joint pain, facet joint nerve blocks, radiofrequency ablation, diagnostic facet joint nerve blocks, randomized controlled trials, systematic review, meta-analysis

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A 2024 report by the National Center for Health Statistics (NCHS) (1) on chronic and high-impact chronic pain in U.S. adults during 2023 found that these conditions were the primary reasons adults sought medical care. Chronic pain is associated with reduced quality of life, opioid misuse, increased anxiety and depression, and unmet mental health needs. According to the report, 24.3% of adults experienced chronic pain, while 8.5% reported high-impact chronic pain during the past 3 months in 2023, an increase from 2019 figures of 20.4% and 7.4%, respectively (1).

Further, an evaluation by Zajacova et al (2) assessing pain among U.S. adults before, during, and after the COVID-19 pandemic using 2019 to 2023 National Health Interview Survey (NHIS) data showed that chronic pain prevalence increased from 20.5% in 2019 to 24.3% in 2023, representing an 18% increase over the study period. In addition, high-impact chronic pain prevalence, which was 7.5% in 2019, increased to 8.5% in 2023, a 13% overall increase. The 2023 increases were widespread across all population subgroups. Long COVID accounted for approximately 13% of the observed increase in both chronic pain and high-impact chronic pain between 2019 and 2023. Thus, in 2023, an estimated 60 million Americans experienced chronic pain and 21 million experienced high-impact chronic pain, the highest prevalence recorded in NHIS.

Additional contributing factors include rising obesity rates (3,4) and the adverse effects of nicotine use (5). Chronic pain remains one of the most prevalent health conditions associated with nicotine use. The prevalence of combustible nicotine product use among individuals with chronic pain is more than double that observed in the general population, ranging from 28% to 68%. Among those receiving treatment for chronic pain, dual users of cigarettes and e-cigarettes demonstrated higher levels of anxiety, depression, pain-related disability, and opioid medication use (5).

Chronic axial spinal pain, whether associated with extremity pain, chest wall pain, or headaches, remains one of the leading causes of disability and healthcare expenditures in the United States and worldwide (6-27). Studies on U.S. health and disability trends (28), as well as cost analyses related to low back and neck pain and other musculoskeletal disorders (28,29), highlight the growing burden of disability and escalating healthcare costs. These conditions consistently rank among the highest in disease-related expenditures.

Pain prevalence varies by spinal region, with the lumbar spine most commonly affected (43%), followed by the cervical (32%) and thoracic spine (13%) (30). The one-year prevalence of low back and neck pain ranges from 22% to 65%, while lifetime prevalence reaches 84% for low back pain and 67% for neck pain. Chronic spinal pain persists for more than one year in up to 60% of patients, even after conservative treatment or surgery (8).

In a 2024 study, Williamson et al (31) evaluated persistent back pain in community-dwelling older adults and found that 77% continued to report back pain after 2 years; 25% reported leg pain, and 14% experienced severe back pain that interfered with daily activities. These findings are consistent with the 2023 NCHS survey data (1). Furthermore, 41.2% of participants reported no change in symptoms over 2 years, and 17.1% reported worsening symptoms. Five key factors were associated with severe pain limitations at follow-up, including pain characteristics, confidence in walking, and attitudes toward activity in later life.

Individuals with chronic low back or neck pain are approximately 3 times more likely to have comorbid conditions compared to the general population (32). These spinal disorders are closely associated with physical functional decline and increased mental health conditions, including depression, generalized anxiety disorder, and somatization (9,31,33).

Based on current literature, controlled diagnostic blocks have identified intervertebral discs, facet joints, nerve root dura, and sacroiliac joints as potential sources of spinal and extremity pain (9,34-36). Updated best evidence synthesis of the diagnostic utility of facet joint nerve blocks for facet joint interventions in the management of chronic spinal pain has shown that the prevalence of facet joint pain ranges from 16% to 45% with estimated false-positive rates of 25% to 50% and 75% to 80% pain relief in the lumbar spine. In the cervical spine, prevalence ranges from 36% to 67% with false-positive rates of 26% to 63% using ≥ 80% pain relief as the standard. In the thoracic spine, prevalence ranges from 34% to 48% with false-positive rates of 42% to 58% using 80% or higher pain relief as the standard. Among interventional options for managing axial spinal pain originating from facet joints, 3 primary modalities are utilized: radiofrequency ablation, intraarticular injections, and therapeutic facet joint nerve blocks (9). Of these, intraarticular injections are used occasionally, whereas facet joint nerve blocks are predominantly used for diagnostic evaluation with controlled blocks (9,34).

Despite advances in diagnostic understanding, the use of interventional techniques for diagnosing and treating facet joint pain remains controversial (7-25,34-55). Several publications have reported a slowing of procedural growth trends across the United States (40-48). Multiple studies have evaluated diagnostic accuracy, clinical effectiveness, and cost utility, with many demonstrating favorable outcomes (7-25,34-56).

Comprehensive guidelines (9) have systematically evaluated the evidence for interventional strategies in the management of facet joint pain, including radiofrequency ablation. For radiofrequency ablation, the level of evidence ranges from Level II, representing moderate strength of recommendation, to Level V, representing weak strength of recommendation for long-term improvement.

In addition to these comprehensive guidelines (9), consensus guidelines have been published by Hurley et al (11) and Cohen et al (10). These consensus statements concluded that cervical medial branch radiofrequency ablation may provide benefit in well-selected patients, with medial branch blocks being more predictive than intraarticular injections. They also noted that stricter selection criteria may improve denervation outcomes, although at the expense of increased false negatives and lower overall success rates.

Multiple systematic reviews have also been published with discordant findings (8,10,13-26). Consequently, a systematic review and meta-analysis of randomized controlled trials (RCTs) was conducted to evaluate the clinical effectiveness of facet joint nerve radiofrequency ablation in managing chronic axial spinal pain of facet joint origin, including the cervical, thoracic, and lumbar spine.

Methods

A systematic review and meta-analysis were conducted in accordance with the methodological and reporting standards outlined by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (57). Additional methodological approaches from previous reviews were also incorporated (7,13,58-64).

Objectives

The objective of this systematic review and meta-analysis of RCTs was to evaluate the efficacy and effectiveness of facet joint nerve radiofrequency ablation in the management of chronic axial spinal pain of facet joint origin, including the cervical, thoracic, and lumbar spine regions.

Eligibility Criteria

All RCTs evaluating radiofrequency ablation in the management of axial spinal pain with a minimum follow-up period of 6 months were included. Studies were required to utilize either diagnostic blocks or clinical criteria to establish the diagnosis of facet joint pain.

Exclusion criteria included studies involving atlantooccipital or atlantoaxial joints or headache only, as well as sacroiliac joint radiofrequency ablation. In addition, intraarticular and pulsed radiofrequency interventions were excluded.

Information Sources

A comprehensive literature search was performed to identify relevant RCTs conducted in all countries and published in any language. The search was executed across multiple databases without language restrictions.

1. PubMed from 1966 https://pubmed.ncbi.nlm.nih.gov/
2. Cochrane Library https://www.cochranelibrary.com/

3. Google Scholar https://scholar.google.com/
4. US National Guideline Clearinghouse (NGC) https://www.ahrq.gov/gam/index.html
5. Clinical Trials https://www.clinicaltrials.gov/
6. Previous systematic reviews and cross-references
7. All other sources including non-indexed journals and abstracts

The search period was from 1966 through October 2025.

Search Strategy

The search strategy focused on chronic axial spinal pain treated with radiofrequency ablation of facet joints. The search terms included: ((((((spinal pain, chronic low back, neck, mid back, and upper back pain) OR chronic neck pain OR chronic low back pain OR chronic thoracic pain) OR facet joint pain) OR post lumbar surgery syndrome, post cervical surgery syndrome, post thoracic surgery syndrome) OR zygapophysial)) AND ((((facet joint) OR zygapophyseal) OR zygapophysial) OR facet joint nerve block OR intraarticular injection OR radiofrequency ablation, neurolysis or neurotomy, randomized trials, systematic review, meta-analysis).

Data Selection

Two review authors (LM and ADK) independently developed the search criteria, conducted the literature search, and extracted data from the selected studies. Any disagreements between the two authors were resolved through consultation with a third author (MRS). To address potential conflicts of interest involving reviewers who are also co-authors of this article, such disagreements were reassigned to independent reviewers for resolution.

Study of Risk of Bias and Methodological Quality Assessment

The included RCTs were evaluated for methodological quality and risk of bias using 2 established criteria: the Cochrane Review Criteria (Appendix Table 1) (65) and the Interventional Pain Management Techniques – Quality Appraisal of Reliability and Risk of Bias Assessment (IPM-QRB) (Appendix Table 2) (66).

Trials that met the inclusion criteria and received a score of 9 or higher out of 13 based on the Cochrane review criteria (65) were classified as high quality. Trials scoring between 5 and 8 were categorized as moderate quality, while those scoring below 5 were considered low quality and excluded from the analysis.

All included trials were also evaluated using the IPM-QRB criteria (66). Studies scoring between 32 and 48 were considered high quality, those with scores from 16 to 31 were rated as moderate quality, and studies scoring below 16 were classified as low quality and excluded from the analysis.

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

The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) framework is a transparent and systematic approach for summarizing evidence and formulating clinical practice recommendations (67,68). It is the most widely adopted tool for assessing the quality of evidence and guiding recommendations in healthcare.

GRADE categorizes evidence into 4 levels of certainty, also referred to as the quality of evidence: very low, low, moderate, and high, as outlined in Table 1. The certainty of evidence is determined by factors such as risk of bias, imprecision, inconsistency, indirectness, and publication bias. These factors may either increase or decrease confidence in the evidence. The reasons for upgrading or downgrading the certainty of evidence are summarized in Table 2.

The methodological quality of the trials and GRADE appraisal were independently conducted by two authors (LM and ADK) in an unblinded manner. In cases of disagreement, a third author (MRS) was consulted to resolve the conflict. When a conflict of interest related to study authorship was identified, the involved authors were excluded from the quality assessment of those specific studies.

Outcome Measures

An outcome was considered clinically significant if there was a reduction of 2 points on the Visual Analog Scale (VAS) or Numeric Rating Scale (NRS), or at least a 50% reduction in pain accompanied by improvement in functional status. A study was considered positive and effective if the primary outcome was statistically significant, defined as $P \leq 0.05$.

Table 3 presents the strength of recommendations based on the National Guideline Clearinghouse Extent of Adherence to Trustworthy Standards (NEATS) instrument (69), as modified by the guideline panel (60-62).

Table 1. *GRADE certainty ratings.*

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

Source: BMJ Best Practice. Evidence-based medicine (EBM) toolkit. Learn EBM. What is GRADE? Accessed 1/27/2026. https://bestpractice-bmj-com.bibliotheek.ehb.be/info/evidence/learn-ebm/what-is-grade/ (68)

Table 2. *Reasons rate certainty in evidence up or down.*

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

Source: BMJ Best Practice. Evidence-based medicine (EBM) toolkit. Learn EBM. What is GRADE? Accessed 1/27/2026. https://bestpractice-bmj-com.bibliotheek.ehb.be/info/evidence/learn-ebm/what-is-grade/ (68)

Table 3. *Guide for strength of recommendations as modified for American Society of Interventional Pain Physicians (ASIPP) guidelines.*

Rating for Strength of Recommendation	
Strong	There is high confidence that the recommendation reflects best practice. This is based on: a) strong evidence for a true net effect (e.g., benefits exceed harms); b) consistent results, with no or minor exceptions; c) minor or no concerns about study quality; and/or d) the extent the panelists' agreement. Other compelling considerations (discussed in the guideline's literature review and analyses) may also warrant a strong recommendation. ASIPP Adaptation: Consensus was achieved that there is high certainty that the net benefit is substantial providing strong recommendation. Recommendation: Strong
Moderate	There is moderate confidence that the recommendation reflects best practice. This is based on: a) good evidence for a true net effect (e.g., benefits exceed harms); b) consistent results, with minor and/or few exceptions; c) minor and/or few concerns about study quality; and/or d) the extent of panelists' agreement. Other compelling considerations (discussed in the guideline's literature review and analyses) may also warrant a moderate recommendation. ASIPP Adaptation: Consensus was achieved that there is high certainty that the net benefit is moderate or there is moderate certainty that the net benefit is moderate to substantial. Recommendation: Moderate
Weak	There is some confidence that the recommendation offers the best current guidance for practice. This is based on: a) limited evidence for a true net effect (e.g., benefits exceed harms); b) consistent results, but with important exceptions; c) concerns about study quality; and/or d) the extent of panelists' agreement. Other considerations (discussed in the guideline's literature review and analyses) may also warrant a weak recommendation. ASIPP Adaptation: The consensus achieved that there is potential improvement in certain individuals or groups of patients based on individual professional judgement and shared decision making. Recommendation: Weak

Adapted and modified from: Jue JJ, et al. Developing and Testing the Agency for Healthcare Research and Quality's National Guideline Clearinghouse Extent of Adherence to Trustworthy Standards (NEATS) Instrument. *Ann Intern Med* 2019; 170:480-487 (69).

Analysis of Evidence

The evidence was evaluated using both qualitative and quantitative synthesis methods. Quantitative synthesis was conducted through conventional meta-analysis and single-arm meta-analysis approaches.

Qualitative Analysis

The qualitative analysis of the evidence was conducted using a modified best-evidence synthesis approach, incorporating multiple criteria, including the Cochrane Review criteria and the United States Preventive Services Task Force (USPSTF) criteria, as shown in Table 4 (70). The analysis categorized evidence into 5 levels, ranging from strong evidence to opinion- or consensus-based evidence.

Quantitative Analysis

Dual-Arm Meta-Analysis

For the dual-arm meta-analysis, Review Manager [Computer program], version 5.4, The Cochrane Collaboration, 2020, was used. Pain and functional improvement outcomes were reported as standardized mean differences (SMD) with 95% confidence intervals (CI). Forest plots were generated to illustrate treatment effects using a random-effects model. Heterogeneity was assessed using the I^2 statistic.

Single-Arm Meta-Analysis

Software Comprehensive Meta-analysis version 3.0 (Biostat Inc., Englewood, NJ) was used for single-arm meta-analysis. The SMD with 95% CI were reported for pain and improvement of function data. Data were plotted using forest plots to evaluate treatment effects. Heterogeneity was interpreted using I^2 statistics.

Summary of Evidence

The evidence was synthesized using qualitative analysis and assessed according to GRADE criteria.

At least two review authors (LM and ADK) independently analyzed the evidence in a standardized manner. Any disagreements were resolved by a third author (MRS) through consensus. In cases involving potential conflicts of interest, such as authorship, the reviewers in question were recused from the assessment and analysis process.

Results

Study Selection

Figure 1, based on 2020 PRISMA guidance (57), shows a flow diagram of the study selection using the PRISMA study selection process.

Based on the search criteria, 31 publications of RCTs (37,71-100) were identified, with inclusion of 17 trials.

Methodologic Quality and Risk of Bias Assessment

Tables 5 and 6 present the methodological quality assessment and risk of bias of the 17 RCTs (37,72-77,81-85,87-91) meeting the inclusion criteria utilizing the Cochrane review criteria and the IPM-QRB criteria. Assessment based on the Cochrane review criteria identified 14 RCTs as high-quality trials, scoring at least 9 of 13 (72-77,81-85,87-89), and 3 trials as moderate quality (37,90,91) with scores of 5-8. However, based on the IPM-QRB instrument, 11 (72,75-77,83-85,87-89,91) of 17 trials were rated as high quality with scores above 32 of 48, whereas 6 trials (37,73,74,81,82,90) were categorized as moderate quality with scores above 16.

Study Characteristics

Table 7 shows the characteristics and outcomes of the studies meeting inclusion criteria.

Quantitative and Qualitative Analysis

Both quantitative and qualitative analyses were conducted for the studies that met the inclusion criteria.

Of the 17 RCTs (37,72-77,81-85,87-91), 5 were placebo-controlled (77,81-84) and 12 were active control (37,72-76,85,87-91).

Table 4. ***Qualitative modified approach to grading of evidence of therapeutic effectiveness studies.***

Level I	Strong	Evidence obtained from multiple relevant high-quality randomized controlled trials
Level II	Moderate	Evidence obtained from at least one relevant high-quality randomized controlled trial or multiple relevant moderate or low-quality randomized controlled trials
Level III	Fair	Evidence obtained from at least one relevant moderate or low-quality randomized trial OR Evidence obtained from at least one relevant high-quality non-randomized trial or observational study with multiple moderate or low-quality observational studies
Level IV	Limited	Evidence obtained from multiple moderate or low-quality relevant observational studies
Level V	Consensus based	Opinion or consensus of large group of clinicians and/or scientists

Modified from: Manchikanti L, et al. A modified approach to grading of evidence. *Pain Physician* 2014; 17:E319-E325 (70).

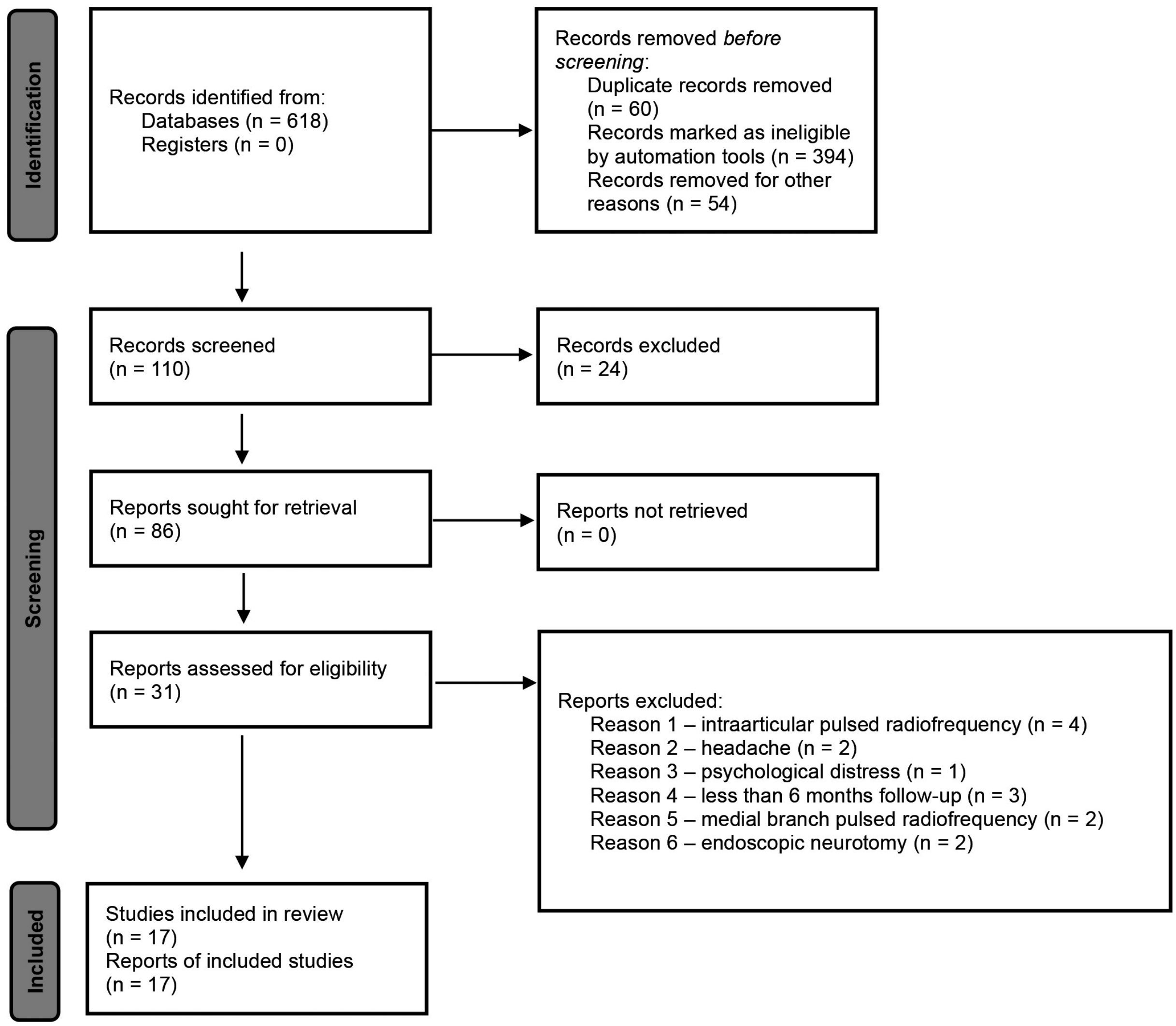


Fig. 1. *Flow diagram illustrating the literature used for evaluating radiofrequency ablation in managing spinal facet joint pain.*

Quantitative Analysis

Dual-Arm Conventional Meta-Analysis

Six-Month Analysis

There were 6 trials (37,72-74,81,89) with 559 patients that compared radiofrequency ablation vs. control in a dual-arm meta-analysis at 6 months. Among these, one was a placebo or sham-controlled trial (81) with 40 patients. The results demonstrated a statistically significant difference in pain levels between the two groups [SMD -0.69 (-0.89, -0.50), $P < 0.001$] (Fig. 2A).

There were 3 trials (37,72,73) with 339 patients that compared control vs. steroid group functionality in a dual-arm meta-analysis at 6 months. There were no placebo or sham control trials. The results did not show a statistically significant difference in functional outcomes between the two groups [SMD -0.28 (-0.50, -0.07), $P = 0.90$] (Fig. 2B).

Twelve-Month Analysis

There were 4 trials (37,73,74,89) with 463 patients that compared radiofrequency ablation vs. control in a dual-arm meta-analysis at 12 months. There were no placebo or sham control trials. The results demon-

Table 5. *Methodological quality assessment of randomized trials of spinal facet joint nerve radiofrequency ablation utilizing Cochrane review criteria.*

	Lakemeier et al, 2013 (72)	McCormick et al, 2023 (73)	Civelek et al, 2012 (74)	Joo et al, 2013 (76)	Juch et al, 2017 (37)	Nath et al, 2008 (81)	Tekin et al, 2007 (82)	van Wijk et, 2005 al (83)	van Kleef et al, 1999 (84)	Çetin & Yektaş, 2018 (85)	McCormick et al, 2019 (87)
Randomization adequate	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Concealed treatment allocation	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Patient blinded	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y
Care provider blinded	N	N	N	N	N	Y	Y	Y	Y	N	N
Outcome assessor blinded	N	N	U	Y	N	Y	Y	Y	Y	Y	Y
Drop-out rate described	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
All randomized participants analyzed in the group	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N
Reports of the study free of suggestion of selective outcome reporting	Y	Y	Y	Y	N	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	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Compliance acceptable in all groups	N	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
Are other sources of potential bias not likely	U	Y	U	Y	Y	Y	U	Y	Y	Y	U
SCORE	9/13	11/13	9/13	12/13	6/13	13/13	12/13	13/13	13/13	12/13	10/13

Y = yes; N = no; U = nuclear
Source: Furlan AD, et al; Editorial Board of the Cochrane Back, Neck Group. 2015 Updated Method Guideline for Systematic Reviews in the Cochrane Back and Neck Group. *Spine (Phila Pa 1976)* 2015; 40:1660-1673 (65).

Table 5 cont. *Methodological quality assessment of randomized trials of spinal facet joint nerve radiofrequency ablation utilizing Cochrane review criteria.*

	Moon et al, 2013 (88)	Moussa & Khedr, 2016 (89)	Song et al, 2019 (90)	van Eerd et al, 2021 (75)	Lord et al, 1996 (77)	Xue et al, 2020 (91)
Randomization adequate	Y	Y	U	Y	Y	Y
Concealed treatment allocation	Y	Y	U	Y	Y	N
Patient blinded	Y	Y	N	Y	Y	N
Care provider blinded	Y	N	N	Y	Y	N
Outcome assessor blinded	Y	Y	Y	Y	Y	N
Drop-out rate described	Y	Y	N	Y	Y	Y
All randomized participants analyzed in the group	N	U	U	Y	Y	Y
Reports of the study free of suggestion of selective outcome reporting	Y	Y	Y	Y	Y	U
Groups similar at baseline regarding most important prognostic indicators	Y	Y	Y	Y	Y	Y
Co-intervention avoided or similar in all groups	Y	Y	N	Y	Y	Y
Compliance acceptable in all groups	N	U	Y	Y	Y	Y
Time of outcome assessment in all groups similar	N	Y	Y	Y	Y	Y
Are other sources of potential bias not likely	U	Y	Y	Y	Y	U
SCORE	9/13	10/13	6/13	13/13	13/13	7/13

Y = yes; N = no; U = nuclear

Source: Furlan AD, et al; Editorial Board of the Cochrane Back, Neck Group. 2015 Updated Method Guideline for Systematic Reviews in the Cochrane Back and Neck Group. *Spine (Phila Pa 1976)* 2015; 40:1660-1673 (65).

strated a statistically significant difference in pain levels between the two groups [SMD -0.46 (-0.69, -0.23), $P < 0.001$] (Fig. 3).

Single-Arm Conventional Meta-Analysis

Six-Month Analysis

Figure 4 shows the results of a single-arm meta-analysis utilizing conventional radiofrequency ablation. There were 7 studies (37,72,74,82,85,87,88) used to assess pain scores at 6 months using NRS. Among these, one was a placebo or sham-controlled trial (82) with 60 patients. As shown in Fig. 4, the pooled mean difference in pain scores from baseline to 6-month follow-up was a decrease of 3.419 points (95% CI: -4.736 to -2.101, $P < 0.0001$).

Twelve-Month Analysis

Figure 5 shows the results of a single-arm meta-analysis utilizing conventional radiofrequency ablation. There were 4 studies (37,74,82,85) used to assess pain scores at 12 months using NRS. Among these, one was a placebo or sham-controlled trial (82) with 60 patients. As shown in Fig. 5, the pooled mean difference in pain scores from baseline to 12-month follow-up was a decrease of 4.190 points (95% CI: -5.748 to -2.632, $P < 0.0001$).

Assessment Utilizing GRADE Criteria

Table 8 shows the assessment of GRADE criteria utilizing 5 levels of evidence and evaluating 5 factors: methodologic limitation, consistency, indirectness, imprecision, and publication bias, with grading as high, moderate, low, or very low. Overall, 2 studies (77,81) demonstrated high-level evidence according to GRADE assessment, whereas 6 studies (72,82,84,85,88,89) were graded as moderate, and 9 studies (37,73-76,83,87,90,91) were graded as low or very low.

Qualitative Analysis

The evidence in this study was analyzed qualitatively using a best-evidence synthesis approach, incorporating multiple criteria, including the Cochrane Review and the USPSTF criteria outlined in Table 4. The analysis utilized 5 levels of evidence, ranging from strong to opinion or consensus based.

Qualitative analysis was based on the number of studies performed and their outcomes.

Table 6. *Methodologic quality assessment of randomized trials of spinal facet joint nerve radiofrequency ablation utilizing IPM – QRB criteria.*

		Lakemeier et al, 2013 (72)	McCormick et al, 2023 (73)	Civelek et al, 2012 (74)	Joo et al, 2013 (76)	Juch et al, 2017 (37)	Nath et al, 2008 (81)	Tekin et al, 2007 (82)	van Wijk et, 2005 al (83)	van Kleef et al, 1999 (84)
I.	TRIAL DESIGN AND GUIDANCE REPORTING									
1.	CONSORT or SPIRIT	2	2	2	2	2	3	2	2	2
II.	DESIGN FACTORS									
2.	Type and Design of Trial	2	2	2	2	2	2	2	2	2
3.	Setting/Physician	1	3	2	2	2	2	2	2	1
4.	Imaging	3	3	3	3	3	3	3	3	3
5.	Sample Size	2	1	1	1	2	3	2	2	2
6.	Statistical Methodology	1	1	1	1	1	1	1	1	1
III.	PATIENT FACTORS									
7.	Inclusiveness of Population									
	For facet joint interventions:	1	2	0	2	2	1	2	2	1
8.	Duration of Pain	2	2	0	2	2	0	2	2	2
9.	Previous Treatments	2	2	2	2	1	0	1	2	2
10.	Duration of Follow-up with Appropriate Interventions	2	2	2	2	1	0	1	1	2
IV.	OUTCOMES									
11.	Outcomes Assessment Criteria for Significant Improvement	2	2	2	2	1	0	1	2	2
12.	Analysis of all Randomized Participants in the Groups	2	2	2	2	0	2	0	0	2
13.	Description of Drop Out Rate	2	2	2	2	0	2	0	2	2
14.	Similarity of Groups at Baseline for Important Prognostic Indicators	2	2	2	2	2	2	2	2	2
15.	Role of Co-Interventions	1	1	1	1	1	1	1	1	1
V.	RANDOMIZATION									
16.	Method of Randomization	2	2	2	2	2	2	2	2	2
VI.	ALLOCATION CONCEALMENT									
17.	Concealed Treatment Allocation	2	2	2	2	0	0	0	2	2
VII.	BLINDING									
18.	Patient Blinding	1	1	0	1	0	0	0	1	1
19.	Care Provider Blinding	0	0	0	0	0	0	0	1	0
20.	Outcome Assessor Blinding	0	0	0	0	0	0	0	1	0
VIII.	CONFLICTS OF INTEREST									
21.	Funding and Sponsorship	2	-2	0	2	2	2	2	2	2
22.	Conflicts of Interest	3	-2	0	3	0	2	0	3	3
TOTAL		37/48	30/48	28/48	38/48	26/48	28/48	26/48	38/48	37/48

Table 6 cont. *Methodologic quality assessment of randomized trials of spinal facet joint nerve radiofrequency ablation utilizing IPM – QRB criteria.*

		Çetin & Yektaş, 2018 (85)	**McCormick et al, 2019 (87)**	**Moon et al, 2013 (88)**	**Moussa & Khedr, 2016 (89)**	**Song et al, 2019 (90)**	**van Eerd et al, 2021 (75)**	**Lord et al, 1996 (77)**	**Xue et al, 2020 (91)**
I.	TRIAL DESIGN AND GUIDANCE REPORTING								
1.	CONSORT or SPIRIT	2	2	2	2	2	3	3	1
II.	DESIGN FACTORS								
2.	Type and Design of Trial	2	3	2	3	2	2	3	2
3.	Setting/Physician	2	2	2	1	1	2	2	2
4.	Imaging	3	3	3	3	3	3	3	2
5.	Sample Size	2	1	2	2	0	2	1	1
6.	Statistical Methodology	1	1	1	1	1	1	1	1
III.	PATIENT FACTORS								
7.	Inclusiveness of Population								
	For facet joint interventions:	2	1	2	2	2	0	2	2
8.	Duration of Pain	2	2	2	2	1	2	2	2
9.	Previous Treatments	2	2	2	2	2	2	2	2
10.	Duration of Follow-up with Appropriate Interventions	3	2	1	3	3	2	2	2
IV.	OUTCOMES								
11.	Outcomes Assessment Criteria for Significant Improvement	2	2	2	2	2	0	4	2
12.	Analysis of all Randomized Participants in the Groups	2	0	0	1	0	2	2	2
13.	Description of Drop Out Rate	2	1	2	2	0	2	2	2
14.	Similarity of Groups at Baseline for Important Prognostic Indicators	2	2	2	2	2	2	2	2
15.	Role of Co-Interventions	1	1	1	1	1	1	1	1
V.	RANDOMIZATION								
16.	Method of Randomization	2	2	2	2	0	2	2	1
VI.	ALLOCATION CONCEALMENT								
17.	Concealed Treatment Allocation	2	2	2	2	0	2	2	0
VII.	BLINDING								
18.	Patient Blinding	1	1	1	1	0	1	1	0
19.	Care Provider Blinding	1	0	1	0	0	1	1	0
20.	Outcome Assessor Blinding	1	1	1	1	1	1	1	0
VIII.	CONFLICTS OF INTEREST								
21.	Funding and Sponsorship	2	2	2	3	3	3	3	2
22.	Conflicts of Interest	0	3	3	3	3	3	3	3
TOTAL		39/48	36/48	41/48	41/48	29/48	39/48	45/48	32/48

Source: Manchikanti L, et al. Assessment of methodologic quality of randomized trials of interventional techniques: Development of an interventional pain management specific instrument. *Pain Physician* 2014; 17:E263-E290 (66).

Table 7. *Study characteristics of randomized controlled trials assessing spinal facet joint nerve radiofrequency ablation.*

Study Study Characteristic Methodological Quality Scoring	Number of Patients & Selection Criteria	Facet Joint Radiofrequency	Comparator	Outcome Measures and Time of Measurement	Results	Strengths	Weaknesses	Conclusions
LUMBAR PLACEBO/SHAM CONTROL								
Nath et al, 2008 (81) RA, DB, sham control trial Quality Scores: Cochrane = 13/13 IPM-QRB = 28/48	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 control group.	n = 20 The 20 patients in the active group received conventional lumbar facet joint radiofrequency neurolysis at 85°C for 60 seconds.	n = 20 Sham control with placement of the needles with injection of local anesthetic without radiofrequency ablation.	NRS, 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 radiofrequency ablation was shown compared to local anesthetic injection and sham lesioning.
Tekin et al, 2007 (82) RA, DB, AC, sham control Quality Scores: Cochrane = 12/13 IPM-QRB = 26/48	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.	n = 40 Either pulsed radiofrequency (42°C for 4 minutes) or conventional radiofrequency ablation (80°C for 90 seconds) in 20 patients in each group.	n = 20 Sham control with local anesthetic injection	VAS and ODI 3, 6, and 12 months	VAS and ODI 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 radiofrequency ablation. 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 radiofrequency ablation up to one year, whereas efficacy with local anesthetic block with sham control radiofrequency ablation and pulsed radiofrequency ablation at 6 months only.
van Wijk et al, 2005 (83) RA, DB, sham control trial Quality Scores: Cochrane = 13/13 IPM-QRB = 38/48	81 patients with chronic low back pain were evaluated with radiofrequency ablation with 41 patients in the control group with at least 50% relief for 30 minutes with a single block	n = 40 40 patients received conventional radiofrequency lesioning at 80°C for 60 seconds and 41 patients received sham lesioning.	n = 41 Sham lesion procedure with intraarticular injection of 0.5 mL lidocaine 2%.	Pain relief, physical activities, analgesic intake, GPE, SF-36, quality of life measures 3 months	GPE improved after radiofrequency facet joint denervation. The VAS in both groups improved. The combined outcome measures showed no difference between radiofrequency 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.

Table 7 cont. *Study characteristics of randomized controlled trials assessing spinal facet joint nerve radiofrequency ablation.*

Study **Study Characteristic** **Methodological Quality Scoring**	**Number of Patients & Selection Criteria**	**Facet Joint Radiofrequency**	**Comparator**	**Outcome Measures and Time of Measurement**	**Results**	**Strengths**	**Weaknesses**	**Conclusions**
Van Kleef et al, 1999 (84) RA, DB, sham control trial Quality Scores: Cochrane = 13/13 IPM-QRB = 37/48	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.	n = 15 The 15 patients in the conventional radiofrequency treatment group received an 80° C radiofrequency lesion for 60 seconds.	n = 16 Sham control of radiofrequency after local anesthetic injection in 16 patients	VAS, pain scores, GPE, ODI 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
LUMBAR ACTIVE CONTROL								
Lakemeier et al, 2013 (72) RA, DB, AC Quality Scores: Cochrane = 9/13 IPM-QRB = 37/48	n = 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 (0.5 mL of bupivacaine) with a single block	n = 27 Radiofrequency denervation was performed after placing the 20-gauge curved RF needle with 10 mm active tip after confirmation of correct placement using electrostimulation, followed by injection of 1 mL of 0.5% bupivacaine through the cannula	n = 29 Intraarticular injection of local anesthetic 0.5 mL of 0.5% bupivacaine and 1 mL of betamethasone 3 mg was injected into the target joint after placing the radiofrequency needle with confirmation with contrast.	RMDQ, VAS, ODI, 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 Radiofrequency ablation had a lower VAS than patients after steroid injection after 6 months The decrease in VAS appears to be less than 2 in steroid group and approximately 2.5 or 3 points in radiofrequency group.	Lack of placebo group. Relatively short-term follow-up	Single diagnostic block with intraarticular injection	Positive Radiofrequency was superior to intraarticular injections

Table 7 cont. *Study characteristics of randomized controlled trials assessing spinal facet joint nerve radiofrequency ablation.*

Study Study Characteristic Methodological Quality Scoring	Number of Patients & Selection Criteria	Facet Joint Radiofrequency	Comparator	Outcome Measures and Time of Measurement	Results	Strengths	Weaknesses	Conclusions
McCormick et al, 2023 (73) P, RA, comparative Quality Scores: Cochrane = 11/13 IPM-QRB = 30/48	n = 32 Patients with chronic low back pain and confirmed facet joint pain with dual medial branch blocks 32 patients met eligible criteria out of 1,128 patients 32 patients were randomized into 2 groups with 12 patients undergoing intraarticular facet steroid injection, 12 patients undergoing facet intraarticular injection, and 20 patients undergoing cooled lumbar medial branch radiofrequency ablation	n = 20 Cooled lumbar medial branch radiofrequency ablation performed for 165 seconds, with the RFA generator temperature set to 60°C For bilateral low back pain, a maximum of 4 facet joints (2 on each side) were denervated by cooled lumbar medial branch radiofrequency ablation For unilateral low back pain, a maximum of 3 facet joints were denervated by cooled lumbar medial branch radiofrequency ablation	n = 12 Intraarticular facet steroid injection utilizing 0.5 mL of 40 mg/mL Kenalog and 0.5 mL of 2% preservative-free lidocaine per facet joint A maximum of 4 facet joints (two on each side) were injected for bilateral low back pain For unilateral low back pain, up to 3 facet joints were injected	NRS, ODI, PGIC 1, 3, 6, & 12 months	In the cooled lumbar medial branch radiofrequency ablation group, 70% (95% CI 48-85), 55% (95% CI 34-74), and 45% (95% CI 26-66) of participants met the NRS responder definition, compared to 25% (95% CI 9-53), 25% (95% CI 9-53), and 17% (95% CI 5-45) in the intraarticular facet steroid injection group at 3, 6, and 12 months, respectively ($p = .014$ at 3 months) The PGIC responder proportion was higher in the cooled lumbar medial branch radiofrequency ablation compared to intraarticular facet steroid injection group at 3 and 6 months ($P < .05$)	Randomized controlled trial with selection criteria of dual diagnostic blocks and 12-month follow-up	Small sample size Active control trial	Positive trial Cooled radiofrequency ablation was superior compared to intraarticular injections
Civelek et al, 2012 (74) RA, AC Quality Scores: Cochrane = 9/13 IPM-QRB = 28/48	100 patients with chronic low back pain with failed conservative therapy and strict selection criteria; however, without diagnostic blocks	n = 50 50 patients were treated with conventional radiofrequency ablation at 80°C for 120 seconds in combination with high dose local anesthetic and steroids	n = 50 50 patients were treated with facet joint nerve blocks	Visual NRS, NASS 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 with 50 patients in each group	No diagnostic blocks were performed. High dose steroids and local anesthetics were utilized in both groups	Positive long-term results Efficacy was shown even without diagnostic blocks, both for facet joint nerve blocks and radiofrequency ablation

Table 7 cont. *Study characteristics of randomized controlled trials assessing spinal facet joint nerve radiofrequency ablation.*

Study **Study Characteristic** **Methodological Quality Scoring**	**Number of Patients & Selection Criteria**	**Facet Joint Radiofrequency**	**Comparator**	**Outcome Measures and Time of Measurement**	**Results**	**Strengths**	**Weaknesses**	**Conclusions**
Juch et al, 2017 (37) MINT RA, non-blinded, pragmatic clinical trial Quality Scores: Cochrane = 6/13 IPM-QRB = 26/48	A total of 251 patients were randomized into facet trial with 126 patients in the control group receiving exercise program as randomized. 125 patients were randomized to intervention group.	n = 125 Patients in the intervention group, radiofrequency ablation after testing positive with at least 50% relief with a single block of facet joint nerves with pain reduction within 30 to 90 minutes after the block. Radiofrequency ablation was performed with a conventional radiofrequency ablation procedure with a 22 gauge electrode. Co-interventions except standardized exercise program were not allowed for 3 months. Over-the-counter analgesics were allowed.	n = 126 Patients randomized to control group received exercise program as randomized.	NRS, global perceived recovery, ODI, EuroQol 5D Health Questionnaire, Rand-36, West Haven-Yale Multidimensional Pain Inventory 3, 6, 9, 12 months	There was no significant difference between radiofrequency ablation group compared to exercise program group in the control.	A large randomized clinical trial	There are numerous weaknesses in this trial. Inappropriate selection criteria with 50% relief for a few hours which is not recommended by any guidelines. Not a blinded procedure. The electrode was too thin with exposed tip may or may not be over the nerve utilizing a perpendicular placement of the electrode. Outcome measures were inappropriate. This study received extensive correspondence and negative comments all over for its defective design and performance.	A poorly designed and performed trial showing negative results.
Çetin & Yektaş, 2017 (85) RA, DB, AC Quality Scores: Cochrane = 12/13 IPM-QRB = 39/48	118 patients were randomized to Group 1 to receive pulsed radiofrequency and Group 2 with 45 patients receiving conventional radiofrequency.	n = 43 Conventional radiofrequency ablation was performed at 80° for 90 seconds. Bupivacaine was injected prior to the procedure and following the procedure, 2 mg of methylprednisolone was injected through RF needle at each level in both groups.	n = 75 Pulsed radiofre-quency was per-formed at 42° for 3 minutes. Bupivacaine was injected prior to the procedure and following the procedure, 2 mg of meth-ylprednisolone was injected through RF needle at each level in both groups.	VAS, Odom criteria 1, 3, 6 months, 1 year, 2 years	Conventional radiofrequency ablation provided significantly better relief at 6 months, one year, and 2 years.	Randomized, double-blind control trial	Active control trials	This trial shows good outcomes with conventional radiofrequency ablation over a period of 2 years.

Table 7 cont. *Study characteristics of randomized controlled trials assessing spinal facet joint nerve radiofrequency ablation.*

Study Study Characteristic Methodological Quality Scoring	Number of Patients & Selection Criteria	Facet Joint Radiofrequency	Comparator	Outcome Measures and Time of Measurement	Results	Strengths	Weaknesses	Conclusions
McCormick et al, 2019 (87) RA, SB, AC Quality Scores: Cochrane = 10/13 IPM-QRB = 36/48	43 patients were randomized to two groups, 21 received cooled radiofrequency ablation while 22 received traditional radiofrequency ablation of medial branch nerve. Patients who had at least 75% pain relief on a diagnostic block were included in study.	n = 21 Received traditional percutaneous radiofrequency ablation of medial branch nerve.	n = 22 Received cooled percutaneous radiofrequency ablation of medial branch nerve.	Primary outcome: ≥ 50% NRS reduction at 6 months. Secondary outcomes: NRS, ODI and patient global impression of change. 6 months	A ≥ 50% decrease in NRS was observed in 52% (95% CI 31% to 74%) and 44% (95% CI 22% to 69%) in the cooled RFA and traditional RFA respectively with no significant difference between the groups (*P* =0 .75).	Randomized, single blinded.	Relatively small sample size, up to 7% participants outcomes were not reported. Followed only for 6 months. Not a double blinded study.	Study showed both cooled radiofrequency ablation and traditional radiofrequency ablation had over 50% success rates in reducing pain and improving function at 6 months. However, there was no significant difference between the groups.
Moon et al, 2013 (88) RA, AC Quality Scores: Cochrane = 9/13 IPM-QRB = 41/48	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.	n = 41 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.	n = 41 An active control trial with needle placement with perpendicular approach.	NRS, ODI One month and 6 months	Patients in both groups showed a statistically significant reduction in NRS and ODI 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.

Table 7 cont. *Study characteristics of randomized controlled trials assessing spinal facet joint nerve radiofrequency ablation.*

Study **Study Characteristic** **Methodological Quality Scoring**	**Number of Patients & Selection Criteria**	**Facet Joint Radiofrequency**	**Comparator**	**Outcome Measures and Time of Measurement**	**Results**	**Strengths**	**Weaknesses**	**Conclusions**
Moussa and Khedr, 2016 (89) RA, DB, AC Quality Scores: Cochrane = 10/13 IPM-QRB = 41/48	120 patients were randomized to 3 groups of 40 each. Patients with chronic low back pain for over one year duration despite at least 3 months of conservative management and who achieved near complete pain reduction after two diagnostic blocks.	n = 40 Intervention group received radiofrequency ablation with denervation of medial branches	n = 40 Control group received percutaneous radiofrequency coagulation of the facet joint capsule n = 40 A third group with 40 patients received sham lesion procedure after local anesthetic injection	Several outcome measures were measured VAS, ODI, and GPE. However, the primary outcome was determined by a predefined multidimensional COM at one year follow-up. 3, 6, 12, 24, and 36 months.	Success measured by COM at 1 year in the radiofrequency coagulation of joint capsule, denervation of medial dorsal branch and sham groups were 67.5%, 57.5% and 10% respective which was statistically significant (*P* = 0.038).	Randomized double blinded. All the interventional procedures were done by one neurosurgeon reducing potential operator-dependent confounding. patients diagnosed with facet joint pain by dual blocks.	Relatively small sample size, average. 8, 13 and 20% of patients lost to follow up at 1, 2 and 3 years respectively.	Study showed that both radiofrequency coagulation of facet joint capsule and medial branch nerve significantly improved pain in chronic low back pain patients at one year compared to the sham group. However, these benefits were seen at 2- and 3-years follow-up for group in which the facet joint capsule was targeted but diminished in the group in which medial branch nerve was targeted.
Song et al, 2019 (90) RA, SB (investigator), AC Quality Scores: Cochrane = 6/13 IPM-QRB = 29/48	40 patients were randomized to two groups of 20 each. One group received Radiofrequency ablation while the other group underwent endoscopic ablation. Patients who had at least 3 months of chronic low back pain and showed at least 80% pain relief following a single diagnostic block.	n = 20 The intervention group underwent fluoroscopy assisted radiofrequency ablation of lumbar medial branch nerve.	n = 20 The control group underwent endoscopic ablation of lumbar medial branch nerve.	VAS and ODI scores were measured. 3 weeks, 6 months, 1 and 2 years.	Radiofrequency group showed significant effectiveness at 3 weeks, 6 months, and 1 year but not significantly effective at 2 years. Endoscopy group showed significantly effective even at 2 years but the efficacy declined. There was no significant difference between the groups 3 weeks after the procedure however, at 6 months and longer the endoscopy group showed significantly better outcomes.	Randomized, investigator blinded study.	Very small sample size, single blinded (investigator only), single center, and patients' medication and physiotherapy were not taken into account. Single diagnostic block was used for diagnosis.	Both radiofrequency ablation and endoscopic ablation of the medial branch nerve were effective but endoscopic ablation has better and longer lasting outcomes.

Table 7 cont. *Study characteristics of randomized controlled trials assessing spinal facet joint nerve radiofrequency ablation.*

Study **Study Characteristic** **Methodological Quality Scoring**	**Number of Patients & Selection Criteria**	**Facet Joint Radiofrequency**	**Comparator**	**Outcome Measures and Time of Measurement**	**Results**	**Strengths**	**Weaknesses**	**Conclusions**
Xue et al, 2020 (91) RA, AC Quality Scores: Cochrane = 7/13 IPM-QRB = 32/48	60 patients were randomized to 2 groups of 30 each. One group received traditional percutaneous radiofrequency ablation, while the other group underwent percutaneous radiofrequency ablation under endoscopic guidance. Patients who had chronic low back pain for longer than 3 months; failed 2 months of conservative treatment; and more than 80% pain relief after controlled differential medial branch block	n = 30 Medial branch traditional radiofrequency	n = 30 Endoscopic ablation	1 day, 1 month, 3 months, 6 months, and 12 months VAS, MacNab score	Both groups with traditional radiofrequency ablation and endoscopic rhizotomy showed significant improvement up to 3-months. After that, endoscopic radiofrequency ablation showed significantly better results at 6-months and 12-months. Complication rate was higher with lack of skin sensation analgesia in 9 patients in the radiofrequency group and 2 patients in the endoscopy group	Randomized controlled trial, dual diagnostic blocks for selection criteria	Small sample size, active control, without blinding, single center There were no reports of percentage of patients with greater than 50% relief.	Negative trial for radiofrequency ablation with 3 months of relief. Overall, endoscopic radiofrequency yielded better results with lesser complications
CERVICAL								
van Eerd et al, 2021 (75) RA, AC Quality Scores: Cochrane = 13/13 IPM-QRB = 39/48	76 patients with chronic cervical facet joint pain were included on the basis of the diagnosis with clinical criteria No diagnostic blocks were performed	n = 37 The intervention group received radiofrequency denervation and bupivacaine injections, 0.25% at each level	n = 39 Facet joint nerve block group, described as the control group, received nerve blocks with bupivacaine injection 0.5 mL, 0.25% at each nerve These patients also underwent sham radiofrequency denervation	The primary outcome at 3 months and 6 months consisted of: • Pain intensity • Self-reported treatment effect • NDI • Use of pain medication • PGIC Duration of effect was determined using telephone interviews 6 weeks, 3 months, 6 months 6-month follow-up measure was defined as primary endpoint	Patient Global Impression of Change (PGIC) significant improvement Facet joint nerve blocks with bupivacaine group, 61.1% Denervation plus bupivacaine, 61.1% Facet joint nerve blocks with bupivacaine alone, 51.3% vs. radiofrequency ablation, 55.6% 3 months: bupivacaine only group, 51.4% RF denervation + bupivacaine, 57.1% 6 months: bupivacaine only group, 41% radiofrequency denervation + bupivacaine, 50%	Randomized active control trial comparing clinically relevant treatments commonly provided in managing patients with axial neck pain	The diagnosis was made based on clinical diagnosis. There were no diagnostic blocks performed	Positive short and long-term improvement 6 months or longer This study showed that local anesthetics are long-acting, at least equivalent to radiofrequency ablation in patients with clinically diagnosed facet joint pain with some decline, though statistically not significant at 6 months

Table 7 cont. *Study characteristics of randomized controlled trials assessing spinal facet joint nerve radiofrequency ablation.*

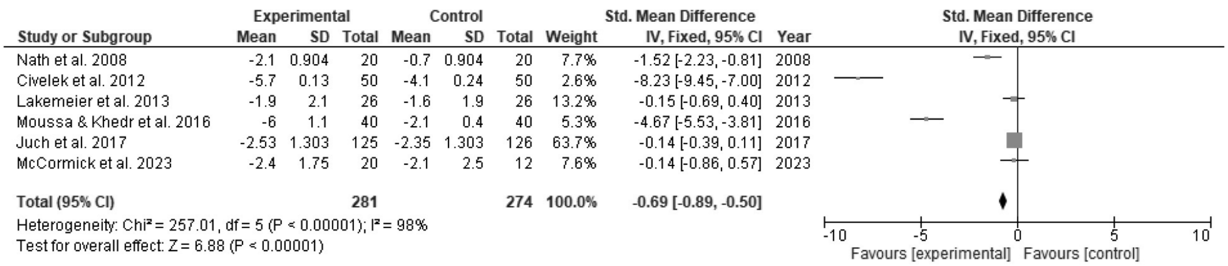
Study **Study Characteristic** **Methodological Quality Scoring**	**Number of Patients & Selection Criteria**	**Facet Joint Radiofrequency**	**Comparator**	**Outcome Measures and Time of Measurement**	**Results**	**Strengths**	**Weaknesses**	**Conclusions**
Lord et al, 1996 (77) RA, DB, sham control Quality Scores: Cochrane = 13/13 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.	n = 12 Diagnostic blocks with 100% pain relief criteria After positioning the needle, patients received 2 mL of 0.5% bupivacaine infiltrating each target nerve. Active treatment group received RF ablation. Needle size: 22-gauge, 10 cm, exposed active tip 4 mm Injectate: 2 mL of 0.5% bupivacaine Conventional RFTN 80°C, 90 seconds Number of lesions: 5 to 6 Duration of procedure: 3 hours	n = 12 Control group received sham RF ablation at temperature of 37°.	• VAS • McGill Pain questionnaire. • 3, 6, and 12 month follow-up Patients were followed until they reported that their pain had returned to 50% of the preoperative level.	6 MONTHS Sham 8% Active Treatment Group 58% Positive 1-YEAR: Active treatment group 58% Positive	First randomized sham controlled trial with extensive outcomes assessment	Small sample size	Positive trial • Short and long-term effectiveness. Study may be criticized for long duration of the technique with 3 hours, with 5-6 lesions and small sample size. • Efficacy was shown in patients with motor vehicle injury and chronic whiplash related neck pain. • A smaller active tip was utilized with a 4 mm active exposed tip. • Chronic degenerative pathology was not studied.

Table 7 cont. *Study characteristics of randomized controlled trials assessing spinal facet joint nerve radiofrequency ablation.*

Study Study Characteristic Methodological Quality Scoring	Number of Patients & Selection Criteria	Facet Joint Radiofrequency	Comparator	Outcome Measures and Time of Measurement	Results	Strengths	Weaknesses	Conclusions
THORACIC								
Joo et al, 2013 (76) RA, AC Quality Scores: Cochrane = 12/13 IPM-QRB = 38/48	In this trial, 40 patients were included either with radiofrequency ablation in 20 patients, or alcohol injection in another 20 patients. However, all these patients have undergone radiofrequency ablation prior to enrollment in the study and they required a repeat procedure with recurrent pain after successful treatment. These patients, even though they were successfully treated with radiofrequency ablation, underwent dual diagnostic block, comparative local anesthetic blocks using lidocaine and bupivacaine. > 50% relief of the targeted pain lasting for more than 6 months was considered as a positive outcome.	n = 20 Radiofrequency ablation was performed at 90°C for 90 seconds after the injection of 0.5 mL of 1% lidocaine to generate a single thermal RFA at each level.	n = 20 20 patients were treated in the alcohol group, 1 mL of dehydrated alcohol was injected slowly over a period of 15 seconds.	NRS, ODI 1 week and 1, 6, 9, 12, 15, 18, 21, and 24 months	3 months 100% vs. 100%s Recurrence of pain = 0% in both groups 6 months 95% vs. 100% Recurrence of pain = 5% in radiofrequency group; 0% in alcohol group 12 months 25% vs. 100% Recurrence of pain = 15% in radiofrequency group; 0% in alcohol group	Randomized active control trial	Small sample size This was performed in patients who already have undergone radiofrequency ablation	Positive trial In this study, the patients were selected who were successful prior to the initiation of the treatment with radiofrequency ablation. They also underwent repeat diagnostic blocks. The authors have outlined outcome criteria of 50% relief of more than 6 months as a successful outcome. However, the data is not reported in these aspects. It appears that 95% of the patients were positive for 6 months in radiofrequency group and 100% patients were positive for over 15 months in alcohol ablation group. Consequently, it appears that the alcohol ablation group was superior to radiofrequency ablation.

AC = active control; COM = combined outcome measure; DB = double-blind; GPE = global perceived effect; IPM-QRB = Interventional Pain Management techniques–Quality Appraisal of reliability and Risk of Bias Assessment; NASS = North American Spine Society; NDI = Neck Disability Index; NRS = Numeric Rating Scale; ODI = Oswestry Disability Index; P = prospective; PGIC = Patient Global Impression of Change ; RA = randomized; Rand-36 = RAND 36-Item Health Survey; RFA = radiofrequency ablation; RFTN = radiofrequency thermoneurolysis; RMDQ = Roland-Morris Disability Questionnaire; SB = single blinded; SF-36 = Short Form-36; VAS = Visual Analog Scale

A.



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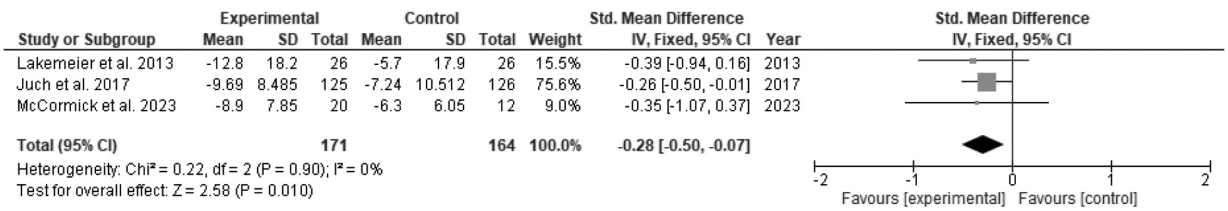


Fig. 2. *Outcome results of radiofrequency ablation at 6-month follow-up with functionality. A. 6 Months NRS radiofrequency ablation vs. control. B. 6 Months Functionality (ODI) radiofrequency ablation vs. control.*

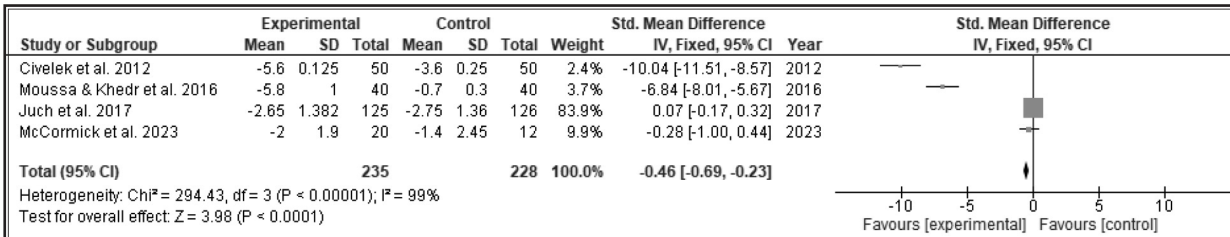


Fig. 3. *Results of 12-month outcomes of radiofrequency with pain relief.*

Based on GRADE criteria and results from the meta-analysis, the evidence is moderate, with a moderate recommendation.

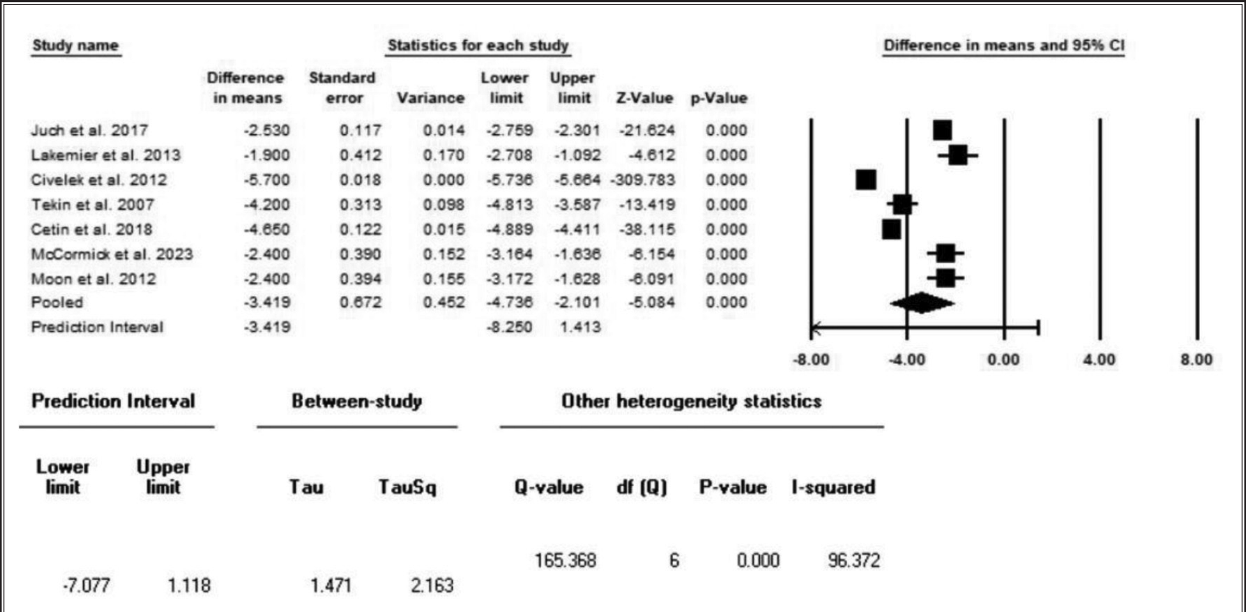
Summary of Evidence

Based on qualitative and quantitative analyses with grading, the evidence is Level II with moderate evidence, moderate certainty, and a moderate recommendation.

Discussion

In the present analysis, a total of 17 RCTs of radiofrequency met the inclusion criteria (37,72-75,81-85,87-89). All studies underwent quality assessment using both the Cochrane review criteria and the IPM-QRB instrument. Applying a best-evidence synthesis approach, incorporating both qualitative and quantitative analyses along with the GRADE framework and clinical applicability criteria, the resulting evidence was found to be valuable, relevant, and clinically applicable.

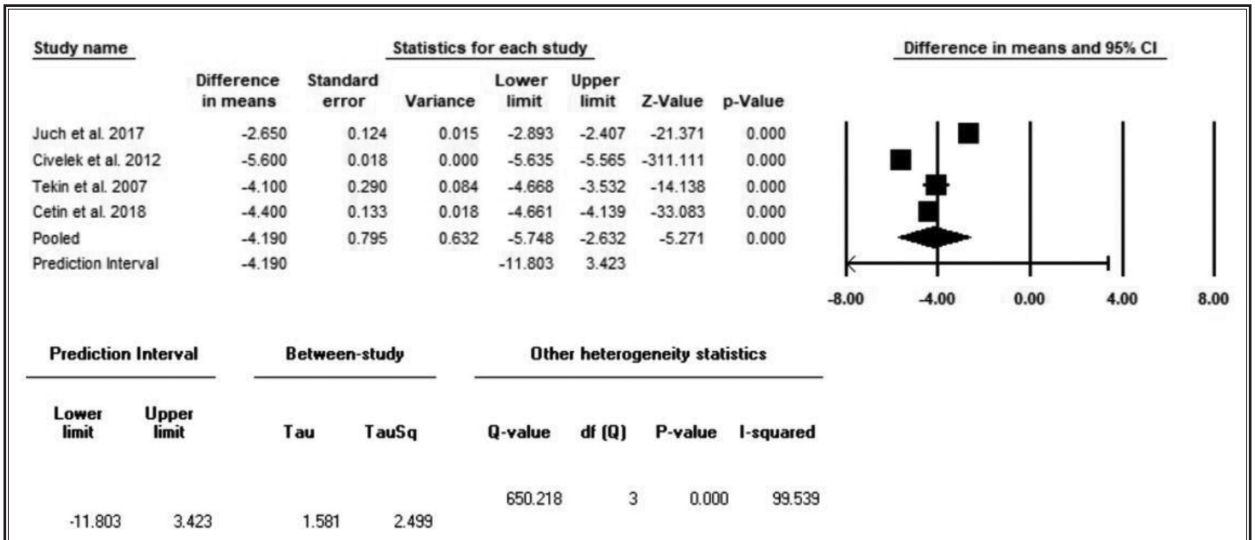
Based on Cochrane review criteria, 14 trials were identified as high quality (72-77,81-85,87-89) and 3 as moderate quality (37,90,91). Using IPM-QRB criteria, 11 trials were rated as high quality (72,75-77,83-85,87-89,91) and 6 as moderate quality (37,73,74,81,82,91). The summary of evidence based on qualitative and quantitative analyses with GRADE assessment was Level II, representing moderate evidence with moder-



Study name	Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Juch et al. 2017	-2.530	0.117	0.014	-2.759	-2.301	-21.624	0.000
Lakemier et al. 2013	-1.900	0.412	0.170	-2.708	-1.092	-4.612	0.000
Civelek et al. 2012	-5.700	0.018	0.000	-5.736	-5.664	-309.783	0.000
Tekin et al. 2007	-4.200	0.313	0.098	-4.813	-3.587	-13.419	0.000
Cetin et al. 2018	-4.650	0.122	0.015	-4.889	-4.411	-38.115	0.000
McCormick et al. 2023	-2.400	0.390	0.152	-3.164	-1.636	-6.154	0.000
Moon et al. 2012	-2.400	0.394	0.155	-3.172	-1.628	-6.091	0.000
Pooled	-3.419	0.672	0.452	-4.736	-2.101	-5.084	0.000
Prediction Interval	-3.419			-8.250	1.413		

Prediction Interval		Between-study		Other heterogeneity statistics			
Lower limit	Upper limit	Tau	TauSq	Q-value	df (Q)	P-value	I-squared
-7.077	1.118	1.471	2.163	165.368	6	0.000	96.372

Fig. 4. *Outcomes assessed with single-arm meta-analysis on NRS at 6 months.*



Study name	Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Juch et al. 2017	-2.650	0.124	0.015	-2.893	-2.407	-21.371	0.000
Civelek et al. 2012	-5.600	0.018	0.000	-5.635	-5.565	-311.111	0.000
Tekin et al. 2007	-4.100	0.290	0.084	-4.668	-3.532	-14.138	0.000
Cetin et al. 2018	-4.400	0.133	0.018	-4.661	-4.139	-33.083	0.000
Pooled	-4.190	0.795	0.632	-5.748	-2.632	-5.271	0.000
Prediction Interval	-4.190			-11.803	3.423		

Prediction Interval		Between-study		Other heterogeneity statistics			
Lower limit	Upper limit	Tau	TauSq	Q-value	df (Q)	P-value	I-squared
-11.803	3.423	1.581	2.499	650.218	3	0.000	99.539

Fig. 5. *Outcomes assess with single-arm meta-analysis on NRS at 12 months.*

ate recommendation. These results are consistent with some previous analyses while differing from others. Numerous systematic reviews and meta-analyses have been published with varying conclusions. According to GRADE assessment, one trial demonstrated high impact with high certainty (77), one trial demonstrated moderate impact with high certainty (81), 6 trials were graded as moderate impact with moderate certainty (72,82,84,85,88,89), 7 trials showed low impact with low certainty (73,75,76,83,87,90,91), and 2 trials demonstrated very low impact with very low certainty (37,74). Based on qualitative and quantitative grading, the overall evidence is Level II with moderate evidence, moderate certainty, and a moderate recommendation.

Among the systematic reviews, the majority have focused on the lumbar spine, with relatively few studies addressing the cervical and thoracic spine.

Xu et al (20) compared radiofrequency ablation

Table 8. *Evidence profile using randomized controlled trials for spinal facet joint nerve radiofrequency ablation for the same outcome and similar certainty of evidence (GRADE assessment).*

CERTAINTY ASSESSMENT								**Number of Patients**	**Impact**	**Certainty**
Study	**Study Design**	**Methodologic Quality**	**Risk of Bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Publication Bias**			
LUMBAR										
Lakemeier et al, 2013 (72)	RA, DB, AC	Cochrane: 9/13 (high) IPM-QRB: 37/48 (high)	Low	Low	NS	NS	None	n = 56 Intervention n = 27 Control n = 27	Moderate	Moderate
McCormick et al, 2023 (73)	P, RA, comparative	Cochrane: 11/13 (high) IPM-QRB: 30/48 (moderate)	Very low	Very low	NS	NS	None	n = 32 Intervention n = 20 Control n = 12	Low	Low
Civelek et al (74)	RA, AC	Cochrane: 9/13 (high) IPM-QRB: 28/48 (moderate)	Low	Low	NS	NS	None	n = 100 Intervention n = 50 Control n = 50	Very low	Very low
Juch et al, 2017 (37)	MINT RA, pragmatic trial	Cochrane: 6/13 (moderate) IPM-QRB: 26/48 (moderate)	Very low	Very low	NS	NS	None	n = 251 Intervention n = 125 Control n = 126	Very low	Very low
Nath et al, 2008 (81)	RA, DB, sham control	Cochrane: 13/13 (high) IPM-QRB: 28/48 (moderate)	Very low	Very low	NS	NS	None	n = 40 Intervention n = 20 Control n = 20	Moderate	High
Tekin et al, 2007 (82)	RA, DB, AC & sham control	Cochrane: 12/13 (high) IPM-QRB: 26/48 (moderate)	Very low	Very low	NS	NS	None	n = 60 Intervention n = 40 Control n =20	Moderate	Moderate

Table 8 cont. *Evidence profile using randomized controlled trials for spinal facet joint nerve radiofrequency ablation for the same outcome and similar certainty of evidence (GRADE assessment).*

CERTAINTY ASSESSMENT								Number of Patients	Impact	Certainty
Study	**Study Design**	**Methodologic Quality**	**Risk of Bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Publication Bias**			
van Wijk et al, 2005 (83)	RA, DB sham control	Cochrane: 13/13 (high) IPM-QRB: 38/48 (high)	Very low	Very low	NS	NS	None	n = 81 Intervention n = 40 Control n = 41	Low	Low
van Kleef et al, 1999 (84)	RA, DB sham control	Cochrane: 13/13 (high) IPM-QRB: 37/48 (high)	Very low	Very low	NS	NS	None	n = 31 Intervention n = 15 Control n = 16	Moderate	Moderate
Çetin & Yektaş, 2018 (85)	RA, DB, AC	Cochrane: 12/13 (high) IPM-QRB: 39/48 (high)	Very low	Very low	NS	NS	None	n = 118 Intervention n = 43 Control n = 75	Moderate	Moderate
McCormick et al, 2019 (87)	RA, SB, controlled	Cochrane: 10/13 (high) IPM-QRB: 36/48 (high)	Very low	Very low	NS	NS	None	n = 43 Intervention n = 22 Control n = 21	Low	Low
Moon et al, 2013 (88)	RA, AC, comparative	Cochrane: 9/13 (high) IPM-QRB: 41/48 (high)	Low	Low	NS	NS	None	n = 82 Intervention n = 41 Control n = 41	Moderate	Moderate
Moussa & Khedr, 2016 (89)	RA, DB, AC	Cochrane: 10/13 (high) IPM-QRB: 41/48 (high)	Low	Low	NS	NS	None	n = 120 Intervention n = 40 Control n =40 n = 40	Moderate	Moderate

Table 8 cont. *Evidence profile using randomized controlled trials for spinal facet joint nerve radiofrequency ablation for the same outcome and similar certainty of evidence (GRADE assessment).*

CERTAINTY ASSESSMENT								**Number of Patients**	**Impact**	**Certainty**
Study	**Study Design**	**Methodologic Quality**	**Risk of Bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Publication Bias**			
Song et al, 2019 (90)	RA, SB, AC	Cochrane: 6/13 (moderate) IPM-QRB: 29/48 (moderate)	High	High	NS	NS	None	n = 40 Intervention n = 20 Control n = 20	Low	Low
Xue et al, 2020 (91)	RA, AC	Cochrane: 7/13 (moderate) IPM-QRB: 32/48 (high)	High	Moderate	NS	NS	None	n = 60 Intervention n = 30 Control n =30	Low	Low
CERVICAL										
van Eerd et al (75)	RA, AC	Cochrane: 13/13 (high) IPM-QRB: 39/48 (high)	Very low	Very low	NS	NS	None	n = 76 Intervention n = 37 Control n = 39	Low	Low
Lord et al, 1996 (77)	RA, DB, sham control	Cochrane: 13/13 (high) IPM-QRB: 45/48 (high)	Very low	Very low	NS	NS	None	n = 24 Intervention n = 12 Control n = 12	High	High
THORACIC										
Joo et al, 2013 (76)	RA, AC	Cochrane: 12/13 (high) IPM-QRB: 38/48 (high)	Very low	Very low	NS	NS	None	n = 40 Intervention n = Control n =	Low	Low

AC = active controlled; DB = double-blind; NS = Not serious; P= prospective; RA = randomized; SB = single-blind and corticosteroid injections for spinal facet and sacroiliac joint pain in a meta-analysis of 33 studies. Their findings demonstrated greater pain relief with radiofrequency at 3 and 6 months, although no significant difference was observed at 12 months. For cervical facet pain, patients treated with corticosteroids had higher functional disability scores compared to those receiving radiofrequency ablation at 3 months, although the difference was not statistically significant.

Park et al (14) performed a systematic review and network meta-analysis of radiofrequency treatments for lumbar facet joint syndrome. Treatments were ranked using surface under the cumulative ranking curve (SUCRA) values. This analysis included 25 RCTs with 1,969 patients and demonstrated mixed quality regarding risk of bias, although most studies showed low risk in several domains. The results supported the effectiveness of medial branch thermal radiofrequency; however, endoscopic neurotomy ranked highest for pain reduction and Oswestry Disability Index (ODI) improvement at 1, 3, 6, and 12 months. At 1 and 6 months, endoscopic ablation showed the highest SUCRA values for pain reduction, followed by medial branch thermal radiofrequency. However, only 2 studies (90,91) evaluated endoscopic ablation, with a total of 50 patients. Both studies were small, single-blinded, and single-center, and one study (90) utilized only a single diagnostic block.

Mazmudar et al (52) provided an economic evaluation of lumbar spine facet interventions, including intraarticular injections, medial branch blocks, and radiofrequency ablation. Their 2020 review concluded that while evidence for intraarticular injections was limited, moderate evidence supported the use of medial branch blocks and radiofrequency neurotomies.

Janapala et al (13) conducted a systematic review and meta-analysis of randomized trials evaluating the efficacy of lumbar facet joint radiofrequency ablation procedures in managing chronic low back pain and reported Level II evidence for both short-term effectiveness of 6 months or less and long-term effectiveness of 6 months or longer. Of the 12 trials (37,72,81-90) included in this analysis, 6 trials (81,82,84,85,89,90) demonstrated both short- and long-term effectiveness, 4 trials (72,86-88) showed short-term effectiveness only, and 2 trials (83,88) demonstrated lack of effectiveness. The evidence analysis for efficacy was based on 5 placebo or sham-controlled trials (81-84,89), with one trial assessing short-term outcomes (81) and 4 trials assessing long-term outcomes (82-84,89). Among these, 3 trials demonstrated positive long-term outcomes (82,84,89), while one trial showed only short-term benefit (81). However, one trial (83) demonstrated negative results for both short-term and long-term outcomes. Consequently, among the 5 studies, 3 showed long-term improvement and 4 showed short-term improvement. These findings were further supported by active-controlled trials with single-arm meta-analysis.

However, among the studies with negative results, Juch et al (37) included 251 patients, with 126 patients in the control group. Despite several limitations (38,101-107), this study remains one of the important contributions in the literature. A second high-quality trial also demonstrated lack of significant improvement with radiofrequency ablation (83). Although positive outcomes were observed in 10 trials, the total number of patients undergoing conventional radiofrequency ablation in these studies was 296 of 717. In contrast, among the 2 negative trials (37,83), 162 of 332 patients underwent radiofrequency ablation. The negative trials included larger patient populations than any of the individual positive studies. Consequently, the evidence is Level II, with positive results in 10 of the 12 trials and 2 trials demonstrating negative findings.

There are additional systematic reviews with discordant conclusions. Maas et al (17) reported lack of effectiveness. Schneider et al (18) demonstrated effectiveness in patients achieving 100% pain relief using parallel needle placement, with improvement observed in approximately 57% of patients. Lee et al (19), in a meta-analysis, concluded that conventional radiofrequency denervation resulted in significant reduction in low back pain compared with sham procedures over a one-year period, based on analysis of 231 patients from multiple studies undergoing denervation procedures. Leggett et al (108), in an earlier systematic review, analyzed 6 sham-controlled RCTs conducted between 1994 and 2008 and reported high variability in selection criteria and outcomes, leading to inconclusive effectiveness. In contrast, Poetscher et al (109) evaluated 9 RCTs comparing radiofrequency treatment with other modalities and placebo and found that radiofrequency denervation was more effective than placebo and steroid injections, although they emphasized that the evidence should be interpreted with caution.

In the review by Janapala et al (13), 40% of the trials (5 of 12) compared cooled radiofrequency ablation (CRFA) to sham procedures. The majority of the trials (7 of 12) compared CRFA to other interventions or different modes of radiofrequency ablation. Lakemeier et al (72) compared CRFA with intraarticular facet joint steroid injections but evaluated only short-term effectiveness. This trial demonstrated positive results for both conventional radiofrequency and intraarticular steroid injections in the short term. Two trials (82,85) compared conventional radiofrequency with pulsed radiofrequency ablation, and in both studies conventional radiofrequency showed positive results, whereas pulsed radiofrequency demonstrated limited effectiveness. One trial (90) compared CRFA with endoscopic ablation. In this study, both groups demonstrated positive outcomes in the short term and long term according to established criteria; however, the effectiveness of endoscopic ablation persisted beyond 2 years, whereas this was not observed in the CRFA group. Overall, CRFA appears to be effective in both short-term and long-term management of chronic low back pain of facet joint origin.

From the meta-analysis, although there was no statistically significant difference in pain VAS scores between CRFA and sham procedures at 6-month follow-up, there was a trend toward CRFA being more effective than sham. These findings may, in part, be related to the small sample sizes of the RCTs, with a cumulative sample size of only 160 patients, including 80 in each arm. Therefore, additional studies with larger patient populations are needed to establish the effectiveness of lumbar radiofrequency ablation. However, in single-arm analysis, radiofrequency ablation using CRFA demonstrated a statistically significant reduction in pain VAS scores at both 6-month and 12-month follow-up compared to baseline.

The comprehensive evidence-based guidelines for facet joint interventions (9) incorporated both randomized controlled trials and observational studies. In the lumbar spine, 11 trials (37,72,74,81-86,88,110) met inclusion criteria, with 9 trials (72,74,81,82,84-86,88,110) demonstrating positive evidence and 2 trials (37,83) showing lack of effectiveness, yielding Level II evidence with a moderate recommendation.

With respect to cervical radiofrequency ablation, the number of systematic reviews is limited to 2, along with 2 guidelines (9-11,16,27).

With respect to thoracic radiofrequency ablation, the number of systematic reviews is limited to one, along with one guideline (8,9).

Manchikanti et al (27) conducted a systematic review of RCTs and observational studies, along with meta-analysis of observational studies, evaluating the effectiveness of cervical radiofrequency ablation in managing chronic neck pain, and reported Level II evidence for long-term effectiveness of 6 months or longer. For qualitative analysis, one RCT (77) with 12 patients in the treatment group and 8 positive observational studies (111-118) including 589 patients demonstrated positive outcomes with moderate to high clinical applicability. However, 2 studies (75,119) including 106 patients showed negative results, one of which was an RCT with low clinical applicability and was downgraded based on GRADE criteria.

For quantitative analysis, while conventional meta-analysis was not feasible, single-arm analysis demonstrated positive results across all included studies (75,79,115,120,121) in both treatment and control groups, with significant reductions in pain scores from baseline to follow-up. Pain reduction ranged from 4.2 and 4.8 points at 6 and 12 months, respectively, in the treatment group, and 4.7 and 4.9 points at 6 and 12 months, respectively, in the control group. These improvements were achieved in most cases with repeat procedures across multiple studies. Overall success rates ranged from 42% to 74% at 6 months and 58% to 76% at 12 months. These findings were derived from studies utilizing stringent diagnostic criteria and multiple lesion techniques, often performed with large needles.

Engel et al (16), in a systematic review including RCTs and observational studies, reported variable outcomes depending on selection criteria, including triple placebo-controlled medial branch blocks, dual comparative medial branch blocks, single medial branch blocks, intraarticular blocks, and clinical assessment alone. Greater pain relief was observed in patients selected using triple placebo-controlled or dual comparative medial branch blocks with 100% relief of index pain. The degree of relief was similar between triple and dual comparative blocks. Engel et al (16) reported a success rate of 52% (95% CI: 40 to 64) in patients selected using placebo-controlled blocks with inclusion of 64 patients, and 61% (95% CI: 52 to 70) in those selected using comparative dual blocks with inclusion of 125 patients, both achieving 100% pain relief. In contrast, with 75% relief using comparative blocks, pooled results from 234 patients showed a success rate of 31% (95% CI: 25 to 37) for complete relief, 44% (95% CI: 37 to 51) for 80% relief, and 59% (95% CI: 52 to 66) for greater than 50% relief. Only one small study with 6 patients evaluated comparative blocks, demonstrating a 50% success rate for greater than 50% relief and 17% for complete relief. Engel et al (16) reported complete relief rates up to 61% with an upper 95% CI of 70%, but did not provide data on 50% success rates. Additionally, multiple lesions were performed in several studies, often requiring multiple passes and extended procedural times.

Hurley et al (11), in consensus practice guidelines on cervical facet joint interventions, concluded that cervical medial branch radiofrequency ablation may provide benefit in well-selected patients, with medial branch blocks being more predictive than intraarticular injections. They also noted that more stringent selection criteria may improve denervation outcomes, although at the cost of increased false negatives and lower overall success rates.

Manchikanti et al (42) evaluated clinical outcomes and cost utility of therapeutic lumbar facet joint nerve blocks compared with radiofrequency ablation in managing chronic low back pain of facet joint origin. Clinical utility was higher with lumbar facet joint nerve blocks, with 96% and 79% achieving significant pain relief of ≥ 50% at 6 months, compared to 74% and 69% in the radiofrequency ablation group. Cost utility was similar between the two interventions, with $4,664 vs. $5,446 per quality-adjusted life year (QALY) for lumbar facet joint nerve blocks vs. radiofrequency ablation.

Overall, radiofrequency ablation demonstrates effectiveness in approximately 54% to 76% of patients, often requiring multiple passes and lesions with prolonged procedural time. In contrast, cervical facet joint nerve blocks are easier to perform, although the duration of relief is shorter, with success rates ranging from 85% to 92% at 12-month follow-up. These findings correspond to Level II evidence with moderate strength of recommendation according to American Society of Interventional Pain Physicians (ASIPP) guidelines, based on one RCT (122) and 3 observational studies (123-125).

Manchikanti et al (8) conducted a systematic review evaluating medial branch blocks and radiofrequency ablation in managing chronic thoracic pain. With inclusion of one RCT involving 20 patients in the treatment group and 5 observational studies, the evidence for radiofrequency ablation was Level III for thoracic pain. They concluded that there is Level II evidence for medial branch blocks and Level III evidence for radiofrequency ablation for long-term management of chronic thoracic pain.

Among cervical RCTs, Lord et al (77) conducted a landmark RCT utilizing a sham-controlled design of percutaneous radiofrequency ablation with multiple lesions in patients with chronic zygapophysial joint pain following whiplash injury. The study included 12 patients in each group (n = 24) and identified the pain source using double-blind, placebo-controlled local anesthetic blocks with 100% relief as the criterion standard. The results showed that the median time to return of pain to at least 50% of preoperative levels was 263 days in the treatment group compared to 8 days in the control group ($P = 0.04$). At 27 weeks, 7 patients (58%) in the treatment group were pain-free. The technique involved a 10 cm, 22-gauge electrode with a 4 mm exposed tip, placed in 2 planes to produce 5 to 6 lesions to account for anatomical variation. The procedure duration was approximately 3 hours per patient (80). The authors also reported that 6 patients (50%) in the control group and 3 patients (25%) in the treatment group experienced recurrence of pain immediately after the procedure. While the study's strengths include rigorous patient selection and technical precision, limitations include small sample size, prolonged procedural time, and the requirement of multiple lesions at each level, which may not be practical in routine clinical settings.

van Eerd et al (75) conducted the second trial assessing the efficacy and long-term effects of radiofrequency denervation in patients with clinically diagnosed cervical facet joint pain. They compared radiofrequency denervation combined with bupivacaine injection to bupivacaine injection alone with sham radiofrequency ablation in 76 patients. In this study, a single lesion was created using a 5 cm needle with a 5 mm active tip. The results were positive in the intervention group, with 55.6% achieving greater than 30% pain reduction compared to 51.3% in the control group, without a statistically significant difference. The Neck Disability Index (NDI) was 15 ± 8.7% in the intervention group compared to 16.5 ± 7.2 in the local anesthetic group. However, the median duration of treatment success was 42 months in the radiofrequency group compared to 12 months in the bupivacaine group, which was statistically significant. This study highlights the importance of local anesthetic blockade alone, with significant improvement observed at 3 months, 6 months, and up to one year. This has been described extensively by Manchikanti et al (122,126) in multiple studies, with an average duration of relief of 14 to 16 weeks. However, this study (75) is limited by the use of a 30% pain reduction threshold rather than the more clinically meaningful 50% or greater improvement in pain and function.

A prospective evaluation by Sapir and Gorup (115) assessed radiofrequency medial branch ablation in litigant and nonlitigant patients with cervical whiplash.

Inclusion criteria required ≥ 80% pain relief following diagnostic medial branch blocks. A total of 50 patients met the inclusion criteria, and 46 completed the study, including 32 litigants and 18 nonlitigants. There was a significant reduction in cervical whiplash symptoms and VAS pain scores both immediately after treatment and at one-year follow-up. Improvement was greater at one year, with NRS scores of 2.5 in nonlitigants and 3.6 in litigants. The authors suggested differences in symptomatology and treatment response between litigants and nonlitigants, although this did not reach statistical significance. Thirteen of the 32 litigant patients settled their cases after treatment; however, recurrence of pain occurred within one year. Overall, 21 patients reported recurrence of pain within one year, with time to recurrence defined as 50% return of pain at 8 ± 2 months.

In a comparative effectiveness study, Manchikanti et al (117) published clinical outcomes and cost utility of therapeutic medial branch blocks compared with radiofrequency ablation in managing chronic neck pain of facet joint origin were evaluated. The primary outcome was NRS, with significant improvement defined as ≥ 50% pain relief. The study included 132 patients receiving cervical medial branch blocks and 163 patients undergoing cervical radiofrequency ablation. One hundred seven patients in the medial branch block group and 105 patients in the radiofrequency group completed one-year follow-up.

Among observational studies meeting inclusion criteria, Speldewinde (111) evaluated 151 patients undergoing cervical radiofrequency ablation in a single-author, single-practice setting. The selection criterion required at least 80% pain relief following controlled comparative local anesthetic blocks. Outcome assessment was appropriate. Patients treated from 2001 to 2007 were designated as cohort A and those treated from 2007 to 2009 as cohort B, with 104 patients in cohort A and 47 in cohort B. The distinction between cohorts was based on technique, with cohort A utilizing a 22-gauge, 10 cm active tip and cohort B utilizing an 18-gauge cannula. Conventional radiofrequency ablation was performed at 80° for 90 seconds in the earlier cohort and at 80° for 60 seconds in the later cohort. A minimum of 3 contiguous lesions were produced at each target nerve. Overall, greater than 50% pain relief was achieved in 76% of patients, with 79% in cohort A and 85% in cohort B. Patients with successful outcomes experienced relief for more than 18 months, with an average duration of 27.5 months and a range of 18 to 68 months. Psychological and functional status also improved significantly in patients with successful pain relief.

MacVicar et al (112) evaluated 104 patients from two separate practices. Inclusion criteria required complete pain relief following controlled diagnostic medial branch blocks. Strict outcome measures were applied, with success defined as complete or at least 80% pain relief for at least 6 months, full restoration of activities of daily living, no need for additional healthcare, and return to work. The procedure utilized a 16-gauge cannula with a 10 cm active tip, producing at least 3 lesions at 80° and 85°C for 90 seconds. The procedure duration was approximately 2 hours for a single facet joint and 1.5 hours for treatment of the third occipital nerve. Sixty-six percent of patients achieved the treatment objective at 6 months. No complications were reported.

Among other observational studies, Shin et al (114) evaluated 28 patients undergoing conventional radiofrequency ablation and reported improvement in 68% of patients. Barnsley (113) assessed percutaneous radiofrequency ablation for chronic neck pain in a consecutive patient series. The results showed that 36 of 45 assessable procedures (80%) achieved significant pain relief, with a mean duration of 36 weeks. Seventy-four percent of patients achieved 100% pain relief. Only one serious adverse event, a local infection, was reported.

McCormick et al (73) compared lumbar medial branch RFA with intraarticular facet steroid injections and concluded that lumbar medial branch RFA demonstrated superior success rates across both pain and functional outcome domains.

Civelek et al (74) compared the clinical effectiveness of facet joint injections and facet joint RFA in patients with chronic low back pain and concluded that facet joint injections should be the initial treatment, with RFA reserved for cases in which pain recurs or injections are ineffective.

Nath et al (81) evaluated the efficacy of percutaneous radiofrequency zygapophysial joint neurotomy in reducing pain and physical impairment in patients with lumbar zygapophysial joint pain confirmed by repeated diagnostic blocks. They demonstrated statistically significant improvement in back and leg pain, as well as back and hip movement, and concluded that radiofrequency is not a placebo and may be effective in carefully selected patients with chronic low back pain.

One randomized trial (84) comparing perpendicular electrode positioning with sham demonstrated improvement in pain and ODI at 2 months and sustained treatment success at 3, 6, and 12 months.

McCormick et al (87) evaluated 6-month outcomes of cooled RFA compared with traditional RFA. Both treatments resulted in approximately 50% success rates when defined by improvement in pain and physical function at 6 months. Although success rates were higher in the cooled RFA group, the difference was not statistically significant.

Moon et al (88) described an alternative "distal approach" technique for lumbar medial branch RFA and compared it with the conventional tunnel vision approach, concluding that the distal approach may provide an improved option for lumbar medial branch RFA.

Moussa and Khedr (89) evaluated 120 patients divided into 3 groups: percutaneous radiofrequency coagulation of the facet joint capsule, percutaneous denervation of the medial dorsal branch, and a control group without radiofrequency lesioning. All groups received local injections of a mixture of local anesthetic and steroid. The results showed that targeting the facet joint capsule provided a technically simpler approach with prolonged pain relief compared to medial dorsal branch denervation.

Xue et al (91) randomized 30 patients to traditional percutaneous radiofrequency ablation and 30 patients to endoscopic-guided RFA. The endoscopic RFA group demonstrated significant benefit at 3 and 6 months.

Joo et al (76) compared alcohol ablation with repeated thermal RFA and concluded that alcohol ablation of the medial branch provided longer pain relief and improved quality of life compared to repeated radiofrequency medial branch neurotomy in patients with recurrent thoracolumbar facet joint pain after successful thermal RFA, without significant complications during 24-month follow-up.

The maximum number of procedures for medial branch blocks was 4 per year, whereas the radiofrequency ablation group underwent up to 2 procedures per year, administered at 3- or 6-month intervals if medically indicated and associated with adequate relief. The results demonstrated significant improvement in 100%, 94%, and 81% of patients in the medial branch block group compared to 100%, 69%, and 64% in the radiofrequency ablation group at 3-, 6-, and 12-month follow-up, respectively, with significant differences at 6 and 12 months. Cost utility analysis showed an average QALY cost of $4,994 for cervical medial branch blocks compared to $5,364 for cervical radiofrequency ablation. In this study, 6 of 132 patients (5%) in the medial branch block group and 53 of 163 patients (33%) in the radiofrequency ablation group required conversion to alternative treatments due to side effects (6 patients, 4%) or inadequate relief (47 patients, 29%).

Multiple issues have been highlighted in systematic reviews related to interventional pain management (9,127-132). Significant controversy exists regarding placebo definitions and methodological challenges in meta-analysis of active control trials. Manchikanti et al (129) demonstrated that sodium chloride injected into the epidural space is not a true placebo. Similarly, epidural lidocaine has also been shown not to function as a placebo (133). In this assessment, local anesthetic was utilized during sham control, which may itself provide significant pain relief (9). Consequently, in dual-arm meta-analysis, it is difficult to isolate the effectiveness of conventional radiofrequency ablation when local anesthetic is administered prior to sham neurolysis or when active control interventions are used. This limitation applies to placebo-controlled, sham-controlled, and active control trials.

None of the previous reviews performed single-arm analysis. It has been shown that single-arm analysis is essential in multiple studies, as demonstrated in this systematic review and meta-analysis (9,127,129-134). Qualitative analysis demonstrated positive results with Level II evidence. Quantitative analysis also demonstrated Level II evidence in dual-arm comparisons. However, single-arm meta-analysis showed clear superiority of conventional radiofrequency ablation compared to local anesthetic injections and other interventions, including pulsed radiofrequency. Although often underappreciated, single-arm analysis is critical in clarifying treatment effectiveness in both groups, particularly when local anesthetic is used as part of sham or control interventions. Consequently, differences in conclusions across studies may reflect methodological variations among investigators (9,127,129-133,135-143).

Conclusion

In conclusion, this systematic review and meta-analysis of 17 RCTs demonstrates that radiofrequency ablation provides a clinically meaningful therapeutic option for patients with chronic axial spinal pain of facet joint origin. The findings indicate moderate-level (Level II) evidence with moderate certainty, supporting its role in achieving significant pain relief and functional improvement in a substantial proportion of patients. While variability in study quality and the relative scarcity of uniformly high-quality trials remain important limitations, the overall body of evidence suggests that radiofrequency ablation is an effective and viable intervention within a multimodal pain management strategy. Future well-designed, high-quality studies are warranted to further refine patient selection, optimize procedural techniques, and strengthen the evidence base.

Author Contributions

The article was designed by LM, MRS and ADK.

Statistical analysis was performed by EK and NK.

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

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About the Authors

Dr. Manchikanti is Director, Pain Management Centers of America, Paducah, KY, Clinical Professor, Anesthesiology and Perioperative Medicine, University of Louisville, Louisville, KY, and Professor of Anesthesiology-Research, Department of Anesthesiology, School of Medicine, LSU Health Sciences Center, Shreveport, LA.
drlm@thepainmd.com

Ms. Emilija Knezevic is a Research Fellow, Advocate Illinois Masonic Medical Center, Chicago, IL.
emmaknezevic02@gmail.com

Dr. Knezevic is Vice Chair for Research and Education, Department of Anesthesiology, Advocate Illinois Masonic Medical Center, Chicago, IL, and Clinical Professor, Department of Anesthesiology and Department of Surgery, College of Medicine, University of Illinois, Chicago, IL.
nick.knezevic@gmail.com

Dr. Sanapati is Assistant Professor (Gratis) of Anesthesiology and Research, Department of Anesthesiology and Perioperative Medicine, University of Louisville School of Medicine, Louisville, KY, and Voluntary Faculty, Indiana University School of Medicine, Evansville, IN.
msanapati@gmail.com

Dr. Kaye is Professor, Interventional Pain Fellowship Director, Vice Chair of Research, Department of Anesthesiology; Professor, Department of Pharmacology, Toxicology, and Neurosciences, Louisiana State University Health Sciences Center at Shreveport, Shreveport, LA; Professor, Department of Anesthesiology, Tulane School of Medicine, and Professor, Department of Anesthesiology and Pharmacology, LSU School of Medicine, New Orleans, LA.
alan.kaye@lsuhs.edu

Dr. Singh is Associate Professor of Anesthesiology, Emory University, School of Medicine, Pain Division Chief, Anesthesia Department, and Medical Director, Emory Pain Center, Atlanta, GA.
vinita.singh@emory.edu

Dr. Pasupuleti is Director, Center for Pain Management, Bowling Green, KY.
rampasupuleti@yahoo.com

Dr. Prajapati, Harvard Medical School, Dept. of Anesthesiology, Critical Care and Interventional Pain Medicine, Beth Israel Deaconess Medical, Boston, MA.
Mprajapa@bidmc.harvard.edu

Dr. Boddu is Medical Director, Advanced Pain & Regenerative Specialists, Oceanside CA.
sr4md@yahoo.com

Dr. Hirsch is the Director of Interventional Neuroradiology, Chief Interventional Spine at the Massachusetts General Hospital and Professor at Harvard Medical School, Boston, MA.
jahirsch@mgh.harvard.edu

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

Bias Domain	**Source of Bias**		**Possible Answers**
Selection	(1) Was the method of randomization adequate?	A random (unpredictable) assignment sequence. Examples of adequate methods are coin toss (for studies with 2 groups), rolling a dice (for studies with 2 or more groups), drawing of balls of different colors, drawing of ballots with the study group labels from a dark bag, computer-generated random sequence, preordered sealed envelopes, sequentially-ordered vials, telephone call to a central office, and preordered list of treatment assignments.	Yes/No/ Unsure
		Examples of inadequate methods are: alternation, birth date, social insurance/security number, date in which they are invited to participate in the study, and hospital registration number.	
Selection	(2) Was the treatment allocation concealed?	Assignment generated by an independent person not responsible for determining the eligibility of the patients. This person has no information about the persons included in the trial and has no influence on the assignment sequence or on the decision about eligibility of the patient.	Yes/No/ Unsure
Performance	(3) Was the patient blinded to the intervention?	Index and control groups are indistinguishable for the patients or if the success of blinding was tested among the patients and it was successful.	Yes/No/ Unsure
Performance	(4) Was the care provider blinded to the intervention?	Index and control groups are indistinguishable for the care providers or if the success of blinding was tested among the care providers and it was successful.	Yes/No/ Unsure
Detection	(5) Was the outcome assessor blinded to the intervention?	Adequacy of blinding should be assessed for each primary outcome separately. This item should be scored "yes" if the success of blinding was tested among the outcome assessors and it was successful or:	Yes/No/ Unsure
		• for patient-reported outcomes in which the patient is the outcome assessor (e.g., pain, disability): the blinding procedure is adequate for outcome assessors if participant blinding is scored "yes"	
		• for outcome criteria assessed during scheduled visit and that supposes a contact between participants and outcome assessors (e.g., clinical examination): the blinding procedure is adequate if patients are blinded, and the treatment or adverse effects of the treatment cannot be noticed during clinical examination	
		• for outcome criteria that do not suppose a contact with participants (e.g., radiography, magnetic resonance imaging): the blinding procedure is adequate if the treatment or adverse effects of the treatment cannot be noticed when assessing the main outcome	
		• for outcome criteria that are clinical or therapeutic events that will be determined by the interaction between patients and care providers (e.g., cointerventions, hospitalization length, treatment failure), in which the care provider is the outcome assessor: the blinding procedure is adequate for outcome assessors if item "4" (caregivers) is scored "yes"	
		• for outcome criteria that are assessed from data of the medical forms: the blinding procedure is adequate if the treatment or adverse effects of the treatment cannot be noticed on the extracted data	
Attrition	(6) Was the drop-out rate described and acceptable?	The number of participants who were included in the study but did not complete the observation period or were not included in the analysis must be described and reasons given. If the percentage of withdrawals and drop-outs does not exceed 20% for short-term follow-up and 30% for long-term follow-up and does not lead to substantial bias a "yes" is scored (N.B. these percentages are arbitrary, not supported by literature).	Yes/No/ Unsure
Attrition	(7) Were all randomized participants analyzed in the group to which they were allocated?	All randomized patients are reported/analyzed in the group they were allocated to by randomization for the most important moments of effect measurement (minus missing values) irrespective of noncompliance and cointerventions.	Yes/No/ Unsure
Reporting	(8) Are reports of the study free of suggestion of selective outcome reporting?	All the results from all prespecified outcomes have been adequately reported in the published report of the trial. This information is either obtained by comparing the protocol and the report, or in the absence of the protocol, assessing that the published report includes enough information to make this judgment.	Yes/No/ Unsure
Selection	(9) Were the groups similar at baseline regarding the most important prognostic indicators?	Groups have to be similar at baseline regarding demographic factors, duration and severity of complaints, percentage of patients with neurological symptoms, and value of main outcome measure(s).	Yes/No/ Unsure

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

Bias Domain	Source of Bias		Possible Answers
Performance	(10) Were cointerventions avoided or similar?	If there were no cointerventions or they were similar between the index and control groups.	Yes/No/ Unsure
Performance	(11) Was the compliance acceptable in all groups?	The reviewer determines if the compliance with the interventions is acceptable, based on the reported intensity, duration, number and frequency of sessions for both the index intervention and control intervention(s). For example, physiotherapy treatment is usually administered for several sessions; therefore it is necessary to assess how many sessions each patient attended. For single-session interventions (e.g., surgery), this item is irrelevant.	Yes/No/ Unsure
Detection	(12) Was the timing of the outcome assessment similar in all groups?	Timing of outcome assessment should be identical for all intervention groups and for all primary outcome measures.	Yes/No/ Unsure
Other	(13) Are other sources of potential bias unlikely?	Other types of biases. For example: • When the outcome measures were not valid. There should be evidence from a previous or present scientific study that the primary outcome can be considered valid in the context of the present. • Industry-sponsored trials. The conflict of interest (COI) statement should explicitly state that the researchers have had full possession of the trial process from planning to reporting without funders with potential COI having any possibility to interfere in the process. If, for example, the statistical analyses have been done by a funder with a potential COI, usually "unsure" is scored.	Yes/No/ Unsure

Adapted and modified from: Furlan AD, et al; Editorial Board of the Cochrane Back, Neck Group. 2015 Updated method guideline for systematic reviews in the Cochrane Back and Neck Group. *Spine (Phila Pa 1976)* 2015; 40:1660-1673 (65).

Appendix Table 2. *Item checklist for assessment of randomized controlled trials of interventional pain management 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
9.	Previous Treatments	

Appendix Table 2 cont. ***Item checklist for assessment of randomized controlled trials of interventional pain management techniques utilizing IPM – QRB.***

		Scoring
	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

Appendix Table 2 cont. ***Item checklist for assessment of randomized controlled trials of interventional pain management techniques utilizing IPM – QRB.***

		Scoring
	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		48

Source: Manchikanti L, et al. Assessment of methodologic quality of randomized trials of interventional techniques: Development of an interventional pain management specific instrument. *Pain Physician* 2014; 17:E263-E290 (66).