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Systematic Review

An Update of the Effectiveness of Therapeutic Lumbar Facet Joint Interventions

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Background: Therapeutic lumbar facet joint interventions are implemented to provide long-term pain relief after the facet joint has been identified as the basis for low back pain. The therapeutic lumbar facet joint interventions generally used for the treatment of low back pain of facet joint origin are intraarticular facet joint injections, lumbar facet joint nerve blocks, and radiofrequency neurotomy.

Objective: To evaluate and update the effect of therapeutic lumbar facet joint interventions in managing chronic low back pain.

Study Design: A systematic review of therapeutic lumbar facet joint interventions for the treatment of chronic low back pain.

Methods: The available literature on lumbar facet joint interventions in managing chronic low back pain was reviewed. The quality assessment and clinical relevance criteria utilized were the Cochrane Musculoskeletal Review Group criteria as utilized for interventional techniques for randomized trials and the criteria developed by the Newcastle-Ottawa Scale criteria for observational studies. The level of evidence was classified as good, fair, and limited or poor based on the quality of evidence developed by the U.S. Preventative Services Task Force. Data sources included relevant literature identified through searches of PubMed and EMBASE from 1966 through June 2012, and manual searches of the bibliographies of known primary and review articles.

Outcome Measures: The primary outcome measure was pain relief with short-term relief defined as up to 6 months and long-term relief as 12 months. Secondary outcome measures were improvement in functional status, psychological status, return to work, and reduction in opioid intake.

Results: For this systematic review, 122 studies were identified. Of these, 11 randomized trials and 14 observational studies met inclusion criteria for methodological quality assessment.

The evidence for radiofrequency neurotomy is good and fair to good for lumbar facet joint nerve blocks for short- and long-term improvement; whereas the evidence for intraarticular injections and pulsed radiofrequency neurotomy is limited.

Limitations: The limitations of this systematic review include the continued paucity of evidence, specifically for intraarticular injection therapy.

Conclusion: In summary, there is good evidence for the use of conventional radiofrequency neurotomy, and fair to good evidence for lumbar facet joint nerve blocks for the treatment of chronic lumbar facet joint pain resulting in short-term and long-term pain relief and functional improvement.

There is limited evidence for intraarticular facet joint injections and pulsed radiofrequency thermoneurolysis.

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

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Persistent low back pain's prevalence and its great effect on society and health care economics have caused the number of diagnostic and therapeutic modalities employed to manage it to grow (1-36). However, it is often difficult to reach a definitive diagnosis and provide appropriate treatment (1,13,27,32,33,37-49). Intervertebral discs, nerve roots, facet joints, and sacroiliac joints have been established, utilizing controlled diagnostic studies (1,13,15,38-49), as potential sources of low back pain. Based on systematic reviews (42,43,46,47) and diagnostic accuracy studies (1,46-71), the prevalence of lumbar facet pain ranges between 25% and 45% with strict selection criteria of 75% to 100% pain relief using controlled blocks in heterogenous populations. The lumbar facet joint was first considered as a source for low back pain in 1911 by Goldthwaite (72) who believed that it was responsible for low back pain, lumbar spine instability, and leg pain. Putti (73) in 1927 agreed with Goldthwaite that the lumbar facet joint was responsible for generating low back and leg pain. By 1933, the lumbar facet joint was recognized as a distinct low back pain condition identified by Ghormley (74) as the "facet syndrome" which is still used today. Mooney and Robertson (75) were the first to "map out" the pain topography of low back and leg pain characteristic of the lumbar facet joint in asymptomatic and symptomatic patients with provocative intraarticular facet joint injections under x-ray guidance using hypertonic saline.

Lumbar facet joints are pairs of joints that stabilize and guide motion in the spine. When these joints misalign or become painful, they can cause pain in the lower back, hip, buttock, or leg. Facet joints are well innervated by the medial branches of the dorsal rami (43,46,76-86). Numerous studies have found free and encapsulated nerve endings in lumbar facet joints, as well as nerves containing substance P and calcitonin gene-related peptide (76,80,81,87-100).

Facet joint pain may be managed by intraarticular injections, facet joint nerve blocks, and neurolysis of facet joint nerves. Conflicting results have been reported regarding the effectiveness of these different treatment modalities in systematic reviews (25,27,33,43,101-107). Datta et al (43), in a systematic review of therapeutic facet joint interventions, presented moderate evidence for therapeutic lumbar facet joint nerve blocks and radiofrequency thermoneurolysis. Geurts et al (103) determined that there was moderate evidence that radiofrequency lumbar facet denervation was more effective for chronic low back pain than placebo. But, they included medial branch neurotomy, intraarticular neurotomy, and dorsal root denervation in their systematic review. Manchikanti et al (101) in their review assessed medial branch neurotomy for managing chronic spinal pain, including randomized and observational reports. They concluded that there was strong evidence for short-term relief and moderate evidence for long-term relief of facet joint pain. The evidence from the Cochrane Reviews, the American College of Occupational and Environmental Medicine (ACOEM) guidelines, and the American Pain Society (APS) guidelines for these interventions has been negative (25,27,33,43,106,107) and marred by controversy (27,33,37,106,107).

Systematic reviews have been shown to be outdated within 2 to 3 years after publication, and even earlier in evolving specialties (108,109). Consequently, this systematic review is undertaken to evaluate the effectiveness of therapeutic facet joint interventions in the treatment of chronic low back pain of lumbar facet joint origin. The objective of this systematic review is to determine the effects of lumbar facet joint interventions and update a previous systematic review (43). Other objectives include the evaluation of short-term and long-term pain relief as well as improvement in functional status.

1.0 Methods

The methodology utilized in this systematic review followed the review process derived from evidence-based systematic reviews and meta-analyses of randomized trials and observational studies (1,110-116), Consolidated Standards of Reporting Trials guidelines for the conduct of randomized trials (117-120), Standards for Reporting Observational Studies (121-123), Cochrane guidelines (25,114), and Chou and Huffman's guidelines (27).

1.1 Criteria for Considering Studies for This Review

1.1.1 Types of Studies

Randomized controlled trials
Nonrandomized observational studies
Case reports and reviews for adverse effects

1.1.2 Types of Patients

Patients of interest were adults aged at least 18 years with chronic lumbar facet joint pain of at least 3 months duration.

Patients must have failed previous pharmacothera-

py, exercise therapy, etc., prior to starting interventional pain management techniques.

1.1.3 Types of Interventions

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

1.1.4 Types of Outcome Measures

- The primary outcome parameter was pain relief with short-term defined as up to 6 months and long-term defined as 12 months.
- The secondary outcome measures were functional improvement; change in psychological status; return to work; reduction or elimination of opioid use, other drugs, or other interventions; and complications.
- At least 2 of the review authors independently, in an unblinded standardized manner, assessed the outcomes measures. Any disagreements between reviewers were resolved by a third author and consensus.

1.2 Literature Search

Searches were performed from the following sources without language restrictions:

1. PubMed from 1966
   www.ncbi.nlm.nih.gov/sites/entrez?db=pubmed
2. EMBASE from 1980
   www.embase.com/
3. Cochrane Library
   www.thecochranelibrary.com/view/0/index.html
4. U.S. National Guideline Clearinghouse (NGC)
   www.guideline.gov
5. Previous systematic reviews and cross references
6. Clinical Trials
   clinicaltrials.gov

The search period included articles from 1966 through June 2012.

1.3 Search Strategy

The search strategy emphasized treating chronic low back, non-cancer pain of facet joint origin with lumbar facet joint injections.

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

1.4 Data Collection and Analysis

The review focused on randomized trials, observational studies, and reports of complications. The population of interest was patients suffering with chronic pain of lumbar facet joint origin. Only lumbar facet joint interventions, including intraarticular injections, facet joint nerve blocks, pulsed radiofrequency, and conventional radiofrequency neurotomy, were evaluated. Reports without appropriate diagnosis, nonsystematic reviews, book chapters, and case reports were excluded.

1.4.1 Selection of Studies

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

1.4.2 Inclusion and Exclusion Criteria

The following are the inclusion and exclusion criteria.

1. Are the patients described in sufficient detail to allow you to decide whether they are comparable to those that are seen in clinical practices of interventional pain management?
   A. Setting – office, hospital, outpatient, inpatient.
   B. Physician – interventional pain physician, general physician, anesthesiologist, physiatrist, neurologist, rheumatologist, orthopedic surgeon, neurosurgeon, etc.
   C. Patient characteristics - duration of pain.
   D. Noninterventional techniques or surgical intervention in the past.
2. Is the intervention described well enough to enable you to provide the same for patients in interventional pain management settings?
   A. Nature of intervention.
   B. Frequency of intervention.
   C. Duration of intervention.
3. Were clinically relevant outcomes measured?
   A. Proportion of pain relief.
   B. Disorder/specific disability.
   C. Functional improvement.
   D. Allocation of eligible and noneligible patients to return to work.
   E. Ability to work.

1.4.3 Clinical Relevance

The clinical relevance of the included studies was evaluated according to 5 questions recommended by the Cochrane Back Review Group (Table 1) (113,124). Each question was scored positive (+) if the clinical relevance item was met, negative (–) if the item was not met, and unclear (?) if data were not available to answer the question.

1.4.4 Methodological Quality or Validity Assessment

The methodological quality assessment was performed by 2 review authors who independently assessed, in an unblinded standardized manner, the internal validity of all the studies.

The methodological quality assessment was performed in a manner to avoid any discrepancies; if a discrepancy occurred, it was evaluated by a third reviewer and settled by consensus.

The quality of each individual article used in this analysis was assessed by Cochrane review criteria (Table 2) (114) for randomized trials, and the Newcastle-Ottawa Scale for observational studies (Tables 3 and 4) (125). For nonrandomized observational studies, the patient population should have had at least 50 total or at least 25 in each group if they were comparison groups. Even though none of these instruments or criteria has been systematically assessed, the advantages and disadvantages of each system were debated.

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

For adverse effects, confounding factors, etc., it was not possible to use quality assessment criteria. Thus, these were considered based on interpretation of the reports published and critical analysis of the literature.

Only the randomized trials meeting the inclusion criteria with at least 6 of 12 criteria were utilized for analysis. However, studies scoring lower were described and provided with an opinion and critical analysis.

Observational studies had to meet a minimum of 50% of applicable criteria for cohort studies and case-control studies. Studies scoring less were also described and provided with an opinion and a critical analysis.

If the literature search provided at least 5 randomized trials meeting the inclusion criteria and they were homogenous for each modality evaluated (intraarticular injections, facet joint nerve blocks, conventional radiofrequency neurotomy, and pulsed radiofrequency), a meta-analysis was performed.

1.4.5 Data Extraction and Management

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

1.4.6 Assessment of Heterogeneity

Whenever meta-analysis was conducted, the I-squared (I^2) statistic was used to identify heterogeneity (126). A combined result with $I^2 > 50\%$ was considered substantially heterogeneous.

Analysis of the evidence was based on the condition (i.e., intraarticular injections, facet joint nerve blocks, conventional radiofrequency neurotomy, or pulsed radiofrequency) to reduce any clinical heterogeneity.

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

Data were summarized using meta-analysis when

Table 1. *Clinical relevance questions.*

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

Scoring adapted and modified from Staal JB, et al. Injection therapy for subacute and chronic low back pain. *Cochrane Database Syst Rev* 2008; 3:CD001824 (124).

Table 2. ***Randomized controlled trials quality rating system.***

A	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 die (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, pre-ordered sealed envelopes, sequentially-ordered vials, telephone call to a central office, and pre-ordered list of treatment assignments. 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.	Yes/No/ Unsure
B	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
C	Was knowledge of the allocated interventions adequately prevented during the study?		
	3. Was the patient blinded to the intervention?	This item should be scored "yes" if the 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
	4. Was the care provider blinded to the intervention?	This item should be scored "yes" if the 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
	5. Was the outcome assessor blinded to the intervention?	Adequacy of blinding should be assessed for the primary outcomes. This item should be scored "yes" if the success of blinding was tested among the outcome assessors and it was successful or: –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., co-interventions, 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.	Yes/No/ Unsure
D	Were incomplete outcome data adequately addressed?		
	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
	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 non-compliance and co-interventions.	Yes/No/ Unsure
E	8. Are reports of the study free of suggestion of selective outcome reporting?	In order to receive a "yes," the review author determines if all the results from all pre-specified 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
F	Other sources of potential bias:		
	9. Were the groups similar at baseline regarding the most important prognostic indicators?	In order to receive a "yes," 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
	10. Were co-interventions avoided or similar?	This item should be scored "yes" if there were no co-interventions or they were similar between the index and control groups.	Yes/No/ Unsure
	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 over 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
	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 important outcome assessments.	Yes/No/ Unsure

Adapted and modified from Furlan AD, et al. 2009 updated method guidelines for systematic reviews in the Cochrane Back Review Group. Spine (Phila Pa 1976) 2009; 34:1929-1941 (114).

Table 3. *Newcastle-Ottawa quality assessment scale: Case control studies.*

Selection
1) Is the case definition adequate?
a) yes, with independent validation *
b) yes, e.g. record linkage or based on self reports
c) no description
2) Representativeness of the cases
a) consecutive or obviously representative series of cases *
b) potential for selection biases or not stated
3) Selection of Controls
a) community controls *
b) hospital controls
c) no description
4) Definition of Controls
a) no history of disease (endpoint) *
b) no description of source
Comparability
1) Comparability of cases and controls on the basis of the design or analysis
a) study controls for _____ (Select the most important factor.) *
b) study controls for any additional factor * (This criteria could be modified to indicate specific control for a second important factor.)
Exposure
1) Ascertainment of exposure
a) secure record (eg surgical records) *
b) structured interview where blind to case/control status *
c) interview not blinded to case/control status
d) written self report or medical record only
e) no description
2) Same method of ascertainment for cases and controls
a) yes *
b) no
3) Non-Response rate
a) same rate for both groups *
b) non respondents described
c) rate different and no designation

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Exposure categories. A maximum of two stars can be given for Comparability.

Wells GA, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analysis. www.ohri.ca/programs/clinical_epidemiology/oxford.asp (125).

at least 5 studies per type of disorder were available meeting the inclusion criteria, such as for intraarticular injections, facet joint nerve blocks, conventional radiofrequency neurotomy, or pulsed radiofrequency.

Qualitative (the direction of a treatment effect) and quantitative (the magnitude of a treatment effect) conclusions were evaluated. Random-effects meta-analysis to pool data was also used (127).

The minimum amount of change in pain score to be clinically meaningful has been described as a 2-point change on a scale of 0 to 10 (or 20 percentage points), based on findings in trials studying general chronic pain (128), chronic musculoskeletal pain (129), and chronic low back pain (111-113,130,131). However, recent stud-

Table 4. *Newcastle-Ottawa quality assessment scale for cohort studies*.

Selection
1) Representativeness of the exposed cohort
a) truly representative of the average _____ (describe) in the community*
b) somewhat representative of the average _____ in the community *
c) selected group of users e.g. nurses, volunteers
d) no description of the derivation of the cohort
2) Selection of the non exposed cohort
a) drawn from the same community as the exposed cohort *
b) drawn from a different source
c) no description of the derivation of the non exposed cohort
3) Ascertainment of exposure
a) secure record (eg surgical records) *
b) structured interview *
c) written self report
d) no description
4) Demonstration that outcome of interest was not present at start of study
a) yes *
b) no
Comparability
1) Comparability of cohorts on the basis of the design or analysis
a) study controls for _____ (select the most important factor) *
b) study controls for any additional factor * (This criteria could be modified to indicate specific control for a second important factor.)
Outcome
1) Assessment of outcome
a) independent blind assessment *
b) record linkage *
c) self report
d) no description
2) Was follow-up long enough for outcomes to occur
a) yes (select an adequate follow up period for outcome of interest) *
b) no
3) Adequacy of follow up of cohorts
a) complete follow up - all subjects accounted for *
b) subjects lost to follow up unlikely to introduce bias - small number lost - > ____ % (select an adequate %) follow up, or description provided of those lost) *
c) follow up rate < ____% (select an adequate %) and no description of those lost
d) no statement

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of 2 stars can be given for Comparability

Wells GA, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analysis. www.ohri.ca/programs/clinical_epidemiology/oxford.asp (125).

ies evaluating interventional techniques have used > 50% pain relief as the cutoff threshold for clinically meaningful improvement in pain relief or functional status (132-145). Consequently, for this analysis, we utilize clinically meaningful pain relief of at least a 3-point change on an 11-point scale of 0 to 10, or 50% pain re-

lief from the baseline, as clinically significant and functional status improvement of 40% or more.

1.4.8 Integration of Heterogeneity

The evidence was assessed separately for each modality. The meta-analysis was performed only if there were at least 5 studies meeting inclusion criteria for each variable.

Statistical heterogeneity was explored using univariate meta-regression (146).

1.5 Summary Measures

Summary measures include 50% or more reduction of pain in at least 40% of the patients, or at least a 3-point decrease in pain scores, and relative risk of adverse events including side effects.

1.6 Analysis of Evidence

Evidence analysis was performed based on United States Preventive Task Force (USPSTF) criteria as illustrated in Table 5 which has been utilized by multiple authors (147).

The Analysis was conducted using 3 levels of evidence ranging from good, fair, and limited or poor.

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

1.7 Outcome of the Studies

In the randomized trials, a study was judged to be positive if the lumbar facet joint intervention was clinically relevant and effective, either with a placebo control or an active control. This indicates that the difference in effect for the primary outcome measure is statistically significant on the conventional 5% level. In a negative study, no significant difference between the treatment groups, or no improvement from baseline is identified.

For observational studies, a study was judged to be positive if the lumbar facet joint intervention was effective, with outcomes reported at one month, 3 months, 6 months, and one year.

The outcomes were judged as improvement in at least 40% of patients at distinct reference points with positive or negative results reported at one month, 3 months, 6 months, and one year.

2.0 Results

Figure 1 shows a flow diagram of the study selection of therapeutic intervention trials and studies. There were 122 studies ultimately considered for inclusion (133,147-267). Of these, 11 randomized trials (133,155,157,162-166,173,178,198,233,250) with 2 duplicate publications (162,163) and 14 observational studies met inclusion criteria (148,149,152,174,183,185,188,225,235,253,254,258-260). Multiple studies were excluded due to ultrasound being used for imaging guidance or there was no imaging guidance at all, as well as obvious reasons for noninclusion. Thirty-six studies were excluded and are described in Table 6.

Tables 7 to 9 illustrate the assessment of studies considered for inclusion. There were 11 randomized trials (133,155,157,162-166,173,178,198,233,250) with 2 duplicate publications (162,163) meeting the inclusion criteria. There were 3 trials that evaluated therapeutic lumbar facet joint nerve blocks (133,198,164), with 2 du-

Table 5. *Method for grading the overall strength of the evidence for an intervention.*

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

Adapted and modified from methods developed by U.S. Preventive Services Task Force (86, 90-100).

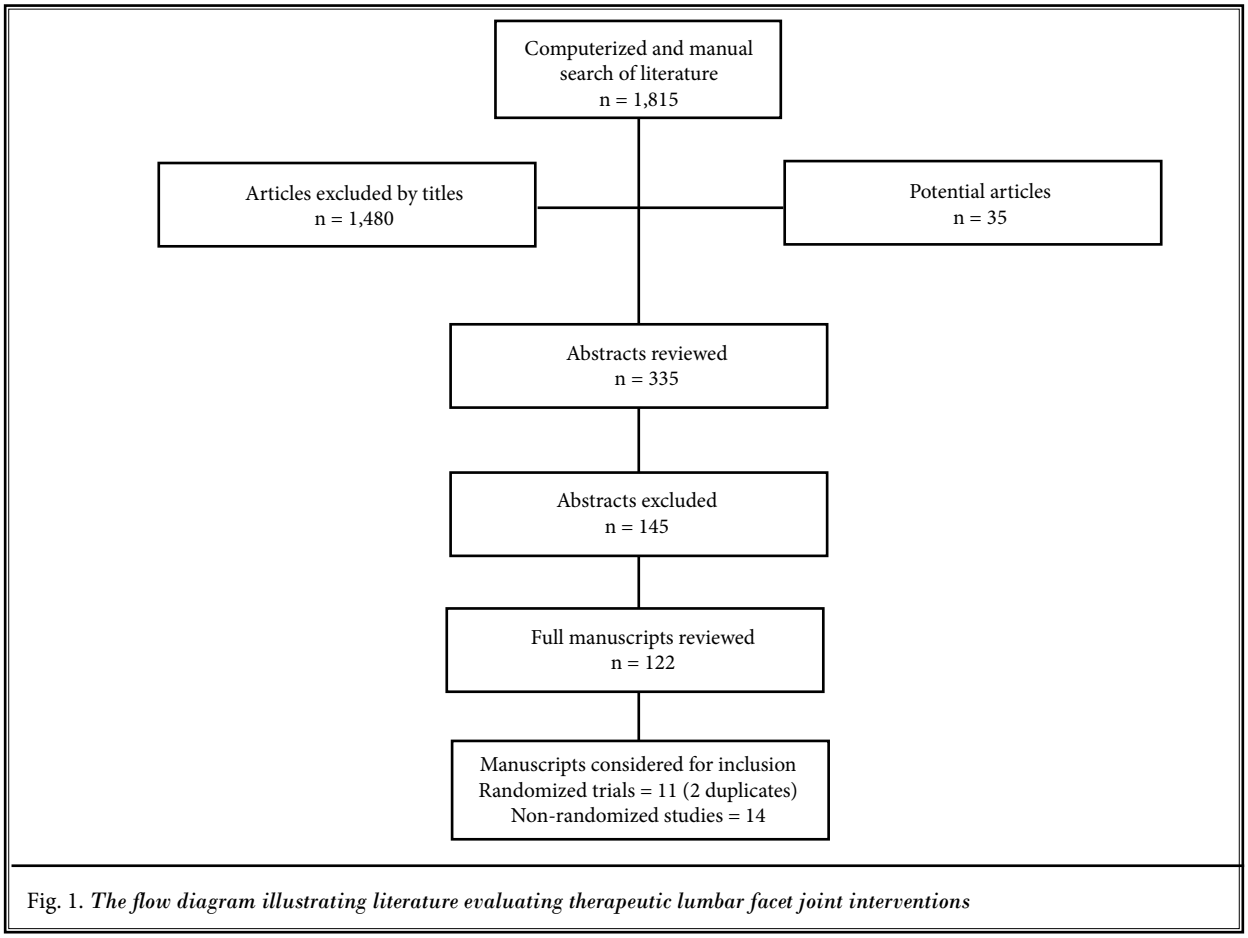

Fig. 1. *The flow diagram illustrating literature evaluating therapeutic lumbar facet joint interventions*

plicate publications (162,163), 7 randomized trials that evaluated lumbar facet joint radiofrequency neurolysis (165,166,173,178,198,233,250), and 2 randomized trials that evaluated intraarticular injections (155,157).

There were 14 observational studies (148,149,152,174,183,185,188,225,235,253,254,258-260), with 6 studies evaluating intraarticular injections (148,149,152,183,225,235) and 8 studies evaluating lumbar facet joint radiofrequency neurotomy (174,185,188,253,254,258-260).

2.1 Clinical Relevance

Of the 25 studies assessed for clinical relevance (133,148,149,152,155,157,162-166, 173,174,178,183,185,188,198,225,233,235,250,253,254,258-260), with 2 duplicate publications (162,163), 16 of them met the criteria with a score of 4 of 5 or greater (133,155,162-166,173,174,178,183,188,198,250,253,258-260). Table 10 illustrates assessment of clinical relevance.

2.2 Methodological Quality Assessment

A methodological quality assessment of the randomized controlled trials meeting inclusion criteria was carried out utilizing Cochrane review criteria as shown in Table 11. Studies achieving Cochrane scores of 9 or higher were considered as high quality, 6 to 8 were considered as moderate quality, and studies scoring less than 6 were excluded.

There were 11 randomized trials (133,155,157,162-166,173,178,198,233,250) with 2 duplicate publications (162,163), of which 8 were high in methodological quality (133,155165,166,173,178,198,233), and 3 were moderate in methodological quality (157,164,250).

A methodological quality assessment of the observational studies meeting inclusion criteria was carried out utilizing Newcastle-Ottawa Scales as illustrated in Tables 12 and 13. For cohort studies, studies scoring 67% or higher were considered high quality, studies scoring 50% or higher were considered moderate qual-

Table 6. *List of excluded randomized trials andnonrandomized studies*.

Manuscript Author(s)	Condition Studied	Number of Patients	Reason for Exclusion	
			Follow-up Period	Other Reason(s)
Randomized				
Lilius et al (156)	Chronic low back pain	109	3 months	Study with short-term follow-up along with lack of diagnostic blocks and comparison of intraarticular or extraarticular injections with a large volume of injection. At best, this study may be appropriate for a diagnostic study with a single block.
Marks et al (158)	Chronic low back pain	86	3 months	The authors compared facet joint nerve blocks and intraarticular injections with high volume injections with very short-term follow-up in a randomized trial as diagnostic blocks.
Nash (159)	Chronic low back pain	67	3 months	Authors compared the effectiveness of intraarticular injections with medial branch blocks on a short-term basis with no controlled local anesthetic blocks, and with lack of long-term follow-up and outcomes
Leclaire et al (167)	Chronic low back pain	70	12 weeks	Relatively small study; however, technique and the diagnostic evaluation with intraarticular injections were inappropriate (168-172).
Gallagher et al (175)	Chronic low back pain	41	One month and 6 months	Authors evaluated 60 patients with a single block and randomized them into 2 groups with 41 patients testing positive. The study showed improvement at one month and 6 months; however, the inclusion criteria, the technical considerations, and statistical analysis were considered as flawed.
Kroll et al (189)	Acute low back pain	50	3 months	Conventional and pulsed radiofrequency neurotomy were studied in acute low back pain.
Ackerman & Ahmad (226)	Chronic low back pain	46	12 weeks	Small study with limited follow-up without diagnostic blocks.
Andres et al (257)	Chronic low back pain	32	6 months	Laser-guided or conventional lumbar medial branch kryorhizotomy was performed in 32 patients.
Kader et al (261)	Chronic nonspecific low back pain with or without leg pain	63	10 weeks	Patients were randomized into 3 groups with back education and standard physiotherapy for 10 weeks, back education and gym ball exercise for 10 weeks, or perifacet injection into the lumbar multifidus muscle with methylprednisolone. Since there was no facet joint injection, the study failed to meet the criteria for inclusion.
Observational				
Cleary et al (161)	Symptomatic lumbar facet joint arthritis	13	6 months	Small study with 13 patients
Buijs et al (176)	Chronic low back pain	33	NA	A small study with evaluation of reproducibility of lesion size.
Lau et al (177)	Chronic low back pain	34	12 months	Small sample size
Vad et al (179)	Low back pain	12	One-year	Small sample size
Mogalles et al (180)	Chronic low back pain	15	6 months	Small sample size
Birkenmaier et al (181)	Chronic low back pain	46	One-year	Cryoneurolysis with a small sample size
Staender et al (182)	Chronic low back pain	76	6 to 43 months	Evaluation of CT-guided kryorhizotomy.
Kawu et al (184)	Chronic low back pain	18	6 months	Small sample size
Chua et al (186)	Chronic spinal pain	NA	NA	A review manuscript describing mechanism and potential indications.

Table 6 (cont). *List of excluded randomized trials andnonrandomized studies.*

Manuscript Author(s)	Condition Studied	Number of Patients	Reason for Exclusion	
			Follow-up Period	Other Reason(s)
Rambaransingh et al (190)	Chronic low back pain	73	1 year	Authors evaluated a combined 104 patients who underwent repeat radiofrequency neurotomy for chronic neck or back pain with follow-up available only in 73 patients after the first and second radiofrequency and only 36 patients after the third radiofrequency respectively.
Manchikanti et al (194)	Study of complications	7,500	2 weeks	Study of complications
DePalma et al (210)	Chronic low back pain	15	12 months	Small sample size
Chaturvedi et al (215)	Chronic low back pain	44	2 years	Small sample size
Bademci et al (219)	Degenerative lumbar disc surgery	40	1 day	The authors evaluated facet joint infiltrative analgesia for postoperative pain relief.
Sarazin et al (229)	Low back pain	NA	NA	The study evaluated the role of lumbar facet joint arthrography with a posterior approach in cadavers.
Mayer et al (237)	Chronic low back pain with segmental rigidity	70	Immediate	The evaluation of prevalence in segmental rigidity.
Schulte et al (240)	Chronic low back pain	39	6 months	Small sample size
Stojanovic et al (241)	Chronic low back pain	NA	Immediate	Authors evaluated a single needle approach for multiple medial branch blocks
Lynch & Taylor (243)	Chronic low back pain	35	3 months	Prospective evaluation with 35 patients in the intraarticular group and 15 in the extraarticular group
Dreyfuss et al (248)	Chronic low back pain	15	12 months	Small sample size
Kamalian et al (251)	Postvertebral augmentation back pain	34	NA	The authors showed management of postvertebral augmentation back pain in a small sample size.
North et al (252)	Chronic low back pain	42	3.2 years	Small sample size and also analysis of prognostic factors
Schaerer (255)	Chronic neck and low back pain	117	13.7 months average	This study showed positive results; however, the full manuscript was not available and it appeared that the number of patients included for lumbar treatment were less than 50.
Schofferman & Kine (256)	Low back pain	20	1 year	Small sample size
Kremer et al (262)	Chronic low back pain	78	1 month	Only one month follow-up with a postal questionnaire or telephone interview with a poor response rate.
Klessinger (264)	Chronic low back pain	40	1 year	Small number of patients with spondylolisthesis leading to exclusion.
Streitberger et al (265)	Chronic low back pain	41	1 year	Factors determining the success of radiofrequency denervation were performed in a nonrandomized prospective study in 44 patients.

ity, and studies scoring less than 50% were considered low quality and were excluded.

For case-control studies, 67% or higher was considered as high quality, 50% or higher was considered as moderate quality, and less than 50% was considered low quality, and those studies were excluded. There were no case-control studies included in this review.

There were 14 observational studies (148,149,152,174,183,185,188,225,235,253,254,258-260) of which 13 were considered as moderate qual-

Table 7. *Study characteristics of randomized controlled trials and observational studies of lumbar radiofrequency neurotomy.*

Reference	Number of Patients & Selection Criteria	Control	Interventions	Outcome Measures	Time of Measurement	Results	Strengths	Weaknesses	Conclusions
Civelek et al, 2012 (198) Randomized, active-control trial	100 patients with chronic low back with failed conservative therapy and strict selection criteria; however, without diagnostic blocks.	Facet joint nerve block with local anesthetic and steroids in 50 patients.	Conventional radiofrequency neurotomy at 80°C for 120 seconds in combination with high dose local anesthetic and steroids, in 50 patients.	Visual Numeric Pain Scale, North American Spine Society patient satisfaction questionnaire, Euro-Qol in 5 dimensions and ≥ 50% relief	One month, 6 months, 12 months	At 6 month follow-up, 92% of the patients in the radiofrequency group and 75% of the patients in the facet joint injection group showed significant improvement. 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 described as double-blind or at least single blind active-control trial with a reasonably large number of patients with 50 in each group. Strict non-invasive selection criteria without diagnostic blocks.	No diagnostic blocks were performed. High dose steroids and local anesthetics were provided in both groups.	Positive results even without diagnostic blocks, both for facet joint nerve blocks and radiofrequency neurotomy.
Cohen et al, 2010 (250) Randomized, double-blind, control trial	151 chronic low back pain patients with 0, 1, or 2 diagnostic blocks 51 patients with no diagnostic block, 50 patients in 2 groups, each group either with a single diagnostic block or double diagnostic block.	Radiofrequency neurotomy in patients without diagnostic blocks.	Conventional radiofrequency neurotomy at 80° C for 90 seconds in all patients; however, in 2 groups with either a single block paradigm or a double block paradigm testing for positive results.	Greater than 50% pain relief coupled with a positive global perceived effect persisting for 3 months.	3 months	Denervation success rates in Groups 0, 1, and 2 were 33%, 39%, and 64% respectively.	Multicenter, randomized controlled trial with or without diagnostic blocks	Authors misinterpreted cost-effectiveness without consideration of many factors reported.	Results were positive when double diagnostic blocks were utilized.
Nath et al, 2008 (165) Randomized, double-blind, sham control trial	40 patients with chronic low back pain for at least 2 years with 80% relief of low back pain after controlled medial branch blocks. The patients were randomized into an active and a control group.	Controlled sham lesion in 20 patients in the control group	The 20 patients in the active group received conventional lumbar facet joint radiofrequency neurolysis at 85°C for 60 seconds. The 20 patients in the control group received sham treatment without radiofrequency neurolysis of the lumbar facet joints.	Numeric Rating Scale, global functional improvement, reduced opioid intake, employment status.	6 months	Significant reduction not only in back, and leg pain; functional improvement; opioid reduction; and employment status in the active group compared to the control group.	Randomized, double-blind trial after the diagnosis of facet joint pain with triple diagnostic blocks	Short-term follow-up with small number of patients	Positive study illustrating the efficacy of radiofreqency neurotomy compared to local anesthetic injection and sham lesioning.

Table 7 (cont.). *Study characteristics of randomized controlled trials and observational studies of lumbar radiofrequency neurotomy.*

Reference	Number of Patients & Selection Criteria	Control	Interventions	Outcome Measures	Time of Measurement	Results	Strengths	Weaknesses	Conclusions
Tekin et al, 2007 (178) Randomized, active and sham, double-blind controlled trial	60 patients with chronic low back pain randomized into 3 groups with 20 patients in each group. Single diagnostic block of facet joint nerves with 0.3 mL of lidocaine 2% with 50% or greater relief.	Sham control with local anesthetic injection	Either pulsed radiofrequency (42°C for 4 minutes) or conventional radiofrequency neurotomy (80°C for 90 seconds) in 20 patients in each group.	Visual analog scale and Oswestry Disability Index	3, 6, and 12 months	Visual analog scale and Oswestry Disability Index scores decreased in all groups from 3 procedural levels. Decrease in pain scores was maintained in the conventional radiofrequency group at 6 months and one year. However, in pulsed radiofrequency group, the improvement was significant only at 6 months, but not one year.	Randomized, double-blind, controlled trial comparing control, pulsed radiofrequency, and conventional radiofreqency neurotomy. Authors also utilized a parallel needle placement approach	Small sample size with a single block and 50% relief as inclusion criteria. Authors have not described the significant improvement percentages.	Positive results in conventional radiofreqency neurotomy up to one year, whereas positive results with local anesthetic block with sham control radiofrequency neurotomy and pulsed radiofrequency neurotomy at 6 months.
van Wijk et al, 2005 (166) Randomized, double-blind, sham control trial	81 patients with chronic low back pain were evaluated with radiofreqency neurotomy with 41 patients in the control group with at least 50% relief for 30 minutes with a single block with intraarticular injection of 0.5 mL lidocaine 2%.	Sham lesion procedure after local anesthetic injection	40 patients received conventional radiofrequency lesioning at 80°C for 60 seconds and 41 patients received sham lesioning.	Pain relief, physical activities, analgesic intake, global perceived effect, Short-form-36, quality of life measures	3 months	Global perceived effect improved after radiofrequency facet joint denervation. The visual analog scale in both groups improved. The combined outcome measures showed no difference between radiofreqency facet joint denervation (27.5% vs. 29.3% success rate).	Double-blind, sham control, randomized trial	Poor selection with a single diagnostic block of 50% pain reduction even though 17.5% of the patients were tested positive. Further, authors described that the needle was positioned parallel; however, the radiographic figures illustrate the needle was being positioned perpendicularly rather than parallel to the nerve.	Negative study with methodologic deficiencies and a short-term follow-up.
Dobrogowski et al, 2005 (233) Randomized, active control trial	45 consecutive patients with chronic low back pain judged to be positive with controlled diagnostic blocks	Injection of saline in patients after conventional radiofrequency neurotomy to evaluate postoperative pain	Conventional radiofrequency neurotomy at 85°C for 60 seconds, preceded by lidocaine injection, followed by injection of either	Visual analog scale, minimum of 50% reduction of pain intensity, patient satisfaction score	One, 3, 6, and 12 months	Greater than 50% of reduction of pain intensity was observed in 66% of the patients 12 months later. There was no difference in the long-term outcomes.	Randomized, active control trial	Very small study evaluating effectiveness of radiofrequency neurotomy and postoperative pain.	Positive results in a small study.

Table 7 (cont.). *Study characteristics of randomized controlled trials and observational studies of lumbar radiofrequency neurotomy.*

Reference	Number of Patients & Selection Criteria	Control	Interventions	Outcome Measures	Time of Measurement	Results	Strengths	Weaknesses	Conclusions
Van Kleef et al, 1999 (173) Randomized, double-blind, sham control trial	31 patients with a history of at least one year of chronic low back pain randomly assigned to one of 2 treatment groups. Single diagnostic block with 50% relief.	Sham control of radiofrequency after local anesthetic injection in 16 patients	The 15 patients in the conventional radiofrequency treatment group received an 80° C radiofrequency lesion for 60 seconds.	Visual analog scale, pain scores, global perceived effect, Oswestry Disability Index	3, 6, and 12 months	After 3, 6, and 12 months, the number of successes in the lesion and sham groups was 9 of 15 (60%) and 4 of 16 (25%), 7 of 15 (47%) and 3 of 16 (19%), and 7 of 15 (47%) and 2 of 16 (13%) respectively. There was a statistically significant difference.	Double-blind, randomized, sham controlled trial	A single block with a small sample with inclusion criteria of 50% pain relief to enter the study. The study has been criticized that electrodes were placed at an angle to the target nerve, instead of parallel (248).	Positive results in a small sample with a single diagnostic block
Martinez-Suárez et al, 2005 (253) Observational report	252 patients with presumptive diagnosis of facet joint pain with chronic low back pain with no diagnostic blocks	None	Conventional radiofrequency neurotomy at 80° C for 120 seconds.	Pain relief	One year	Effectiveness in 75% of the cases at one year.	None	No diagnostic blocks performed in an observational study.	Positive results even without diagnostic blocks.
Masala et al, 2012 (260) Prospective evaluation	92 patients with facet joint syndrome diagnosed by strict inclusion criteria and controlled diagnostic blocks	None	Pulsed radiofrequency neurotomy	Visual analog scale and Oswestry Disability Index	6 and 12 months	In all cases, pain improvement and quality of life were statistically significant.	Proper selection with controlled diagnostic blocks.	Observational study	Positive results for pulsed radiofrequency at one year.
Tomé-Bermejo et al, 2011 (185) Prospective evaluation	86 patients with chronic low back pain A single block with 50% pain relief.	None	Conventional radiofrequency neurotomy at 80° C for 90 seconds.	Pain relief, visual analog scale, Oswestry Disability Questionnaire, and satisfaction assessment	One year	A total of 89% of the patients experienced significant relief from pain after radiofrequency neurotomy with this relief lasting 6 months or more in 66%, and a minimum of one year in 50% of cases.	Prospective evaluation with relatively long-term follow up.	Non-randomized evaluation Single block with 50% relief	Positive results with single block
Speldewinde, 2011 (188) Prospective evaluation	151 patients undergoing 180 procedures with chronic low back pain were evaluated. Diagnosis was based on dual blocks with at least 80% relief of the index pain.	None	Conventional radiofrequency neurotomy at 80° for 90 seconds.	Numeric rating scale, functional rating index, 4 active days of daily living scale, general health questionnaire, depression, anxiety, and stress scale, duration of pain relief.	12 months	The overall success rate was 69% with the majority of the patients reporting over 80% relief lasting an average duration of 11 months.	Authors performed dual diagnostic blocks with 80% relief as the criterion standard.	Prospective evaluation with no control group.	Positive results in well selected patient group.

Table 7 (cont.). *Study characteristics of randomized controlled trials and observational studies of lumbar radiofrequency neurotomy.*

Reference	Number of Patients & Selection Criteria	Control	Interventions	Outcome Measures	Time of Measurement	Results	Strengths	Weaknesses	Conclusions
Yilmaz et al, 2010 (258) Retrospective analysis	50 patients with chronic low back pain secondary to lumbar facet syndrome with at least 80% pain relief by controlled, diagnostic medial branch blocks.	None	Conventional radiofrequency neurotomy at 80°C for 100 to 120 seconds each producing 2 or 3 more lesions per level.	Visual analog scale, health-related quality of life state, EuroQol Group-5 Dimension Self-Report Questionairre measures of pain, disability, and treatment satisfaction.	12 months	86% of the patients obtained a reduction of at least 60% of pain. 64% of the patients used no treatment co-interventions during the first year follow-up.	Strict selection criteria and production of multiple lesions at the target points.	Retrospective evaluation in a small number of patients. Multiple lesions at each level.	Positive results
Son et al, 2010 (259) Retrospective review	60 consecutive patients with chronic low back pain treated with radiofrequency neurotomy from March 2006 to February 2009. Patients had only low back pain without radicular pain and also failed conservative management	None	Dual diagnostic blocks were performed with at least 50% relief. Conventional radiofrequency neurotomy at 80°C for 60-90 seconds or until disappearance of pain.	Duration and quantity of pain relief by visual analog scale	6 months and one year	Mean duration of pain relief was 9.8 months with a range of 5 to 16 months in 60% of patients. Overall, successful relief was 88% and mean duration of relief was 10.8 months.	No specific strengths except that patients were selected by dual diagnostic blocks and procedures were repeated if needed.	A retrospective evaluation with 50% relief with dual blocks as the criterion standard. At least 5 patients underwent 4 radiofrequency neurotomy procedures which is high compared to recommended number of procedures.	Borderline positive or undetermined results.
Tzaan & Tasker, 2000 (254) Retrospective evaluation	69 patients with chronic low back pain of at least 6 months were evaluated with diagnostic facet joint injections with at least 50% pain reduction with a single block	None	Conventional radiofrequency neurotomy at 80°C for 90 seconds.	Pain relief	Mean follow-up 5.6 months	Proportion of successful procedures was 41%.	None	Selection by single block with 50% pain relief. In addition, multiple procedures were performed under general anesthesia.	Undetermined results
Gofeld et al, 2007 (174) Clinical audit	Chronic low back pain patients of at least 6 months duration and double diagnostic blocks.	None	Conventional radiofrequency neurotomy at 80°C for 60 seconds.	Pain relief	6, 12, and 24 months. Of the 209 patients, 174 completed the study and 35 were lost to follow-up or did not provide complete data for assessment.	Of the 174 patients with complete data, 68.4% experienced good to excellent pain relief lasting from 6 to 24 months.	Large proportion of patients with long-term follow-up. Authors utilized parallel placement of the needle in the nerve. Procedures were repeated if needed.	Retrospective evaluation with no control group.	Positive results in a large proportion of patients over long periods of time.

Table 8. *Study characteristics of randomized controlled trials of therapeutic lumbar facet joint nerve blocks.*

Reference	Number of Patients & Selection Criteria	Control	Interventions	Outcome Measures	Time of Measurement	Results	Strengths	Weaknesses	Conclusions
Civelek et al, 2012 (198) Randomized, active-control	100 patients with chronic low back pain who failed conservative therapy and strict selection criteria; however, without diagnostic blocks.	Pain blocks of facet joint nerves with local anesthetic and steroids.	Conventional radiofrequency neurotomy at 80°C for 120 seconds in combination with high dose local anesthetic and steroids.	Visual Numeric Pain Scale, North American Spine Society patient satisfaction questionnaire, Euro-Qol Group 5-dimension self report questionnaire, ≥ 50% pain relief	One month, 6 months, 12 months	At the end of one year, 90% of patients in the radiofrequency group and 69% of the patients in the facet joint nerve block group showed significant improvement vs. 92% and 75% at 6-month follow-up.	Randomized described as double-blind or at least single blind active-control trial with a reasonably large number of patients with 50 in each group. Strict noninvasive selection criteria without diagnostic blocks.	No diagnostic blocks were performed. High dose steroids and local anesthetics were provided in both groups.	Positive results even without diagnostic blocks, both for facet joint nerve blocks and radiofrequency neurotomy.
Manchikanti et al, 2007, 2008, 2010 (133,162,163) Randomized, double blind, active control trial	120 patients with chronic low back pain of facet joint origin treated with therapeutic lumbar facet joint nerve blocks. Double diagnostic blocks with 80% relief.	Local anesthetic only	Total of 120 patients with 60 patients in each group with local anesthetic alone or local anesthetic and steroids. Both groups were also divided into 2 categories each with the addition of Sarapin.	Numeric Rating Scale, Oswestry Disability Index, employment status, and opioid intake.	3, 6, 12, 18, and 24 months	Significant pain relief was shown in 85% of Group I and 90% of Group II at the end of the 2 year study period in both groups, with an average of 5-6 total treatments.	First of its nature with a large proportion of patients randomized double-blind in an active-control manner with 2-year follow-up after the diagnosis of facet joint pain with controlled diagnostic blocks	Lack of placebo group	Positive results
Manchikanti et al, 2001 (164) Randomized, active-control	73 patients with chronic low back pain diagnosed with dual diagnostic blocks were selected	None	Facet joint nerve blocks with local anesthetic and Sarapin or with local anesthetic, Sarapin, and	Numeric pain rating scale, functional status, opioid intake, employment status	2½ years	Results showed significant improvement in patients in both groups; however, multiple procedures were performed. Significant relief with one to 3 injections was 100% up to 3 months, 82% for 4 to 6 months, and 21% for 7 to 12 months.	Prospective evaluation	Though it is described as a randomized, clinical trial, there was no appropriate randomization.	Positive results

Table 9. *Study characteristics of randomized controlled trials and observational studies of lumbar intraarticular injections.*

Reference	Number of Patients & Selection Criteria	Control	Interventions	Outcome Measures	Time of Measurement	Results	Strengths	Weaknesses	Conclusions
Carette et al 1991 (155) Randomized, double blind, placebo or active-control trial	Patients with chronic low back pain who reported immediate relief of their pain after injection of local anesthetic into the facet joints. Single diagnostic blocks with 50% relief were randomly assigned to receive injections under fluoroscopic guidance.	Intraarticular injection of isotonic saline	Injection of either sodium chloride or methylprednisolone into the facet joints (49 for isotonic saline and 48 for sodium chloride). Only one injection was provided.	Visual Analog Scale, McGill Pain Questionnaire, mean sickness impact profile.	One, 3, and 6 months	After one month, 42% of the patients in the methylprednisolone group and 33% in the sodium chloride group reported marked or very marked improvement. At the 6 month evaluation, 46%in the methylprednisolone group and 15% in the placebo group showed sustained relief. Revised statistics showed 22% improvement in active group and 10% in control group.	Well-performed randomized, double-blind controlled trial	Only single block was applied and patients were treated with steroids without local anesthetic with only one treatment and expected 6 months of relief.	The authors concluded that results were negative in an active-control trial with injection of either sodium chloride solution or steroid into the facet joints after diagnosis with a single block.
Fuchs et al 2005 (157) Randomized, double-blind, active-control trial	Sixty patients with chronic low back pain were included with patients randomly assigned into 2 groups. No diagnostic blocks	Active-control study with no control group	Intraarticular injection of hyaluronic acid versus glucocorticoid injection.	Visual Analog Scale, Rowland-Morris Questionnaire, Oswestry Disability Index, low back outcomes score, Short Form-36	3 months and 6 months	Patients reported lasting pain relief, better function, and improved quality of life with both treatments.	Randomized, active-control, double-blind study	Relatively small sample of patients with 6 month follow-up without a placebo group, without diagnostic blocks.	Undetermined results with high number of injections during a 6-month period.
Celik et al 2011 (183) Prospective evaluation	80 patients suffering from chronic low back pain were included in this study.	Diclofenac sodium, thiocolchicoside and recommended bedrest	Patients in Group II received zygapophysial joint blockade by prilocaine, bupivacaine, and methylprednisolone acetate.	Visual Analog Scale and Oswestry low back disability questionnaire	1, 3, and 6 months.	Visual analog scale and Oswestry Disabilty Questionnaire scores were significantly lower than pre-treatment scores. Posttreatment: The decreases in the scores in Group II were greater than those of Group I.	A comparative prospective study.	The study was not randomized or blinded.	Positive results with intraarticular zygapophysial injections.
Anand & Butt 2007 (225) Prospective evaluation	57 patients with chronic low back pain unresponsive to medical treatment underwent facet joint injections with mechanical low back pain of at least 3 months	None	Intraarticular facet joint injections with local anesthetic and steroids.	Pain relief	8 weeks and 6 months	At the first follow-up visit after 8 weeks, 53% of the patients claimed relief. At the second follow-up visit after 6 months, 68% of the patients reported improvement	None	Nonrandomized study without controls	Positive results

Table 9 (cont.). *Study characteristics of randomized controlled trials and observational studies of lumbar intraarticular injections.*

Reference	Number of Patients & Selection Criteria	Control	Interventions	Outcome Measures	Time of Measurement	Results	Strengths	Weaknesses	Conclusions
Murtagh 1988 (148) Prospective observational study	100 patients were selected based on the clinical groups that patients suffered with lumbar facet syndrome. Single diagnostic blocks	None	Intraarticular injection with local anesthetic and followed by intraarticular injection with steroids based on the positive response in 94% of the patients.	Pain relief	3 months Only one therapeutic injection was carried out	54% of the patients demonstrated long-term relief.	Prospective evaluation with 100 patients included.	Very high number of positives, consequently false-positive were not excluded. Both injections were made on the same day.	Positive results in 54% of the patients with one intraarticular steroid injection.
Bani et al 2002 (235) Retrospective evaluation	230 patients with chronic low back pain were treated between 1997 and 2001 with injection of local anesthetic and steroids with variable length histories of low back pain.	None	Intraarticular facet joint injection with local anesthetic and steroids.	Pain relief	6-12 months	Long lasting relief of the back and leg pain occurred in 18.7% of the patients for one year. Overall, 49.6% of the patients showed some improvement with 50.4% of the patients with no improvement.	Authors performed a single diagnostic block in a large number of patients.	A retrospective evaluation. Multiple injectionsOverall poor selection criteria	Negative results
Lippitt 1984 (152) Retrospective evaluation	99 patients receiving a total of 117 facet joint injections in a retrospective uncontrolled review with chronic low back pain. No diagnostic blocks	None	Intraarticular injection of local anesthetic and steroids. Four patients received repeat injections.	Pain relief and return to work	3 months	Forty-two percent of the patients reported good or excellent relief with fair results in 9%, with no relief in 44%. Eight of the patients had complete relief with one treatment, 5 patients had less than 3 months of relief.	Relatively large sample size	Retrospective evaluation without appropriate outcome parameters.	Positive short-term with one block.
Destouet et al 1982 (149) Observational study	54 patients with chronic low back pain without sciatica were included with injection of lumbar facet joints. No diagnostic blocks	None	Injection of intraarticular local anesthetic and steroids under fluoroscopy.	Pain relief	3, 6, and 12 months.	Twenty-nine (54%) of patients had initial pain relief and 11 (38%) of those who responded to facet blocks have had prolonged relief. Six patients were free of pain for 6 to 12 months with a single injection.	None	Relatively small study. Inclusion of postsurgical patients without diagnostic blocks. With a single ..	Positive short-term with one block.

Table 10. *Clinical relevance of included studies.*

Manuscript Author(s)	A) Patient description	B) Description of interventions and treatment settings	C) Clinically relevant outcomes	D) Clinical importance	E) Benefits vs. potential harms	Total Criteria Met
Manchikanti et al (133,162,163)	+	+	+	+	+	5/5
Murtagh (148)	+	+	--	--	+	3/5
Destouet et al (149)	+	+	--	--	+	3/5
Lippitt (152)	+	+	--	--	+	3/5
Carette et al (155)	+	+	+	--	+	4/5
Fuchs et al (157)	+	+	--	--	--	2/5
Manchikanti et al (164)	+	+	+	+	+	5/5
Nath et al (165)	+	+	+	+	+	5/5
van Wijk et al (166)	+	+	+	--	+	4/5
Van Kleef et al (173)	+	+	+	+	+	5/5
Gofeld et al (174)	+	+	--	+	+	4/5
Tekin et al (178)	+	+	+	+	+	5/5
Celik et al (183)	+	+	+	--	+	4/5
Tomé-Bermejo et al (185)	+	+	--	--	+	3/5
Speldewinde (188)	+	+	+	+	+	5/5
Civelek et al (198)	+	+	+	+	+	5/5
Anand & Butt (225)	+	+	--	--	+	3/5
Dobrogowski et al (233)	+	+	--	--	+	3/5
Bani et al (235)	--	+	--	--	--	1/5
Cohen et al (250)	+	+	--	+	+	4/5
Martinez-Suárez et al (253)	+	+	+	+	+	5/5
Tzaan & Tasker (254)	+	--	+	--	--	2/5
Yilmaz et al (258)	+	+	+	+	+	5/5
Son et al (259)	+	+	+	+	+	5/5
Masala et al (260)	+	+	+	--	+	4/5

+ = positive; - = negative; U = unclear

Scoring adapted from Staal JB, et al. Injection therapy for subacute and chronic low-back pain. Cochrane Database Syst Rev 2008; 3:CD001824 (124).

ity (148,149,152,174,183,185,188,225,235,254,258-260) and one was considered as low quality (253).

2.3 Meta-Analysis

There were 11 randomized trials (133,155,157,164-166,173,178,198,233,250) with 2 duplicate publications (162,163) meeting the inclusion criteria. There were 3 trials that evaluated therapeutic lumbar facet joint nerve blocks (133,198,164), 7 trials that evaluated lumbar facet joint radiofrequency neurolysis (165,166,173,178,198,233,250), and 2 trials that evaluated intraarticular injections (155,157). Of the 7 randomized trials evaluating radiofrequency neurotomy meeting the inclusion criteria, one trial was conducted with triple diagnostic blocks (165), 2 trials with dual diagnostic blocks (233,250), 4 trials with a single diagnostic block (166,173,178,250), and 2 trials did not use diagnostic blocks (198,250) Further, selection criteria and multiple other parameters also were heterogeneous among the studies. Thus, no meta-analysis could be performed.

2.4 Study Characteristics

Tables 7 to 9 illustrate the study characteristics of the included studies for randomized trials and for observational studies evaluating facet joint interventions.

Table 11. *Methodological quality assessment of randomized trials.*

	Manchikanti et al (133,162,163)	Carette et al (155)	Fuchs et al (157)	Manchikanti et al (164)	Nath et al (165)	van Wijk et al (166)	van Kleef et al (173)	Tekin et al (178)	Civelek et al (198)	Dobrogowski et al (233)	Cohen et al (250)
Randomization adequate	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
Concealed treatment allocation	Y	Y	N	N	Y	Y	Y	Y	Y	U	N
Patient blinded	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N
Care provider blinded	Y	Y	N	N	Y	Y	Y	Y	N	Y	U
Outcome assessor blinded	N	Y	Y	N	Y	Y	Y	Y	U	U	U
Drop-out rate described	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
All randomized participants analyzed in the group	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Reports of the study free of suggestion of selective outcome reporting	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Groups similar at baseline regarding most important prognostic indicators	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Co-intervention avoided or similar in all groups	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
Compliance acceptable in all groups	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Y = yes; N = no; U = unclear

Scoring adapted from Staal JB, et al. Injection therapy for subacute and chronic low-back pain. Cochrane Database Syst Rev 2008; 3:CD001824 (124).

Table 12. *Methodological quality assessment of case control studies utilizing Newcastle-Ottawa quality assessment scale.*

	Celik et al (183)
Selection	
1) Is the case definition adequate?	
a) yes, with independent validation *	
b) yes, e.g., record linkage or based on self reports	X
c) no description	
2) Representativeness of the cases	
a) consecutive or obviously representative series of cases *	X
b) potential for selection biases or not stated	
3) Selection of Controls	
a) community controls *	X
b) hospital controls	
c) no description	
4) Definition of Controls	
a) no history of disease (endpoint) *	
b) no description of source	
Comparability	
1) Comparability of cases and controls on the basis of the design or analysis	X
a) study controls for _____ (Select the most important factor.) *	
b) study controls for any additional factor * (This criteria could be modified to indicate specific control for a second important factor.)	
Exposure	
1) Ascertainment of exposure	
a) secure record (eg surgical records) *	X
b) structured interview where blind to case/control status *	
c) interview not blinded to case/control status	
d) written self report or medical record only	
e) no description	
2) Same method of ascertainment for cases and controls	
a) yes *	X
b) no	
3) Non-Response rate	
a) same rate for both groups *	X
b) non respondents described	
c) rate different and no designation	
SCORE	7/13

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability.

Wells GA, et al The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analysis. www.ohri.ca/programs/clinical_epidemiology/oxford.asp (125).

Table 13. *Methodological quality assessment of cohort studies utilizing Newcastle-Ottawa quality assessment scale.*

	Murtagh (148)	Destouet et al (149)	Lippitt (152)	Gofeld et al (174)	Tomé-Bermejo et al (185)	Speldewinde (188)	Anand & Butt (225)	Bani et al (235)	Martinez-Suárez et al (253)	Tzaan & Tasker (254)	Yilmaz et al (258)	Son et al (259)	Masala et al (260)
Selection													
1) Representativeness of the exposed cohort													
a) truly representative of the average _____ (describe) in the community*	X	X	X	X	X	X	X	X	X	X	X	X	X
b) somewhat representative of the average pain patients in the community *													
c) selected group of users e.g., nurses, volunteers													
d) no description of the derivation of the cohort													
2) Selection of the non exposed cohort													
a) drawn from the same community as the exposed cohort *	X	X	X	X	X	X	X	X		X	X	X	X
b) drawn from a different source													
c) no description of the derivation of the non exposed cohort													
3) Ascertainment of exposure													
a) secure record (e.g., surgical records) *													
b) structured interview *	X	X	X	X	X	X	X	X	X	X	X	X	X
c) written self report													
d) no description													
4) Demonstration that outcome of interest was not present at start of study													
a) yes *	X	X	X	X	X	X	X	X	X	X	X	X	X
b) no													
Comparability													
1) Comparability of cohorts on the basis of the design or analysis													
a) study controls for _____ (select the most important factor) *													
b) study controls for any additional factor * (This criteria could be modified to indicate specific control for a second important factor.)													

Table 13. (cont.) *Methodological quality assessment of cohort studies utilizing Newcastle-Ottawa quality assessment scale.*

Outcome (Exposure)																						
1) Assessment of outcome																						
a) independent blind assessment *																						
b) record linkage *	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
c) self report																						
d) no description																						
2) Was follow-up long enough for outcomes to occur																						
a) yes (select an adequate follow up period for outcome of interest) *	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
b) no																						
3) Adequacy of follow-up of cohorts																						
a) complete follow up - all subjects accounted for *								X	X	X												
b) subjects lost to follow up unlikely to introduce bias - small number lost - > ____ % (select an adequate %) follow up, or description provided of those lost) *	X	X	X	X	X	X							X	X	X	X	X	X	X	X	X	X
c) follow up rate < ____% (select an adequate %) and no description of those lost																						
d) no statement																						
SCORE	7/12	7/12	7/12	7/12	7/12	7/12	7/12	7/12	7/12	7/12	7/12	6/12	7/12	7/12	7/12	7/12	7/12	7/12	7/12	7/12	7/12	7/12

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability
Wells GA, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analysis. www.ohri.ca/programs/clinical_epidemiology/oxford.asp (125).

2.5 Analysis of Evidence

The evidence was synthesized based on the modality of treatment. Tables 14 to 16 illustrate the results of therapeutic studies.

2.5.1 Radiofrequency Neurotomy

There were multiple randomized trials and observational studies assessing the role of radiofrequency neurotomy in managing chronic low back pain of facet joint origin. Of the 7 randomized trials, 6 of them were positive (165,173,178,198,233,250). Only one study showed definite negative results (166). The strong positive results were illustrated by Nath et al (165) using triple blocks for the diagnosis with 80% pain relief as the criterion standard for diagnosis. van Kleef et al (173) used a single block with 50% relief showing positive results which may be considered as moderate results. Tekin et al (178) compared sham lesioning after local anesthetic injection with pulsed and conventional radiofrequency and showed moderately strong results with conventional radiofrequency. Cohen et al (250) and Dobrogowski et al (233) also studied radiofrequency neurotomy after diagnosis with dual blocks with 50% pain relief as the criterion standard, showing positive results by Cohen et al and weakly positive results by Dobrogowski et al. Cohen et al also evaluated single block diagnosis with 50% pain relief as the criterion standard and radiofrequency neurotomy; they reported weakly positive results in 39% of their patients, which is considered negative.

Civelek et al (198) and Cohen et al (250) evaluated without diagnostic blocks and the results were positive by Civelek whereas Cohen et al, even though published as positive, had results that were negative with only 33% showing positive results after radiofrequency.

Among the 8 observational studies,

Table 14. *Effectiveness of conventional and pulsed lumbar radiofrequency neurotomy.*

Study	Study Characteristics	Methodological Quality Scoring	Patients	Interventions	Pain Relief and Function			Results						Comments
					3 mos.	6 mos.	12 mos.	Short-Term ≤ 6 mos.		Long-Term				
										> 6 mos.		≥ 1 year		
								RF	Sham or Active	RF	Sham	RF	Sham	
RANDOMIZED														
Civelek et al, 2012 (198)	RA, AC	9/12	100	CRF = 50 Facet joint nerve blocks = 50	NA	92% vs. 75%	90% vs. 69%	NA	NA	P	P	P	P	Positive short and long-term results
Cohen et al, 2010 (250)	RA, DB	8/12	"0" block = 51 One block = 20 Two blocks = 14	CRF	"0" group = 33% One block = 39% Two blocks = 64%	NA	NA	P in two block group	NA	NA	NA	NA	NA	Positive short-term results with dual blocks
Nath et al, 2008 (165)	RA, DB, Sham control	12/12	40	Radiofrequency = 20 Sham = 20	NA	Significant proportion of patients in interventional group	NA	P	N	P	N	NA	NA	Positive short and long-term
Tekin et al, 2007 (178)	RA, AC and sham, DB	12/12	60	CRF = 20 PRF = 20 Control = 20	NA	SI with CRF	SI with CRF	NA	NA	P	N	P	N	Positive short and long-term results
van Wijk et al, 2005 (166)	RA, DB, Sham control	12/12	81	Radiofrequency = 40 Sham = 41	27.5% vs. 29.3%	27.5% vs. 29.3%	27.5% vs. 29.3%	N	N	N	N	N	N	Negative results
Dobrogowski et al, 2005 (233)	RA, AC	10/12	45	CRF	NA	60%	NA	NA	NA	P	NA	NA	NA	Positive short and long-term results
van Kleef et al, 1999 (173)	RA, DB, sham control	12/12	31	Radiofrequency = 15 Sham = 16	60% vs. 25%	47% vs. 19%	47% vs. 13%	P	N	P	N	P	N	Positive short and long-term results
OBSERVATIONAL														
Masala et al, 2012 (260)	O	7/12	92	PRF	NA	100%	100%	NA	NA	P	NA	P	NA	Positive short and long-term results
Tomé-Bermejo et al, 2011 (185)	P	7/12	86	CRF	89%	66%	50%	P	NA	P	NA	P	NA	Positive short and long-term results

Table 14. *Effectiveness of conventional and pulsed lumbar radiofrequency neurotomy.*

Study	Study Characteristics	Methodological Quality Scoring	Patients	Interventions	Pain Relief and Function			Results						Comments
					3 mos.	6 mos.	12 mos.	Short-Term ≤ 6 mos.		Long-Term				
										> 6 mos.		≥ 1 year		
								RF	Sham or Active	RF	Sham	RF	Sham	
Speldewinde, 2011 (188)	P	7/12	151	CRF	69%	69%	69%	P	NA	P	NA	P	NA	Positive short and long-term results
Yilmaz et al, 2010 (258)	R	7/12	50	CRF	NA	NA	86%	NA	NA	NA	NA	P	NA	Positive short and long-term results
Son et al, 2010 (259)	R	7/12	60	CRF	NA	60%	60%	NA	NA	P	NA	P	NA	Undetermined short and long-term results
Gofeld et al, 2007 (174)	Clinical audit	7/13	174	CRF	NA	68.4%	96.4%	P	NA	P	NA	P	NA	Positive short and long-term results
Martinez-Suárez et al, 2005 (253)	O	6/12	252	CRF	NA	NA	75%	NA	NA	NA	NA	P	NA	Positive short and long-term results
Tzaan & Tasker, 2000 (254)	R	7/12	69	CRF	NA	41%	NA	NA	NA	U	NA	NA	NA	Positive short and long-term results

RA = randomized; DB = double-blind; AC = active control; R = retrospective; O = observational; P = prospective; SI = significant improvement; CRF = conventional radiofreqency neurotomy; PRF = pulsed radiofreqency neurotomy; P = positive; N = negative; NA= not applicable; U = undetermined

Table 15. *Effectiveness of therapeutic lumbar facet joint nerve blocks.*

Study	Study Characteristics	Methodological Quality Scoring	Participants	Interventions	Pain Relief and Function			Results									Comments
					3 mos.	6 mos.	12 mos.	Short-term ≤ 6 mos.			Long-Term						
											> 6 mos			≥ 1 year			
								ST	LA	SAL	ST	LA	SAL	ST	LA	SAL	
Civelek et al, 2012 (198)	RA, AC	9/12	100	LA with steroid = 50 CRF = 50	NA	75% vs. 92%	69% vs. 90%	NA	NA	NA	P	NA	NA	P	NA	NA	Positive short and long-term results
Manchikanti et al, 2007, 2008, 2010 (133,162,163)	RA, DB, AC	11/12	120	LA with steroid = 60 LA = 60	82% vs. 83%	93% vs. 83%	85% vs. 84%	P	P	NA	P	P	NA	P	P	NA	Positive with local anesthetic with or without steroids
Manchikanti et al, 2001 (164)	RA, AC	8/12	73	LA with steroid = 41 LA = 32	SI	SI	SI	P	P	NA	P	P	NA	P	P	NA	Positive short and long-term results

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

Table 16. *Effectiveness of lumbar intraarticular injections.*

Study	Study Characteristics	Methodological Quality Scoring	Participants	Interventions	Pain Relief and Function			Results									Comment(s)
					3 mos	6 mos	12 mos	Short-term ≤ 6 mos.			Long-Term						
											> 6 mos			≥ 1 year			
								ST	LA or HA	SAL	ST	LA or HA	SAL	ST	LA or HA	SAL	
RANDOMIZED																	
Carette et al, 1991 (155)	RA, DB, PC or AC Single block confirmed	11/12	97	Methylprednisolone acetate =49 Isotonic saline =48 patients	33% vs. 42%	22% vs. 10%	NA	N	NA	N	N	NA	N	NA	NA	NA	Negative results
Fuchs et al, 2005 (157)	R, DB, AC	8/12	60	Hyaluronic acid versus glucocorticoid with 6 injections.	Significant proportion of patients	Significant proportion of patients	NA	U	U	NA	U	U	NA	NA	NA	NA	Undetermined
OBSERVATIONAL																	
Murtagh, 1988 (148)	P	7/12	100	Local anesthetic and steroids.	54%	NA	NA	P	NA	NA	NA	NA	NA	NA	NA	NA	Positive short-term results
Destouet et al, 1982 (149)	O	7/12	54	Local anesthetic and steroids	54%	38%	38%	P	NA	NA	N	NA	NA	N	NA	NA	Positive short-term with a single block
Lippitt, 1984 (152)	R	7/12	99	Local anesthetic and steroids	51%	NA	NA	P	NA	NA	NA	NA	NA	NA	NA	NA	Positive short-term with a single block
Celik et al, 2011 (183)	P	7/13	80	Conservative vs. local anesthetic and steroid	Significant proportion of patients in treatment group	Significant proportion of patients	NA	P	NA	NA	P	NA	NA	NA	NA	NA	Positive short-term and long-term results
Anand & Butt, 2007 (225)	P	7/12	57	Local anesthetic and steroids	53%	68%	NA	P	NA	NA	P	NA	NA	NA	NA	NA	Positive short-term and long-term results
Bani et al, 2002 (235)	R	7/12	230	Local anesthetic and steroids	NA	NA	18.7%	NA	NA	NA	NA	NA	NA	N	NA	NA	Negative

RA = randomized; DB = double-blind; AC = active control; PC = placebo control; R = retrospective; O = observational; P = prospective; LA = local anesthetic; HA = hyaluronidase; ST = steroid; SAL = saline; P = positive; N = negative; NA = not applicable; U = undetermined

7 reported positive results (174,185,188,253,254,258,260) and one reported undetermined results (259).

Thus, based on 6 positive randomized trials (165,173,178,198,233,250) and 7 positive observational studies (174,185,188,253,254,258,260), the evidence for conventional radiofrequency neurotomy in managing chronic low back pain of facet joint origin in the lumbar spine is good for short- and long-term relief.

Based on only one observational study (260), the evidence is limited for pulsed radiofrequency neurotomy for managing chronic low back pain of facet joint origin.

2.5.2 Facet Joint Nerve Blocks

There were 3 randomized trials (133,164,198) with 2 duplicate publications (162,163) evaluating the role of facet joint nerve blocks, 2 were of high quality (133,198) and one was of moderate quality (164). All 3 studies reported positive results with or without steroids. However, only one study was appropriately conducted and of high quality (133), reporting appropriate and positive results in 85% of patients receiving local anesthetic only and 90% of the patients receiving local anesthetic and steroids, with approximately 5 or 6 procedures on average over a period of 2 years.

The second study (198), which was high quality, compared local anesthetic blocks and radiofrequency neurotomy; both procedures had positive results. In essence, they showed at the end of one year, 90% of the patients in the radiofrequency group and 69% of the patients in the facet joint nerve block group showed significant improvement. They also showed that at 6-month follow-up, 92% in the radiofrequency group and 75% in the facet joint nerve block group were positive. However, they did not use any diagnostic blocks for selection, even though they used strict selection criteria, which was noninvasive. The third study (164), by the same authors as the high quality study, (133,162,163) was of moderate quality, and also showed positive results with multiple procedures as needed after assessment with proper selection criteria and dual diagnostic blocks.

Based on the available evidence of 2 high quality studies (133,198) and one moderate quality study (164), the evidence for lumbar facet joint nerve blocks using local anesthetics with or without steroid for managing chronic low back pain of facet joint origin is fair to good for short- and long-term improvement.

2.5.3 Intraarticular Injections

In reference to intraarticular injections, among the 2 randomized trials meeting the inclusion criteria (155,157), the results were negative for the high quality randomized, double-blind placebo or active-control trial by Carette et al (155) at 6 months, and the moderate quality study by Fuchs et al (157), which was weakly positive or undetermined for a high number of injections. Among the 6 nonrandomized studies meeting the inclusion criteria for intraarticular injections (148,149,152,183,225,235), 5 studies reported positive results (148,149,152,183,225), whereas in one study (235), the results were negative.

Based on the one moderate quality study with weakly positive or undetermined results (157) and 5 observational studies (148,149,152,183,225), the evidence for intraarticular injections is limited.

2.5.4 Summary of Evidence

The evidence for conventional radiofrequency neurotomy is good for short- and long-term improvement, the evidence for pulsed radiofrequency neurotomy is limited, the evidence for lumbar facet joint nerve blocks is fair to good for short- and long-term improvement, and the evidence for intraarticular injections is limited.

3.0 Complications

There were no major side effects or complications noted in any of the studies included in this systematic review (133,155,162-166,173,174,178,183,188,198,250,253,258-260).

Complications from facet joint nerve blocks, intraarticular injections, or radiofrequency neurolysis in the lumbar spine are exceedingly rare (1,39,40,43,48,51,52,56,58,60,101,104,133,148-311). The most common complications of lumbar facet joint interventions are twofold: complications related to the placement of the needle and complications related to the administration of various drugs and the application of heat, cryo, or laser. Most problems, such as local swelling, pain at the site of the needle insertion, and pain in the low back, are short-lived and self-limited.

More serious complications may include dural puncture, spinal cord trauma, subdural injection, neural trauma, injection into the intervertebral foramen, and hematoma formation; infectious complications including epidural abscess and bacterial meningitis; and side effects related to the administration of steroids, local anesthetics, and other drugs (1,39,40,43,48,51,52,56,58,60,101,104,133,148-311).

Other minor complications include lightheadedness, flushing, sweating, nausea, hypotension, syncope,

pain at the injection site as described earlier, and nonpostural headaches.

Side effects related to the administration of steroids are generally attributed to the chemistry or to the pharmacology of the steroids (302). The major theoretical complications of corticosteroid administration include suppression of the pituitary-adrenal axis, hyperadrenocorticism, Cushing syndrome, osteoporosis, avascular necrosis of bone, steroid myopathy, epidural lipomatosis, weight gain, fluid retention, and hyperglycemia.

The evaluation of the effect of neuraxial steroids on weight and bone mass density showed no significant differences in patients undergoing various types of interventional techniques with or without steroids (303); multiple other studies have echoed the same (304-306). Brill et al (305) also evaluated the effect of 3 consecutive epidural steroid injections with 40 mg methylprednisolone acetate once monthly for 3 months on weight gain and found no significant change in weight. However, in a systematic review of low dose corticosteroids with rheumatoid arthritis, which included 7 studies on lumbar bone mineral density meta-analysis and 6 studies on femur bone mineral density meta-analysis, Lee et al (306) reported that corticosteroids resulted in a moderate worsening in lumbar bone mineral density compared with controls, whereas the femoral bone mineral density differences were not significant. They concluded that bone mineral density loss after low-dose corticosteroid treatment in patients with rheumatoid arthritis has practical implications for the long-term management of patients with rheumatoid arthritis on low-dose corticosteroids. Similarly, Korczowska et al (304), assessing low-dose and short-term glucocorticoid treatment and the risk of osteoporosis in women with rheumatoid arthritis, concluded that the benefits from the anti-inflammatory effect of low-dose glucocorticoid therapy are questionable. Their assessment also applies to patients who have used glucocorticoids on a long-term basis. Multiple other studies also evaluating epidural injections showed no significant difference whether steroids were used or not (133-145).

A study by Manchikanti et al (194) included over 7,500 episodes, or 43,000 spinal facet joint nerve blocks, with 3,162 lumbar facet joint nerve blocks performed under fluoroscopic guidance in an ambulatory surgery center by one of 3 physicians. The complications encountered during each procedure and postoperatively were prospectively evaluated. The results showed no major complications. Multiple side effects and complications observed in lumbar facet joint nerve blocks included intravascular penetration in 4% of the procedures, local bleeding in 73%, and oozing in 10%.Local hematoma was seen in only 0.1%. Profuse bleeding, bruising, soreness, nerve root irritation, and all other effects, such as vasovagal reactions, were observed in 1% or less.

Reported complications of radiofrequency thermoneurolysis include a worsening of the usual pain, burning or dysesthesias, decreased sensation and allodynia in the paravertebral skin or the facets denervated, transient leg pain, persistent leg weakness, and inadvertent lesioning of the spinal nerve or ventral ramus resulting in motor deficits, sensory loss, and possible deafferentation pain. A spinal cord lesion can lead to paraplegia; loss of motor, proprioception, and sensory function; bowel and bladder dysfunction; Brown-Séquard syndrome; and spinal cord infarction.

4.0 Discussion

This systematic review on the effectiveness of lumbar facet joint interventions revealed rather mixed results. Overall, it evaluated 25 studies, of which 11 randomized trials and 14 observational studies met inclusion criteria. The evidence for conventional radiofrequency neurotomy is good based on 6 of 7 randomized trials that had positive results, and 6 of 7 observational studies that had positive results. In contrast, for pulsed radiofrequency, there were only 2 studies, one that had positive results while the other had undetermined results, yielding a final conclusion of limited evidence. There is fair to good evidence for lumbar facet joint nerve blocks using local anesthetic with or without steroids, based on 3 randomized trials all of which were positive. In reference to intraarticular injections, one high-quality randomized, double-blind trial showed negative results (155), whereas a moderate-quality randomized controlled trial showed undetermined results with 6 injections, which is considered excessive (157). Nonrandomized studies showed positive results. Overall the evidence for intraarticular injections is limited.

The results from this systematic review are consistent or superior to the findings from the systematic review by Datta et al (43) which concluded that the evidence for therapeutic lumbar facet joint nerve radiofrequency neurotomy and facet joint nerve blocks in the treatment of chronic lumbar facet joint pain was moderate. Other than the recent American Society of Interventional Pain Physicians guidelines (1), all other current guidelines (27) have either overlooked or ig-

nored therapeutic lumbar facet joint nerve blocks for the treatment of chronic lumbar facet joint pain. This is despite the fact that the evidence has been readily available in the literature from multiple randomized controlled trials that demonstrate the effectiveness of therapeutic facet joint nerve blocks in the treatment of chronic cervical, thoracic, and lumbar facet joint pain (133-135,163,164,198).

ACOEM practice guidelines for the treatment of low back pain and APS guidelines for the evaluation and management of low back pain were unable to provide any clear rationale for conclusions that did not recommend radiofrequency neurotomy or facet joint nerve blocks for treatment of patients with chronic low back pain because they were based on insufficient evidence. Both the ACOEM and APS guidelines lack a systematic approach to evaluating the literature; use assessment tools that are not considered standard; present their analysis in a disorganized fashion; are deficient of any input from pain medicine physicians; and make conclusions that are often inconsistent, are based on an incomplete review of the literature, and/or rely on outdated research while ignoring more recent high quality published studies (1,32,33,107,312-318).

The APS guidelines underwent a critical review by Manchikanti et al (32,33). The APS guidelines relating to therapeutic interventions were reassessed by Manchikanti et al (33) wherein a literature search was completed and manuscripts were assessed using the same criteria used by the APS guidelines. The conclusions from the APS guidelines were compared to the critical assessment by Manchikanti et al (33) using the same grading system developed by the USPSTF (147). The results of this analysis using the APS criteria and the same grading system showed fair evidence for therapeutic lumbar facet joint nerve blocks and radiofrequency neurotomy. When incorporating current literature that was absent in the analysis used for the APS guidelines, therapeutic lumbar facet joint nerve blocks improved from fair to good. This critical analysis demonstrated that the APS guidelines assessed multiple studies incorrectly, excluded studies of high quality, failed to include current literature, and utilized flawed methodology. Similar to the above analysis, Van Zundert et al (197) reassessed the evidence by Chou and Huffman (27). They described that the review by Chou et al (314) concludes that there is insufficient (poor) evidence from randomized trials (conflicting trials, sparse and lower quality data, or no randomized trials) to reliably evaluate a variety of interventional therapies for spine-related pain. Van Zundert et al (197) further state that even though the title of the above manuscript (312) states that it is a systematic review, it looks more like a narrative review because the authors did not comply with general guidelines for writing a systematic review of RCTs, the Quality of Reporting of Meta-analysis (QUOROM) (110), and the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement (108). Van Zundert et al (197) considered that the main problem was the lack of structured overview of the results. They criticized that Chou et al (312) discussed the value of treatment based on previous reviews and did not present the outcomes of the trials in a structured way. Chou et al's conclusions were based on 6 trials. Several of those 6 trials had shortcomings. Van Zundert et al (197) criticized that 3 studies did not report the standard errors of the change in time (166,175,178). One study also did not do an intention-to-treat analysis (175), and in another study, flaws were detected in the assessment of the diagnostic block (167). Consequently, Van Zundert et al (197) performed a meta-analysis including all 6 trials (165,166,173,175,178,189), which showed a significantly better effect of radiofrequency compared to placebo. Furthermore, when they excluded the trials with shortcomings, the analysis of the only 2 included studies (165,173), showed even significantly better results for radiofrequency neurotomy (314). Thus, they concluded that the results of these 2 different analyses indicate that radiofrequency treatment of the facet joints is significantly more effective than placebo.

The criteria described above, which has been misinterpreted by Chou et al (312), also illustrates significantly different results for facet joint nerve blocks (32,33,107,313,319). However, it appears there is no significant difference in reference to intraarticular injections. All the evaluations showed similar results with limited evidence.

Facet arthrosis has been suggested as a cause of low back pain for decades (320,321). However, the exact source of pain in the facet joints is ambiguous. Theories on the generation of pain range from mechanical alterations to vascular changes and molecular signaling. While disc degeneration can clearly cause low back pain, some patients may not experience pain until degenerative changes in the facet joints alter mechanical alignment sufficiently to produce "articular" low back pain (322). Eubanks et al (321) and others (323) concluded that evidence of facet arthrosis appears early and can be linked to the amount of heavy work done before age 20. Indeed, it appears that facet arthrosis

starts early, with nearly 60% of adults showing some signs of degenerative changes by the time they reach age 30. After this early rise in arthritic changes, subsequent degeneration appears to steadily increase until the seventh decade when the evidence of arthrosis becomes ubiquitous (321).

A systematic review is defined as, "the application of scientific strategies that limit bias by the systematic assembly, critical appraisal, and synthesis of all relevant studies on a specific topic" (7,32,33,37,108-116,324-328). The Institute of Medicine (IOM) in their document for standards for systematic reviews (326) defined "standards for systematic reviews" as "a process, action, or procedure for performing systematic reviews that is deemed essential to producing scientifically valid, transparent, and reproducible results." Further, this document also described that systematic reviews of comparative effectiveness research – a type of research that compares different treatment options for the same disease – can be narrow in scope and consist of simple comparisons, such as the effectiveness of one drug versus another. They also can address more complex questions, such as the comparative effectiveness of drugs versus surgery for a specific condition. In addition, the committee's standards apply principally to publically funded systematic reviews of comparative effectiveness research that focus specifically on treatments. They concluded that the evidence base for how best to conduct systematic reviews is limited, and no set of standards is generally accepted or consistently applied. Consequently, in developing its standards, the IOM committee relied on the current methodological evidence and guidance from organizations that produce systematic reviews; therefore, the same biases that have existed over the years can continue to exist despite IOM's review and development of standards.

Systematic reviews are labor intensive and require expertise in both the subject matter and review methods. Thus, expertise in only one area is not enough and may lead to inaccurate conclusions, which in turn may lead to inappropriate application of the results (106,107,109,114,313). Thus, this systematic review was performed by experts in the subject matter, which is crucial, but they also have knowledge in review methodology. A systematic review differs from a narrative review because a systematic review attempts to minimize bias by the comprehensiveness and reproducibility of the search and selection of articles for review, and provides assessment of the methodological quality of the studies (109). In this systematic review, we attempted to answer specific, narrow clinical questions in depth – the level of evidence with recommendation for therapeutic facet joint interventions. A systematic searching, selecting, appraising, interpreting, and summarizing of data from original studies was performed. The study summaries were qualitative and quantitative. In this review we have also searched for other types of integrative evidence including other systematic reviews and cost effectiveness studies. Further, recent evaluations in reference to guideline warfare, evidence-based medicine, and comparative effectiveness research have been extensively discussed (7,32,33,37,106,107,319,328 ,329).

The IOM standards for systematic reviews (326) described 4 major standards: 1) standards for initiating the systematic review, 2) standards for finding and assessing individual studies, 3) standards for synthesizing the body of evidence, and 4) standards for reporting systematic reviews. Each one of the standards describe in detail multiple standards.

Further, the IOM also described multiple challenges and guidance in developing guidelines (327).

The IOM states that the literature assessing the best methods for guideline development have evolved dramatically in the 20 years since the IOM's first report on the subject (330). The new definition from IOM for guidelines is as follows (327):

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

1. Be based on a systematic review of the existing evidence
2. Be developed by a knowledgeable, multidisciplinary panel of experts and representatives from key affected groups
3. Consider important patient subgroups and patient preferences, as appropriate
4. Be based on an explicit and transparent process that minimizes distortions, biases, and conflicts of interest
5. Provide a clear explanation of the logical relationships between alternative care options and health outcomes, and provide ratings of both the quality of evidence and the strength of recommendations
6. Be reconsidered and revised as appropriate when important new evidence warrants modifications of recommendations.

The IOM also described standards for developing trustworthy clinical practice guidelines, which include the following:

- Establishing transparency
- Management of conflict of interest with appropriate disclosures reflecting all current and planned commercial, non-commercial, intellectual, institutional, and patient/public activities pertinent to the potential scope of the guidelines, with exclusion criteria to exclude members with conflicts of interest
- Guideline development group composition
- Clinical practice guideline – systematic review intersection
- Establishing evidence foundations for and rating strength of recommendations
- Articulation of recommendations
- External review
- Updating.

The outcomes of facet joint interventions to a great extent may depend on the diagnosis. Multiple authors have evaluated the factors related to accuracy of the diagnosis and its influence on outcomes. It is well known that facet joint nerve blocks are inherently nonspecific, even when low volumes are injected under fluoroscopic guidance. Thus, a strong case can be made for increasing the criteria to a more stringent 75% pain relief. A study by Dreyfuss et al (331) found that a 0.5 mL low volume facet joint nerve block using conventional landmarks resulted in contrast medium spread into the epidural space or intervertebral foramen in 16% of cases, and between the cleavage plain of the multifidus and longissimus muscles in all injections. Kaplan et al (332) also demonstrated the ability of lumbar medial branch blocks to anesthetize the zygapophysial joint. Consequently, 75% or higher relief with controlled diagnostic blocks has been recommended. The rationale behind using 50% relief as criteria to proceed to a therapeutic radiofrequency neurotomy was outlined by Schwarzer et al (48) who cited the high evidence of concurrent spinal pathology occurring with lumbar facet joint degeneration as the primary reason. Further, Fujiwara et al (333) found that even though lumbar degenerative disc disease frequently occurs in the absence of lumbar facet joint degeneration, patients with severe lumbar facet joint arthritis virtually always have radiologic evidence of degenerative disc disease and/or other spinal pathology. The role of 50% or 80% relief on the diagnostic accuracy has been evaluated (163,334,335). In these studies, it was illustrated that the prevalence specifically with 50% relief and a single block is inordinately high (73%), along with proof that the diagnosis was sustained in patients at the end of 2 years when it was made by controlled diagnostic blocks with 80% minimum relief criteria. In contrast, when the diagnosis was made by 50%, the diagnosis of facet joint pain was sustained only in 51% of patients at the end of 2 years. In addition, 80% pain relief also has shown a lack of confounding when sedation was administered, either with midazolam or fentanyl (336,337). Even though dual blocks with 80% relief as a criterion standard appears to be the best, some have argued that there is no difference between the outcome, specifically with radiofrequency neurotomy (197). In fact, the results were also significant when patients were selected without any diagnostic blocks, as shown in one study by Civelek et al (198), even though another study by Cohen et al (250) showed inferior results.

Cohen et al (338) emphasized that one reason that double blocks were not used for their study on the success of lumbar zygapophysial joint radiofrequency denervation as a function of diagnostic block relief was that the use of controlled blocks was not cost-effective. Manchikanti et al (339) commented that the whole concept of single blocks resulting in 50% or more relief followed by radiofrequency denervation creates many questions regarding the reliability of diagnostic blockade, increased health care costs, and coverage for facet joint nerve blocks and radiofrequency neurotomy. Schwarzer et al (52), using 90% relief of pain as a standard, showed the prevalence of lumbar zygapophysial joint pain is 37% of patients. The same authors showed a placebo response in 32% of the patients receiving normal saline. Most publications agree that 2 diagnostic blocks must be performed before radiofrequency denervation, and many payers are requiring 80% or more pain relief. Further, Cohen et al (250), in a randomized controlled trial, investigated costs and outcomes of radiofrequency treatment using 3 different medial branch block treatment paradigms. Those treatment paradigms were: radiofrequency without using a screening block; radiofrequency if the patient obtained significant relief after a single diagnostic block with 50% relief; and radiofrequency denervation only if a patient had an appropriate response, with a positive response of 50% or more relief with 2 confirmatory blocks. By 3 months after radiofrequency treatment, the proportion of successful outcomes of each individual group cohort was highest in the group where

patients received radiofrequency treatment after 2 diagnostic blocks with 64% of the patients reporting relief. However, by utilizing the total number of patients, Cohen et al (250) confused the entire data and misinterpreted the results, concluding that it was more cost effective to perform radiofrequency neurotomy without any type of diagnostic blocks. Such misinformation and inappropriate evaluation only lead to unnecessary radiofrequency neurotomy increasing health care costs (13,107). Consequently, a single block will definitely increase costs of care as the single diagnostic block will lead to an increase in the number of radiofrequency denervations, which are more expensive and time consuming. Cost effectiveness of controlled, comparative, local anesthetic facet joint nerve blocks has been evaluated and found to be superior to an algorithmic approach starting with discography for axial pain (39).

Further, multiple studies that evaluated managing axial low back pain after ruling out facet joint pain have shown similar results to facet joint nerve blocks or radiofrequency neurotomy by managing pain with epidural injections (140,141,145), indicating that even if some patients were mixed due to false-negative results, they will not suffer and may be managed appropriately with other modalities. This is in contrast to the argument that these patients will go on suffering if they tested as false-negative.

The limitations of this systematic review include limited literature available for analysis, the flawed methodology in many studies leading to their exclusion, and a myriad of discrepancies in the techniques, outcome measures, and follow-up periods. Even though multiple studies have considered themselves as placebo-controlled, their study patients all received local anesthetic injection, resulting in a facet joint nerve block. Facet joint nerve blocks themselves have been illustrated to provide significant pain relief (133). Thus, these studies could be construed as active-controlled trials even though sham treatment was utilized. Thus, proper terminology may be that these are sham-controlled but not placebo-controlled. It is not always feasible to perform placebo-controlled studies in an interventional setting, and the absence of these studies has led to some third party payers denying payment for effective therapies. Nonanalgesic solutions (e.g., saline) injected into painful structures have been reported to result in significant pain relief not only for spinal pain, but also for other chronic pain conditions as well (155,340-348). In addition, the placebo and nocebo effects, and decisions to consider all local anesthetic injections as placebo, are due to a lack of understanding about the scientific basis for placebo and nocebo (342,343,349-365). It is believed that neural blockade can result in the long-term alleviation of pain by interrupting nociceptive input, disrupting the reflex arc of afferent pain fibers, inhibiting ectopic discharges from injured nerves, and possibly reversing central sensitization (3,366). Corticosteroids may also inhibit the synthesis or release of a number of pro-inflammatory mediators, and cause a reversible local anesthetic effect (366-371). Local anesthetics can provide short- to long-term symptomatic relief through their mitigating effects on excessive nociceptive processing, reducing the release of neurotransmitters implicated in pain, increasing blood flow to ischemic nerve tissue, and phenotypic changes (371-385). A prolonged effect for local anesthetics has been demonstrated in multiple studies evaluating epidural injections and facet blocks (133-145,162-164). Sato et al (378) evaluated the analgesic effects of repetitive administration of epidural ropivacaine in a rat model of neuropathic pain, and found evidence of plastic changes in the peripheral nervous system. In a preclinical study conducted by Tachihara et al (379) evaluating the effects of local anesthetic, corticosteroid, and combination treatment in an experimental model of lumbar disc herniation, the authors found that nerve root infiltration in all treatment groups prevented mechanical allodynia; however, no additional benefit was observed by the addition of corticosteroid.

The results of this systematic review may be applied in interventional pain management practices. For this systematic review, placebo- and active-control trials were included. Active-control or practical clinical trials measure effectiveness, and may better reflect how a treatment will fare in clinical practice than placebo-controlled studies evaluating efficacy, which frequently have poor generalizability (109,114,386-390). The differences between placebo-controlled trials and active-controlled trials include the fact that whereas placebo-controlled trials measure absolute effect size, active-controlled trials compare different therapies (391). In addition, adding methodologically sound observational studies also adds impetus to the practical nature of this systematic review.

The limitations of this review include continued paucity of large randomized trials for radiofrequency neurotomy and the widespread variations in methodology, selection criteria, outcome measures, and technique. Thus, the results of this systematic review suggest that significant improvements in pain scores and

functional status can be obtained with radiofrequency neurotomy and facet joint injections in appropriately selected patients.

In conclusion, the results of this systematic review provide good evidence for conventional radiofrequency neurotomy, fair to good evidence for lumbar facet joint nerve blocks for both short- and long-term improvement, whereas evidence is limited for intraarticular injections and pulsed radiofrequency neurotomy.

5.0 Conclusion

This systematic review utilized strict criteria for inclusion and methodological quality. The evidence is good for conventional radiofrequency neurotomy, fair to good for lumbar facet joint nerve blocks for short- and long-term improvement and limited for intraarticular injections and pulsed radiofrequency neurotomy in managing chronic low back pain secondary to involvement of facet joints.

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