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A Systematic Review

Therapeutic Facet Joint Interventions in Chronic Spinal Pain: A Systematic Review of Effectiveness and Complications

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Background: Facet joint interventions are used frequently for managing chronic spinal pain. Evidence continues to accumulate supporting the clinical effectiveness of these procedures and defining potential complications.

Objective: To evaluate the effectiveness of three types of facet joint interventions (facet joint injections, medial branch blocks and facet joint neurotomy) in managing spinal pain.

Study Design: A systematic review utilizing the criteria established by the Agency for Healthcare Research and Quality (AHRQ) for evaluation of randomized and non-randomized trials and Cochrane Musculoskeletal Review Group for randomized trials.

Methods: Data sources included relevant literature of the English language identified through searches of MEDLINE and EMBASE (January 1966 to November 2004), manual searches of bibliographies of known primary and review articles, and abstracts from scientific meetings within the last 2 years.

Analyses were performed for the different modes of facet joint interventions of cervical, thoracic and lumbar spine, to determine short- and long-term outcome measurements and complications associated with the procedures.

Outcome Measures: The primary outcome measure was pain relief. For facet joint injections and medial branch blocks, short-term pain relief was defined as relief less than 6 weeks, and long-term as 6 weeks or longer. For medial branch radiofrequency neurotomy, short-term relief was defined as pain relief of less than 3 months, and long-term as 3 months or longer. Other outcome measures included functional improvement, improvement of psychological status, and return to work.

Results: For lumbar intraarticular facet joint injections, there was moderate evidence for short-term improvement, and limited evidence for long-term improvement. The evidence was negative for cervical intraarticular facet joint injections.

For cervical and lumbar medial branch blocks with local anesthetics and steroids, the evidence was moderate.

The evidence for pain relief with radiofrequency neurotomy of medial branch nerves was moderate to strong.

Conclusion: The evidence for facet joint interventions ranged from negative to strong.

Keywords: Spinal pain, neck pain, low back pain, facet or zygapophysial joints, intraarticular facet joint injections, medial branch blocks, medial branch radiofrequency neurotomy

The concept that facet (zygapophysial) joints can cause low back pain was proposed by Goldthwait (1) in 1911. Since then, numerous investigators have suggested that facet joints can cause lumbar, thoracic and cervical spine pain (2-4). Indeed, there is an extensive body of evidence supporting the existence of facet joint pain (2-30), although some dispute the validity of the diagnosis (31-34).

In addition to causing localized spinal pain, facet joints may refer pain to adjacent structures. Pain referral patterns of facet joints have been well described (7-18). Cervical facet joint pain may radiate to the neck, head and shoulders and lumbar facet joint pain may refer to the back, buttocks and proximal lower extremities. Referred pain may assume a pseudoradicular pattern, making the underlying diagnosis difficult to confirm. There is a growing impression that diagnostic blocks are needed to confirm facet joints as a source of the pain in a given patient, because there is little or no evidence that facet joint pain can be diagnosed on the basis of clinical examination or by medical imaging alone (6, 28-30, 35-59).

Cervical, thoracic and lumbar facet joints are innervated by the medial branches of the dorsal rami (19-29). Facet joints can be blocked by intraarticular injections or by anesthetizing the medial branches of the dorsal rami, which innervate the target joint.

In accordance with criteria established by the International Association for the Study of Pain (59), zygapophysial (facet) joints have been shown to be the source of chronic pain in 15% to 45% of patients with chronic low back pain (37, 38, 46, 47, 53, 54), 54% to 60% of the patients with chronic neck pain (54-57) and 42% to 48% of the patients with thoracic pain (54, 58). These prevalence numbers are derived from analysis of placebo-controlled blocks or comparative local anesthetic blocks. Specificity, sensitivity, and reliability of comparative local anesthetic blocks against placebo, as well as a lack of reliability of single blocks

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have been shown (2-4, 6, 38, 46, 47, 51, 52, 54, 57, 58).

Facet joint pain may be managed by intraarticular injections, medial branch blocks and neurolysis of medial branch nerves. However, conflicting results have been reported for the value of intraarticular injections of facet joints, medial branch blocks, and radiofrequency neurolysis of medial branches in several systematic and narrative reviews (60-65). Further, none of the systematic reviews evaluated all three interventions, independently or in combination.

This review was undertaken to assess systematically, the effectiveness of intraarticular facet joint blocks, medial branch blocks and medial branch radiofrequency denervation in the treatment of chronic spinal pain of facet joint origin.

Methods

Literature Search

The literature search included MEDLINE and EMBASE (Jan 1966 – Nov 2004), Cochrane database, systematic reviews, narrative reviews, cross-references to the reviews and various published trials, and peer reviewed abstracts from scientific meetings during the past two years, published in the English language. The search strategy consisted of diagnostic interventional techniques, facet (zygapophysial joint) injections with local anesthetics and steroids, medial branch facet nerve blocks with local anesthetics and steroids, and medial branch (facet nerve) radiofrequency neurotomy. The emphasis of the analysis was on chronic spinal pain of facet joint origin.

Selection Criteria And Data Extraction

This review focused on randomized and observational studies, and reports of complications. The population of interest was patients suffering with chronic spinal pain for at least 3 months who underwent facet joint injections and medial branch blocks and 6 months for radiofrequency neurotomy. To be included in this review, ideally, all studies should have documented the existence of spinal pain of facet origin using controlled diagnostic facet joint or nerve blocks. Due to the scarcity of such studies, some studies with single blocks were also considered.

Three types of facet interventions were included in this review: intraarticular facet joint injections, medial branch blocks, and medial branch radiofrequency neurotomy. All studies providing appropriate management with outcome evaluations of at least 3 months and statistical analysis were reviewed. The primary outcome measure was pain relief at various time points. The secondary outcome measures were functional or psychological improvement, return to work, and complications.

For evaluating the quality of individual articles, we used the criteria from the Agency for Healthcare Research and Quality (AHRQ) (66). Important domains and elements for randomized and observational trials, are shown in Tables 1 and 2. For inclusion, studies must have met at least 50% of the key domains and elements. Criteria described by the Cochrane Review Group for Musculoskeletal Disorders (67) were also used for evaluation of randomized trials, as shown in Appendix A.

Each study was evaluated for inclusion criteria, the study population, outcomes data, and statistical analysis. Inclusion criteria are shown in Appendix B, and a study should have answered questions in a positive manner (at least partially) in all categories.

Table 1. *AHRQ's key domains and elements for systems to rate the quality of randomized controlled trials*

Domain[#]	Elements*
Study Question	• **Clearly focused and appropriate question**
Study Population	• Description of study population
	• **Specific inclusion and exclusion criteria**
	• Sample size justification
Randomization	• *Adequate approach to sequence generation*
	• ***Adequate concealment method used***
	• *Similarity of groups at baseline*
Blinding	• ***Double-blinding (e.g., of investigators, caregivers, subjects, assessors, and other key study personnel as appropriate) to treatment allocation***
Interventions	• **Intervention(s) clearly detailed for all study groups (e.g., dose, route, timing for drugs, and details sufficient for assessment and reproducibility for other types of interventions)**
	• Compliance with intervention
	• Equal treatment of groups except for intervention
Outcomes	• **Primary and secondary outcome measures specified**
	• Assessment method standard, valid, and reliable
Statistical Analysis	• ***Appropriate analytic techniques that address study withdrawals, loss to follow-up, missing data, and intention to treat***
	• Power calculation
	• Assessment of confounding
	• Assessment of heterogeneity, if applicable
Results	• **Measure of effect for outcomes and appropriate measure of precision**
	• Proportion of eligible subjects recruited into study and followed up at each assessment
Discussion	• **Conclusions supported by results with possible biases and limitations taken into consideration**
Funding or Sponsorship	• ***Type and sources of support for study***

[#] *Key domains are in italics*

*Elements appearing in italics are those with an empirical basis. Elements appearing in bold are those considered essential to give a system a Yes rating for the domain. For purposes of this systematic review, the bold elements were considered, and to be included studies needed to have at least 5 of the 10 essential elements. Adapted from ref. 66

Table 2. *AHRQ's key domains and elements for systems to rate quality of observational studies*

Domain[#]	Elements
Study Question	• **Clearly focused and appropriate question**
Study Population	• **Description of study populations**
	• Sample size justification
Comparability of Subjects†	For all observational studies:
	• Specific inclusion/exclusion criteria for all groups
	• Criteria applied equally to all groups
	• Comparability of groups at baseline with regard to disease status and prognostic factors
	• Study groups comparable to non-participants with regard to confounding factors
	• *Use of concurrent controls*
	• Comparability of follow-up among groups at each assessment
	Additional criteria for case-control studies:
	• Explicit case definition
	• Case ascertainment not influenced by exposure status
	• Controls similar to cases except without condition of interest and with equal opportunity for exposure
Exposure or Intervention	• **Clear definition of exposure**
	• Measurement method standard, valid and reliable
	• Exposure measured equally in all study groups
Outcome Measurement	• **Primary/secondary outcomes clearly defined**
	• Outcomes assessed blind to exposure or intervention status
	• Method of outcome assessment standard, valid and reliable
	• Length of follow-up adequate for question
Statistical Analysis	• Statistical tests appropriate
	• Multiple comparisons taken into consideration
	• Modeling and multivariate techniques appropriate
	• Power calculation provided
	• **Assessment of confounding factors**
	• Dose-response assessment, if appropriate
Results	• **Measure of effect for outcomes and appropriate measure of precision**
	• Adequacy of follow-up for each study group
Discussion	• **Conclusions supported by results with possible biases and limitations taken into consideration**
Funding or Sponsorship	• ***Type and sources of support for study***

[#] Key domains are in italics
*Elements appearing in italics are those with an empirical basis. Elements appearing in bold are those considered essential to give a system a Yes rating for the domain. For purposes of this systematic review, the bold elements were considered, and to be included studies needed to have at least 5 of the 8 essential elements.
†Domain for which a Yes rating required that a majority of elements be considered.
Adapted from ref. 66

Analysis of Evidence

Qualitative analysis was conducted, using five levels of evidence for effectiveness as illustrated in Table 3. Pain relief was evaluated on both a short-term (less than 6 weeks) and long-term (6 weeks or longer) basis for intraarticular injections and medial branch blocks, whereas less than 3 months was considered as short-term and 3 months or longer was considered long-term for radiofrequency neurotomy. For randomized trials, a study was judged to be positive if the facet joint intervention was more effective than the reference treatment. For observational studies, results were considered positive if the treatment was effective by defined criteria (e.g., >50% pain relief). All other conclusions were considered negative. If, in the opinion of the reviewers, there were inconsistencies in the conclusions, disagreements were resolved by discussion and consensus.

Results

Intraarticular Facet Joint Blocks

Our search strategy identified a total of 235 articles. There were 11 relevant articles that were deemed eligible for further consideration of inclusion criteria.

Methodological Quality

Four randomized studies of intraarticular lumbar steroid facet joint injections (68-71) and one randomized study of the cervical spine (72) were identified, which compared results to those of similar groups not receiving intraarticular steroids. Of these, Carette et al (68) and Barnsley et al (72) met the inclusion criteria and methodological quality criteria (Table 4). Other randomized trials by Lilius et al (69), Marks et al (70), and Nash (71) did not meet inclusion criteria and were excluded. Marks et al (70) and Nash (71) compared the effects of intraarticular injections with medial branch blocks. Even though the number of patients included was of clinical significance with 86 and 67, respectively, patient selection failed to include controlled diagnostic blocks, there was not a blinded evaluation by an independent observer, and the authors utilized poor assessment tools. Lilius et al (69) included patients with neurological deficits, failed to confirm diagnosis, and used excessive volumes (3 mL to 8 mL) of active agents.

Two of the randomized studies, one by Carette et al (68) involving lumbar facet joint injections and the second one by Barnsley et al (72) involving cervical facet joint injections, are considered high quality and have been repeatedly quoted in the literature. Details of randomized tri-

Table 3. *Designation of levels of evidence*

Level I	**Conclusive:** Research-based evidence with multiple relevant and high-quality scientific studies or consistent reviews of meta-analyses
Level II	**Strong:** Research-based evidence from at least one properly designed randomized, controlled trial; or research-based evidence from multiple properly designed studies of smaller size; or multiple low quality trials.
Level III	**Moderate:** a) Evidence obtained from well-designed pseudorandomized controlled trials (alternate allocation or some other method); b) evidence obtained from comparative studies with concurrent controls and allocation not randomized (cohort studies, case-controlled studies, or interrupted time series with a control group); c) evidence obtained from comparative studies with historical control, two or more single-arm studies, or interrupted time series without a parallel control group.
Level IV	**Limited:** Evidence from well-designed nonexperimental studies from more than one center or research group; or conflicting evidence with inconsistent findings in multiple trials
Level V	**Indeterminate:** Opinions of respected authorities, based on clinical evidence, descriptive studies, or reports of expert committees.

Adapted and modified from ref. 4

als included in the evidence synthesis and methodological quality for intraarticular injections are shown in Table 4. Even though methodological criteria for both the above studies was considered optimal, Carette et al (68) failed to exclude placebo responders, which may account for the relatively high incidence of patients in their study with presumed facet joint pain. They showed a prevalence of lumbar facet joint pain of 58% in patients with spine pain, based on inclusion criteria in Phase I of the study. False-positive rates have been evaluated by multiple investigators with a calculated prevalence of facet pain of 17% to 47% for the lumbar spine (16, 46, 47, 53, 54). Consequently, failure to exclude placebo responders diluted the findings of true responses, making detection of differences between the study and control groups difficult. Further, even though results were judged to be positive at 6 months in the methylprednisolone group, they performed various types of analyses and finally concluded that there was no significant difference between groups.

Barnsley et al (72) performed a well-conducted study, but faced criticism. They included a total of 41 patients whose origin of neck pain was posttraumatic, following whiplash. Consequently, results may not be extrapolated to treatment of patients with cervical facet joint pain from nontraumatic causes, because responses to intraarticular steroid injections is not known for cervical facet joint pain of spontaneous origin.

Among the observational reports, numerous studies were evaluated for inclusion. Among these, five studies (73-

Table 4. *Characteristics of published randomized trials of intraarticular facet joint injections*

Study/Methods	Participants	Interventions	Outcome(s)	Result(s)	Conclusion(s) Short-term relief < 6 weeks Long-term relief ≥ 6 weeks
Lumbar Spine					
Carrette et al (68) Lumbar facet joint injections Randomized, double-blind, placebo-controlled trial AHRQ Score 10/10 Cochrane Score 10/10	190 patients entered Phase I of the study. Of these, 110 (58%) reported a reduction of 50% or more in their pain after the injections of lidocaine. Nine patients were not included in the study. Thus, 101 patients entered the randomized trial (Phase II), 51 in the methylprednisolone group, and 50 in the placebo group.	The patients received injections of either 20 mg (1 mL) of methylprednisolone acetate mixed with 1 mL of isotonic saline or 2 mL of isotonic saline in each of the facet joints. All the injections were preceded by arthrography and were performed under fluoroscopic guidance.	95 patients of 101 were followed for 6 months and their condition assessed with scales of pain severity, back mobility, and limitation of function.	42% of the patients who received methylprednisolone and 33% of those who received placebo reported marked or very marked improvement with no significant difference among the groups at 3 months and after 3 months with no significant difference at 1 month and 3 months. The proportion of patients treated with methylprednisolone who reported marked or very marked improvement 6 months after the injections increased to 46%, whereas it decreased to 15% for the patients who received placebo with a statistically significant difference ($p = 0.002$	Negative short-term and long-term
Cervical Spine					
Barnsley et al (72) Cervical facet joint injections Randomized, double-blind, trial of intraarticular AHRQ Score 10/10 Cochrane Score 9/10	41 patients with cervical pain after whiplash and with relief of pain after controlled diagnostic blocks randomized to intraarticular steroid or local anesthetic cervical facet joint injections.	Patients randomized to intraarticular injection of 5.7 mg betamethasone or 1ml intraarticular bupivacaine.	Return of pain to 50% of preinjection pain level.	No significant difference in duration of pain relief. Median duration of time to return of pain to 50% was 3 days in the steroid group and 3.5 days in the local anesthetic group.	Negative short-term and long-term

77) met the inclusion criteria. Among the prospective trials included in the evidence synthesis, 3 (73-75) of the 5 studies (73-77) were prospective and 2 were retrospective (76, 77). Among these, pain relief was the only outcome measure evaluated in all the studies except in one study, where return to work also was evaluated (76). Characteristics and results of observational studies of intraarticular facet joint injections are illustrated in Table 5 along with methodological scores.

Effectiveness

Carette et al (68) ultimately concluded that the results of their study were negative at 6 months, although patients who received intraarticular methylprednisolone were considerably improved compared to the control group. Notwithstanding their suggestion that concurrent treatments may have influenced the outcomes, for purposes of this systematic review, in terms of pain relief following intraarticular facet joint injections, the outcome is considered to have been positive for lumbar facet pain at 6 months. The second study, by Barnsley et al (72), obtained negative results with cervical intraarticular injections of steroids and local anesthetic.

Among the non-randomized trials, 3 prospective evaluations (73-75) and 2 retrospective evaluations (76, 77) met inclusion criteria. Among the prospective trials included in the evidence synthesis, Lynch and Taylor (75) reported initial pain relief in 31 of 35 patients receiving intraarticular steroids, whereas 8 of the 15 patients receiving extraarticular steroids reported pain relief. Long-term relief was reported in 62% at 3 months and 56% at 6 months. Destouet et al (74) reported significant pain relief for 1 to 3 months in 54% of the patients and for 3 to 6 months in 38% of the patients. Murtagh (73) reported long-term relief of longer than 3 months in 54% of patients, although a large fraction of the patients included had nonspecific back pain or radicular symptom. Among the retrospective evaluations, Lippitt (76) reported greater than 50% relief initially in 42% of patients, which declined to 14% at 6 months and 8% at 12 months. Lau et al (77) reported initial relief in 56% of patients, which declined to 44% at 3 months, and 35% at 6 to 12 months.

Level of Evidence

Based on the present review, only the randomized trial of lumbar spine pain by Carette et al (68) may be considered to be positive (albeit controversial), however, at 6 months, improvement remained below 50%. In contrast, the second randomized trial of cervical spine pain following whiplash injury by Barnsley et al (72), was negative. Among the non-randomized trials, short-term positive results were noted in 4 of the 5 studies with long-term positive results in, 3 of the 5 studies.

Overall, the evidence was Level III, or moderate for short-term improvement and limited for long-term relief with intraarticular lumbar facet joint injections. The evidence for cervical facet joint pain was negative.

Table 5. ***Characteristics and results of observational studies of lumbar facet joint injections***

Study/Methods	Participants	Intervention(s)	Outcome(s)	Result(s)	Conclusion(s) Short-term relief < 6 weeks Long-term relief ≥ 6 weeks
Murtagh (73) Prospective study AHRQ Score -6/8	100 patients with low back pain with pain relief after lumbar intraarticular facet joint injections using fluoroscopy or CT.	Patients with immediate relief of pain after local anesthetic injections received repeat intraarticular injection of 6 mg betamethasone.	Follow-up in all patients. Subjective relief as determined by patient response.	54% of patients had more than 3 months of pain relief.	Positive short-term and long-term
Destouet et al (74) Prospective study AHRQ Score -6/8	54 patients studied; 13 had previous lumbar surgery. Patients received intraarticular facet injections.	Patients with immediate relief of pain with fluoroscopically guided intraarticular local anesthetic injections received 1 ml 0.25% bupivacaine and 40 mg depot methylprednisolone for treatment.	Pain relief.	54% of patients had initial relief; whereas 38% had continued pain relief for 3 months or longer.	Positive short-term and negative long-term
Lynch and Taylor (75) Prospective study AHRQ Score 6/8	35 patients in intraarticular and 15 in extraarticular group, with presumed lumbar facet pain were studied.	Intraarticular or extraarticular injections with 60 mg methylprednisolone.	Pain relief.	89% of patients had pain relief initially in the intraarticular group; intraarticular injections were better than extraarticular.	Positive short-term and long-term
Lippitt (76) Retrospective review AHRQ Score -5/8	99 patients with clinical diagnosis of lumbar facet pain received facet joint injections with fluoroscopy.	Intraarticular injection of 1 ml 1% lidocaine and 80 mg depot methylprednisolone.	Pain relief, return to work.	42% of patients had initial relief which declined to 14% at 6 months.	Negative short-term and long-term
Lau et al (77) Retrospective study AHRQ Score -6/8	34 consecutive patients with clinical diagnosis of lumbar facet pain received facet joint injections with fluoroscopy.	Intraarticular injection of bupivacaine and depot methylprednisolone.	Pain relief.	56% of patients reported immediate pain relief, which declined to 44% at 3 months and 35% at 6 to 12 months.	Positive short-term and negative long-term

Medial Branch (Facet Joint Nerve) Blocks

Our search strategy identified a total of 162 references. There were 6 relevant articles that were deemed eligible for consideration of inclusion criteria.

Methodological Quality

The therapeutic role of medial branch blocks was evaluated in 4 randomized clinical trials (70, 71, 78, 79) and two non-randomized clinical trials (80, 81).

Of the 4 randomized clinical trials (70, 71, 78, 79), only one study by Manchikanti et al (78) met inclusion criteria. Marks et al (70) and Nash (71) compared the effectiveness of intraarticular injections with medial branch blocks. They failed to appropriately diagnose facet joint pain by controlled local anesthetic blocks, and the studies lacked long-term follow-up and outcomes. Further, they did not perform the studies to evaluate potential therapeutic benefit. Thus, both studies failed to meet inclusion criteria. The study by Manchikanti et al (81) was excluded, as the study purpose was to evaluate the stability of lumbar facet joint pain diagnosed by controlled, comparative local anesthetic blocks, rather than therapy itself. Consequently, because no other outcome parameters were measured, the study was excluded. The report by Manchikanti et al (79) was also excluded, as it evaluated the therapeutic potential of Sarapin in neural blockade, rather than pain relief on a long-term basis. On the other hand, the randomized controlled trial by Manchikanti et al (78) met inclusion criteria, and was included in the evidence synthesis for lumbar facet pain; the characteristics of this study are shown in Table 6, along with methodological quality criteria.

Among the observational studies, the only study meeting inclusion criteria for evidence synthesis was by Manchikanti et al (80), which evaluated the effectiveness of cervical medial branch blocks in the management of chronic neck pain (Table 6).

Effectiveness

Only 2 studies, one randomized evaluation (78) and one observational study (79) met methodological criteria and were included in evidence synthesis. The randomized trial (78) evaluated the effectiveness of medial branch blocks in lumbar facet joint pain and the observational study (79) evaluated cervical medial branch blocks for managing chronic neck pain. Both studies showed significant pain relief and improvement in other outcome parameters.

Level of Evidence

According to the levels of evidence described in Table 3, evidence was moderate or level III for short-term and long-term relief with lumbar and cervical medial branch blocks in managing chronic low back or neck pain.

Medial Branch Radiofrequency Neurotomy

Our search strategy yielded a total of 124 reports. Following detailed review, 17 relevant articles were identified to for subsequent evaluation.

Methodological Quality

For the current systematic review, four randomized trials evaluating the efficacy of medial branch facet radiofrequency neurotomy were identified, one with cervical medial branch neurotomy (82) and three with lumbar medial branch neurotomy (83-85). Among the randomized trials, only 2 met inclusion criteria. The study by Lord et al (82) evaluated the effectiveness of percutaneous radiofrequency neurotomy from cervical zygapophysial joint pain and the study by van Kleef et al (83) evaluated the effectiveness of radiofrequency lumbar facet denervation for chronic low back pain. The methodological scoring for both of the studies is illustrated in Table 7, along with study descriptions.

Other randomized trials were excluded as they failed to meet inclusion or methodological criteria. The study by

Table 6. *Characteristics of published reports of cervical and lumbar medial branch blocks*

Study/Methods	Participants	Intervention(s)	Outcome(s)	Result(s)	Conclusion(s)
Lumbar Spine					Short-term relief < 3 months Long-term relief ≥ 3 months
Manchikanti et al, (78) Lumbar medial branch blocks Randomized, controlled trial AHRQ Score - 8/10 Cochrane Score - 6/10	200 patients with low back pain were evaluated. 73 patients were enrolled in study after confirmation of facet pain by controlled diagnostic facet nerve blocks.	Medial branch blocks with fluoroscopy. Patients randomized into 2 groups: local anesthetic, bupivacaine, with or without Sarapin®. Patients had repeat procedures as clinically indicated.	Outcomes were evaluated over a period of 2½ years. Measurements were performed at 1 month, 3 months, 6 months, 12 months, 18 months, 24 months, and 32 months. Outcomes included pain relief, physical health, psychological status, narcotic intake, and employment status.	Cumulative significant relief with 1 to 3 injections up to 2.5 years. Overall, significant relief for a mean of 6.5 months. There was significant improvement noted in overall health status with improvement in pain relief, psychological status, and return to work status.	Positive short-term and long term
Cervical Spine					
Manchikanti et al (80) Cervical medial branch blocks Prospective AHRQ Score - 8/8	100 consecutive patients with cervical facet pain diagnosed by comparative, controlled local anesthetic blocks.	Medial branch blocks with fluoroscopy with bupivacaine with or without methylprednisolone. Patients had repeat blocks as clinically indicated.	Pain relief Oswestry Disability Index Psychological status Work status Timings: 3 months, 6 months, and 12 months	Significant pain relief at 3, 6 and 12 months, compared to baseline measurements. There was also significant improvement in disability status, psychological status, and return to work.	Positive short-term and long term

Table 7. *Characteristics of published randomized trials of medial branch neurotomy*

Study/Methods	Participants	Intervention(s)	Outcome(s)	Result(s)	Conclusion(s) Short-term relief < 3 months Long-term relief ≥ 3 months
Cervical Spine					
Lord et al (82) Cervical zygapophysial joint nerve radiofrequency Randomized, placebo-controlled, double-blind trial AHRQ Score - 9/10 Cochrane Score - 9/10	24 patients with neck pain > 3 months' duration in cervical spine, confirmed by controlled blocks Control =12 Treatment=12	RF group lesion 90 sec lesion at 80° C of medial branch; Control group received sham treatment with electrode insertion.	3, 6 and 12 month follow-up; 0 to 5 of 100 on VAS scale; Word count 3 or less on McGill Pain Questionnaire	Median time to return of pain in treatment group was 263 days; 8 days in control group; 10 patients underwent second procedures with varying results.	Positive short- term and long-term
Lumbar Spine					
van Kleef et al (83) Lumbar zygapophysial joint radiofrequency Randomized, placebo-controlled, double-blind trial AHRQ Score - 9/10 Cochrane Score - 7/10	31 patients (16 in Control , 15 in Treatment) with low back pain of at least 12 months' duration, confirmed by diagnostic controlled blocks.	RF group lesion 60 sec at 80° C of medial branch; Control group received sham treatment with electrode insertion.	2, 3, 6 and 12 months follow-up. Number of successes, (> 2 pt reduction VAS, > 50% Global and Oswestry)	Statistically higher improvement in treatment than control at the indicated times (e.g.; 67% treat, 37% sham at 2 months).	Positive short- term and long-term

LeClaire et al (85), which appeared to be a well-performed, double-blind, placebo-controlled trial, had several deficiencies. This study failed to define the study population using appropriate diagnostic criteria. This was considered to be a major error, because patients were evaluated with a single diagnostic block and pain relief was considered to be more than one day's relief during the 7-day period following the diagnostic block. Consequently, any results or conclusions also would be erroneous. A study by Gallagher et al (84) was not included because it used the invalidated Shealy technique, failed to describe appropriate diagnostic techniques and outcome analysis, and it was not clear whether interventions were performed with fluoroscopy.

Three other studies were excluded from inclusion and evidence synthesis; one study used intraarticular facet joint denervation (86), which is not medial branch neurotomy and is of unclear clinical relevance, and the other two studies (87, 88) described radiofrequency lesioning of dorsal root ganglia.

There were 9 observational studies (89-97) identified that met inclusion criteria for the review. Of these, 4 (Table 8) evaluated cervical facet radiofrequency thermoneurolysis (89, 93, 94, 96) and 6 (Table 9) studies evaluated low back pain (90, 91, 94-97); 2 of the studies (92, 94) included evaluations of thoracic facet joint pain (Table 10). Some studies (94, 96) evaluated more than one level.

Among the 4 prospective trials, McDonald et al (93) and Sapir and Gorup (89) evaluated the effectiveness of cervical medial branch radiofrequency, whereas Dreyfuss et al (90) and Vad et al (97) evaluated the effectiveness of lumbar radiofrequency.

All of the studies evaluated pain relief. One study (90) evaluated multiple outcomes at 3, 6, and 12 months. Two studies (95, 97) evaluated pain relief and function and a third study (96) evaluated pain relief, analgesic intake, and mood. Characteristics and results of observational studies of facet joint neurotomy, along with methodological criteria are described in Tables 8-10.

Effectiveness

Using the inclusion criteria, the studies by Lord et al (82) and van Kleef et al (83) were included for evidence synthesis. In addition, 4 prospective, non-randomized, observational studies by Dreyfuss et al (90), Sapir and Gorup (89), McDonald et al (93) and Vad et al (97) and 5 retrospective evaluations, by Stolker et al (92), Tzaan and Tasker (94), North et al (95) Schaerer (96) and Schofferman and Kine (91) were included in evidence synthesis.

Lord et al (82) evaluated percutaneous radiofrequency neurotomy for management of chronic cervical facet joint pain in a randomized, double blind, placebo-controlled trial. They concluded that for patients with chronic cervical facet joint pain, confirmed by double-blinded, placebo-controlled local anesthetic blocks, percutaneous radiofrequency neurotomy with multiple lesions of target nerves can provide long lasting relief.

van Kleef et al (83) randomized 31 patients to radiofrequency neurolysis or sham lesioning of lumbar facet medial branch nerves. At 3, 6, and 12 months, there were statistically more successes in the treatment group than the sham group. These results demonstrated that radiofrequency denervation of the lumbar facet joints can be effective for pain reduction in patients with lumbar facet joint pain.

Among the non-randomized or observational studies, Dreyfuss et al (90) described lumbar facet joint radiofrequency neurotomy and found 60% improvement in 80% of patients at 1 year. McDonald et al (93) determined the long-term efficacy of percutaneous radiofrequency medial branch neurotomy for the treatment of chronic neck pain in 28 patients diagnosed as having cervical zygapophysial joint pain, on the basis of controlled diagnostic blocks. They reported a median duration of relief after the first procedure of 219 days when failures were included, and 422 days when only the successes were considered. In addition, radiofrequency neurotomy of the cervical zygapophysial joints significantly reduced headache se-

Table 8. *Characteristics and results of observational studies of cervical medial branch neurotomy*

Study/Methods	Participants	Intervention(s)	Outcome(s)	Result(s)	Conclusion(s)
				Short-term relief < 3 months Long-term relief ≥ 3 months	
McDonald et al (93) Prospective, non-randomized AHRQ Score - 7/8	28 patients with cervical facet pain diagnosed by comparative local anesthetic blocks.	Cervical facet nerve radiofrequency; repeated when pain returned.	Pain relief and duration of benefit.	Complete pain relief obtained in 71% of patients after initial procedure. Median duration of relief was 219 days for all patients; 422 days for initial responders.	Positive short-term and long term
Tzaan and Tasker (94) Retrospective AHRQ Score - 6/8	118 consecutive procedures in 90 patients diagnosed by local anesthetic facet nerve block.	Radiofrequency facet neurotomy at involved levels.	Pain relief.	41% of patients had >50% relief at an average follow-up of 5.6 months.	Negative short-term and long term
Schaerer (96) Retrospective AHRQ Score - 6/8	117 patients with a total of 50 cervical procedures.	Radiofrequency facet neurotomy at involved levels.	Pain, analgesics and mood.	50% of 50 patients had >50% pain relief, with average follow-up of 13.7 months.	Negative short-term and long term
Sapir and Gorup (89) Prospective nonrandomized AHRQ Score 7/8	46 patients with cervical whiplash symptoms completed the study. Litigant and non-litigant patients were included.	The 2-phase diagnostic cervical medial branch blocks, followed by radiofrequency neurotomy.	VAS and self-report of improvement (SRI)	The difference between groups in the degree of symptomatology or response to treatment did not reach significance.	Positive short and long-term

Table 9. *Characteristics and results of observational studies of lumbar medial branch neurotomy*

Study/Methods	Participants	Intervention(s)	Outcome(s)	Result(s)	Conclusion(s)
				Short-term relief < 3 months Long-term relief ≥ 3 months	
Dreyfuss et al (90) Prospective nonrandomized AHRQ Score 8/8	15 patients with chronic lumbar facet pain diagnosed by comparative local anesthetic blocks.	Lumbar radiofrequency; EMG of multifidus muscle used to determine accuracy of neurotomy.	Pain relief, functions, EMG at 6 weeks; pain relief & outcomes assessment at 3, 6, and 12 months.	60% of patients obtained at least 90% relief of pain at 12 months, and 87% at least 60% relief at 12 months.	Positive short-term and long term
Schofferman and Kine (91) Retrospective AHRQ Score - 7/8	20 patients underwent repeat radiofrequency neurotomy. Medial branch blocks used for initial diagnosis.	Radiofrequency neurotomy of the lumbar facets; repeated as indicated clinically.	Pain relief.	Mean duration of relief of initial RF was 10.5 months. Second treatment effective in 85%; mean duration of relief of 11.6 months.	Positive short-term and long term
Vad et al (97) Prospective nonrandomized AHRQ Score - 8/8	12 patients with sports-related low back pain diagnosed with medial branch blocks.	Radiofrequency neurotomy of the lumbar facets.	Pain relief and return to pretreatment level of function.	Mean duration of pain relief: 1.3 years. 83% of patients returned to pretreatment level of function.	Positive short-term and long term
North et al (95) Retrospective AHRQ Score - 7/8	82 patients with lumbar pain of facet origin diagnosed by facet nerve blocks.	Radiofrequency neurotomy of the lumbar facets for 42 patients.	Pain relief and function.	45% of patients with radiofrequency reported >50% pain relief at 2 years.	Negative short-term and long term
Tzaan and Tasker (94) Retrospective AHRQ Score - 6/8	90 patients diagnosed by local anesthetic blocks.	Radiofrequency facet neurotomy at involved levels.	Pain relief.	41% of patients had >50% relief at an average follow-up of 5.6 months.	Negative short-term and long term.
Schaerer (96) Retrospective AHRQ Score - 6/8	117 patients 71 lumbar procedures	Radiofrequency facet neurotomy at involved levels.	Pain, analgesics and mood.	35% of 71 lumbar RF had >50% pain relief, with average follow-up of 13.7 months.	Negative short-term and long term

Table 10. *Characteristics and results of observational studies of thoracic medial branch neurotomy*

Study/Methods	Participants	Intervention(s)	Outcome(s)	Result(s)	Conclusion(s)
				Short-term relief < 3 months Long-term relief ≥ 3 months	
Stolker et al (92) Retrospective AHRQ Score - 7/8	40 patients with chronic thoracic facet pain diagnosed with medial branch block.	Thoracic radiofrequency facet neurotomy.	Pain relief.	At an average followup of 31 months, 83% had >50% relief.	Positive short-term and long term
Tzaan and Tasker (94) Retrospective AHRQ Score - 6/8	90 consecutive patients diagnosed by local anesthetic facet nerve block.	Radiofrequency facet neurotomy at involved levels.	Pain relief.	41% of patients had >50% relief at an average follow-up of 5.6 months.	Negative short-term and long term

verity in 80% of patients, both at short-term and long-term follow-up.

Among the retrospective evaluations, Tzaan and Tasker (94) evaluated 118 consecutive percutaneous radiofrequency facet rhizotomies performed on 90 patients for cervical, thoracic and lumbar pain. They reported that with the first procedure, greater than 50% subjective reduction of pain was present in 41% of patients. They included cervical, thoracic and lumbosacral facets and noted no significant difference between unilateral or bilateral involvement. North et al (95) evaluated radiofrequency lumbar facet denervation with long-term outcome assessment by a disinterested third party interview. Forty-five percent of patients undergoing denervation reported at least 50% relief of pain at long-term follow-up. Schaerer (96) evaluated the value of radiofrequency facet rhizotomy in the treatment of patients with chronic neck and low back pain problems in 90 consecutive patients, undergoing 117 procedures. They reported that overall results were good to excellent in 50% of the patients in cervical spine and 35% in lumbar spine with an average follow-up time of 13.7 months. Schofferman and Kine (91) demonstrated that radiofrequency neurolysis can be repeated when pain returns, re-establishing long-term pain relief in 85% of patients.

Criticisms faced by these trials include the overall relatively small number of patients. The total number of patients combined for cervical and lumbar regions in the randomized trials was 27 in the treatment groups, compared to 28 in the control groups. Consequently, the number of patients undergoing a cervical or lumbar intervention is small. An additional criticism for van Kleef's et al's (83) study is that they included patients after a single diagnostic block, which increases the false-positive rate.

Level of Evidence

Evidence for radiofrequency neurotomy was Level III to Level II, moderate to strong for short-term and long-term relief of lumbar and cervical facet joint pain.

Safety and Complications

Our search strategy yielded 246 articles regarding spinal injections. The most common and worrisome complications of facet joint interventions are related to needle placement and drug administration. Potential complications include dural puncture, spinal cord trauma, infection, intraarterial or intravenous injection, spinal anesthesia, chemical meningitis, neural trauma, pneumothorax, radiation exposure, facet capsule rupture, hematoma formation, and steroid side effects (98-114). The risks associated with needle injections may be higher in the cervical spine, particularly with intraarticular facet joint injections, and perhaps particulate steroid injections into vessels in the neck, given the proximity of the cervical spinal cord. However, quantitative data are lacking.

Potential side effects with radiofrequency denervation include painful cutaneous dysesthesias, increased pain due to neuritis or neurogenic inflammation, anesthesia dolorosa, cutaneous hyperesthesia, pneumothorax and deafferentation pain. Unintentional damage to a spinal nerve during medial branch radiofrequency, causing a motor deficit, is also a possible complication of the neurolytic procedure.

Data regarding the incidence or prevalence of complications are sparse, with respect to specific complications with intraarticular facet joint injections and medial branch blocks. A retrospective chart review of patients undergoing radiofrequency neurotomy for facet joint pain over a five-year period provides some data regarding the complication rates associated with the procedure (113). Kornick et al (113) reported six minor complications with radiofrequency neurolysis in the lumbar spine. During 116 separate denervation procedures, 6 minor complications were noted, including 3 cases of localized pain lasting > 2 weeks and 3 cases of neuritic pain lasting < 2 weeks. There were no cases of infection or new sensory or motor deficits. The overall rate of complications, which were minor, was 1%.

Discussion

Several systematic and narrative reviews have evaluated facet joint interventions. However, none of the systematic evaluations included all three interventions, independently or in combination in their evidence synthesis. Nelemans et al (65) reviewed intraarticular injections in a systematic review and provided a negative opinion. Intraarticular injections also have been evaluated in non-systematic reviews. Medial branch blocks have not been systematically evaluated for their therapeutic effectiveness.

Nelemans et al (65) performed a partial review of intraarticular injections showing negative effects. Slipman et al (64) also analyzed the effectiveness of intraarticular injections for the low

back only, however, it is not clear whether or not the study was a systematic review. Their conclusions were more favorable for intraarticular injections in the lumbar spine in managing low back pain. Manchikanti et al (4) also reviewed the effectiveness of intraarticular injections during the preparation of interventional pain management guidelines. However, the guidelines are not considered to be a systematic review.

Regarding radiofrequency, there have been 3 systematic reviews and a critical review by Slipman et al (64) of medial branch neurotomy. Geurts et al's (60) systematic review included only randomized controlled trials and included 6 studies, two of which were dorsal root ganglion radiofrequency lesioning studies, and a third involved intraarticular facet denervation. The remaining 3 studies involved medial branch radiofrequency lesioning. Two of the studies involved lumbar and one study involved cervical radiofrequency lesioning. In the abstract section of the paper, the authors stated that "All studies, whether high or low quality, reported positive outcomes." Of the two lumbar medial branch radiofrequency lesioning studies, the study by van Kleef et al (83) was rated as high quality and the one by Gallagher et al (84) was rated as low quality and both were positive studies. By the "Best Synthesis Method" of Slavin (115), this combination of one positive high quality and one additional positive low quality study assigned the level of "Moderate Evidence" to the efficacy of radiofrequency lesioning in the lumbar region. However, the positive study by Lord et al (82) involving cervical radiofrequency lesioning in whiplash patients was rated as high quality, but using the "best synthesis method" the authors concluded that there was limited evidence "that pain complaints in whiplash patients can be treated by RF denervation of cervical zygapophysial joints," because it was a solitary study and the "Best synthesis method" required at least one more study of low quality to reach the level of "Moderate Evidence" or one additional high quality study to reach to the level of "Strong Evidence." The review by Geurts et al (60) has been the subject of criticism for inappropriate methodology and inaccurate conclusions (116-118)

The review by Manchikanti et al (63) argued that restricting analysis of the efficacy of an intervention to only randomized controlled trials ignores a large body of accumulated evidence about the intervention. Thus, both randomized controlled trials and observational studies were subjected to rigorous analysis for quality using criteria described in an Agency for Healthcare Research and Quality (AHRQ) publication (66). Based on stringent criteria, Manchikanti et al (67) identified 7 randomized trials of radiofrequency neurotomy for spinal pain, of which 4 related to medial branch neurotomy. One of these 4 studies was by LeClaire et al (85). Two of these four studies were excluded in the evidence synthesis analysis due to study deficiencies. The study by LeClaire et al (85) was excluded due to failure to meet the AHRQ criteria for inclusion. The criteria stated by the authors were "patients 18-65 years of age who had experienced significant relief of their low back pain for at least 24 hours during the week after intraarticular facet injections under fluoroscopy using Omnipaque (240 mg, 0.3 mL), as reported by the patient and the physiatrist. The medication used was lidocaine hydrochloride 2% without epinephrine (0.5 mL) and triamcinolone acetonide (40 mg, 0.5 mL)." Thus, a method lacking validation was employed to select patients for randomization to active treatment or placebo treatment. The study by Gallagher et al (84) was excluded because it used the invalidated Shealy technique and important aspects, such as effects on physical impairment and disability were not investigated. Manchikanti et al (63) included for evidence synthesis studies by Lord et al (82) and van Kleef et al (83) and 4 prospective evaluations and 3 retrospective evaluations. They excluded numerous studies that failed to meet inclusion criteria.

The review by Niemisto et al (61) included only randomized controlled trials and was based on current recommendations of the Cochrane Collaboration Back Review Group. Seven randomized controlled trials were identified as meeting the criteria and were included in the analysis, including 2 trials involving radiofrequency lesioning of the dorsal root ganglion for cervicobrachial pain and 1 trial involving a solitary central intradiscal radiofrequency lesion for discogenic pain. Of the 4 trials involving radiofrequency lesioning of the medial branches, 1 was cervical (82) and 3 were lumbar (82-84). Qualitative analysis was performed, assigning the evidence of efficacy for the intervention to 1 of 4 levels of evidence, Level A (Strong), Level B (Moderate), Level C (Limited) and Level D (no evidence). The cervical radiofrequency lesioning study by Lord et al (82) was reviewed in detail. The reviewers rated the study as high quality and noted that 7/12 patients in the treatment group and only 1/12 patients in the control group were pain free at 27 weeks post-lesioning and that the median time to return of 50% of the preoperative pain level was 263 days in the intervention group and only 8 days in the control group. Despite this, Niemisto et al (61) concluded that there was only "limited" (level C) evidence that radiofrequency lesioning "had a positive short-term effect on chronic cervical zygapophysial joint pain" because it was a singular study and lacked the corroboration needed to reach a Level B (moderate - 1 high quality *plus* 1 or more low quality studies) or Level A (strong - multiple high quality studies) classification of evidence.

Despite problems with the studies of LeClaire et al (85) and Gallagher et al (84) noted previously, Niemisto et al (61) chose to include them in their analysis. Utilizing their criteria, they concluded that radiofrequency denervation had a positive short-term effect in van Kleef et al (83), a neutral effect in LeClaire et al (85), and considered the findings of Gallagher et al (84) unclear, "because they did not include an intention-to-treat analysis." Thus, Niemisto et al (61) concluded that evidence of short-term effect was conflicting.

We observe, similar to Geurts et al (60) that Niemesto et al (61) utilized inconsistent methodology, did not exclude 2 studies performed inappropriately (84, 85), and arrived at conflicting conclusions. Even though the review was described as being within the framework of Cochrane Collaboration Back Review Group guidelines, the conclusions may have been unwarranted.

The review by Slipman et al (64) was limited to intraarticular injections and radiofrequency lesioning of medial branch nerves in the lumbar spine. They reviewed 15 studies that discussed radiofrequency neurotomy, and out of these, selected 4 prospective studies for analysis, including randomized controlled trials by van Kleef et al (83), LeClaire et al (85) and Gallagher et al (84), and the case series by Dreyfuss et al (90), a prospective, observational study. The authors remarked that "each

study reported a positive response to the RF treatment." They noted that "Gallagher et al (84) in their abstract mentioned that the solution used for the initial diagnostic injection was a combination of local anesthetic and steroid, whereas the main text of the paper states that the solution used was only local anesthetic." The study by van Kleef et al (83) was criticized for patient selection on the basis of a single positive diagnostic block "which as discussed previously, is known to have a false positive rate of approximately 38%", and the fact that "the technique may have been in error, because he placed the electrodes at an angle to the target nerve" rather than orienting electrodes parallel to the nerve, as has been shown to be of theoretical advantage in laboratory studies. They also noted that LeClaire et al (85) used the inclusion criterion of significant relief of low back pain for at least 24 hours during the week after the diagnostic facet block. The study was further criticized for the use of the Roland Morris score as an important outcome measure, which describes functional limitation and not pain relief. Despite the criticisms noted, they rated the evidence in favor of radiofrequency lesioning of the medial branches for low back pain at Level 3, Moderate.

In contrast to previous systematic reviews, the present systematic review has several additional features: facet joint interventions involving cervical, thoracic, and lumbar facet joints were evaluated; randomized and observational studies were taken into consideration; the review was performed by physicians who perform these procedures, although none of the reviewed studies were conducted by these physicians.

In the present systematic review, regarding intraarticular facet joint injections, only the randomized trial of lumbar spine pain by Carette et al (68) may be considered to be positive (albeit controversial), with only a 42% success rate. In contrast, the second randomized trial of cervical spine pain following whiplash injury by Barnsley et al (72), was negative. Among the non-randomized trials, positive results were noted for short-term relief in 4 of the 5 studies; however, long-term relief was noted only in 3 of the 5 studies. The evidence was moderate for short-term and long-term pain relief with intraarticular lumbar facet joint injections. However, the only randomized trial of cervical spine facets was negative, with no observational studies available. Consequently, evidence for cervical facet joint injections was negative.

The evidence was moderate for short-term and long-term pain relief with lumbar and cervical medial branch blocks in managing chronic low back and neck pain.

Regarding radiofrequency neurotomy, there was one properly designed randomized, controlled trial, each, for cervical and lumbar regions. However, the number of patients was small. Additional evidence was provided by mixed positive short-term and long-term results from observational studies. The evidence for radiofrequency neurotomy was moderate to strong for short-term and long-term pain relief of lumbar and cervical facet joint pain.

Conclusion

Based on a systematic review of the studies described herein, with intraarticular facet joint injections there was moderate evidence for short-term and long-term relief of chronic lumbar facet pain, and negative evidence for cervical facet joint injections. For medial branch blocks there was moderate evidence in managing lumbar and cervical facet joint pain. For radiofrequency facet neurolysis there was moderate to strong evidence for short-term and long-term relief of lumbar and cervical facet joint pain.

Appendix A. *Methodologic quality criteria list (key items of internal validity) of Cochrane Musculoskeletal Review Group (67)*

Patient selection

1. *Treatment allocation*

Was the method of randomization described and adequate?
Was the treatment allocation concealed?

2. *Were the groups similar at baseline regarding the most important prognostic indicators?*

Intervention

3. Was the care provider blinded?

4. Was controlled for co-interventions which could explain the results?

5. Was the compliance rate (each group) unlikely to cause bias?

6. Was the patient blinded?

Outcome measurement

7. *Was the outcome assessor blinded?*

8. *Was at least one of the primary outcome measures applied?*

9. *Was the withdrawal/drop-out rate unlikely to cause bias?*

Statistics

10. Did the analysis include an intention-to-treat analysis?

Appendix B. *General Inclusion/exclusion criteria (61)*

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) Non-interventional techniques or surgical intervention in the past
   - E) Additional exclusion criteria
   - F) Additional inclusion criteria
2. Is the intervention described adequately to enable you to provide the same treatment 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 non-eligible patients to return to work
   - E) Ability to work
   - F) Psychological assessment or improvement

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Rereferences

1. Goldthwait JE. The lumbosacral articulation: An explanation of many cases of lumbago, sciatica, and paraplegia. *Boston Med and Surg J* 1911; 164:365-372.
2. Bogduk N. International Spinal Injection Society guidelines for the performance of spinal injection procedures. Part 1: Zygapophysial joint blocks. *Clin J Pain;* 1997; 13:285-302.
3. Boswell M, Singh V, Staats P, Hirsch JA. Accuracy of precision diagnostic blocks in the diagnosis of chronic spinal pain of facet or zygapophyseal joint origin: A systematic review. *Pain Physician* 2003; 6:449-456.
4. Manchikanti L, Staats PS, Singh V, Schultz DM, Vilims BD, Jasper JF, Kloth DS, Trescot AM, Hansen HC, Falasca TD, Racz GB, Deer T, Burton AW, Helm S, Lou L, Bakhit CE, Dunbar EE, Atluri SL, Calodney AK, Hassenbusch S, Feler CA. Evidence-based practice guidelines for interventional techniques in the management of chronic spinal pain. *Pain Physician* 2003; 6:3-80.
5. Pang WW, Mok MS, Lin ML, Chang DP, Hwang MH. Application of spinal pain mapping in the diagnosis of low back pain—analysis of 104 cases. *Acta Anaesthesiol Sin* 1998; 36:71-74.
6. Manchikanti L, Singh V, Pampati V, Damron KS, Barnhill RC, Beyer CD, Cash KA. Evaluation of the relative contributions of various structures in chronic low back pain. *Pain Physician* 2001; 4:308-316.
7. Fukui S, Ohseto K, Shiotani M, Ohno K, Karasawa H, Naganuma Y, Yuda Y. Referred pain distribution of the cervical zygapophyseal joints and cervical dorsal rami. *Pain* 1996; 68:79-83.
8. Dwyer A, Aprill C, Bogduk N. Cervical zygapophyseal joint pain patterns. I: A study in normal volunteers. *Spine* 1990; 15:453-457.
9. Aprill C, Dwyer A, Bogduk N. The prevalence of cervical zygapophyseal joint pain patterns. II: A clinical evaluation. *Spine* 1990; 15:458-461.
10. Pawl RP. Headache, cervical spondylosis, and anterior cervical fusion. *Surg Ann* 1977; 9:391-498.
11. Windsor RE, Nagula D, Storm S. Electrical stimulation induced cervical medial branch referral patterns. *Pain Physician.*2003; 6:411-418.
12. Dreyfuss P, Tibiletti C, Dreyer SJ. Thoracic zygapophyseal joint pain patterns: A study in normal volunteers. *Spine* 1994; 19:807-811.
13. Mooney V, Robertson J. The facet syndrome. *Clin Orthop* 1976; 115:149-156.
14. McCall IW, Park WM, O'Brien JP. Induced pain referral from posterior elements in normal subjects. *Spine* 1979; 4:441-446.
15. Marks R. Distribution of pain provoked from lumbar facet joints and related structures during diagnostic spinal infiltration. *Pain* 1989; 39:37-40.
16. Fukui S, Ohseto K, Shiotani M, Ohno K, Karasawa H, Naganuma Y. Distribution of referral pain from the lumbar zygapophyseal joints and dorsal rami. *Clin J Pain* 1997; 13:303-307.
17. Hirsch C, Ingelmark BE, Miller M. The anatomical basis for low back pain. *Acta Orthop Scand* 1963; 33:1-17.
18. Windsor RE, King FJ, Roman SJ, Tata NS, Cone-Sullivan LA, Thampi S, Acebey M, Gilhool JJ, Rao R, Sugar R. Electrical stimulation induced lumbar medial branch referral patterns. *Pain Physician* 2002; 5: 347-353.
19. Bogduk N. The clinical anatomy of the cervical dorsal rami. *Spine* 1982; 7:319-330.
20. Jackson HC, Winkelmann RK, Bickel WH. Nerve endings in the human lumbar spinal column and related structures. *J Bone Joint Surg AM* 1966; 48A:1272-1281.
21. Cavanaugh JM, Ozaktay AC, Yamashita HT, King AI. Lumbar facet pain: Biomechanics, neuroanatomy, and neurophysiology. *J Biomech* 1996; 29:1117-1129.
22. Bogduk N, Wilson AS, Tynan W. The human lumbar dorsal rami. *J Anat* 1982; 134: 383-397.
23. Suseki K, Takahashi Y, Takahashi K et al. Innervation of the lumbar facet joints. *Spine* 1997; 22:477-485.
24. Bogduk N. The innervation of the lumbar spine. *Spine* 1983; 8:286-293.
25. Chua WH, Bogduk N. The surgical anatomy of thoracic facet denervation. *Acta Neurochir* 1995; 136:140-144.
26. Stilwell DL. The nerve supply of the vertebral column and its associated structures in the monkey. *Anat Rec* 1956; 125:139-169.
27. Zhang J, Tsuzuki N, Hirabayashi S, Saiki K, Fujita K. Surgical anatomy of the nerves and muscles in the posterior cervical spine: a guide for avoiding inadvertent nerve injuries during the posterior approach. *Spine* 2003; 28:1379-1384.
28. Dreyfuss P, Schwarzer AC, Lau P, Bogduk N. Specificity of lumbar medial branch and L5 dorsal ramus blocks. *Spine* 1997; 22:895-902.
29. Kaplan M, Dreyfuss P, Halbrook B, Bogduk N. The ability of lumbar medial branch blocks to anesthetize the zygapophysial joint. *Spine* 1998; 23:1847-1852.
30. Barnsley L, Bogduk N. Medial branch blocks are specific for the diagnosis of cervical zygapophyseal joint pain. *Reg Anesth* 1993; 18:343-350.
31. Jackson RP, Jacobs RR, Montesano PX. Facet joint injection in low back pain. A prospective statistical study. *Spine* 1988; 13:966-971.
32. Jackson RP. The facet syndrome: Myth or reality? *Clin Orthop* 1992; 279:110-121.
33. Deyo RA. Fads in the treatment of low back pain. *N Engl J Med* 1991; 325:1039-1040.
34. Ferrari R. Letter to the editor. *Spine* 2002; 27:327-328.
35. Bogduk N, Holmes S. Controlled zygapophysial joint blocks: The travesty of cost-effectiveness. *Pain Med* 2000; 1:24-34.
36. Schwarzer AC, Wang S, O'Driscoll, Harrington T, Bogduk N, Laurent R. The ability of computed tomography to identify a painful zygapophysial joint in patients with chronic low back pain. *Spine* 1995; 20:907-912.
37. Schwarzer AC, Aprill CN, Derby R, Fortin J, Kine G, Bogduk N. Clinical features of patients with pain stemming from the lumbar zygapophysial joints. Is the lumbar facet syndrome a clinical entity? *Spine* 1994; 19: 1132-1137.
38. Manchikanti L, Pampati V, Fellows B, Baha A. The inability of the clinical picture to characterize pain from facet joints. *Pain Physician* 2000; 3:158-166.
39. Schwarzer AC, Derby R, Aprill CN, Fortin J, Kine G, Bogduk N. The value of the provocation response in lumbar zygapophysial joint injections. *Clin J Pain* 1994; 10:309-313.
40. Barnsley L, Lord S, Bogduk N. Compara-

tive local anesthetic blocks in the diagnosis of cervical zygapophysial joints pain. *Pain* 1993; 55:99-106.

41. Lord SM, Barnsley L, Bogduk N. The utility of comparative local anesthetic blocks versus placebo-controlled blocks for the diagnosis of cervical zygapophysial joint pain. *Clin J Pain* 1995; 11:208-213.
42. Revel ME, Listrat VM, Chevalier XJ, Dougados M, N'guyen MP, Vallee C, Wybier M, Gires F, Amor B. Facet joint block for low back pain: Identifying predictors of a good response. *Arch Phys Med Rehabil* 1992; 73: 824-828.
43. Revel M, Poiraudeau S, Auleley GR, Payan C, Denke A, Nguyen M, Chevrot A, Fermanian J. Capacity of the clinical picture to characterize low back pain relieved by facet joint anesthesia. Proposed criteria to identify patients with painful facet joints. *Spine* 1998; 23:1972-1977.
44. Schwarzer AC, Derby R, Aprill CN, Fortin J, Kine G, Bogduk N. Pain from the lumbar zygapophysial joints: A test of two models. *J Spinal Disord* 1994; 7:331-336.
45. Laslett M, Oberg B, Aprill CN, McDonald B. Zygapophysial joint blocks in chronic low back pain; a test of Revel's model as a screening test. *BMC Musculoskelet Disord*. 2004; 5:43.
46. Manchikanti L, Pampati VS, Fellows B, Pakanati RR. Prevalence of lumbar facet joint pain in chronic low back pain. *Pain Physician* 1999; 2:59-64.
47. Manchikanti L, Pampati VS, Fellows B, Bakhit CE. The diagnostic validity and therapeutic value of lumbar facet joint nerve blocks with or without adjuvant agents. *Cur Rev Pain* 2000; 4:337-344.
48. Bogduk N. Low back pain. In *Clinical Anatomy of the Lumbar Spine and Sacrum,* ed 3.Churchill Livingstone, New York, 1997; pp 187-214.
49. Bogduk N, Lord S. Cervical zygapophysial joint pain. *Neurosurgery* 1998; 8:107-117.
50. Aprill C, Bogduk N. The prevalence of cervical zygapophyseal joint pain. *Spine* 1992; 17:744-747.
51. Barnsley L, Lord S, Wallis B, Bogduk N. False-positive rates of cervical zygapophysial joint blocks. *Clin J Pain* 1993; 9:124-130.
52. Schwarzer AC, Aprill CN, Derby R, Fortin J, Kine G, Bogduk N. The false positive rate of uncontrolled diagnostic blocks of the lumbar zygapophysial joints. *Pain* 1994; 58:195-200.
53. Schwarzer AC, Wang SC, Bogduk N, McNaught PJ, Laurent R. Prevalence and clinical features of lumbar zygapophysial joint pain: A study in an Australian population with chronic low back pain. *Ann Rheum Dis* 1995; 54:100-106.
54. Manchikanti L, Boswell MV, Singh V, Pampati V, Damron KS, Beyer CD. Prevalence of facet joint pain in chronic spinal pain of cervical, thoracic, and lumbar regions. *BMC Musculoskelet Disord* 2004; 5:15.
55. Barnsley L, Lord SM, Wallis BJ, Bogduk N. The prevalence of chronic cervical zygapophyseal joint pain after whiplash. *Spine* 1995; 20:20-26.
56. Lord SM, Barnsley L, Wallis BJ, Bogduk N. Chronic cervical zygapophysial joint pain after whiplash: A placebo-controlled prevalence study. *Spine* 1996; 21:1737- 1745.
57. Manchikanti L, Singh V, Rivera J, Pampati V. Prevalence of cervical facet joint pain in chronic neck pain. *Pain Physician* 2002; 5: 243-249.
58. Manchikanti L, Pampati V, Beyer CD, Damron KS. Evaluation of the prevalence of thoracic facet joint pain in chronic thoracic pain. *Pain Physician*2002; 5:354-359.
59. Merskey H, Bogduk N. Classification of chronic pain: *Descriptions of chronic pain syndromes and definitions of pain terms.* Second Edition. IASP Press, Seattle, 1994.
60. Geurts JW, van Wijk RM, Stolker RJ, Groen GJ. Efficacy of radiofrequency procedures for the treatment of spinal pain: A systematic review of randomized clinical trials. *Reg Anesth Pain Med* 2001; 26:394-400.
61. Niemisto L, Kalso E, Malmivaara A, Seitsalo S, Hurri H, Cochrane Collaboration Back Review Group. Radiofrequency denervation for neck and back pain: a systematic review within the framework of the Cochrane collaboration back review group. *Spine* 2003, 28:1877-1888.
62. Dreyfuss PH, Dreyer SJ. Lumbar zygapophysial (facet) joint injections. *Spine J* 2003; 3:50S-59S.
63. Manchikanti L, Singh V, Vilims BD, Hansen HC, Schultz DM, Kloth DS. Medial branch neurotomy in management of chronic spinal pain: Systematic review of the evidence. *Pain Physician*2002; 5:405-418.
64. Slipman CW, Bhat AL, Gilchrist RV, Issac Z, Chou L, Lenrow DA. A critical review of the evidence for the use of zygapophysial injections and radiofrequency denervation in the treatment of low back pain. *Spine J* 2003; 3:310-316.
65. Nelemans PJ, deBie RA, deVet HC, Sturmans F. Injection therapy for subacute and chronic benign low back pain. *Spine* 2001; 26:501-515.
66. West S, King V, Carey TS, Lohr KN, McKoy N, Sutton SF, Lux L. Systems to rate the strength of scientific evidence. Evidence Report/Technology Assessment No. 47 University of North Carolina: Agency for Healthcare Research and Quality. AHRQ Publication No. 02-E016; April 2002.
67. van Tulder M, Assendelft W, Koes B, Bouter LM. Method guidelines for systematic reviews in the Cochrane Collaboration Back Review Group for Spinal Disorders. *Spine* 1997; 22:2323-2330.
68. Carette S, Marcoux S, Truchon R, Grondin C, Gagnon J, Allard Y, Latulippe M. A controlled trial of corticosteroid injections into facet joints for chronic low back pain. *N Engl J Med* 1991; 325:1002-1007.
69. Lilius G, Laasonen EM, Myllynen P, Harilainen A, Gronlund G. Lumbar facet joint syndrome. A randomized clinical trial. *J Bone Joint Surg* (Br) 1989; 71:681-684.
70. Marks RC, Houston T, Thulbourne T. Facet joint injection and facet nerve block. A randomized comparison in 86 patients with chronic low back pain. *Pain* 1992; 49: 325-328.
71. Nash TP. Facet joints. Intra-articular steroids or nerve blocks? *Pain Clinic* 1990; 3: 77-82.
72. Barnsley L, Lord SM, Wallis BJ, Bogduk N. Lack of effect of intra-articular corticosteroids for chronic pain in the cervical zygapophyseal joints. *N Engl J Med* 1994; 330: 1047-1050.
73. Murtagh FR. Computed tomography and fluoroscopy guided anesthesia and steroid injection in facet syndrome. *Spine* 1988; 13:686-689.
74. Destouet JM, Gilula LA, Murphy WA, Monsees B.. Lumbar facet joint injection: Indication, technique, clinical correlation, and preliminary results. *Radiology* 1982; 145: 321-325.
75. Lynch MC, Taylor JF. Facet joint injection for low back pain. A clinical study. *J Bone Joint Surg Br* 1986; 68:138-141.
76. Lippitt AB. The facet joint and its role in spine pain. Management with facet joint injections. *Spine* 1984; 9:746-750.
77. Lau LS, Littlejohn GO, Miller MH. Clinical evaluation of intra-articular injections for lumbar facet joint pain. *Med J Aust* 1985; 143:563-565.
78. Manchikanti L, Pampati VS, Bakhit C, Rivera JJ, Beyer CD, Damron KS, Barnhill RC. Effectiveness of lumbar facet joint nerve blocks in chronic low back pain: A randomized clinical trial. *Pain Physician* 2001; 4:101-117.
79. Manchikanti KN, Pampati V, Damron KS, McManus CD. A double-blind, controlled evaluation of the value of Sarapin in neural blockade. *Pain Physician* 2004; 7:59-62.
80. Manchikanti L, Manchikanti KN, Damron KS, Pampati V. Effectiveness of cervical medial branch blocks in chronic neck pain: A prospective outcome study. *Pain Physician* 2004; 7:195-201.
81. Manchikanti L, Singh V, Pampati V. Are diagnostic lumbar medial branch blocks valid? Results of 2-year follow up. *Pain Physician* 2003; 6:147-153.
82. Lord SM, Barnsley L, Wallis BJ, McDonald GJ, Bogduk N. Percutaneous radiofrequency neurotomy for chronic cervical zygapophyseal joint pain. *N Eng J Med* 1996; 335:1721-1726.
83. van Kleef M, Barendse GAM, Kessels A, Voets HM, Weber WE, de Lange S. Randomized trial of radiofrequency lumbar facet denervation for chronic low back pain. *Spine* 1999; 24:1937-1942.
84. Gallagher J, Vadi PLP, Wesley JR. Radiofrequency facet joint denervation in the treatment of low back pain - A prospective controlled double-blind study to assess efficacy. *Pain Clinic* 1994; 7:193-198.

85. LeClaire R, Fortin L, Lambert R, Bergeron YM, Rossignol M. Radiofrequency facet joint denervation in the treatment of low back pain: a placebo-controlled clinical trial to assess efficacy. *Spine* 2001; 26:1411-1417.
86. Sanders M, Zuurmond WWA. Percutaneous intraarticular lumbar facet joint denervation in the treatment of low back pain: A comparison with percutaneous extra-articular lumbar facet denervation. *Pain Clin* 1999; 11:329-335.
87. van Kleef M, Liem L, Lousberg R, Barendse G, Kessels F, Sluijter M. Radiofrequency lesion adjacent to the dorsal root ganglion for cervicobrachial pain. A prospective double blind randomized study. *Neurosurgery* 1996; 38:1127-1131.
88. Slappendel R, Crul BJ, Braak GJ, Geurts JW, Booij LH, Voerman VF, de Boo T. The efficacy of radiofrequency lesioning of the cervical spinal dorsal root ganglion in a double blinded randomized study: No difference between 40°C and 67°C treatments. *Pain* 1997; 73:159-163.
89. Sapir D, Gorup JM. Radiofrequency medial branch neurotomy in litigant and non-litigant patients with cervical whiplash. *Spine* 2001; 26:E268-E273.
90. Dreyfuss P, Halbrook B, Pauza K, Joshi A, McLarty J, Bogduk N. Efficacy and validity of radiofrequency neurotomy for chronic lumbar zygapophysial joint pain. *Spine* 2000; 25:1270-1277.
91. Schofferman J, Kine G. Effectiveness of repeated radiofrequency neurotomy for lumbar facet pain. *Spine* 2004; 29:2471-2473.
92. Stolker RJ, Vervest AC, Groen GJ. Percutaneous facet denervation in chronic thoracic spinal pain. *Acta Neurochir* 1993; 122: 82-90.
93. McDonald GJ, Lord SM, Bogduk N. Long-term follow-up of patients treated with cervical radiofrequency neurotomy for chronic neck pain. *Neurosurgery* 1999; 45: 61-68.
94. Tzaan WC, Tasker RR. Percutaneous radiofrequency facet rhizotomy – experience with 118 procedures and reappraisal of its value. *Can J Neurol Sci* 2000; 27:125-130.
95. North RB, Han M, Zahurak M, Kidd DH. Radiofrequency lumbar facet denervation: Analysis of prognostic factors. *Pain* 1994; 57:77-83.
96. Schaerer JP. Radiofrequency facet rhizotomy in the treatment of chronic neck and low back pain. *Int Surg* 1978; 63:53-59.
97. Vad VB, Cano WG, Basrai D et al. Role of radiofrequency denervation in lumbar zygapophyseal joint synovitis in baseball pitchers: a clinical experience. Pain Physician. 2003;6:307-312.
98. Muffolerro AJ, Nader R, Westmark RM, Nauta HJ, Garges KJ, Hadjipavlou AG. Hematogenous pyogenic facet joint infection of the subaxial cervical spine. A report of two cases and review of the literature. *J Neurosurg Spine* 2001; 95:135-138.
99. Doita M, Nishida K, Miyamoto H, Yoshiya S, Kurosaka M, Nabeshima Y. Septic arthritis of bilateral lumbar facet joints: report of a case with MRI findings in the early stage. *Spine* 2003; 28:E198-202.
100. Orpen NM, Birch NC. Delayed presentation of septic arthritis of a lumbar facet joint after diagnostic facet joint injection. *J Spinal Disord Tech* 2003; 16:285-287.
101. Alcock E, Regaard A, Browne J. Facet joint injection: A rare form cause of epidural abscess formation. *Pain* 2003; 103:209-210.
102. Magee M, Kannangara S, Dennien B, Lonergan R, Emmett L, van der Wall H. Paraspinal abscess complicating facet joint injection. *Clin Nucl Med* 2000; 25:71-73.
103. Windsor RE, Pinzon EG, Gore HC. Complications of common selective spinal injections: Prevention and management. *Am J Orthop* 2000; 29:759-770.
104. Marks R, Semple AJ: Spinal anaesthesia after facet joint injection. *Anaesthesia* 1988; 43:65-66.
105. Cook NJ, Hanrahan P, Song S. Paraspinal abscess following facet joint injection. *Clin Rheumatol* 1999; 18:52-53.
106. Manchikanti L, Cash K, Moss T, Rivera JJ, Pampati V. Risk of whole body radiation exposure and protective measures in fluoroscopically guided interventional techniques: A prospective evaluation. *BMC Anesthesiol* 2003; 3:2.
107. Berrigan T. Chemical meningism after lumbar facet joint block. *Anesthesia* 1992; 7:905-906.
108. Thomson SJ, Lomax DM, Collett BJ. Chemical meningism after lumbar facet joint nerve block with local anesthetic and steroids. *Anesthesia* 1993; 46:563-564.
109. Raj PP, Shah RV, Kay AD, Denaro S, Hoover JM. Bleeding risk in interventional pain practice: Assessment, management, and review of the literature. *Pain Physician* 2004; 7:3-52.
110. Dreyfuss P, Kaplan M, Dreyer SJ. Zygapophyseal joint injection techniques in the spinal axis. In Lennard T (ed.) *Pain Procedures in Clinical Practice*, 2nd ed. Hanley & Belfus, Inc., Philadelphia, 2000, pp 276-308.
111. Manchikanti L. Role of neuraxial steroids in interventional pain management. *Pain Physician* 2002; 5:182-199.
112. Manchikanti L, Pampati V, Beyer C, Damron KS, Cash KA, Moss TL. The effect of neuraxial steroids on weight and bone mass density: A prospective evaluation. *Pain Physician* 2000; 3:357-366.
113. Kornick CA, Kramarich SS, Lamer TJ, Sitzman BT. Complications of lumbar facet radiofrequency denervation. *Spine* 2004; 29:1352-1354.
114. Windsor RE, Storm S, Sugar R. Prevention and management of complications resulting from common spinal injections. *Pain Physician* 2003; 6:473-484.
115. Slavin RE. Best-evidence synthesis: An alternative to meta-analytical and traditional reviews. Educational Researcher 1986; 9:5-11.
116. Hopayian K. The need for caution in interpreting high quality systematic reviews. *BMJ* 2001; 323:681-684.
117. Manchikanti L. Evidence-based interventional pain medicine: Is there any evidence? *Pain Physician* 2002; 5:1-7.
118. Bogduk N. In defense of radiofrequency neurotomy. Letter to the editor. *Reg Anesth Pain Med* 2002; 27:439-447.