■■■ Systematic Review

Medial Branch Neurotomy in Management of Chronic Spinal Pain: Systematic Review of the Evidence

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Zygapophysial or facet joints have been implicated as cause of low back, mid back, upper back and neck pain with referred pain. Cervical, thoracic and lumbar facet joints are innervated by the medial branches of the dorsal rami. Zygapophysial (facet) joints have been implicated as the source of chronic pain in 15% to 45% of the patients with chronic low back pain, 54% to 60% of the patients with chronic neck pain and 48% of the patients with thoracic pain.

A systematic review of the evidence of effectiveness of radiofrequency denervation in the management of chronic spinal pain was undertaken. This review included randomized clinical trials, as well as non-randomized or observational studies in the analysis. Literature search included MEDLINE, EMBASE, 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. An algorithmic approach was followed in study evaluation with a description of inclusion and exclusion criteria. A set of high-performing scales or checklists pertaining to randomized clinical trials and observational trials derived from the Agency for Healthcare Research and Quality (AHRQ) was utilized; Systems to Rate the Strength of Scientific Evidence. Qualitative analysis was conducted, using five levels of evidence for effectiveness of medial branch neurotomy.

Our search strategy identified over 1,000 citations as the result of electronic and manual screening. A total of 7 randomized trials of radiofrequency neurotomy for spinal pain were identified. However, only 4 related to medial branch neurotomy. Two of the four met the inclusion criteria. Among the multiple observational studies considered for inclusion, 4 prospective evaluations were included in the systematic review. In addition, 3 retrospective evaluations were also included. Two randomized trials comprised of 27 patients receiving active treatment. The first study consisted of cervical facet joint pain and the second consisted of lumbar facet joint pain. Both studies showed positive results. Similar to randomized trials, prospective, as well as retrospective evaluations showed positive evidence, both in short-term and long-term.

The results of this systematic review of 2 well-designed randomized trials, 4 prospective well-designed trials without randomization and 3 retrospective evaluations provided strong evidence that radiofrequency denervation offers short-term relief and moderate evidence of long-term relief of pain with chronic low back, thoracic and neck pain of facet joint origin.

Keywords: Back pain, neck pain, thoracic pain, spinal pain, facet joints, zygapophysial joints, medial branches, radiofrequency denervation, medial branch neurotomy, randomized controlled trial, prospective trial, retrospective evaluation, systematic review

Among the chronic pain problems, spinal pain emanating from lumbar, thoracic and cervical spine constitutes the majority of the problems (1-13). Kuslich et al (14) identified zygapophysial (facet) joints as capable of transmitting pain in the low back. The concept that facet joints are involved in the etiology of low back pain was described by Goldthwait (15) in 1911. Since then, multiple investi-gators have implicated zygapophysial or facet joints as cause of low back, mid back and upper back, and neck pain with referred pain (16). In experimental studies, cervical, thoracic and lumbar facet joints have been evaluated by intraarticular joint injections under fluoroscopic guidance (17-20). These injections demonstrated that capsular distention results in local and referred pain. Referral patterns for the cervical, thoracic and lumbar facet joints have been presented based on the results of these injections (17-20). Multiple investigators showed lumbar facet joints as capable of being a source of pain in the low back and referred pain in the lower extremity in normal volunteers; cervical facet joints as capable of being a source of neck pain, headache and upper extremity pain (17-25). Cervical, thoracic and lumbar facet joints are innervated by the medial branches of the dorsal rami (16, 26-30). There is no evidence that facet joint pain can be diagnosed by clinical examination or by medical imaging (17, 31-34). These joints can be blocked either by intraarticular injections or by anesthetizing the medial

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branches of the dorsal rami that innervate the target joint. In accordance with the criteria established by the International Association for the Study of Pain (35), zygapophysial (facet) joints have been implicated as the source of chronic pain in 15% to 45% of the patients with chronic low back pain (34, 36-40), 54% to 60% of the patients with chronic neck pain (41-43) and 48% of the patients with thoracic pain (44). These prevalence numbers are derived from the only available means of establishing a diagnosis of facet joint pain by diagnostic blocks of the putatively offending joint. These may be blocks of the joint itself or of the nerves that innervate it. Further, these may be placebo-controlled blocks or comparative local anesthetic blocks. Specificity, sensitivity, lack of reliability of single blocks and reliability of comparative local anesthetic blocks against placebo have been shown (16, 45-49).

Facet joint pain may be managed by either intraarticular injections, medial branch blocks or neurolysis of medical branches. Conflicting results have been reported by intraarticular injections of facet joints (50-54), medial branch blocks (53-55) and radiofrequency neurotomy of medial branches (56-61). Multiple systematic and narrative reviews also have yielded mixed results (1, 62-67).

Healthcare decisions are increasingly being made on research-based evidence, rather than on expert opinion or clinical experience alone. Thus, it is essential to examine the systematic approaches to assessing the strength of scientific evidence in modern medicine. However, evidence-based medicine, as well as systematic reviews have been misunderstood and misinterpreted. Evidence-based medicine is a loose term which has been used based not only on the necessity to present a particular view, but also based on personal philosophy, bias, and conjecture. The pioneering group of evidence based medicine in the late 70s, led by David Sackett, proposed the term *critical appraisal* to describe the application of the basic rules of the evidence (68). A current definition of evidence-based medicine is the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients. Thus, evidence-based medicine is essentially what most clinicians have been trying to practice all their working lives. The practice of evidence-based medicine requires the integration of individual clinical expertise with the best available external clinical evidence from systematic research. Decisions that affect the care of patients should be made with a *due weight* according to *all* valid, relevant information. However, in contrast to the philosophy of evidence-based medicine, most systematic reviews utilized only ran-

domized controlled trials even though systematic analysis is increasingly utilizing observational studies, as well as other types of evidence (69, 70). Admittedly, meta-analysis restricted to RCTs is usually preferred to meta-analyses of observational studies (71-73). However, the number of published meta-analyses concerning observational studies in health has increased substantially with 678 from 1955 to 1992, to more than 400 in 1996 alone (70). In many situations, randomized designs are not feasible, and only data from observational studies are available (74). An observational study is defined as an etiologic or effectiveness study using data from an existing database, a cross-sectional study, a case series, a case-controlled design, a design with historic controls, or a cohort design (75). Further, observational data is essential to assess the effectiveness of an intervention in a community as opposed to the special setting of a controlled trial (76). However, in interventional pain management, all the systematic reviews thus far have utilized only randomized controlled trials (63, 77-80).

In an Agency for Healthcare Research and Quality (AHRQ) Publication (81), for evaluating systems related to rating the quality of individual articles, the authors defined important domains and elements for four types of studies, which included systematic reviews, randomized clinical trials, observational studies, and diagnostic test studies. To arrive at a set of high-performing skills or checklist pertaining to systematic reviews, the authors took account of five key domains which included study question, search strategy, inclusion and exclusion criteria, data extraction and funding or sponsorship. In AHRQ evaluation, only one checklist fully addressed all seven domains, whereas two additional checklists and one scale addressed six of the seven domains (81, 82). Based on the five key domains as described by AHRQ (81), a look at multiple systematic reviews available in the literature failed to meet criteria on many of the aspects, such as study question, which should clearly delineate the type of intervention and the type of condition with appropriate outcome; search strategy which should include all the available evidence, including MEDLINE, EMBASE, reviews and other hand search methodology; inclusion and exclusion criteria which should include all the studies, but most all of them have included only randomized controlled clinical trials and some have included inappropriate diagnostic criteria; poor data extraction; and finally, funding and sponsorship issues. There has been only one systematic review of randomized clinical trials for efficacy of radiofrequency procedures for the treatment of spinal pain by Geurts et al (63). Unfortunately, this was marred with inappropriate methodology, inaccurate conclusions, fol-

lowed by criticism (65, 66). Geurts et al (63) included a total of six studies (57, 58, 60, 83-85), two of which (83, 84) were dorsal root ganglion radiofrequency studies, and a third study was intraarticular facet denervation (85). Thus, only three studies were facet radiofrequency, one of which was cervical and the remaining two were lumbar (57, 58, 60). Geurts et al (62) in their results showed that all six trials met the inclusion criteria. They also stated that "this small number, along with clinical and technical heterogeneity precluded statistical analysis. All studies, whether high or low quality, reported positive outcomes." In contrast to the description in the results section, they concluded that there is only moderate evidence that radiofrequency lumbar facet denervation is more effective for chronic low back pain than placebo, and there was only limited evidence existent for efficacy of radiofrequency neurotomy in chronic cervical zygapophysial joint pain after flexion/extension injury.

Thus, we considered that there is paucity of evidence for systematic reviews of medial branch neurotomy in the management of chronic spinal pain. This systematic review was undertaken to assess the effectiveness of radiofrequency denervation in the treatment of spinal pain of facet joint origin.

METHODS

To follow the modern evidence and the true definition of evidence-based medicine, we have included in this systematic review not only the randomized clinical trials, but also observational studies, including cross-sectional studies, case-controlled studies, retrospective and other observational investigations. Our literature search included MEDLINE, EMBASE, 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. All the literature available through early 2002 was utilized. The search strategy consisted of radiofrequency with emphasis on chronic pain/low back pain/neck pain/mid back or thoracic pain and/or medial branch neurotomy/facet joint/zygapophysial joint pain. Further, the inclusion of the evaluations were limited to only the studies describing chronic pain of duration of at least three months and retrospective analysis including a minimum of 50 patients.

Strength of Evidence

For evaluating systems related to rating the quality of in-

dividual articles, or describing AHRQ publication, which extensively evaluated systems to rate the strength of scientific evidence (81). This document described important domains and elements for systems to rate the quality of individual articles for randomized clinical trials and observational studies.

Data Extraction

Study evaluation and inclusion and exclusion algorithmic approach is shown in Table 1. Under this, if study population inclusion/exclusion criteria or appropriate diagnostic criteria were not met, the study was eliminated from consideration for the review.

Methodologic quality assessment was performed as described in Table 2. A set of high-performing scales or checklists pertaining to RCTs by assessing their coverage of the seven key domains as described in Table 2 were utilized. These included study population, randomization, blinding, interventions, outcomes, statistical analysis, and funding or sponsorship. For observational studies, the six key domains as described in Table 2 were utilized which included study population, comparability of subjects, exposure or intervention, outcome measurement, statistical analysis and funding or sponsorship. A score of 4 or more for randomized trials and a score of 3 or more was required to meet inclusion criteria. Studies were also eliminated if there were no appropriate outcomes or statistical analysis. Thus, for a study to be included, it had to meet at least 4 of 7 criteria for randomized and 3 of 5 criteria as non-randomized trials. Modified quality abstraction forms described by AHRQ were utilized.
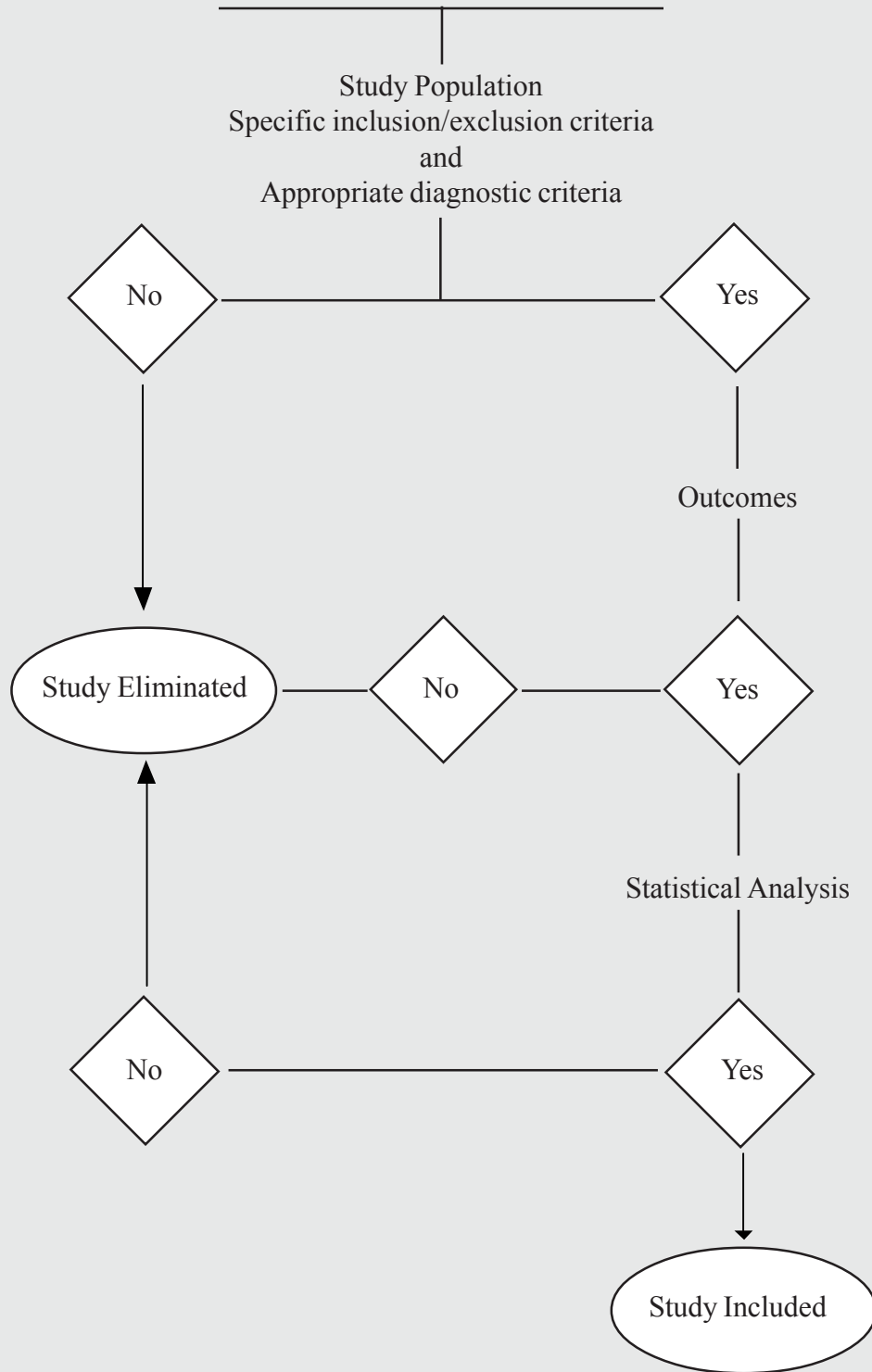
Qualitative Analysis

Qualitative analysis was conducted, using five levels of evidence for effectiveness of medial branch neurotomy.

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 of appropriate size (with at least 60 patients in smallest group); or research-based evidence from multiple properly designed studies of smaller size; or at least one randomized trial, supplemented by predominantly positive

Table 1. *Study evaluation (inclusion/exclusion) algorithm*

Study Population
Specific inclusion/exclusion criteria
and
Appropriate diagnostic criteria

No — Yes

Study Eliminated — No — Yes

Outcomes

No — Yes

Statistical Analysis

Study Included

Table 2. *Important domains and elements for systems to rate quality of individual articles*

Randomized Clinical Trials	**Observational Studies**
(Seven Key Domains)	(Five Key Domains)
Study question	Study question
Study population	*Study population*
Randomization	*Comparability of subjects*
Blinding	*Exposure or intervention*
Interventions	*Outcome measurement*
Outcomes	*Statistical analysis*
Statistical analysis	Results
Results	Discussion
Discussion	*Funding or sponsorship*
Funding or sponsorship	

* Key domains in italics with empirical basis.   Adapted and modified from (81).

prospective and/or retrospective evidence.

Level III – Moderate: Evidence from a well-designed small randomized trial or evidence from well-designed trials without randomization, or quasi-randomized studies, single group, pre-post cohort, time series, or matched case-controlled studies or positive evidence from at least one meta-analysis.

Level IV – Limited: Evidence from well-designed nonexperimental studies from more than one center or research group

Level V – Indeterminate: Opinions of respected authorities, based on clinical evidence, descriptive studies, or reports of expert committees.

A consistent outcome was defined as a situation in which 60% or more studies agreed on the result of pain relief and/or improvement of functional status. Relief of 3-6 months was defined as short-term where as relief longer than 6 months was longterm.

RESULTS

Our search strategy identified over 1,000 citations as the result of electronic and manual screening.

Randomized Trials

A total of seven randomized trials of radiofrequency neu-

rotomy for spinal pain were identified (56, 57, 59, 60, 83-85). Of these, only four related to medial branch neurotomy (56, 57, 59, 60). Among the other three, Sanders and Zuurmond (85) performed percutaneous intraarticular facet joint denervation, while the remaining two (83, 84) described radiofrequency lesioning of dorsal root ganglion.

The study population, as defined by the inclusion and exclusion criteria, consisted of patients with chronic neck or low back pain. Study quality evaluation showed that trials by Lord et al (56) and Van Kleef et al (57) have met all the key criteria and more than four of key domains. Study by Le Claire et al (60) failed to meet one of the key criteria, namely study population with descriptions of specific inclusion and exclusion criteria, as well as appropriate diagnostic evaluation and criteria for inclusion in the study. Even though this randomized evaluation met six of the seven key domains, it failed to meet one of the three criteria for inclusion, thus creating a fatal deficiency resulting in non-inclusion in this analysis. Study by Gallagher et al (59) was also not included, because it used the invalidated Shealy technique and such important aspects as the effects on physical impairment and disability were not investigated. Characteristics and results of randomized clinical trials included in analysis undergoing medial branch neurotomy is described in Table 3. Both studies showed positive short-term and long-term effects in a significant number of patients.

Table 3. *Description of randomized clinical trials included in the effectiveness analysis*

Study & Authors	Lord et al 1996 (56)	Van Kleef et al 1999 (57)
Number of patients	Treatment = 12 Control = 12	Treatment = 15 Control = 16
Description of Patients	Patients with neck pain of >3 months' duration, who had pain in one or more cervical (C3-C7) zygapophysial joints after a motor vehicle injury. Zygapophysial joint involvement was confirmed by placebo-controlled diagnostic blocks. Mean age 44 years in treatment group, and 43 years in control group.	Patients with cLBP of >12 months' duration. Conservative therapy attempted without success. Absence of any neurologic deficit, and >50% pain relief from a diagnostic dorsal ramus nerve blockade with a local anesthetic solution. Mean age was 46.6 years in treatment group and 41.4 years in control group.
Objectives	To evaluate the efficacy of RF denervation by comparing it with a control procedure	To assess the clinical efficacy of RF denervation of the lumbar zygapophysial joints in reducing pain, functional disability, and physical impairment in patients with back pain.
Intervention	i. Radiofrequency lesion group was treated with a 90-second RF lesion of 80°C of the medial branch of the cervical dorsal ramus. ii. In control or sham group, electrodes were introduced as in treatment group, but no radiofrequency lesion was made.	i. Radiofrequency lesion group was treated with a 60-second RF lesion of 80°C of the medial branch of the posterior primary ramus of the segmental nerves L3-L5. ii. In control or sham group, electrodes were introduced as in treatment group, but no radiofrequency lesion was made.
Median duration of pain in months (range)	Treatment = 44 (23-94) Control =34 (25-92)	Treatment = 26 (12-120) Control =48 (12-192)
Follow-up	3 months 6 months 12 months	2 months 3 months 6 months 12 months
Outcomes	Success rate (a score of 0-5 out of 100 on VAS scale a word count of <3 on the McGill Pain Questionnaire and the restoration of all four activities of daily living.	Number of successes (%) (>2-point reduction on VAS scale and >50% reduction on global perceived effect) Change in VAS mean, high, lowChange in Oswestry Disability ScaleGlobal perceived effect
Results	i. Seven patients in treatment and one in control group remained free of pain. The median time to return of at least 50% of the preoperative level of pain was 263 days in treatment group and 8 days in control group. ii. Five patients in each study group underwent second procedures. Three patients in the active-treatment group, who had less than 3 months of relief after the first procedure, did not have relief of their pain after the second procedure. One patient in the control group had no relief after either the initial procedure or the "escape" procedure with active treatment. iii. Success rate of 75% with one or two treatments.	i. After 8 weeks of treatment, 10 of the 15 patients undergoing radiofrequency were successful compared to 6 of the 16 in the control group. The differences in effect on the visual analog scale scores, global perceived effect, and the Oswestry Disability Scale were statistically significant. ii. After 3 months, the number of successes in the lesion and sham groups were 9and 4 (60% vs. 25%) with statistically significant difference (p = 0.02). iii. After 6 months, the number of successes in the lesion and sham groups were 7 and 3 (47% vs. 19%) with statistically significant difference (p = 0.02). iv. After 12 months, the number of successes in the lesion and sham groups were 7 and 2 respectively (47% vs. 13%) with statistically significant difference (p = 0.02).
Study Conclusion	Positive long-term effect	Positive long-term effect

Table 4. *Description and results of non-randomized prospective trials included in the analysis*

Study &Author(s)	Dreyfuss et al 2000 (58)	Stoker et al 1993 (88)	Sapir & Gorup (61)	McDonald et al (86)
Objective(s)	i. To establish the efficacy of lumbar medial branch neurotomy under optimum conditions. ii. To avoid shortcomings of the previous reports of the efficacy of lumbar medial branch neurotomy which have been confounded by poor patient selection, inaccurate surgical technique and inadequate assessment of outcome	i. To evaluate effectiveness of percutaneous facet denervation and chronic thoracic spinal pain.	i. To assess the effect of monetary gain on treatment of zygapophysial joint pain in cervical whiplash. ii. To determine whether radiofrequency medial branch neurotomy is effective treatment of whiplash.	i. To determine the long-term efficacy of percutaneous radiofrequency medial branch neurotomy in the treatment of chronic neck pain.
Description of Patients	i. Fifteen patients with chronic low back pain whose pain was relieved by controlled, diagnostic medial branch blocks of the lumbar zygapophysial joints, underwent lumbar medial branch neurotomy. ii. Before surgery, all were evaluated by visual analog scale and a variety of validated measures of pain, disability and treatment satisfaction.iii. A total of 460 people responded to invitations to participate in the study. After the interview, 138 patients remained potentially eligible. After physical examination, 41 patients remained potentially eligible and proceeded to lumbar medial branch blocks. Twenty-two patients who reported at least 80% relief of pain for longer than one hour after the lidocaine blocks underwent confirmatory blocks using 0.5% bupivacaine. Fifteen of the twenty-two patients undergoing bupivacaine blocks obtained at least 80% relief of pain for longer than 2 hours and were offered radiofrequency neurotomy.	i. Forty patients with chronic thoracic spinal pain of >12 months duration which failed to respond to conservative treatment and with a previous evaluation by a specialist, mainly neurologists and orthopedic surgeons, were included. ii. The diagnosis of facet syndrome also was made by clinical criteria and a transient positive response to a prognostic blockade of the medial branch of the dorsal ramus of the thoracic spinal nerve.	i. Fifty-nine patients underwent diagnostic blocks of the cervical medial branch nerves of the posterior primary ramus under fluoroscopic imaging guidance using the controlled 2-phase diagnostic method. ii.. The presence of zygapophysial joint pain was confirmed if the blocks were successful. A block was considered successful when the patient obtained a greater than 80% reduction in self-reported symptoms. Patients failed 20 weeks of conservative management after cervical whiplash. iii. The patients were classified as litigant or non-litigant based on whether the potential for monetary gain via litigation existed. Each group underwent identical evaluation and treatment. There were 32 patients in litigation group and 18 patients in non-litigation group. iv. Data was available from 46 patients for final analysis with 4 exclusions or withdrawals. v. Demographics and clinical characteristics among litigants and non-litigants.	i. Twenty-eight patients diagnosed as having cervical zygapophysial joint pain on the basis of controlled diagnostic blocks were included.
Intervention	i. Radiofrequency medial branch neurotomy was performed under fluoroscopy with appropriate needle placement after lidocaine infiltration at 85° C for 90 seconds coagulating the target nerve 8-10 mm along its length with 2 lesions. ii. Lesioning was performed at 2 levels for each joint. iii. Electromyography of the multifidus muscle was performed before and after surgery to ensure accuracy of the neurotomy.	i. Percutaneous radiofrequency denervation of the facet joints was carried out.	i. All patients underwent the same diagnostic procedural method for the 2-phase diagnostic cervical medial branch blocks. ii. Radiofrequency neurotomy was performed with a Radionics lesion generator using a disposable 22-gauge, 100-mm, 4-mm active tip RF lesioning needles with two separate lesions at 80° for 90 seconds at each level denervated.	i. Cervical radiofrequency of zygapophysial joint nerves were performed as described by Lord et al (56). ii. The procedure was repeated in patients whose pain recurred.
Outcomes	i. Outcomes were conducted at: 6 weeks, 3 months, 6 months, and 12 months. ii. Outcome measurements included electromyography, lifting tasks, North American Spine Society outcome instrument.	i. Pain relief	i. The visual analog scale (VAS) ii. Self-report of improvement (SRI)iii. Medication usage	i. Outcome measures were the proportion of patients who responded to the initial procedure and the duration of relief subsequently obtained. ii. Outcome was correlated with the operator performing the procedure, the type of electrode used, litigation status, and the type of diagnostic blocks used to establish the diagnosis.
Results	i. Sixty percent of the patients obtained at least 90% relief of pain at 12 months. ii. Eighty seven percent obtained at least 60% relief. iii. Relief was associated with denervation of the multifidus in those segments in which the medial branches had been coagulated. iv. Prelesion electrical stimulation of the medial branch nerve with measurement of impudence was no associated with outcome	i. Forty patients underwent 51 percutaneous thoracic facet denervations. ii. After 2 months, 19 patients (47.5%) were pain free and 14 patients (35%) had more than 50% pain relief, with a total of 82.5% of the patients reporting greater than 50% relief. iii. 17.5% of the patients had no relief. iv. With long-term follow-up of average 31 months in 36 [patients, 44% were pain-free and 39% had more than 50% pain relief, with a total of 83% of the patients presenting greater than 50% relief. v. Adverse effects consisted of postoperative pain in five patients.	i. The overall reduction in cervical whiplash symptoms and visual analog pain scores were insignificant immediately after treatment (non-litigants vs litigants: 2.0 vs 2.5, p=0.36). ii. At one year, the overall reduction in cervical whiplash symptoms and visual analog pain scores were significant (non-litigants vs litigants: 2.9 vs 4.0, p=0.05). iii. One-year follow-up scores were higher than immediate post-treatment scores (non-litigants vs. litigants: 2.5 vs 3.6). iv. The difference between litigants and non-litigants in the degree of symptomatology or response to treatment did not reach significance. v. The potential for secondary gain in patients who have cervical facet arthropathy as a result of a whiplash injury does not influence response to treatment.	i. Complete relief of pain was obtained in 71% of the patients after an initial procedure. ii. No patient who failed to respond to a first procedure responded to a repeat procedure, but if pain returned after a successful initial procedure, relief could be reinstated by a repeat procedure. iii. The median duration of relief after a first procedure was 219 days when failures were included, but 422 days when only successful cases were considered. iv. The median duration of relief after repeat procedure was at least 219 days. v. Outcome did not differ according to the operator, the type of electrode used, litigation status, or the type of diagnostic block used.
Study Conclusion	Positive long-term effect	Positive long-term effect	Positive long-term effect	Positive long-term effect

Observational Studies

A number of observational studies were considered for inclusion. Results of the included studies are shown in Table 4. Among the observational studies, there were 4 prospective evaluations included in this systematic review (58, 61, 86, 87). Retrospective evaluations included 3 studies (88-90). Multiple studies were excluded as they failed to meet the criteria established for the inclusion.

Among the four prospective evaluations, Dreyfuss et al (58) described lumbar facet joint radiofrequency neurotomy in 15 patients utilizing strict criteria and procedural considerations. This study showed 60% improvement in 80% of the patients at one year. Stolker et al (87) studied thoracic facet joint neurolysis in 45 patients and reported positive results, 47.5% of the patients to be pain-free with an additional 35% with relief greater than 50% after two months. After a follow up of 18 to 54 (average 31 months in 36 cases) they reported 83% of the patients with greater than 50% pain relief. Sapir and Gorup (61) and McDonald et al (86) reported on their experience of cervical facet joint neurotomy. Sapir and Gorup (61) studied 46 patients. The overall reduction in cervical whiplash symptoms and visual analog pain scores were significant immediately after treatment and at one year in both litigant and non-litigant patients. McDonald et al (86) determined the long-term efficacy of percutaneous radiofrequency medial branch neurotomy in 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 complete relief of pain in 71% of the patients after an initial procedure. They reported that the median duration of relief after a first procedure was 219 days when failures were included, but 422 days when only successful were considered. The median duration of relief after repeat procedures was at least 219 days. Their results showed that radiofreqency neurotomy of the cervical zygapophysial joints significantly reduced headache severity in 80% of the patients, both at short-term and long-term follow-up. Thus, the present systematic review by including prospective trials showed the generalizability of the results which complement the results of controlled trials (68).

Among the retrospective studies included, all the studies showed significant improvement, thus, these results compliment the results of controlled trials, as well as prospective trials.

Among the retrospective evaluations, Tzaan and Tasker (88) evaluated 118 consecutive percutaneous radiofrequency facet rhizotomies performed on 90 patients. They reported that with the first procedure, greater than 50% subjective reduction of pain was present in 41% overall patients with 37% of the cases done under local anesthesia, and 46% in cases done under general anesthesia with no significant difference noted. They also included cervical, thoracic and lumbosacral facets and noted no significant difference between the region involved or bilateral involvement. North et al (89) also evaluated radiofrequency lumbar facet denervation and analyzed prognostic factors. The long-term outcome was assessed by disinterested third party interview. Forty-five percent of patients undergoing denervation reported at least 50% relief of pain and long-term follow-up. However, they also reported that among the patients who only underwent temporary blocks, 13% reported relief by at least 50% at long-term follow-up. Schaerer (90) evaluated the value of radiofrequency facet rhizotomy in the treatment of patients with chronic neck and low back pain problems in 117 consecutive patients. They reported that overall results in 50 procedures were fair to excellent in 68% of the patients compared to 62% of the patients in the 71 lumbar rhizotomies with an average follow-up time of 13.7 months.

Clinical Relevance of the Included Studies

All of the studies described in the intervention underwent reasonable diagnostic process prior to radiofrequency neurotomy. They also described the interventions, results, and statistical analysis in a reasonable way. Studies not meeting the criteria were excluded. In the consideration of space, the references are provided for randomized trials only (60, 83-85).

Analysis of Evidence

In randomized trials (56, 57), the total of number of patients (combined for cervical and lumbar regions) in the treatment group was 27 compared to 28 in the control group. There was one dropout in the study by Van Kleef et al (57) and none in the study by Lord et al (56). Thus, the number of patients undergoing an intervention in two different regions has failed to meet the minimum required for a large randomized trial (at least 60 patients in smallest group). However, results were positive in both trials.

In prospective evaluations (58, 61, 86, 87), total number of patients studied were 133, with long-term relief (> 6 months) in 70% to 80% of the patients. The retrospective

evaluations were all positive (89-91). Combined evidence of radiofrequency neurotomy of medial branches from randomized trials, complemented with non-randomized trials (prospective and retrospective evaluations) provided strong evidence of short-term relief and moderate evidence of long-term relief of chronic neck and low back pain.

DISCUSSION

In spite of the extensive data search, we found only four randomized controlled trials, of which two were considered to be of sufficient quality to be included in this systematic review. Thus, we have also included 4 prospective evaluations and an additional 3 retrospective evaluations in this analysis. All the studies included in the review, both randomized and non-randomized met the criteria. Several retrospective evaluations were excluded. Randomized, prospective, and retrospective studies showed positive outcomes in short-term, as well as long-term. All the studies included small number of patients except retrospective evaluations. The overall number of patients in both randomized trials was 55, of which 27 patients received active treatment. These studies were considered of high quality and properly performed despite inherent difficulty with such studies in recruiting patients, and obtaining funding. Lord et al (56) used placebo-controlled or comparative local anesthetic blocks. However, Van Kleef et al (57) used single local anesthetic which could result in false-positive diagnosis of facet joint pain.

Bogduk (66) responding to the systematic review by Geurts et al (62) defended the radiofrequency neurotomy and identified numerous deficiencies in the systematic review and difficulties with randomized trials. Bogduk (66) described that the tenure of the review was unfortunately nihilistic, and he defended radiofrequency therapy lest the articles be abused by organizations intent upon discrediting radiofrequency neurotomy. He felt that elimination from consideration of studies with fewer than 20 patients was egregious on two counts. He described that first it seems to be a convention among systematic reviewers to use a quality scale in which maximum points are accorded to studies with samples sizes of 100 and minimum points are accorded to studies with 50 patients. The second issue related to ethics which was not considered by the authors of the review. Thus, arbitrary sample sizes ignore the true test that is provided by the rules of statistics. However, the sample size is only one determinant of statistical power. Other variables include amount of pain relief, improvement in functional status, and the duration over which the pain relief and functional im-

provement is sustained. Large numbers are feasible for drug trials and trials of physical therapy. However, these are not feasible, specifically in strictly controlled trials with one-year follow-up for interventional procedures, neither in academic nor in private practice settings. Thus, ethical, practical and pragmatic differences apply to the conduct of a double-blind studies of surgeries (66). Calling for "large numbers" on the basis of systems developed for conservative treatments of low risk is at best extremely difficult or even impossible, and fworst unethical when applied to interventional therapies. Further, some of the reviewers not aware of interventional pain management may also consider using local anesthetic in the control group as a non-placebo. Bogduk (66) described that the reasons for few studies in radiofrequency neurotomy are that there are precious few academics skilled in radiofrequency neurotomy who might be able to conduct placebo-control trials; however, most of those individuals have already contributed to the literature. Bogduk (66) added that private practitioners cannot be expected to conduct such trials. To do so without funding would constitute a financial suicide in the United States. In Bogduk's opinion, individuals in private practice have no chance of obtaining a grant unless they have a track record in research and he was not aware of such individuals with sufficient esteem to attract a grant successfully (66). Even when the study of Lord et al (56) was submitted as a grant application, it was denied funding on the grounds that the investigators had too poor a track record in research and that these patients with whiplash would not be relieved of their pain. Further, when a placebo-controlled study of lumbar radiofreqency neurotomy was proposed to the same body, it was officially deemed unnecessary on the grounds that we already had the results of Gallagher's study (59). Dreyfuss et al (58) proposed a double-blind controlled trial similar to the trial by Lord et al (56). However, this was not completed and was completed as a prospective evaluation due to multitude of reasons.

Hopwood and Manning (91) highlighted various drawbacks for a controlled trial of epidural steroids. Thus, in the United States, it is almost impossible to conduct the studies that authors in systematic reviews call for. The difficulties range from patient refusal to enroll in a placebo-controlled study as most patients believe that they will be allocated into a placebo group, most patients demand unblinding or withdraw from the study when they do not respond, unblinding after 12 months, 6 months or even after 3 months is a difficult venture, patients are not interested in undergoing extensive paperwork involved

in these studies; referring physicians, patient attorneys, and third party payors uniformly deny participation in such studies. Further, credibility of any study sponsored by manufacturers of equipment or drug companies has been questioned. Thus, it is unfortunate that the rules of systematic evaluation by these reviewers portray the rules of modern evidence-based medicine mandating the inclusion of only randomized controlled trials contrary to the overwhelming evidence to include all types of evidence. Bogduk (66) also questioned the necessity and logic required for more than one study to prove that radiofrequency neurotomy is not a placebo.

Among the prospective studies, comparative local anesthetic or placebo-controlled blocks were used in two studies whereas in the other two studies, only single local anesthetic block was utilized. Long-term follow up was utilized in all the studies. Patients in all the studies suffered with chronic pain of long duration.

This review follows the originally defined evidence-based practice in terms of four basic contingencies: 1) recognition of patient problem and construction of a structured clinical question: 2) the ability to efficiently and effectively search the medical literature to retrieve the best available evidence to answer the clinical question: 3) critical appraisal of the evidence: and 4) integration of the evidence with all aspects of individual patient decision making to determine the best clinical care for the patient. Thus, this systematic review differs from a multitude of other systematic reviews in interventional pain management.

Systematic review is a type of scientific investigation of the literature on a given topic in which the "subjects" are the articles being evaluated. In contrast, a narrative review is similar to a systematic review but without all the safeguards to control against bias (92). Table 5 illustrates the differences between narrative and systematic reviews. Thus, before a research team conducts a systematic review, it develops a well-designed protocol that lists:

1. A focused study question,
2. A specific search strategy, including the database to be searched, and how studies will be identified and selected for the review according to inclusion and exclusion criteria,
3. The types of data to be extracted from each article, and
4. How the data will be synthesized, either as a text summary or as some type of quantitative aggregation or meta-analysis.

These steps are taken to protect the work against various

Table 5. *Key distinctions between narrative and systematic reviews.*

Core Feature	Narrative Review	Systematic Review
Study question	Often broad in scope	Often a focused clinical question.
Data sources and search strategy	Which databases were searched and search strategy are not typically provided.	Comprehensive search of many databases as well as the so-called gray literature. Explicit search strategy provided.
Selection of articles for study	Not usually specified, potentially biased.	Criterion-based selection, uniformly applied.
Article review or appraisal	Variable, depending on who is conducting the review.	Rigorous critical appraisal, typically using a data extraction form.
Study quality	If assessed, may not use formal quality assessment.	Some assessment of quality is almost always included as part of the data extraction process.
Synthesis	Often a qualitative summary.	Quantitative summary (meta-analysis) if the data can be appropriately pooled; qualitative otherwise.
Inferences	Sometimes evidence-based.	Usually evidence-based.

Source: Adapted from Cook et al (92)

forms of unintended bias in the identification, selection, and use of published work in these reviews (92). The major difference between these two approaches synthesizing the clinical or scientific literature is that a systematic review attempts to minimize bias by the comprehensiveness and reproducibility of the search for and the selection of articles for review. The biases that can occur in systematic reviews are also similar to those that are possible in clinical studies. Thus, a good study design for randomized controlled trials requires that allocation to treatment or control be randomized with the investigator blinded to the subsequently assigned treatment known as allocation concealment. This helps to ensure comparability of study groups and minimizes selection bias (81). In systematic reviews, the literature search is not broad enough or the reasons for inclusion and exclusion of articles are not clearly specified, selection bias can arise in the choice of articles that are reviewed (92-94). Further, systematic reviews also typically focus on how well the study was designed, conducted and analyzed. Thus, systematic reviews are considered to provide a measure of quality for each study in the review. Systematic reviews comprise evidence based on research papers from the published literature and, whenever possible, from the "gray" or unpublished literature as well. However, much of the material identified are used for systematic reviews is from the peer-reviewed literature, the processes and thoroughness of review conducted by general reviewers and by those doing systematic reviews may not be the same. However, it is well known that systematic reviews yield different types of results.

In observational studies, some factor other than randomization determines treatment, assignment, or exposure. The two major types of observational studies are cohort and case-controlled studies. In a cohort study, a group is assembled and followed forward in time to evaluate an outcome of interest. The starting point for the follow-up may occur back in time (retrospective cohort) or at the present time (prospective cohort) (86). In either situation, participants are followed to determine whether they develop the outcome of interest. Conversely, for a case-controlled study, the outcome itself is the basis for selection into the study. Previous interventions or exposures are then evaluated for all possible association with the outcome of interest. In all observation studies, selection of an appropriate comparison group of people without either the intervention/exposure of or the outcome of interest is generally the most important and the most difficult design issue. Ensuring the comparability of the treatment groups in a study is what makes the randomized

controlled trial presumably a powerful research design. Observational studies are generally considered more liable to bias than randomized, clinical trials, but certain questions can be answered only by using observational studies.

Domains for rating the overall strength of body of evidence depends on quality, quantity and consistency. Overall quality of a body of scientific studies is influenced by study design, conduct, analysis or methodologic rigor. Quantity is a term which describes the extent to which there is a relationship between the technology or exposure being evaluated and outcome, as well as to the amount of information supporting that relationship. Three main factors contributing the quantity or the magnitude of effect (i.e., estimated effects such as mean differences, odds ratio, relative risk, or other comparative measures); the number of studies performed on the topic in question, (eg, only a few versus perhaps a dozen or more); and the number of individuals studied, aggregated over all the relevant and comparable investigations, which provides the width of the confidence limits for the different estimates.

Consistency is the degree to which a body of scientific evidence is in agreement with itself and with outside information. More specifically, a body of evidence is said to be consistent when numerous studies done in different populations using different study designs to measure the same relationship essentially similar or compatible results. This essentially means that the studies have produced reasonably reproducible results.

CONCLUSION

The studies reviewed provide strong evidence that radiofrequency denervation offers short-term, as well as long-term relief of pain, chronic neck, thoracic and low back pain of zygapophysial of facet joint origin. While the present "gold standard" is the large randomized controlled study, practical and ethical considerations as illustrated loom lagre in evaluation of interventional techniques. The present body of evidence presented in this review shows the effectiveness with a truly evidence-based medicine approach, which included not only the randomized trials, but also observational trials. Thus, while awaiting on conclusive evidence for radiofrequency neurotomy, the present review concludes that radiofrequency neurotomy of cervical, thoracic, or lumbosacral medial branches is an effective treatment for management of chronic spinal pain.

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