

## Systematic Review

# e Spinal Endoscopic Adhesiolysis in Post Lumbar Surgery Syndrome: An Update of the Assessment of the Evidence

Standiford Helm, MD<sup>1</sup>, Salim M. Hayek, MD, PhD<sup>2</sup>, James Colson, MS, MD<sup>3</sup>, Pradeep Chopra, MD<sup>4</sup>, Timothy R. Deer, MD<sup>5</sup>, Rafael Justiz, MD<sup>6</sup>, Mariam Hameed, MD<sup>7</sup>, and Frank J.E. Falco, MD<sup>8</sup>

From: <sup>1</sup>The Helm Center for Pain Management, Laguna Hills, CA; <sup>2</sup>University Hospitals of Cleveland, Cleveland, OH and Outcomes Research Consortium, Cleveland, OH; <sup>3</sup>West Virginia University Hospital, Morgantown, WV; <sup>4</sup>Brown Alpert Medical School, Providence, RI; Boston University School of Medicine, Boston, MA, and Interventional Pain Center, Pawtucket, RI; <sup>5</sup>The Center for Pain Relief, Charleston, WV, and West Virginia University School of Medicine, Charleston, WV; <sup>6</sup>Oklahoma Pain Physicians, Oklahoma City, OK, and <sup>7</sup>Johns Hopkins University School of Medicine, Baltimore, MD; <sup>8</sup>Mid Atlantic Spine & Pain Physicians, Newark, DE; and Temple University Hospital, Philadelphia, PA

Additional author affiliations and conflicts of interest on P. SE143

Address Correspondence:  
Standiford Helm, MD  
The Helm Center for Pain Management  
24902 Moulton Parkway  
Suite 200  
Laguna Hills, CA 92637  
drhelm@thehelmcenter.com

Disclaimer: There was no external funding in the preparation of this manuscript.  
Conflict of interest: None.

Manuscript received:  
10/02/2012  
Accepted for publication:  
10/28/2012

Free full manuscript:  
www.painphysicianjournal.com

**Background:** Post lumbar surgery syndrome refers to pain occurring or present after lumbar surgery. While the causes of pain after lumbar surgery are multi-factorial, scarring is a significant source of that pain. Low back and/or leg pain after lumbar surgery can persist despite appropriate conservative therapy. Spinal endoscopy allows direct visual evaluation of the epidural space, along with mechanical lysis of any adhesions present.

**Study Design:** A systematic review of the effectiveness of spinal endoscopic adhesiolysis in post lumbar surgery syndrome.

**Objective:** To evaluate and update the effectiveness of spinal endoscopic adhesiolysis in treating post lumbar surgery syndrome.

**Methods:** The available literature on spinal endoscopic adhesiolysis in treating post lumbar surgery syndrome was reviewed. The quality assessment and clinical relevance criteria utilized were the Cochrane Musculoskeletal Review Group criteria as utilized for interventional techniques for randomized trials and the criteria developed by the Newcastle-Ottawa Scale criteria for observational studies.

The level of evidence was classified as good, fair, and limited or poor based on the quality of evidence developed by the U.S. Preventive Services Task Force (USPSTF).

Data sources included relevant literature identified through searches of PubMed and EMBASE from 1966 to September 2012, and manual searches of the bibliographies of known primary and review articles.

**Outcome Measures:** Pain relief and functional improvement were the primary outcome measures. Other outcome measures were improvement of psychological status, opioid intake, and return to work.

Short-term effectiveness was defined as improvement of 12 months or less; whereas, long-term effectiveness was defined 12 months or longer.

**Results:** For this systematic review, 21 studies were identified. Of these, one randomized controlled trial (RCT) and 5 observational studies met the inclusion criteria. Two of the observational studies were excluded because of other methodological issues, despite showing positive outcomes.

Using current criteria for successful outcomes, these studies indicate that there is fair evidence for the effectiveness of spinal endoscopy in the treatment of persistent low back and/or leg pain in post lumbar surgery syndrome.

**Limitations:** The limitations of this systematic review include the paucity of literature.

**Conclusion:** The evidence is fair that spinal endoscopy is effective in the treatment of post lumbar surgery syndrome.

**Key words:** Spinal pain, chronic low back pain, post lumbar surgery syndrome, epidural scarring, adhesiolysis, endoscopy

Pain Physician 2013; 16:SE125-SE150

**S**pinal endoscopy is a minimally invasive procedure that allows directed visualization and treatment of pathology in the epidural space. This review focuses on the treatment of epidural scarring causing pain after lumbar spinal surgery. The use of spinal endoscopy is being expanded to include the diagnosis and treatment of other pathologies, including disc herniations and spinal stenosis. These applications are beyond the focus of this review.

Pain after lumbar surgery is common (1-9). With the increasing amount and complexity of surgery being done, persistent back and leg pain after surgery can be expected to increase (10). There are multiple suggested causes for pain after back surgery, including adhesions, secondary stenosis, internal disc disruption at adjacent levels, recurrent disc herniation, facet or sacroiliac joint pain, arachnoiditis, failure to fuse, diagnostic error, and finally, idiopathic despite proper indications and technique (1).

Epidural scarring has several causes, the most common being spine surgery (11-26). The incidence of epidural scar formation in laminectomy without fusion is estimated at 5% to 30% (27). Bosscher and Heavner (28) found that using epiduroscopy as the diagnostic tool, 83% of all post lumbar surgery patients with persistent pain had severe epidural scarring. In patients with more extensive surgery, severe scarring was present in 91% of patients. Using MRI, only 16% of these patients were diagnosed with fibrosis, suggesting that fibrosis is significantly underdiagnosed in this population.

Other causes of scarring include annular tears with nuclear leakage, including after percutaneous procedures, infection, and the cumulative effect of otherwise clinically insignificant venous microbleeds that occur as the spine degenerates (29-35). Epidural scarring can lead to pain (31,36-39), and may be, given its ubiquity after spinal surgery, a cause of pain after surgery (6,40-42). There are several causes of pain after scarring, including tethering of the nerve root, preventing its free movement in the spinal canal and foramen; entrapment of the nerve or of a vein which in turn entraps the nerve, leading to swelling of the nerve with attendant pain, either in the back or legs; sequestration of the nerve, so that medications applied to the nerve cannot reach it (43,44). While some have questioned whether scarring does lead to radicular pain (45,46), others claim the association of radicular pain with scarring (1,44,47-49). Bosscher and Heavner (28) found that concordant pain was found in 84% of patients with post lumbar surgery syndrome and concluded that epidural fibrosis is the underlying pathology in most of these patients. Consequently, post lumbar

surgery syndrome with resultant problems contributes to the increasing prevalence of chronic low back pain and associated exploding diagnostic and therapeutic modalities and a disproportionate increase of health care expenditures in the United States and across the world (50-110).

Scarring from post lumbar surgery syndrome has been treated with epidural injections and percutaneous adhesiolysis (1,25,105-113). Imaging techniques, such as computed tomography (CT) and magnetic resonance imaging (MRI) are limited in their ability to either visualize epidural fibrosis or to identify the causes of pain. Spinal endoscopic adhesiolysis offers the advantage of directly visualizing pathology and often in documenting the causes of that pain.

The role of treating adhesiolysis has been evaluated in several systematic reviews, narrative reviews, and guidelines (1,24,77,79,106,109,110,114-117). Hayek et al (1), in 2009, evaluated the effectiveness of endoscopic adhesiolysis in post lumbar surgery syndrome. Van Boxem et al (114) rated the evidence for adhesiolysis as 2 C+, effectiveness only demonstrated in observational studies. The American College of Occupational and Environmental Medicine (ACOEM) found adhesiolysis and, by extension, endoscopic adhesiolysis, was not to be recommended due to insufficient evidence (115). However, these conclusions were contradicted in a reassessment (116). The American Pain Society (APS) guidelines indicate that the level of evidence is poor for spinal endoscopy (77), criticized for flawed synthesis in critical analysis (79,118,119). The National Institute for Health and Clinical Excellence (NICE) has reviewed adhesiolysis, with a description of the procedure, but provided no specific recommendation (117).

It is essential to update systematic reviews to assess current evidence (120,121). Consequently, this systematic review was undertaken to determine the effectiveness and update the current evidence of percutaneous endoscopic adhesiolysis in the treatment of post lumbar surgery syndrome and to determine the risks and adverse effects associated with treatment. The update is from a previous systematic review (1).

## **1.0 METHODS**

### **1.1 Research Protocol**

A systematic review of randomized trials, observational studies, and reports of complications dealing with spinal endoscopy for the treatment of pain of at least 6 months duration in post lumbar surgery patients was

performed. Attendant to this review was an assessment of complications of these procedures.

**1.2 Eligibility Criteria (Criteria for Including and Excluding Studies in the Systematic Review)**

Inclusion criteria were patients suffering with chronic intractable low back pain due to post lumbar laminectomy syndrome with or without radicular findings of at least six months duration. Only spinal endoscopic procedures were evaluated. All studies providing appropriate management with outcome evaluations of 6 months or longer and statistical evaluations were reviewed. Reports without appropriate diagnosis, non-systematic reviews, book chapters, and case reports were excluded. The patients must be at least 18 years old.

**1.3 Outcomes**

The primary outcome was pain relief. Secondary measures were functional improvement, change in psychological status, return to work, and reduction in opioid use or interventions. Historically, a 2-point improvement in the 11-point (0-10) visual analog scale (VAS) was felt to be clinically significant (122-125). However, this standard of relief has changed, so that clinically meaningful improvement is currently defined as a 50% improvement in pain relief or a 40% improvement in functional status (25,107,108,125-141). In this review, either a 3-point or a 50% improvement in VAS or a 40% improvement in functional status was used as the threshold for clinically meaningful improvement.

Short-term effectiveness was defined as less than 12 months; whereas, long-term effectiveness was defined as 12 months or longer.

**1.4 Key Questions and Analytic Framework**

**1.4.1 Key Questions**

The first question was whether spinal endoscopy is effective in the treatment of chronic low back and/or

lower extremity pain of at least 6 months duration in post-surgical patients non-responsive to conservative treatment, including fluoroscopically guided epidural injections.

The second question to be addressed was the severity and risk of complications associated with these techniques.

**1.4.2 Databases and Other Information Sources Used to Identify Relevant Studies**

The review included English language randomized trials, observational studies, and reports of complications published from 1966 to September 2012. Databases included in the search are Medline, EMBASE, Cochrane Review Database, and Google Scholar. Other sources include Clinical Trial Registry, systematic reviews, narrative reviews, and cross-references to the reviews. Bibliographies of reviewed papers were also examined. In addition, authors known to be active in the field were contacted.

**1.4.3 Search Strategy**

The search strategy focused on chronic low back pain secondary to post surgery syndrome treated with spinal endoscopy.

Search terms included post lumbar surgery syndrome, failed back surgery syndrome, epidural fibrosis, chronic low back pain, adhesiolysis, epidural neuroplasty, epidural neurolysis, lysis of adhesions, and spinal endoscopy.

**1.5 Study Selection Process**

Only studies of clinical relevance were assessed. Clinical relevance was assessed according to the Cochrane Back Review Group (142,143). Table 1 shows the questions used to assess clinical relevance. At least 3 clinical relevance questions had to be positive for a study to be considered clinically relevant.

**1.6 Methodological Quality Assessment**

The quality of each individual article used in this analysis was assessed by modified Cochrane review

Table 1. *Clinical relevance questions.*

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

Scoring adapted and modified from Staal JB, et al. Injection therapy for subacute and chronic low-back pain. Cochrane Database Syst Rev 2008; 3:CD001824 (143).

criteria (Table 2) (144) for randomized trials and the Newcastle-Ottawa Scale for observational studies (Tables 3 and 4) (145-147). The case series format for the Newcastle-Ottawa Scale was used for all studies with

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

A	1. Was the method of randomization adequate?	A random (unpredictable) assignment sequence. Examples of adequate methods are coin toss (for studies with 2 groups), rolling a die (for studies with 2 or more groups), drawing of balls of different colors, drawing of ballots with the study group labels from a dark bag, computer-generated random sequence, pre-ordered sealed envelopes, sequentially-ordered vials, telephone call to a central office, and pre-ordered list of treatment assignments. Examples of inadequate methods are: alternation, birth date, social insurance/security number, date in which they are invited to participate in the study, and hospital registration number.	Yes/No/Unsure
B	2. Was the treatment allocation concealed?	Assignment generated by an independent person not responsible for determining the eligibility of the patients. This person has no information about the persons included in the trial and has no influence on the assignment sequence or on the decision about eligibility of the patient.	Yes/No/Unsure
C	Was knowledge of the allocated interventions adequately prevented during the study?		
	3. Was the patient blinded to the intervention?	This item should be scored "yes" if the index and control groups are indistinguishable for the patients or if the success of blinding was tested among the patients and it was successful.	Yes/No/Unsure
	4. Was the care provider blinded to the intervention?	This item should be scored "yes" if the index and control groups are indistinguishable for the care providers or if the success of blinding was tested among the care providers and it was successful.	Yes/No/Unsure
	5. Was the outcome assessor blinded to the intervention?	Adequacy of blinding should be assessed for the primary outcomes. This item should be scored "yes" if the success of blinding was tested among the outcome assessors and it was successful or: –for patient-reported outcomes in which the patient is the outcome assessor (e.g., pain, disability): the blinding procedure is adequate for outcome assessors if participant blinding is scored "yes" –for outcome criteria assessed during scheduled visit and that supposes a contact between participants and outcome assessors (e.g., clinical examination): the blinding procedure is adequate if patients are blinded, and the treatment or adverse effects of the treatment cannot be noticed during clinical examination –for outcome criteria that do not suppose a contact with participants (e.g., radiography, magnetic resonance imaging): the blinding procedure is adequate if the treatment or adverse effects of the treatment cannot be noticed when assessing the main outcome –for outcome criteria that are clinical or therapeutic events that will be determined by the interaction between patients and care providers (e.g., co-interventions, hospitalization length, treatment failure), in which the care provider is the outcome assessor: the blinding procedure is adequate for outcome assessors if item "4" (caregivers) is scored "yes" –for outcome criteria that are assessed from data of the medical forms: the blinding procedure is adequate if the treatment or adverse effects of the treatment cannot be noticed on the extracted data.	Yes/No/Unsure
D	Were incomplete outcome data adequately addressed?		
	6. Was the drop-out rate described and acceptable?	The number of participants who were included in the study but did not complete the observation period or were not included in the analysis must be described and reasons given. If the percentage of withdrawals and drop-outs does not exceed 20% for short-term follow-up and 30% for long-term follow-up and does not lead to substantial bias a "yes" is scored. (N.B. these percentages are arbitrary, not supported by literature).	Yes/No/Unsure
	7. Were all randomized participants analyzed in the group to which they were allocated?	All randomized patients are reported/analyzed in the group they were allocated to by randomization for the most important moments of effect measurement (minus missing values) irrespective of non-compliance and co-interventions.	Yes/No/Unsure
E	8. Are reports of the study free of suggestion of selective outcome reporting?	In order to receive a "yes," the review author determines if all the results from all pre-specified outcomes have been adequately reported in the published report of the trial. This information is either obtained by comparing the protocol and the report, or in the absence of the protocol, assessing that the published report includes enough information to make this judgment.	Yes/No/Unsure
F	Other sources of potential bias:		
	9. Were the groups similar at baseline regarding the most important prognostic indicators?	In order to receive a "yes," groups have to be similar at baseline regarding demographic factors, duration and severity of complaints, percentage of patients with neurological symptoms, and value of main outcome measure(s).	Yes/No/Unsure
	10. Were co-interventions avoided or similar?	This item should be scored "yes" if there were no co-interventions or they were similar between the index and control groups.	Yes/No/Unsure
	11. Was the compliance acceptable in all groups?	The reviewer determines if the compliance with the interventions is acceptable, based on the reported intensity, duration, number and frequency of sessions for both the index intervention and control intervention(s). For example, physiotherapy treatment is usually administered over several sessions; therefore it is necessary to assess how many sessions each patient attended. For single-session interventions (e.g., surgery), this item is irrelevant.	Yes/No/Unsure
	12. Was the timing of the outcome assessment similar in all groups?	Timing of outcome assessment should be identical for all intervention groups and for all important outcome assessments.	Yes/No/Unsure

Adapted and modified from Furlan AD, et al. 2009 updated method guidelines for systematic reviews in the Cochrane Back Review Group. *Spine (Phila Pa 1976)* 2009; 34:1929-1941 (144).

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

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

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

Adapted and modified from Wells GA, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analysis. [www.ohri.ca/programs/clinical\\_epidemiology/oxford.asp](http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp) (145).

more than one group; otherwise, the cohort format was used. Non-randomized observational studies were included only if at least 50 subjects were enrolled or at

least 25 in each group if there were comparison groups. Randomized trials meeting the inclusion criteria utilizing the Cochrane review criteria, as shown in Table

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

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

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

Adapted and modified from Wells GA, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analysis. [www.ohri.ca/programs/clinical\\_epidemiology/oxford.asp](http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp) (145).



2, with at least 9 of 12 criteria were considered high quality. Studies with Cochrane scores of 6 to 8 were considered moderate quality and studies with Cochrane scores less than 6 were excluded.

Observational studies had to meet a minimum 7 of 9 criteria for case-controlled studies. Cohort studies with a comparison group had a maximum score of 9 and had to have a score of at least 5 to be included; cohort studies without a comparison group had a maximum score of 6 and had to have a maximum score of 4 to be included.

**1.7 Data Extraction and Synthesis**

Each study was evaluated by at least 2 authors for stated criteria and any disagreements were discussed by a third reviewer. If there was a conflict of interest with the reviewed manuscript with authorship or any other type of conflict, the involved authors did not review the manuscript for quality assessment, clinical relevance, evidence synthesis, or grading of evidence.

If the literature search provided at least 5 randomized trials meeting the inclusion criteria for each condition evaluated, no observational studies were utilized.

**1.7.1 Methods for Handling Missing Information**

Missing information was evaluated on a case by case basis. If the data available was insufficient to evaluate the study or if it did not meet the endpoint criteria, the study was excluded.

**1.8 Analysis of Evidence**

The analysis of the strength of evidence was conducted using 3 levels of evidence; good, fair, and limited or poor as adopted from the U.S. Preventative Services Task Force (USPSTF), as shown in Table 5 (147). These criteria have been utilized in multiple systematic reviews (77,79,106,111,112,148-160).

**2.0 RESULTS**

Figure 1 shows a flow diagram of study selection as recommended by Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (161). The literature search found 310 articles potentially dealing with the key questions of either the effectiveness of spinal endoscopy in treating low back pain or complications related to this procedure. Of these, 49 were accepted based upon title. Of the articles accepted by title, 22 were accepted for full manuscript review. Of the excluded articles, 10 were systematic or other reviews (1,44,53,55,77,79,115-117,162-164). Ten more reports were excluded because they were case reports, descriptions of the procedure, or otherwise did not meet the criteria for potentially being high quality evidence evaluating the efficacy of spinal endoscopy (165-174). Seven articles dealt with complications (175-181). Two studies dealt with overlapping patient groups (182,183). Only the report with the longer follow up was evaluated (182). One study was a preliminary report (184).

The remaining 21 studies were evaluated as to whether they met the inclusion criteria. Table 6 details the 13 observational and 2 RCT studies that were excluded (185-198).

Table 7 shows the characteristics of studies considered for inclusion. There was one RCT (199), with a duplicate publication of preliminary results (184), and 5 observational studies (182,200-203).

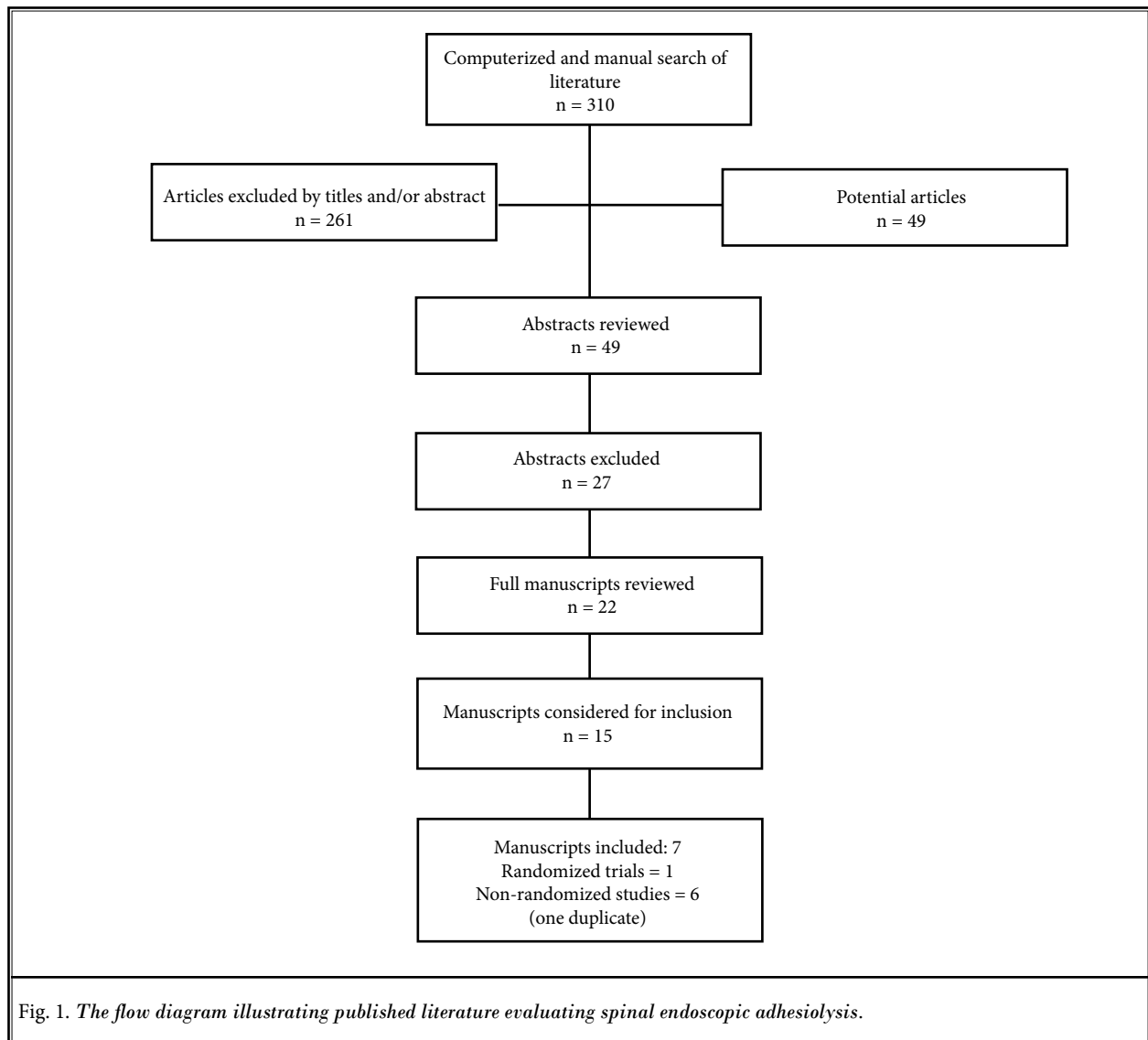
**2.1 Clinical Relevance**

Of the one RCT (199), with a duplicate publication (184), and 5 observational studies (182,200-203) meeting the inclusion criteria, all 6 passed the screen for clinical relevance, with a score of at least 3 out of 5. The clinical relevance findings are shown in Table 8.

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

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

Adapted and modified from methods developed by U.S. Preventive Services Task Force (147).



## 2.2 Quality Assessment

A methodological quality assessment of the RCT meeting the inclusion criteria was carried out using the Cochrane review criteria as shown in Table 9. Studies achieving Cochrane scores of 67% or higher were considered to be high quality, studies scoring 50% or higher were considered moderate quality, and studies scoring less than 50% were considered to be of poor quality and excluded.

The one RCT evaluated was of high quality. Eighty percent of the patients in this study had post lumbar surgery syndrome.

A methodological quality assessment of the 5 observational studies meeting the inclusion criteria was carried out utilizing the Newcastle-Ottawa Scales as illustrated in Tables 10 and 11. One study (202) was case control and 4 studies (182,200-203) were cohort studies.

For cohort studies, studies achieving scores of 67% or higher were considered high quality, 50% or higher were considered moderate quality, and studies scoring less than 50% were considered low quality and were excluded. Table 10 presents the scoring for the case-controlled study.



## Spinal Endoscopic Adhesiolysis in Post Lumbar Surgery Syndrome

Table 6. List of excluded randomized trials and observational studies.

Manuscript Author(s)	Number of Patients	Treated vs. Control	Reason for Exclusion	
			Follow-up Period	Other Reason(s)
<b>Randomized Controlled Trials</b>				
Dashfield et al, 2005 (185)	60 patients	30 with endoscopically placed local anesthetic and steroid  30 with caudal epidural injection of local anesthetic and steroid	6 months	Inclusion criteria were sciatica in the absence of lumbar surgery; no patients had post lumbar surgery syndrome. Intent was specifically to study patients without adhesions.
<b>Observational Studies</b>				
Richardson et al, 2001 (186)	38	Epiduroscopy	12 months	Failure to have 50 patients. Only 50% of patients had post lumbar surgery syndrome.
Warnke & Mourgela, 2007 (187)	23	Subarachnoid endoscopy (thecaloscopy)	24 months	Failure to have 50 patients. Procedure was subarachnoid, not epidural. Patients without post lumbar surgery syndrome were included.
Richter et al, 2011 (188)	154	Laser epiduroscopy	Not provided	Post lumbar surgery patients were excluded.
Richter & Rothstein, 2011 (189)	24	Laser epiduroscopy	3 months to 6 months, mean 4 months	Failure to have 50 patients. 15 of 24 patients did not have post lumbar surgery syndrome.
Ruetten et al, 2003 (190)	93	Epiduroscopy	2 months	Only 21 of 93 patients had post lumbar surgery syndrome.
Saberski, 2000 (191)	35	22 epiduroscopy 13 laminectomy and discectomy	2 months	Failure to have > 25 patients in each group. No patients had post lumbar laminectomy syndrome; only disc herniation was evaluated.
Sakai et al, 2008 (192)	19	Epiduroscopy	3 months	Failure to have > 50 patients. No patients had post lumbar laminectomy syndrome; only sciatica was evaluated.
Tobita et al, 2003 (193)	55	Epiduroscopy and subarachnoid endoscopy in all patients	None	Procedure was done for diagnosis only, with no therapy provided. No patients had post lumbar laminectomy syndrome.
Avellanal & Diaz-Reganon, 2008 (194)	19	Interlaminar epiduroscopy	6 months	Failure to have > 50 patients.
Geurts et al, 2002 (195)	24	Epiduroscopy	12 months	Failure to have > 50 patients.
Igarashi et al, 2004 (196)	58 34 monosegmental 24 multisegmental	Epiduroscopy	12 months	Only patients with spinal stenosis were studied; no patients had post lumbar surgery syndrome.
Takeshima et al, 2009 (197)	28	Epiduroscopy	6 months	Failure to have > 50 patients. All patients did have post lumbar surgery syndrome.
Mavrocordatos & Cahana, 2011 (198)	32	Epiduroscopy with targeted O2/O3 and steroid delivery	2 years	Failure to have > 50 patients. Chronic refractory low back pain.

Table 7. Assessment of randomized trials and observational studies for inclusion criteria.

Manuscript Authors	Type of Study	Number of patients	Treatment vs. Comparator	Length of Follow up	Outcome Parameters	Comments
Manchikanti et al, 2005 (199)	RA, PC, AC	83 patients with chronic, refractory low back and lower extremity pain were randomized 2:3 into an active control or interventional group. 73% of group one and 84% of group two had post lumbar surgery syndrome.	Control group received endoscopy to S3 with steroid/ local anesthetic injection; interventional group received epiduroscopic adhesiolysis with targeted steroid/ local anesthetic injection.	Up to 12 months	Pain relief VAS, ODI, P-3 psychological evaluation, ROM measurements, work status and opioid intake	Significant pain relief (50%) at 3 months 80%, 6 months 56%, and 12 months 48% compared to 33% of controls at 1 month only; improvements in ODI, ROM, and psychological status were noted over controls. Epiduroscopic adhesiolysis with targeted steroid/local anesthetic administration is more effective than control treatment for chronic low back and lower extremity pain without major adverse effects.
Di Donato et al, 2010 (182)	P	350 patients with chronic low back pain attributable to FBSS, spondylolisthesis, stenosis, or hernia, who failed conservative therapies, divided into 3 groups based on ODI scores	Epiduroscopy with the injection of ozone and ciprofloxacin	60 months	Relief of pain VAS, disability evaluated by ODI up to 60 months. VAS < 5 and ODI < 40% were considered positive outcomes.	Short-term follow-up revealed significant pain relief in all patients and a ODI of < 40% in 79% of cases; at 60 months, 65% had significant pain relief with a ODI < 40% in 78% of patients. Epiduroscopy with adhesiolysis and targeted hyaluronidase, ozone is effective in providing pain relief and improvement in disability in the short and long-term treatment of chronic spinal low back pain.
Manchikanti et al, 1999 (200)	RE	120 patients, postlaminectomy; nonresponsive to conservative therapy	2 treatment groups: Group 1, 60 patients nonendoscopic adhesiolysis; Group 2, 60 patients endoscopic; 2 procedures were performed in each group.	12 months	No pain relief, pain relief < or > 50%	Percutaneous adhesiolysis had average 3 procedures/year; endoscopic, 1.3/year. Both procedures provided significant pain relief, mean 15 weeks for percutaneous and 20 weeks for endoscopic, but percutaneous was more cost effective.
Manchikanti et al, 2000 (201)	RE	85 patients with refractory low back pain. 86% of patients had prior lumbar surgery.	Endoscopic adhesiolysis	Minimum 12 months	No pain relief, pain relief < or > 50%	Significant pain relief for a mean of 19 weeks; All had significant relief after the initial procedure, then declined to 52% at 3 - 6 months and 21% at 6 - 12 months.
Murai et al, 2007 (202)	P, AC	183 patients with refractory low back and leg pain. 37 patients had previous lumbar surgery; 87 had not had surgery.	Endoscopic adhesiolysis	3 months	RMDQ, VAS, Japanese Orthopedic Association (JOA) scores, dissatisfaction with ADLs	Both groups had a 50% reduction in VAS scores at 3 months. VAS and JOA scores were significantly lower at 1 and 3 months for the non-operated group compared to the operated group.
Kim et al, 2011 (203)	P, AC	109 patients with refractory chronic low back and radicular pain. Group 1 had 18 spinal stenosis, 1 disc herniation, and 1 post lumbar surgery syndrome; Group 2 had 42 spinal stenosis, 25 disc herniation, 8 post lumbar surgery syndrome, and 3 idiopathic	2 treatment groups: Group 1, 20 patients for endoscopy; Group 2, 78 patients for laser endoscopy. Both groups received a local injection of triamcinolone.	6 months minimum	Pain relief using VAS and functional status using RMDQ scores and MacNab criteria	The mean VAS for Group 1 went from 8.5 to 4.6 at one month and then 6.1 at 6 months. Group 2 went from 7.6 to 4.9 at one month and then 3.6 at 6 months. Both groups had significant relief, but the laser procedure provided lasting relief, while epiduroscopy alone had loss of relief over time.

RA = randomized; PC = Placebo control; AC = Active-control; P = Prospective; RE = Retrospective; VAS = Visual analog scale; ODI = Oswestry Disability Index; RMDQ = Roland Morris Disability Questionnaire; P-3 = Pain Patient Profile; FBSS = Failed back surgery syndrome; ROM = Range of motion; ADLs = Activities of Daily Living

Table 8. *Clinical relevance of included studies.*

Manuscript Author(s)	A) Patient description	B) Description of interventions and treatment settings	C) Clinically relevant outcomes	D) Clinical importance	E) Benefits versus potential harms	Total Criteria Met
Manchikanti et al (199)	+	+	+	+	+	5/5
Di Donato et al (182)	+	+	+	+	+	5/5
Manchikanti et al (200)	+	+	+	+	+	5/5
Manchikanti et al (201)	+	+	+	+	+	5/5
Murai et al (202)	+	+	+	+	+	5/5
Kim et al (203)	+	+	+	+	+	5/5

+ = positive; - = negative ; U = unclear

Scoring adapted from Staal JB, et al. Injection therapy for subacute and chronic low-back pain. Cochrane Database Syst Rev 2008; 3:CD001824 (143).

Table 9. *Methodological quality assessment of randomized trials.*

	Manchikanti et al (199)
Randomization adequate	Y
Concealed treatment allocation	Y
Patient blinded	Y
Care provider blinded	N
Outcome assessor blinded	Y
Drop-out rate described	Y
All randomized participants analyzed in the group	Y
Reports of the study free of suggestion of selective outcome reporting	Y
Groups similar at baseline regarding most important prognostic indicators	Y
Co-interventions avoided or similar	Y
Compliance acceptable in all groups	Y
Time of outcome assessment in all groups similar	Y
SCORE	11/12

Y=yes; N=no; U=unsure

Scoring adapted from Staal JB, et al. Injection therapy for subacute and chronic low-back pain. Cochrane Database Syst Rev 2008; 3:CD001824 (143).

For case-control studies, 67% or higher was considered as high quality, 50% or higher was considered as moderate quality, and less than 50% was considered low quality, and excluded. Two studies (200,202) were of high quality and 3 studies (182,201,203) were of moderate quality.

### 2.3 Study Characteristics

Table 12 presents the study characteristics of the one RCT (199), with a duplicate publication (184), and the 5 observational studies (182,200-203) of per-

cutaneous endoscopic adhesiolysis meeting inclusion criteria.

Four studies including one RCT with 2 publications (184,199), and 3 observational studies (200,201,203) had sufficient methodological strength to be used to address the question of the efficacy of endoscopic adhesiolysis in the treatment of low back and leg pain caused by post lumbar surgery syndrome (Table 13).

Based upon one high quality RCT (199), with a duplicate publication (184), one high quality observational study (200), and 2 moderate quality observational stud-

Table 10. *Methodological quality assessment of case control studies utilizing Newcastle-Ottawa quality assessment scale.*

<b>Selection</b>	<b>Murai et al (202)</b>
1) Is the case definition adequate?	
a) yes, with independent validation *	X
b) yes, e.g. record linkage or based on self reports	
c) no description	
2) Representativeness of the cases	
a) consecutive or obviously representative series of cases *	X
b) potential for selection biases or not stated	
3) Selection of Controls	
a) community controls *	X
b) hospital controls	
c) no description	
4) Definition of Controls	
a) no history of prior lumbar surgery *	X
b) no description of source	
<b>Comparability</b>	
1) Comparability of cases and controls on the basis of the design or analysis	
a) study controls for post lumbar surgery syndrome *	X
b) study controls for any additional factor * (This criteria could be modified to indicate specific control for a second important factor.)	
<b>Exposure</b>	
1) Ascertainment of exposure	
a) secure record (eg surgical records) *	X
b) structured interview where blind to case/control status *	
c) interview not blinded to case/control status	
d) written self report or medical record only	
e) no description	
2) Same method of ascertainment for cases and controls	
a) yes *	X
b) no	
3) Non-Response rate	
a) same rate for both groups *	X
b) non respondents described	
c) rate different and no designation	
	SCORE 8/12

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

Adapted and modified from Wells GA, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analysis. [www.ohri.ca/programs/clinical\\_epidemiology/oxford.asp](http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp) (145).

## Spinal Endoscopic Adhesiolysis in Post Lumbar Surgery Syndrome

Table 11. *Methodological quality assessment of cohort studies utilizing Newcastle-Ottawa quality assessment scale.*

	Manchikanti et al (200)	Manchikanti et al (201)	Di Donato et al (182)	Kim et al (203)
<b>Selection</b>				
1) Representativeness of the exposed cohort				
a) truly representative of the average pt with low back pain in the community *	X	X	X	X
b) somewhat representative of the average pain patients in the community *				
c) selected group of users e.g. nurses, volunteers				
d) no description of the derivation of the cohort				
2) Selection of the non exposed cohort				
a) drawn from the same community as the exposed cohort *	X	NA	NA	NA
b) drawn from a different source				
c) no description of the derivation of the non exposed cohort				
3) Ascertainment of exposure				
a) secure record (eg surgical records) *	X	X	X	X
b) structured interview *				
c) written self report				
d) no description				
4) Demonstration that outcome of interest was not present at start of study				
a) yes *	X	X	X	X
b) no				
<b>Comparability</b>				
1) Comparability of cohorts on the basis of the design or analysis				
a) study controls for post lumbar laminectomy syndrome*	X	X	X	X
b) study controls for any additional factor * (This criteria could be modified to indicate specific control for a second important factor.)				
<b>Outcome (Exposure)</b>				
1) Assessment of outcome				
a) independent blind assessment *			X	
b) record linkage *	X	X		
c) self report				
d) no description				X
2) Was follow-up long enough for outcomes to occur				
a) yes (select an adequate follow up period for outcome of interest) *	X	X	X	X
b) no				
3) Adequacy of follow up of cohorts				
a) complete follow up - all subjects accounted for *	X	X		X
b) subjects lost to follow up unlikely to introduce bias - small number lost - > ____ % (select an adequate % follow up, or description provided of those lost) *				
c) follow up rate < 70% (select an adequate %) and no description of those lost				
d) no statement			X	
SCORE	8/12	7/12	7/12	7/12

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

Adapted and modified from Wells GA, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analysis. [www.ohri.ca/programs/clinical\\_epidemiology/oxford.asp](http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp) (145).

Table 12. Characteristics of randomized controlled trials and observational studies of percutaneous endoscopic adhesiolysis studies meeting inclusion criteria.

Reference, Year	Number of Patients Selection Criteria	Control/Comparator	Outcome Measures	Time of Measurements	Results	Strengths	Weaknesses	Methodological Quality Assessment
Manchikanti et al, 2005 (199)	83 patients with low back and lower extremity pain of at least 2 years duration, facet disease ruled out, who failed conservative therapy. 73% of active control group and 84% of treated group had failed lumbar surgery syndrome. Patients had failed conservative therapy, including fluoroscopically guided epidural injections and percutaneous adhesiolysis.	Epiduroscopy to target area, with less than 100 cc of saline infusion followed, after mechanical adhesiolysis, with 1% lidocaine and steroid/epiduroscope advanced to S3 followed by 10 cc of 1% lidocaine and steroid	VAS, ODI, work status, range of motion, P-3	1, 3, 6, 12 months	90% of epiduroscopy group had > 50% relief at 1 month, 80% did at 3 months, 56% did at 6 months, and 48% at 12 months. 33% of active control had >50% relief at 1 month and none did thereafter.	Pragmatic randomized controlled trial that showed effectiveness of endoscopic adhesiolysis in patients who did not respond to percutaneous adhesiolysis.	Study included primarily post lumbar surgery syndrome patients, but was not exclusively this diagnosis. Study did not evaluate effectiveness of repeating procedure.  A high percentage of patients were unblinded.	11/12
Di Donato et al, 2010 (182)	350 patients with low back pain of at least 6 months duration due to post lumbar surgery syndrome, spondylolisthesis, stenosis, or disc herniation who had failed conservative therapy and refused fusion	Endoscopic adhesiolysis with mean 110 ml of saline with hyaluronidase followed by 8 ml of ozone and 50 mg of Cipro Floxin. All patients wore an orthopedic corset for 2 weeks after the procedure.	VAS (0 - 2, 3 - 5, and > 5), ODI	1 week, 3, 6, 12, 36, 48, and 60 months	At 3 months, 94% of patients had an ODI of <40% and 90% of patients had VAS < 5. At 12 months, 82% had an ODI < 40% and 74% had significant pain relief. High levels of pain relief and functional benefit persisted at more distant time periods.	Only study to follow patients for 5 years. Evaluated use of ozone instead of local anesthetic and steroid.	All patients had a pre-procedure VAS of > 5. A successful outcome was a VAS of < 5. It is not possible to tell how many patients had a 50% reduction or a 3 point reduction in VAS. An ODI of < 40% was considered a success. 60% of patients had an ODI equal to or less than 40% at the start of the study, so it is not possible to assess functional improvement. Percentage of patients with post lumbar surgery syndrome is not provided.	7/12
Manchikanti et al, 1999 (200)	120 post lumbar surgery patients. Facet and sacroiliac joint pain was excluded.	60 patients with percutaneous adhesiolysis; 60 patients with endoscopic adhesiolysis	> 50% pain relief; number of procedures	1, 3, 6, 12 months	At one month, 72% of percutaneous and 97% of endoscopic patients had > 50% relief. At 3 months, it was 10% and 52%. After the second procedure, 22% of the percutaneous group had > 50% relief, whereas 75% of the endoscopic group did. Percutaneous adhesiolysis is more cost-effective than endoscopic adhesiolysis.	All patients were post lumbar surgery patients. Direct comparison between percutaneous and endoscopic adhesiolysis.	Retrospective evaluation. Limited outcome parameters	8/12

VAS = visual analog scale; P-3 = Pain Patient Profile; ODI = Oswestry Disability Index; RMDQ = Roland Morris Disability Questionnaire

Table 12 (cont.). Characteristics of randomized controlled trials and observational studies of percutaneous endoscopic adhesiolysis studies meeting inclusion criteria.

Reference, Year	Number of Patients Selection Criteria	Control/Comparator	Outcome Measures	Time of Measurements	Results	Strengths	Weaknesses	Methodological Quality Assessment
Manchikanti et al., 2000 (201)	85 patients with low back and leg pain that did not respond to epidural or facet injections or to percutaneous adhesiolysis. Duration of pain was < 4 years in 21% of patients and > 4 years in 79%. 86% had prior lumbar surgery syndrome.	Endoscopic adhesiolysis with between 10 and 110 cc of saline and 5 - 60 cc of radio-opaque dye, followed by local anesthetic and steroid. Average of 1.3 procedures/patient.	> 50% pain relief, number of endoscopies performed	At least 12 months	94% had > 50% relief at 2 months and 52% at 6 months. 21% had significant relief at 12 months.	Evaluated patients who had failed to respond to epidural or facet injections and to percutaneous adhesiolysis. 86% of patients had post lumbar surgery syndrome.	Only VAS was evaluated. Retrospective study. No active comparator	7/12
Murai et al., 2007 (202)	183 patients enrolled at 15 centers. Low back pain and sciatica not responsive to conservative therapy including epidural, facet, and sacroiliac injections. 37 patients had post lumbar surgery syndrome. 87 patients had not been operated on.	Endoscopic adhesiolysis followed by local anesthetic and steroid	Japanese Orthopedic Association (JOA) scores, Japanese version of RMDQ; VAS for leg and low back, leg numbness and dissatisfaction with activities of daily living	1 and 3 months	Both groups improved significantly at 1 and 3 months. The non-operated group had significantly lower scores at 1 and 3 months than did the operated group. Both groups had 50% reduction in VAS at both time periods.	Compared response in post lumbar surgery syndrome and non-operated patients	The duration of follow up was only 3 months. Duration of pain prior to intervention was not provided. 32% of patients dropped out. Data was collected by patients filling out a survey rather than by seeing patients.	8/12
Kim et al., 2011 (203)	98 out of 109 patients with chronic low back pain and radiculopathy who had failed conservative therapy, including epidural steroid injections were followed for ≥ 6 months. 20 underwent endoscopic adhesiolysis (1 had post lumbar surgery syndrome, 1 had disc extrusion, 18 had spinal stenosis). 78 had laser endoscopy (8 had post lumbar surgery syndrome, 42 had spinal stenosis, and 25 had lumbar disc protrusion, 3 idiopathic).	Laser epiduroscopy versus epiduroscopic adhesiolysis	VAS for back and leg pain; RMDQ; MacNab criteria	1 month and minimum of 6 months' follow-up. 90% of enrolled patients completed the study.	For endoscopy patients, VAS went from 8.5 to 4.6 at 1 month, but increased back to 6.1 at last observation. For laser endoscopy patient, the VAS went from 7.6 to 4.9 at 1 month and at last observation, was 3.6	Compared endoscopy to laser endoscopy. Large number of patients. Laser endoscopy patients showed persistent relief, whereas endoscopic adhesiolysis patients had return of symptoms.	No active control group. Relatively few patients had post lumbar surgery syndrome	7/12

VAS = visual analog scale; P-3 = Pain Patient Profile; ODI = Oswestry Disability Index; RMDQ = Roland Morris Disability Questionnaire



Table 13. Results of randomized and observational studies on the effectiveness of endoscopic adhesiolysis in treating low back and/or leg pain due to post lumbar surgery syndrome.

Study	Study Characteristics	Methodological Quality Scoring	Participants	Pain relief and Function	Results		Comments
					Short term < 12 mos.	Long-term relief ≥ 12 mos.	
Manchikanti et al (199)	RA, AC	11/12	86 patients  50 patients had endoscopic adhesiolysis; 33 had endoscopic caudal steroid injection.  73% of active control group and 84% of treated group had failed lumbar surgery syndrome.	90% of epiduroscopy group had > 50% relief at 1 month, 80% did at 3 months, 56% did at 6 months, and 48% at 12 months.  33% of active control had > 50% relief at 1 month and none did thereafter.	P	P	High quality study showing evidence of effectiveness
Manchikanti et al (200)	RE	8/12	60 patients with percutaneous adhesiolysis; 60 patients with endoscopic adhesiolysis  100% had post lumbar surgery syndrome.	At 6 months, after a second procedure, 75% of the endoscopic group had > 50% relief, while only 22% of the percutaneous group did.  However, looking at both groups regardless of the number of procedures done, 40% of endoscopic patients had > 50% relief, whereas 72% of percutaneous group did. The percutaneous group had about twice as many procedures as the endoscopic.	P	N	High quality observational study showing short-term evidence of effectiveness
Manchikanti et al (201)	RE	7/12	85 patients receiving endoscopic adhesiolysis  86% had post lumbar surgery syndrome.  27 patients had 2 procedures	94% had >50% relief at 2 months and 52% at 6 months. 21% had significant relief at 12 months.	P	N	Moderate quality study showing short-term evidence of effectiveness
Kim et al (203)	P, AC	7/12	109  20 had endoscopic adhesiolysis; 78 had laser endoscopy.  9% had post lumbar surgery syndrome.	Endoscopic adhesiolysis patients had significant, > 50%, relief at one month, but pain relief was decreasing at last follow-up. Laser endoscopy group had persistent significant relief at last follow-up.	P	N	Moderate quality study showing short-term evidence of effectiveness, limited by low percentage of patients with post lumbar surgery syndrome.

RA = randomized; AC = active-control; P = prospective; RE = retrospective; P = positive; N = negative

ies (201,203), using the USPSTF criteria, the evidence is fair that endoscopic adhesiolysis is effective for both short-term (< 12 months) and long-term ( $\geq$  12 months) in the treatment of chronic low back and/or leg pain due to post lumbar surgery syndrome.

### **3.0 COMPLICATIONS**

Spinal endoscopic adhesiolysis is generally a well tolerated procedure, with minimal and transient complications, including localized pain and self-limited irritation of the nerve root (1,44,110,111,114,162,173,175,188-190,204-220). Spinal endoscopy has, however, also been associated with significant complications, most significantly blindness associated with excessive epidural hydrostatic pressure associated with the administration of high volumes of fluid, greater than 100 ml during the procedure, or a bolus of fluid. The mechanism of blindness is believed to be sudden or excessive subarachnoid pressure leading to either decreased retinal perfusion or macular hemorrhage. Amirikia et al (215) described a case of bilateral retinal hemorrhage and blindness in an 80-year old with macular degeneration. The volume injected was not noted, but the irrigation is described as lasting 5 minutes. They recommend decreasing flow and volume. Retinal hemorrhage was also been reported after saline infusion used to treat post lumbar puncture headache (216). Tabandeh (217) reported a case of hemorrhage after epiduroscopy, but no details of saline use were provided. Gill and Heavner (176) reviewed blindness after epiduroscopy, evaluating 12 cases. About 80% of these cases resolved. They recommended injecting the saline at less than 1 ml/second; this rate is far above the current standard of about 100 ml/60 minutes or about 0.03 ml/second.

Another potential complication of excessive epidural hydrostatic pressure, including that caused by injection into a loculation, is spinal cord or root compression with neural damage.

Other complications potentially associated with epiduroscopy include dural tear, epidural bleeding with potential hematoma formation, and infection.

Dural tears themselves are usually asymptomatic. However, they can result in the access of various medications into the subarachnoid space. Hypertonic saline is known to be neurotoxic and would be expected to cause neural injury if allowed to enter the subarachnoid space. For this reason, the standard protocol when hypertonic saline is used is to wait about 30 minutes after the injection of local anesthetic to ensure that no subarachnoid or subdural block is present. Many practi-

tioners avoid using hypertonic saline during endoscopy in order to remove the risk of the injection of subarachnoid hypertonic saline.

The non-iodinated contrast solution, iotrolan, has been implicated as the cause of encephalopathy and rhabdomyolysis after being unintentionally injected into the subarachnoid space during epiduroscopy (181).

In and of itself, entering the subarachnoid space is not a cause for concern. There is a body of literature focused on the endoscopic examination of the subarachnoid space, called thecaloscopy (168,187,193,218-220). Further, neuroendoscopy, which involves endoscopic examination and laser treatment of the ventricles, has been described (221).

Justiz et al (179) reported a case of neurogenic bladder after endoscopy in a patient with post lumbar surgery syndrome, possibly related to hypertonic saline in the subarachnoid space. Her symptoms persisted until she was provided nitrofurantoin 3 years after the onset. Cessation of the nitrofurantoin caused the retention to recur. She was maintained on long-term nitrofurantoin, with benefit. The authors hypothesized that the nitrofurantoin caused increased nitric oxide levels with subsequent improved bladder function.

Murai et al (202) noted transient leg weakness, but no permanent complications in a prospective study of 183 patients. Heavner and Bosscher (205) noted that the literature documents the safety of epiduroscopy and that the incidence of complications decreases with experience.

Avellanal and Diaz-Reganon (194) reported transient decreased hearing during saline infusion. Heavner et al (178) described 2 cases of intravenous injection of contrast during epiduroscopy.

One issue related to complications is the radiation exposure during the procedure. Komiya et al (180) found that the average time of fluoroscopy use for their epiduroscopies was just less than 10 minutes. This amount of fluoroscopy resulted in an exposure to a humanoid model of 238 mGy. Physician exposure was 0.67 mGy outside the lead apron. Based upon these findings, Komiya et al (180) recommended that physicians limit themselves to 70 epiduroscopy procedures per year. However, Heavner and Bosscher's (177) experience mirrors that of most physicians performing epiduroscopy with less exposure.

Van Boxem et al (114) note that aside from retinal complications, the complications of spinal endoscopy are similar to those associated with percutaneous adhesiolysis.

There have been reports of complications with laser-assisted spinal endoscopy, including motor paralysis resulting from thermal damage to nerve roots (203). Other complications are related to administered drugs – steroids and local anesthetics (85,89,91,111-113,151,222-225).

The experience reported in the literature indicates that the incidence of complications associated with spinal endoscopy is low. The complications reported are generally minimal and self-limited. The most serious complication, retinal side effects, can be minimized or eliminated by attention to technique. This procedure should be considered low risk for serious adverse complications when performed by properly trained practitioners.

#### **4.0 Discussion**

Endoscopic adhesiolysis is safe and effective in treating post lumbar surgery syndrome patients who have failed other modalities, including percutaneous adhesiolysis. Like many other interventional procedures, it is not curative and requires repeat treatment. Quality studies consistently show that a significant number of patients respond, or that 50% of patients show a significant response. Thus, the procedure can be repeated twice per year.

The exclusion of Dashfield et al's RCT (185) warrants specific discussion. The only discussion of epiduroscopy contained in Chou and Huffman's APS guidelines (77) is based upon Dashfield's report. Dashfield et al, in response to a criticism of their RCT made by Richardson et al (170), made clear that, "Our study was designed to answer the question of whether the site of epidural corticosteroid placement within the epidural space was important in patients with little or no epidural scar tissue. We did not investigate the role of epiduroscopic adhesiolysis in patients with epidural scar tissue" (226). In that the rationale for doing endoscopy is, at a minimum, to break up scarring, Dashfield and Taylor (226) are asking a non-clinically relevant question. Consequently, this study lacks clinical relevance. The NICE re-assessment of endoscopy done in 2009 specifically recognizes this fact and describes Dashfield and Taylor's study (226) as being of limited relevance (117). Extending NICE's analysis (117) to Chou and Huffman's APS guidelines (77), Chou and Huffman's discussion of endoscopic adhesiolysis is of limited relevance.

Cost effectiveness and technical issues with endoscopy have impeded its widespread use. The focal length of the fiberoptic endoscope was set at infinity, making

visualization difficult. There was also disagreement amongst practitioners as the identity of the various structures observed. Limitations on what therapeutic maneuvers could be done limited interest in the procedure. Finally, competing and much more widely accepted treatments for post lumbar laminectomy syndrome existed.

With the change of the focal length of the scope from infinity to 6 mm, visualization has markedly improved. Using a different endoscope, Bosscher and Heavner (227) have demonstrated that the epiduroscopy was more reliable than either clinical evaluation or MRI in determining the level of clinically significant spinal pathology in low back or leg pain patients. Epiduroscopy has a potential role as a diagnostic tool (228). Studies are in progress to help clarify what structures are pain generators and to confirm what structures are being visualized. The potential exists for the use of other therapies, including laser ablation and the introduction of ozone. All of these factors have created a resurging interest in endoscopic procedures.

This review is a systematic review of the currently available literature regarding adhesiolysis. While there new literature has become available since the 2009 systematic review (1), much of that literature was excluded either because it was not germane to the current review's focus on post lumbar surgery syndrome or because it did not meet current criteria related to study size. Thus, we continue to have a paucity of literature, particularly that of current, high quality literature documenting the value of endoscopy in its various forms.

The fundamental question concerns the effectiveness of spinal endoscopic adhesiolysis in the treatment of chronic low back and/or lower extremity pain of at least 6 months duration in post-surgical patients non-responsive to conservative modalities of management and fluoroscopically directed epidural injections. Using USPSTF criteria, the evidence is fair that endoscopic adhesiolysis is effective in treating chronic low back and/or lower extremity pain caused by post lumbar surgery syndrome.

The second question to be addressed is the severity and risk of complications associated with these techniques.

The incidence of complications of spinal endoscopy is low and the complications are generally minimal and self-limited. The most serious complication, retinal side effects, can be minimized or eliminated by attention to technique. This procedure should be considered to be low risk for serious adverse complications.

## 5.0 CONCLUSION

Endoscopic adhesiolysis is a safe, when performed by trained personnel, and effective procedure in the treatment of post lumbar surgery syndrome. The procedure generated widespread interest in the early part of the first decade of this millennium. Interest in the procedure waned because of technical issues related to the equipment; specifically, problems of visualization related to focal length, difficulty in identifying structures which were visualized, a limitation of therapeutic interventions which could be performed, and the cost and limited applicability of the procedure. These issues are now being addressed, with improved focal length and an enhanced understanding of the structures visualized. Epiduroscopy has been shown to have a unique role in diagnosing the level from which clinically significant low back pain arises. There is considerable interest in new therapies, such as laser ablation of epidural tissues and the injection of ozone into the epidural space. The process of determining the indications for the effectiveness, safety of, and ease of applicability of these endoscopic procedures is a growing, dynamic field of intellectual interest and activity.

## ACKNOWLEDGMENTS

The authors also wish to thank Vidyasagar Pampati, MSc, for statistical assistance; Sekar Edem for assistance in the search of the literature; Alvaro F. Gómez, MA, and Laurie Swick, BS, for manuscript review; and Tonie M. Hatton and Diane E. Neihoff, transcriptionists, for their assistance in preparation of this manuscript. The authors thank *Pain Physician* for permitting to reproduce Hayek et al's manuscript from 2009 (1). We would like to thank the editorial board of *Pain Physician* for review and criticism in improving the manuscript.

## Author Affiliations

Dr. Helm is Medical Director, The Helm Center for Pain Management, Laguna Hills, CA.

Dr. Hayek is Professor, Department of Anesthesiol-

ogy, Chief of the Division of Pain Medicine, University Hospitals of Cleveland, Cleveland, OH; and a member of the Outcomes Research Consortium, Cleveland, OH.

Dr. Colson is Assistant Professor of Anesthesiology, Department of Anesthesiology, Pain Medicine Service, West Virginia University Hospitals, Morgantown, WV.

Dr. Chopra is Assistant Professor of Medicine, Department of Medicine, Division of Biology and Medicine, Brown Medical School; Assistant Professor of Anesthesiology, Boston University School of Medicine; and Medical Director, Interventional Pain Management Center of Rhode Island, Pawtucket, RI.

Dr. Deer is Medical Director, The Center for Pain Relief, and Clinical Professor, Anesthesiology, West Virginia University School of Medicine, Charleston, WV.

Dr. Justiz is Medical Director, Oklahoma Pain Physicians, Oklahoma City, OK.

Dr. Hameed is with the Department of Physical Medicine and Rehabilitation, The Johns Hopkins University School of Medicine, Baltimore, MD.

Dr. Falco is Medical Director of Mid Atlantic Spine & Pain Physicians, Newark, DE; Director, Pain Medicine Fellowship Program, Temple University Hospital, Philadelphia, PA; and Associate Professor, Department of PM&R, Temple University Medical School, Philadelphia, PA.

## Conflict of Interest:

Dr. Hayek is a consultant for Boston Scientific.

Dr. Helm is a clinical investigator with Epimed and receives research support from Cephalon/Teva, Astra-Zeneca, and Purdue Pharma, LP. He has attended an Advisory Group meeting for Actavis.

Dr. Deer is a consultant and research advisor for Bioness, Flowonix, Jazz, Medtronic, Nevro, St. Jude, Spinal Modulation, and Vertos.

Dr. Justiz is a consultant and research advisor for St. Jude Medical and Anulex Technologies.

Dr. Falco is a consultant for St. Jude Medical Inc. and Joimax Inc.

## REFERENCES

1. Hayek SM, Helm S, Benyamin RM, Singh V, Bryce DA, Smith HS. Effectiveness of spinal endoscopic adhesiolysis in post lumbar surgery syndrome: A systematic review. *Pain Physician* 2009; 12:419-435.
2. Schofferman J, Reynolds J, Herzog R, Covington E, Dreyfuss P, O'Neill C. Failed back surgery: Etiology and diagnostic evaluation. *Spine J* 2003; 3:400-403.
3. Slipman CW, Shin CH, Patel RK, Isaac Z, Huston CW, Lipetz JS, Lenrow DA, Braverman DL, Vresilovic EJ Jr. Etiologies of failed back surgery syndrome. *Pain Med* 2002; 3:200-214.
4. Waguespack A, Schofferman J, Slosar P, Reynolds J. Etiology of long-term failures of lumbar spine surgery. *Pain Med* 2002; 3:18-22.
5. Waddell G, Kummel EG, Lotto WN, Graham JD, Hall H, McCulloch JA. Failed lumbar disc surgery and repeat surgery following industrial injuries. *J Bone Joint Surg Am* 1979; 61:201-207.
6. Fritsch E, Heisel J, Rupp S. The failed back surgery syndrome: Reasons, intraoperative findings, and long-term results: A report of 182 operative treatments. *Spine (Phila Pa 1976)* 1996; 21:626-633.
7. Osterman H, Sund R, Seitsalo S, Keskimäki I. Risk of multiple reoperations after lumbar discectomy: A population-based study. *Spine (Phila Pa 1976)* 2003; 28:621-627.
8. Bono CM, Lee CK. Critical analysis of trends in fusion for degenerative disc disease over the past 20 years: Influence of technique on fusion rate and clinical outcome. *Spine (Phila Pa 1976)* 2004; 29:455-463.
9. Mirza SK, Deyo RA. Systematic review of randomized trials comparing lumbar fusion surgery to nonoperative care for treatment of chronic back pain. *Spine (Phila Pa 1976)* 2007; 32:816-823.
10. Deyo RA, Mirza SK, Martin BI, Kreuter W, Goodman DC, Jarvik JG. Trends, major medical complications, and charges associated with surgery for lumbar spinal stenosis in older adults. *JAMA* 2010; 303:1259-1265.
11. Yang J, Ni B, Liu J, Zhu L, Zhou W. Application of liposome-encapsulated hydroxycamptothecin in the prevention of epidural scar formation in New Zealand white rabbits. *Spine J* 2011; 11:218-223.
12. Robertson JT. Role of peridural fibrosis in the failed back: A review. *Eur Spine J* 1996; 5:S2-S6.
13. Gill GG, Scheck M, Kelley ET, Rodrigo JJ. Pedicle fat grafts for the prevention of scar in low-back surgery: A preliminary report on the first 92 cases. *Spine (Phila Pa 1976)* 1985; 10:662-667.
14. Bartynski WS, Petropoulou KA. The MR imaging features and clinical correlates in low back pain-related syndromes. *Magn Reson Imaging Clin N Am* 2007; 15:137-154.
15. Sizer Jr PS, Phelps V, Dedrick G, Matthijs O. Differential diagnosis and management of spinal nerve root-related pain. *Pain Pract* 2002; 2:98-121.
16. Farrokhi MR, Vasei M, Fareghbal S, Farrokhi N. The effect of methylene blue on peridural fibrosis formation after laminectomy in rats: An experimental novel study. *Spine J* 2011; 11:147-152.
17. Ran B, Song YM, Liu H, Liu LM, Gong Q, Li T, Zeng JC, Yuan HF. Novel biodegradable -TCP/poly(amino acid) composite artificial lamina following spinal surgery for prevention of intraspinal scar adhesion. *Eur Spine J* 2011; 20:2240-2246.
18. Liu J, Ni B, Zhu L, Yang J, Cao X, Zhou W. Mitomycin C-polyethylene glycol controlled-release film inhibits collagen secretion and induces apoptosis of fibroblasts in the early wound of a postlaminectomy rat model. *Spine J* 2010; 10:441-447.
19. Mastronardi L, Pappagallo M, Tatta C, Roperto R, Elswaf A, Ferrante L. Prevention of postoperative pain and of epidural fibrosis after lumbar microdiscectomy: Pilot study in a series of forty cases treated with epidural vaseline-sterile-oil-morphine compound. *Spine (Phila Pa 1976)* 2008; 33:1562-1566.
20. Gibson JN, Waddell G. Surgical interventions for lumbar disc prolapse: Updated cochrane review. *Spine (Phila Pa 1976)* 2007; 32:1735-1747.
21. Massie JB, Schimizzi AL, Huang B, Kim CW, Garfin SR, Akeson WH. Topical high molecular weight hyaluronan reduces radicular pain post laminectomy in a rat model. *Spine J* 2005; 5:494-502.
22. Massie JB, Huang B, Malkmus S, Yaksh TL, Kim CW, Garfin SR, Akeson WH. A preclinical post laminectomy rat model mimics the human post laminectomy syndrome. *J Neurosci Methods* 2004; 137:283-289.
23. Robertson JT, Soble-Smith J, Powers N, Nelson PA. Prevention of cerebrospinal fistulae and reduction of epidural scar with new surgical hemostat device in a porcine laminectomy model. *Spine (Phila Pa 1976)* 2003; 28:2298-3303.
24. Manchikanti L, Boswell MV, Singh V, Benyamin RM, Fellows B, Abdi S, Bue-
- naventura RM, Conn A, Datta S, Derby R, Falco FJE, Erhart S, Diwan S, Hayek SM, Helm S, Parr AT, Schultz DM, Smith HS, Wolfer LR, Hirsch JA. Comprehensive evidence-based guidelines for interventional techniques in the management of chronic spinal pain. *Pain Physician* 2009; 12:699-802.
25. Manchikanti L, Singh V, Cash KA, Pampati V, Datta S. Fluoroscopic caudal epidural injections in managing post lumbar surgery syndrome: Two-year results of a randomized, double-blind, active-control trial. *Int J Med Sci* 2012; 9:582-591.
26. Pospiech J, Pajonk F, Stolke D. Epidural scar tissue formation after spinal surgery: An experimental study. *Eur Spine J* 1995; 4:213-219.
27. Jonsson B, Stromqvist B. Repeat decompression of lumbar nerve roots. A prospective two-year evaluation. *J Bone Joint Surg Br* 1993; 75:894-897.
28. Bosscher H, Heavner J. Incidence and severity of epidural fibrosis after back surgery: An endoscopic study. *Pain Pract* 2012; 10:18-24.
29. McCarron RF, Wimpee MW, Hudkins PG, Laros GS. The inflammatory effect of nucleus pulposus. A possible element in the pathogenesis of low-back pain. *Spine (Phila Pa 1976)* 1987; 12:760-764.
30. Racz G, Holubec J. Lysis of adhesions in the epidural space. In: *Techniques of Neurolysis*. Kluwer Academic, Boston, 1989, pp 57-72.
31. Miyoshi S, Sekiguchi M, Konno S, Kikuchi S, Kanaya F. Increased expression of vascular endothelial growth factor protein in dorsal root ganglion exposed to nucleus pulposus on the nerve root in rats. *Spine (Phila Pa 1976)* 2011; 36:E1-E6.
32. Scuderi GJ, Cuellar JM, Cuellar VG, Yeomans DC, Carragee EJ, Angst MS. Epidural interferon gamma-immunoreactivity: A biomarker for lumbar nerve root irritation. *Spine (Phila Pa 1976)* 2009; 34:2311-2317.
33. Valat JP, Genevay S, Marty M, Rozenberg S, Koes B. *Sciatica*. *Best Pract Res Clin Rheumatol* 2010; 24:241-252.
34. Navani A, Dominguez CL, Hald JK, Fishman SM. An injection from the past: Fluoroscopic evidence of remote injections of radiopaque substances. *Reg Anesth Pain Med* 2006; 31:82-85.
35. Smuck M, Benny B, Han A, Levin J. Epidural fibrosis following percutaneous disc decompression with coblation technology. *Pain Physician* 2007; 10:691-696.
36. Otoshi K, Kikuchi S, Konno S, Sekigu-



- chi M. The reactions of glial cells and endoneurial macrophages in the dorsal root ganglion and their contribution to pain-related behavior after application of nucleus pulposus onto the nerve root in rats. *Spine (Phila Pa 1976)* 2009; 35:10-17.
37. Kobayashi S, Takeno K, Yayama T, Awara K, Miyazaki T, Guerrero A, Baba H. Pathomechanisms of sciatica in lumbar disc herniation: Effect of periradicular adhesive tissue on electrophysiological values by an intraoperative straight leg raising test. *Spine (Phila Pa 1976)* 2010; 35:2004-2014.
  38. Otoshi K, Kikuchi S, Kato K, Sekiguchi M, Konno S. Anti-HMGB1 neutralization antibody improves pain-related behavior induced by application of autologous nucleus pulposus onto nerve roots in rats. *Spine (Phila Pa 1976)* 2011; 36:E692-E698.
  39. Racz GB, Heavner JE, Singleton W, Carline M. Hypertonic saline and corticosteroid injected epidurally for pain control. In: Raj P (ed). *Techniques of Neurolysis*. Klumer Academic Publishers, Boston, 1989, pp 73-86.
  40. Ross JS, Robertson JT, Frederickson RC, Petrie JL, Obuchowski N, Modic MT, deTribolet N. Association between peridural scar and recurrent radicular pain after lumbar discectomy: Magnetic resonance evaluation. ADCON-L European Study Group. *Neurosurgery* 1996; 38:855-861.
  41. Kayaoglu CR, Calikoglu C, Binler S. Reoperation after lumbar disc surgery: Results in 85 cases. *J Int Med Res* 2000; 31:318-323.
  42. Fishbain D, Manchikanti L. Pain and emotional status (multiple letters). *Pain Physician* 2002; 5:338-340.
  43. Racz GB, Heavner JE, Diede JH. Lysis of epidural adhesions utilizing the epidural approach. In: Waldman SD, Winnie AP (eds). *Interventional Pain Management*. WB Saunders, Philadelphia, 1996, pp 339-351.
  44. Racz GB, Heavner JE, Trescot A. Percutaneous lysis of epidural adhesions evidence for safety and efficacy. *Pain Pract* 2008; 8:277-286.
  45. Dullerud R, Amundsen T, Lie H, Juel NG, Abdelnoor M, Magnaes B. Clinical results after percutaneous automated lumbar nucleotomy. A follow-up study. *Acta Radiol* 1995; 36:418-424.
  46. Pawl RP. Arachnoiditis and epidural fibrosis: The relationship to chronic pain. *Curr Rev Pain* 1998; 2:93-99.
  47. Hoyland JA, Freemont AJ, Jayson MI. Intervertebral foramen venous obstruction. A cause of periradicular fibrosis? *Spine (Phila Pa 1976)* 1989; 14:558-568.
  48. Rydevik BL. The effects of compression on the physiology of nerve roots. *J Manipulative Physiol Ther* 1992; 15:62-66.
  49. Songer MN, Ghosh L, Spencer DL. Effects of sodium hyaluronate on peridural fibrosis after lumbar laminotomy and discectomy. *Spine (Phila Pa 1976)* 1990; 15:550-554.
  50. Hoy D, Brooks P, Blyth F, Buchbinder R. The epidemiology of low back pain. *Best Pract Res Clin Rheumatol* 2010; 24:769-781.
  51. Martin BI, Turner JA, Mirza SK, Lee MJ, Comstock BA, Deyo RA. Trends in health care expenditures, utilization, and health status among US adults with spine problems, 1997 - 2006. *Spine (Phila Pa 1976)* 2009; 34:2077-2084.
  52. Freburger JK, Holmes GM, Agans RP, Jackman AM, Darter JD, Wallace AS, Castel LD, Kalsbeek WD, Carey TS. The rising prevalence of chronic low back pain. *Arch Intern Med* 2009; 169:251-258.
  53. Institute of Medicine (IOM) Consensus Report. *Relieving Pain in America: A Blueprint for Transforming Prevention, Care, Education, and Research*, June 29, 2011. <http://www.iom.edu/-/media/Files/Report%20Files/2011/Relieving-Pain-in-America-A-Blueprint-for-Transforming-Prevention-Care-Education-Research/Pain%20Research%202011%20Report%20Brief.pdf>
  54. Manchikanti L, Singh V, Caraway DL, Benyamin RM, Hirsch JA. Medicare physician payment systems: Impact of 2011 schedule on interventional pain management. *Pain Physician* 2011; 14:E5-E33.
  55. Manchikanti L, Caraway DL, Parr AT, Fellows B, Hirsch JA. Patient Protection and Affordable Care Act of 2010: Reforming health care reform for the new decade. *Pain Physician* 2011; 14:E35-E67.
  56. Gentile DA, Woodhouse J, Lynch P, Maier J, McJunkin T. Reliability and validity of the Global Pain Scale with chronic pain sufferers. *Pain Physician* 2011; 14:61-70.
  57. Gomes LM, Garcia JB, Ribamar JS Jr, Nascimento AG. Neurotoxicity of subarachnoid preservative-free S(+)-ketamine in dogs. *Pain Physician* 2011; 14:83-90.
  58. Manchikanti L, Ailiani H, Koyyalagunta D, Datta S, Singh V, Eriator I, Sehgal N, Shah RV, Benyamin RM, Vallejo R, Fellows B, Christo PJ. A systematic review of randomized trials of long-term opioid management for chronic non-cancer pain. *Pain Physician* 2011; 14:91-121.
  59. Manchikanti L, Vallejo R, Manchikanti KN, Benyamin RM, Datta S, Christo PJ. Effectiveness of long-term opioid therapy for chronic non-cancer pain. *Pain Physician* 2011; 14:E133-E156.
  60. Solanki DR, Koyyalagunta D, Shah RV, Silverman SM, Manchikanti L. Monitoring opioid adherence in chronic pain patients: Assessment of risk of substance misuse. *Pain Physician* 2011; 14:E119-E131.
  61. Manchikanti L, Parr AT, Singh V, Fellows B. Ambulatory surgery centers and interventional techniques: A look at long-term survival. *Pain Physician* 2011; 14:E177-E215.
  62. Manchikanti L, Malla Y, Wargo BW, Fellows B. Comparative evaluation of the accuracy of immunoassay with liquid chromatography tandem mass spectrometry (LC/MS/MS) of urine drug testing (UDT) opioids and illicit drugs in chronic pain patients. *Pain Physician* 2011; 14:175-187.
  63. Manchikanti L, Falco FJ, Benyamin RM, Helm S 2nd, Parr AT, Hirsch JA. The impact of comparative effectiveness research on interventional pain management: Evolution from Medicare Modernization Act to Patient Protection and Affordable Care Act and the Patient-Centered Outcomes Research Institute. *Pain Physician* 2011; 14:E249-E282.
  64. Deer TR, Smith HS, Burton AW, Pope JE, Doleys DM, Levy RM, Staats PS, Wallace MS, Webster LR, Rauck RL, Cousins M. Comprehensive consensus based guidelines on intrathecal drug delivery systems in the treatment of pain caused by cancer pain. *Pain Physician* 2011; 14:E283-E312.
  65. Hayek SM, Deer TR, Pope JE, Panchal SJ, Patel V. Intrathecal therapy for cancer and non-cancer pain. *Pain Physician* 2011; 14:219-248.
  66. Manchikanti L, Malla Y, Wargo BW, Fellows B. Comparative evaluation of the accuracy of benzodiazepine testing in chronic pain patients utilizing immunoassay with liquid chromatography tandem mass spectrometry (LC/MS/MS) of urine drug testing. *Pain Physician* 2011; 14:259-270.
  67. Gupta S. Double needle technique: An alternative method for performing difficult sacroiliac joint injections. *Pain Physician* 2011; 14:281-284.
  68. Manchikanti L, Falco FJE, Singh V, Benyamin RM, Hirsch JA. The Independent Payment Advisory Board. *Pain Physician* 2011; 14:E313-E342.
  69. Zhu J, Falco FJ, Formoso F, Onyewu O, Irwin FL. Alternative approach for lumbar transforaminal epidural steroid injections. *Pain Physician* 2011; 14:331-341.
  70. Ivanova JI, Birnbaum HG, Schiller M, Kantor E, Johnstone BM, Swindle RW. Real-world practice patterns, health-care

- utilization, and costs in patients with low back pain: The long road to guideline-concordant care. *Spine J* 2011; 11:622-632.
71. Manchikanti L, Falco FJE, Hirsch JA. Necessity and implications of ICD-10: Facts and fallacies. *Pain Physician* 2011; 14:E405-E425.
  72. Gharibo C, Varlotta G, Rhame E, Liu ECJ, Bendo J, Perloff M. Interlaminar versus transforaminal epidural steroids for the treatment of sub-acute lumbar radicular pain: A randomized, blinded, prospective outcome study. *Pain Physician* 2011; 14:499-511.
  73. Kim DD, Vakharya R, Kroll HR, Shuster A. Rates of lead migration and stimulation loss in spinal cord stimulation: A retrospective comparison of laminotomy versus percutaneous implantation. *Pain Physician* 2011; 14:513-524.
  74. Boogaard S, Heymans MW, Patijn J, de Vet HC, Faber CG, Peters ML, Loer SA, Zuurmond WW, Perez R. Predictors for persistent neuropathic pain—a Delphi survey. *Pain Physician* 2011; 14:559-568.
  75. Luo X, Pietrobon R, Sun SX, Liu GG, Hey L. Estimates and patterns of direct health care expenditures among individuals with back pain in the United States. *Spine (Phila Pa 1976)* 2004; 29:79-86.
  76. Rubinstein SM, van Middelkoop M, Assendelft WJ, de Boer MR, van Tulder MW. Spinal manipulative therapy for chronic low-back pain: An update of a Cochrane review. *Spine (Phila Pa 1976)* 2011; 36:E825-E846.
  77. Chou R, Huffman L. *Guideline for the Evaluation and Management of Low Back Pain: Evidence Review*. American Pain Society, Glenview, IL, 2009. [www.americanpainsociety.org/uploads/pdfs/LBPEvidRev.pdf](http://www.americanpainsociety.org/uploads/pdfs/LBPEvidRev.pdf)
  78. Staal JB, de Bie RA, de Vet HC, Hildebrandt J, Nelemans P. Injection therapy for subacute and chronic low back pain: An updated Cochrane review. *Spine (Phila Pa 1976)* 2009; 34:49-59.
  79. Manchikanti L, Datta S, Gupta S, Munglani R, Bryce DA, Ward SP, Benyamin RM, Sharma ML, Helm II S, Fellows B, Hirsch JA. A critical review of the American Pain Society clinical practice guidelines for interventional techniques: Part 2. Therapeutic interventions. *Pain Physician* 2010; 13:E215-E264.
  80. Manchikanti L, Singh V, Caraway DL, Benyamin RM, Falco FJE, Hirsch JA. Physician payment outlook for 2012: Déjà Vu. *Pain Physician* 2012; 15:E27-E52.
  81. Schultz DM, Webster L, Kosek P, Dar U, Tan Y, Sun M. Sensor-driven position-adaptive spinal cord stimulation for chronic pain. *Pain Physician* 2012; 15:1-12.
  82. DePalma MJ, Ketchum JM, Saullo TR, Laplante BL. Is the history of a surgical discectomy related to the source of chronic low back pain? *Pain Physician* 2012; 15:E53-E58.
  83. Varhabhatla NC, Zuo Z. Rising complication rates after intrathecal catheter and pump placement in the pediatric population: Analysis of national data between 1997 and 2006. *Pain Physician* 2012; 15:65-74.
  84. Klessinger S. Radiofrequency neurotomy for treatment of low back pain in patients with minor degenerative spondylolisthesis. *Pain Physician* 2012; 15:E71-E78.
  85. Kim H, Choi YL, Lee DK, Choi SS, Lee IO, Kong MH, Kim NS, Lim SH, Lee M. The neurological safety of intrathecal acyclovir in rats. *Pain Physician* 2012; 15:E107-E113.
  86. Manchikanti L, Singh V, Hirsch JA. Saga of payment systems of ambulatory surgery centers for interventional techniques: An update. *Pain Physician* 2012; 15:109-130.
  87. Magalhaes FN, Dotta L, Sasse A, Teixeira MJ, Fonoff ET. Ozone therapy as a treatment for low back pain secondary to herniated disc: A systematic review and meta-analysis of randomized controlled trials. *Pain Physician* 2012; 15:E115-E129.
  88. Wang W, Sun YH, Wang YY, Wang YT, Wang W, Li YQ, Wu SX. Treatment of functional chest pain with antidepressants: A meta-analysis. *Pain Physician* 2012; 15:E131-E142.
  89. Wewalka M, Abdelrahimsai A, Wiesinger GF, Uher EM. CT-guided transforaminal epidural injections with local anesthetic, steroid, and tramadol for the treatment of persistent lumbar radicular pain. *Pain Physician* 2012; 15:153-159.
  90. Kang SS, Hwang BM, Son H, Cheong IY, Lee SJ, Chung TY. Changes in bone mineral density in postmenopausal women treated with epidural steroid injections for lower back pain. *Pain Physician* 2012; 15:229-236.
  91. Lee MG, Huh BK, Choi SS, Lee DK, Lim BG, Lee M. The effect of epidural resiniferatoxin in the neuropathic pain rat model. *Pain Physician* 2012; 15:287-296.
  92. Manchikanti L, Abdi S, Atluri S, Balog CC, Benyamin RM, Boswell MV, Brown KR, Bruel BM, Bryce DA, Burks PA, Burton AW, Calodney AK, Caraway DL, Cash KA, Christo PJ, Damron KS, Datta S, Deer TR, Diwan S, Eriator I, Falco FJE, Fellows F, Geffert S, Gharibo CG, Glaser SE, Grid-er JS, Hameed H, Hameed M, Hansen H, Harned ME, Hayek SM, Helm II S, Hirsch JA, Janata JW, Kaye AD, Kaye AM, Kloth DS, Koyyalagunta D, Lee M, Malla Y, Manchikanti KN, McManus CD, Pampati V, Parr AT, Pasupuleti R, Patel VB, Sehgal N, Silverman SM, Singh V, Smith HS, Snook LT, Solanki DR, Tracy DH, Vallejo R, Wargo BW. American Society of Interventional Pain Physicians (ASIPP) guidelines for responsible opioid prescribing in chronic non-cancer pain: Part I – Evidence assessment. *Pain Physician* 2012; 15:S1-S66.
  93. Manchikanti L, Abdi S, Atluri S, Balog CC, Benyamin RM, Boswell MV, Brown KR, Bruel BM, Bryce DA, Burks PA, Burton AW, Calodney AK, Caraway DL, Cash KA, Christo PJ, Damron KS, Datta S, Deer TR, Diwan S, Eriator I, Falco FJE, Fellows F, Geffert S, Gharibo CG, Glaser SE, Grider JS, Hameed H, Hameed M, Hansen H, Harned ME, Hayek SM, Helm II S, Hirsch JA, Janata JW, Kaye AD, Kaye AM, Kloth DS, Koyyalagunta D, Lee M, Malla Y, Manchikanti KN, McManus CD, Pampati V, Parr AT, Pasupuleti R, Patel VB, Sehgal N, Silverman SM, Singh V, Smith HS, Snook LT, Solanki DR, Tracy DH, Vallejo R, Wargo BW. American Society of Interventional Pain Physicians (ASIPP) guidelines for responsible opioid prescribing in chronic non-cancer pain: Part 2 – Guidance. *Pain Physician* 2012; 15:S67-S116.
  94. Manchikanti L, Helm II S, Fellows B, Janata JW, Pampati V, Grider JS, Boswell MV. Opioid epidemic in the United States. *Pain Physician* 2012; 15:ES9-ES38.
  95. Smith HS. Opioids and neuropathic pain. *Pain Physician* 2012; 15:ES93-ES110.
  96. Nijs J, Kosek E, Van Oosterwijk J, Meeus M. Dysfunctional endogenous analgesia during exercise in patients with chronic pain: To exercise or not to exercise? *Pain Physician* 2012; 15:ES205-ES213.
  97. Manchikanti L, Singh V, Caraway DL, Benyamin RM, Falco FJE, Hirsch JA. Proposed physician payment schedule for 2013: Guarded prognosis for interventional pain management. *Pain Physician* 2012; 15:E615-E627.
  98. Manchikanti L, Hirsch JA. Obamacare 2012: Prognosis unclear for interventional pain management. *Pain Physician* 2012; 15:E629-E640.
  99. Manchikanti L, Caraway DL, Falco FJE, Benyamin RM, Hansen H, Hirsch JA. CMS proposal for interventional pain management by nurse anesthetists: Evidence by proclamation with poor prognosis. *Pain Physician* 2012; 15:E641-E664.



100. Nijs J, Crombez G, Meeus M, Knoop H, Damme SV, Cauwenbergh V, Bleijenberg G. Pain in patients with chronic fatigue syndrome: Time for specific pain treatment? *Pain Physician* 2012; 15:E677-E686.
101. Manchikanti L, Benyamin RM, Swicegood JR, Falco FJE, Datta S, Pampati V, Fellows B, Hirsch JA. Assessment of practice patterns of perioperative management of antiplatelet and anticoagulant therapy in interventional pain management. *Pain Physician* 2012; 15:E955-E968.
102. Manchikanti L, Falco FJE, Singh V, Pampati V, Parr AT, Benyamin RM, Fellows B, Hirsch JA. Utilization of interventional techniques in managing chronic pain in the Medicare population: Analysis of growth patterns from 2000 to 2011. *Pain Physician* 2012; 15:E969-E982.
103. Gupta S, Gupta M, Nath S, Hess GM. Survey of European pain medicine practice. *Pain Physician* 2012; 15:E983-E994.
104. Deer TR, Kim C, Bowman R, Ranson MT, Yee BS. Study of percutaneous lumbar decompression and treatment algorithm for patients suffering from neurogenic claudication. *Pain Physician* 2012; 15:451-460.
105. Manchikanti L, Pampati V, Falco FJE, Hirsch JA. Growth of spinal interventional pain management techniques: Analysis of utilization trends and medicare expenditures 2000 to 2008. *Spine (Phila Pa 1976)* 2013; 38:157-168.
106. Helm S II, Benyamin RM, Chopra P, Deer TR, Justiz R. Percutaneous adhesiolysis in the management of chronic low back pain in post lumbar surgery syndrome and spinal stenosis: A systematic review. *Pain Physician* 2012; 15:E435-E462.
107. Manchikanti L, Cash KA, McManus CD, Pampati V. Assessment of effectiveness of percutaneous adhesiolysis in managing chronic low back pain secondary to lumbar central spinal canal stenosis. *Int J Med Sci* 2013; 10:50-59.
108. Manchikanti L, Singh V, Cash KA, Pampati V, Datta S. Assessment of effectiveness of percutaneous adhesiolysis and caudal epidural injections in managing lumbar post surgery syndrome: A 2-year follow-up of randomized, controlled trial. *J Pain Res* 2012; 5:597-608.
109. Epter RS, Helm S, Hayek SM, Benyamin RM, Smith HS, Abdi S. Systematic review of percutaneous adhesiolysis and management of chronic low back pain in post lumbar surgery syndrome. *Pain Physician* 2009; 12:361-378.
110. Trescott AM, Chopra P, Abdi S, Datta S, Schultz DM. Systematic review of effectiveness and complications of adhesiolysis in the management of chronic spinal pain: An update. *Pain Physician* 2007; 10:129-146.
111. Parr AT, Manchikanti L, Hameed H, Conn A, Manchikanti KN, Benyamin RM, Diwan S, Singh V, Abdi S. Caudal epidural injections in the management of chronic low back pain: A systematic appraisal of the literature. *Pain Physician* 2012; 15:E159-E198.
112. Manchikanti L, Buenaventura RM, Manchikanti KN, Ruan X, Gupta S, Smith HS, Christo PJ, Ward SP. Effectiveness of therapeutic lumbar transforaminal epidural steroid injections in managing lumbar spinal pain. *Pain Physician* 2012; 15:E199-E245.
113. Benyamin RM, Manchikanti L, Parr AT, Diwan SA, Singh V, Falco FJE, Datta S, Abdi S, Hirsch JA. The effectiveness of lumbar interlaminar epidural injections in managing chronic low back and lower extremity pain. *Pain Physician* 2012; 15:E363-E404.
114. Van Boxem K, Cheng J, Patijn J, van Kleef M, Lataster A, Mekhail N, Van Zundert J. 11. Lumbosacral radicular pain. *Pain Pract* 2010; 10:339-358.
115. American College of Occupational and Environmental Medicine (ACOEM). *Low Back Disorders. In: Occupational Medicine Practice Guidelines: Evaluation and Management of Common Health Problems and Functional Recovery of Workers. Second Edition.* American College of Occupational and Environmental Medicine Press, Elk Grove Village, 2007.
116. Manchikanti L, Singh V, Derby R, Schultz DM, Benyamin RM, Prager JP, Hirsch JA. Reassessment of evidence synthesis of occupational medicine practice guidelines for interventional pain management. *Pain Physician* 2008; 11:393-482.
117. *Interventional procedure overview of therapeutic endoscopic division of epidural adhesions in NICE Interventional Procedure Guidance.* National Institute for Health and Clinical Excellence (NICE). April 2009, p 23.
118. Chou R, Atlas SJ, Loeser JD, Rosenquist RW, Stanos SP. Guideline warfare over interventional therapies for low back pain: Can we raise the level of discourse? *J Pain* 2011; 12:833-839.
119. Manchikanti L, Benyamin RM, Falco FJE, Caraway DL, Datta S, Hirsch JA. Guidelines warfare over interventional techniques: Is there a lack of discourse or straw man? *Pain Physician* 2012; 15:E1-E26.
120. Sampson M, Shojania KG, Garrity C, Horsley T, Ocampo M, Moher D. Systematic reviews can be produced and published faster. *J Clin Epidemiol* 2008; 61:531-536.
121. Shojania KG, Sampson M, Ansari MT, Ji J, Doucette S, Moher D. How quickly do systematic reviews go out of date? A survival analysis. *Ann Intern Med* 2007; 147:224-233.
122. Farrar JT, Portenoy RK, Berlin JA, Kinman JL, Strom BL. Defining the clinically important difference in pain outcome measures. *Pain* 2000; 88:287-294.
123. Salaffi F, Stancati A, Silvestri CA, Ciapetti A, Grassi W. Minimal clinically important changes in chronic musculoskeletal pain intensity measured on a numerical rating scale. *Eur J Pain* 2004; 8:283-291.
124. Bombardier C. Outcome assessments in the evaluation of treatment of spinal disorders: Summary and general recommendations. *Spine (Phila Pa 1976)* 2000; 25:3100-3103.
125. Hagg O, Fritzell P, Nordwall A. The clinical importance of changes in outcome scores after treatment for chronic low back pain. *Eur Spine J* 2003; 12:12-20.
126. Manchikanti L, Singh V, Falco FJE, Cash KA, Pampati V. Evaluation of lumbar facet joint nerve blocks in managing chronic low back pain: A randomized, double-blind, controlled trial with a 2-year follow-up. *Int J Med Sci* 2010; 7:124-135.
127. Manchikanti L, Singh V, Falco FJE, Cash KA, Fellows B. Comparative outcomes of a 2-year follow-up of cervical medial branch blocks in management of chronic neck pain: A randomized, double-blind controlled trial. *Pain Physician* 2010; 13:437-450.
128. Manchikanti L, Singh V, Falco FJE, Cash KA, Pampati V, Fellows B. The role of thoracic medial branch blocks in managing chronic mid and upper back pain: A randomized, double-blind, active-control trial with a 2-year follow-up. *Anesthesiol Res Pract* 2012; 2012:585806.
129. Manchikanti L, Singh V, Falco FJ, Cash KA, Fellows B. Cervical medial branch blocks for chronic cervical facet joint pain: A randomized double-blind, controlled trial with one-year follow-up. *Spine (Phila Pa 1976)* 2008; 33:1813-1820.
130. Manchikanti L, Singh V, Cash KA, Pampati V, Damron KS, Boswell MV. A randomized, controlled, double-blind trial of fluoroscopic caudal epidural injections in the treatment of lumbar disc herniation and radiculitis. *Spine (Phila Pa 1976)* 2011; 36:1897-1905.

131. Manchikanti L, Cash RA, McManus CD, Pampati V, Fellows B. Fluoroscopic caudal epidural injections with or without steroids in managing pain of lumbar spinal stenosis: One year results of randomized, double-blind, active-controlled trial. *J Spinal Disord Tech* 2012; 25:226-234.
132. Manchikanti L, Cash KA, McManus CD, Pampati V, Fellows B. Results of 2-year follow-up of a randomized, double-blind, controlled trial of fluoroscopic caudal epidural injections in central spinal stenosis. *Pain Physician* 2012; 15:371-384.
133. Manchikanti L, Singh V, Cash KA, Pampati V, Damron KS, Boswell MV. Effect of fluoroscopically guided caudal epidural steroid or local anesthetic injections in the treatment of lumbar disc herniation and radiculitis: A randomized, controlled, double blind trial with a two-year follow-up. *Pain Physician* 2012; 15:273-286.
134. Manchikanti L, Cash KA, McManus CD, Pampati V. Fluoroscopic caudal epidural injections in managing chronic axial low back pain without disc herniation, radiculitis or facet joint pain. *J Pain Res* 2012; 5:381-390.
135. Manchikanti L, Singh V, Cash KA, Pampati V, Falco FJE. The role of fluoroscopic interlaminar epidural injections in managing chronic pain of lumbar disc herniation or radiculitis: A randomized, double-blind trial. *Pain Pract* 2012 Dec. 27. [Epub ahead of print]
136. Manchikanti L, Cash KA, McManus CD, Pampati V, Benyamin R. Fluoroscopic lumbar interlaminar epidural injections in managing chronic lumbar axial or discogenic pain. *J Pain Res* 2012; 5:301-311.
137. Manchikanti L, Cash KA, Pampati V, Malla Y. Fluoroscopic cervical epidural injections in chronic axial or disc-related neck pain without disc herniation, facet joint pain, or radiculitis. *J Pain Res* 2012; 5:227-236.
138. Manchikanti L, Cash KA, Pampati V, Wargo BW, Malla Y. Management of chronic pain of cervical disc herniation and radiculitis with fluoroscopic cervical interlaminar epidural injections. *Int J Med Sci* 2012; 9:424-434.
139. Manchikanti L, Malla Y, Cash KA, McManus CD, Pampati V. Fluoroscopic epidural injections in cervical spinal stenosis: Preliminary results of a randomized, double-blind, active control trial. *Pain Physician* 2012; 15:E59-E70.
140. Manchikanti L, Malla Y, Cash KA, McManus CD, Pampati V. Fluoroscopic cervical interlaminar epidural injections in managing chronic pain of cervical post-surgery syndrome: Preliminary results of a randomized, double-blind active control trial. *Pain Physician* 2012; 15:13-26.
141. Manchikanti L, Cash KA, McManus CD, Damron KS, Pampati V, Falco FJE. Lumbar interlaminar epidural injections in central spinal stenosis: Preliminary results of a randomized, double-blind, active control trial. *Pain Physician* 2012; 15:51-63.
142. van Tulder M, Furlan A, Bombardier C, Bouter L; Editorial Board of the Cochrane Collaboration Back Review Group. Updated method guidelines for systematic reviews in the Cochrane Collaboration Back Review Group. *Spine (Phila Pa 1976)* 2003; 28:1290-1299.
143. Staal JB, de Bie R, de Vet HC, Hildebrandt J, Nelemans P. Injection therapy for subacute and chronic low-back pain. *Cochrane Database Syst Rev* 2008; 3:CD001824.
144. Furlan AD, Pennick V, Bombardier C, van Tulder M; Editorial Board, Cochrane Back Review Group. 2009 updated method guidelines for systematic reviews in the Cochrane Back Review Group. *Spine (Phila Pa 1976)* 2009; 34:1929-1941.
145. Wells GA, Shea B, O'Connell D, Peterson J, Welch V, Losos M, Tugwell P. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analysis. [www.ohri.ca/programs/clinical\\_epidemiology/oxford.asp](http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp).
146. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ* 2003; 327:557-560.
147. Harris RP, Helfand M, Woolf SH, Lohr KN, Mulrow CD, Teutsch SM, Atkins D; Methods Work Group, Third US Preventive Services Task Force. Current methods of the US Preventive Services Task Force. *Am J Prevent Med* 2001; 20:21-35.
148. Hansen H, Manchikanti L, Simopoulos TT, Christo PJ, Gupta S, Smith HS, Hameed H, Cohen SP. A systematic evaluation of the therapeutic effectiveness of sacroiliac joint interventions. *Pain Physician* 2012; 15:E247-E278.
149. Helm S II, Deer TR, Manchikanti L, Datta S, Chopra P, Singh V, Hirsch JA. Effectiveness of thermal annular procedures in treating discogenic low back pain. *Pain Physician* 2012; 15:E279-E304.
150. Simopoulos TT, Manchikanti L, Singh V, Gupta S, Hameed H, Diwan S, Cohen SP. A systematic evaluation of prevalence and diagnostic accuracy of sacroiliac joint interventions. *Pain Physician* 2012; 15:E305-E344.
151. Diwan SA, Manchikanti L, Benyamin RM, Bryce DA, Geffert S, Hameed H, Sharma ML, Abdi S, Falco FJE. Effectiveness of cervical epidural injections in the management of chronic neck and upper extremity pain. *Pain Physician* 2012; 15:E405-E434.
152. Manchikanti KN, Atluri S, Singh V, Geffert S, Sehgal N, Falco FJE. An update of evaluation of therapeutic thoracic facet joint interventions. *Pain Physician* 2012; 15:E463-E481.
153. Atluri S, Singh V, Datta S, Geffert S, Sehgal N, Falco FJE. Diagnostic accuracy of thoracic facet joint nerve blocks: An update of the assessment of evidence. *Pain Physician* 2012; 15:E483-E496.
154. Benyamin RM, Wang VC, Vallejo R, Singh V, Helm S II. A systematic evaluation of thoracic interlaminar epidural injections. *Pain Physician* 2012; 15:E497-E514.
155. Singh V, Manchikanti L, Onyewu O, Benyamin RM, Datta S, Geffert S, Parr AT, Falco FJE. An update of appraisal of accuracy of thoracic discography as a diagnostic test for chronic spinal pain. *Pain Physician* 2012; 15:E757-E776.
156. Onyewu O, Manchikanti L, Falco FJE, Singh V, Geffert S, Helm S II, Cohen SP, Hirsch JA. An update of the appraisal of the accuracy and utility of cervical discography in chronic neck pain. *Pain Physician* 2012; 15:E777-E806.
157. Falco FJE, Datta S, Manchikanti L, Sehgal N, Geffert S, Singh V, Smith HS, Boswell MV. An updated review of diagnostic utility of cervical facet joint injections. *Pain Physician* 2012; 15:E807-E838.
158. Falco FJE, Manchikanti L, Datta S, Wargo BW, Geffert S, Bryce DA, Atluri S, Singh V, Benyamin RM, Sehgal N, Ward S, Helm S II, Gupta S, Boswell MV. Systematic review of therapeutic effectiveness of cervical facet joint interventions: An update. *Pain Physician* 2012; 15:E839-E868.
159. Falco FJE, Manchikanti L, Datta S, Sehgal N, Geffert S, Onyewu O, Singh V, Bryce DA, Benyamin RM, Simopoulos TT, Vallejo R, Gupta S, Ward SP, Hirsch JA. An update of the systematic assessment of the diagnostic accuracy of lumbar facet joint nerve blocks. *Pain Physician* 2012; 15:E869-E907.
160. Falco FJE, Manchikanti L, Datta S, Sehgal N, Geffert S, Onyewu O, Zhu J, Coubarous S, Hameed M, Ward SP, Sharma M, Hameed H, Singh V, Boswell MV. An update of the effectiveness of therapeutic lumbar facet joint interventions. *Pain Physician* 2012; 15:E909-E953.
161. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, Clarke M, Devereaux PJ, Kleijnen J, Moher D. The

- PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *Ann Intern Med* 2009; 151:W65-W94.
162. Chopra P, Smith HS, Deer TR, Bowman RC. Role of adhesiolysis in the management of chronic spinal pain: A systematic review of effectiveness and complications. *Pain Physician* 2005; 8:87-100.
  163. Gillespie G, MacKenzie P. Epiduroscopy -A review. *Scot Med J* 2004; 49:79-81.
  164. Saberski LR, Brull SJ. Spinal and epidural endoscopy: A historical review. *Yale J Biol Med* 1995; 68:7-15.
  165. Helm S II, Gross JD, Varley KG. Mini-surgical approach for spinal endoscopy in the presence of stenosis of the sacral hiatus. *Pain Physician* 2004; 7:323-325.
  166. Choi YK, Barbella JD. Evaluation of epidurographic contrast patterns with fluoroscopic-guided lumbar interlaminar ventral epidural injection. *Pain Pract* 2009; 9: 275-281.
  167. Heavner JE, Bosscher H, Dunn D, Lehman T. Xanthosis in the spinal epidural space an epiduroscopy finding. *Pain Pract* 2004; 4:39-41.
  168. Mourgela S, Anagnostopoulou S, Sakellaropoulos A, Koulousakis A, Warnke JP. Endoscopic anatomy of the thecal sac using a flexible steerable endoscope. *J Neurosurg Sci* 2007; 51:93-98.
  169. Raffaelli W, Righetti D. How we can see and treat the epidural space: Epiduroscopy. *Eur J Pain Suppl* 2011; 5:395-399.
  170. Richardson J, Kallewaard JW, Groen GJ. Spinal endoscopy for chronic sciatica. *Br J Anaesth* 2005; 95:275-276.
  171. Saberski LR, Kitahata LM. Direct visualization of the lumbosacral epidural space through the sacral hiatus. *Anesth Analg* 1995; 80:839-840.
  172. Warnke J, Di X. Percutaneous approach for thecaloscopy of the lumbar subarachnoidal space. *Minim Invasive Neurosurg* 2007; 50:129-131.
  173. Manchikanti L, Saini B, Singh V. Spinal endoscopy and lysis of epidural adhesions in the management of chronic low back pain. *Pain Physician* 2001; 4:240-265.
  174. Saberski LR, Kitahata L. Persistent radiculopathy diagnosed and treated with epidural endoscopy. *J Anesth* 1996; 10:292-295.
  175. Chan JW. Bilateral scotomas associated with retinal hemorrhages following endoscopic spinal surgery. *Eye* 2004; 18:752-753.
  176. Gill JB, Heavner JE. Visual impairment following epidural fluid injections and epiduroscopy: A review. *Pain Med* 2005; 6:367-374.
  177. Heavner JE, Bosscher H. Epiduroscopy and radiation exposure. *Reg Anesth Pain Med* 2009; 34:79.
  178. Heavner J, Wyatt D, Bosscher H. Lumbosacral epiduroscopy complicated by intravascular injection. *Anesthesiology* 2007; 107:347-350.
  179. Justiz R, Taylor V, Day M. Neurogenic bladder: A complication after endoscopic adhesiolysis with return of bladder function while using nitrofurantoin. *Anesth Analg* 2010; 110:1496-1498.
  180. Komiya K, Igarashi T, Suzuki H, Hirabayashi Y, Waechter J, Seo N. In vitro study of patient's and physician's radiation exposure in the performance of epiduroscopy. *Reg Anesth Pain Med* 2008; 33:98-101.
  181. Mizuno J, Gauss T, Suzuki M, Hayashida M, Arita H, Hanaoka K. Encephalopathy and rhabdomyolysis induced by iotrolan during epiduroscopy. *Can J Anesth* 2007; 54:49-53.
  182. Di Donato A, Fontana C, Alemanno D, Di Giacomo A. Epiduroscopy in treatment of degenerative chronic low back pain: A prospective analysis and follow-up at 60 months. *Clin Res Reg Aff* 2010; 27:69-74.
  183. Di Donato AD, Fontana C, Pinto R, Beltrutti D, Pinto G. The effectiveness of endoscopic epidurolysis in treatment of degenerative chronic low back pain: A prospective analysis and follow-up at 48 months. *Acta Neurochir Suppl* 2011; 108:67-73.
  184. Manchikanti L, Rivera JJ, Pampati V, Damron KS, Beyer CD, Brandon DE, Wilson SR. Spinal endoscopic adhesiolysis in the management of chronic low back pain: A preliminary report of a randomized, double-blind trial. *Pain Physician* 2003; 6:259-267.
  185. Dashfield AK, Taylor MB, Cleaver JS, Farrow D. Comparison of caudal steroid epidural with targeted steroid placement during spinal endoscopy for chronic sciatica: A prospective, randomized, double-blind trial. *Br J Anaesth* 2005; 94:514-559.
  186. Richardson J, McGurgan P, Cheema S, Prasad R, Gupta S. Spinal endoscopy in chronic low back pain with radiculopathy. A prospective case series. *Anaesthesia* 2001; 56:454-460.
  187. Warnke J, Mourgela S. Endoscopic treatment of lumbar arachnoiditis. *Minim Invasive Neurosurg* 2007; 50:1-6.
  188. Richter E, Abramova MV, DeAndres J, Lierz P, Manchiaro P, Van Buyten JP, Kim JD, Jang JH, Jung FH, Kim JY, Jang SJ, Salgado H, Salgado P, Alo KM. Anterior epiduroscopic neural decompression: Eight-center experience in 154 patients. *Eur J Pain Suppl* 2011; 5:401-407.
  189. Richter E, Rothstein L. Minimally invasive anterior epidural endoscopic disc and neural decompression. *J Neurosurg Rev* 2011; 1:520-528.
  190. Ruetten S, Meyer O, Godolias G. Endoscopic surgery of the lumbar epidural space (epiduroscopy): Results of therapeutic intervention in 93 patients. *Minim Invasive Neurosurg* 2003; 46:1-4.
  191. Saberski L. A retrospective analysis of spinal canal endoscopy and laminectomy outcomes data. *Pain Physician* 2000; 3:193-196.
  192. Sakai T, Aoki H, Hojo M, Takada M, Murata H, Sumikawa K. Adhesiolysis and targeted steroid/local anesthetic injection during epiduroscopy alleviates pain and reduces sensory nerve dysfunction in patients with chronic sciatica. *J Anesth* 2008; 22:242-247.
  193. Tobita T, Okamoto M, Tomita M, Yamakura T, Fujihara H, Baba H, Uchiyama S, Hamann W, Shimoji K. Diagnosis of spinal disease with ultrafine flexible fiberscopes in patients with chronic pain. *Spine (Phila Pa 1976)* 2003; 28:2006-2012.
  194. Avellanal M, Diaz-Reganon G. Interlaminar approach for epiduroscopy in patients with failed back surgery syndrome. *Br J Anaesth* 2008; 101:244-249.
  195. Geurts JW, Kallewaard JW, Richardson J, Groen GJ. Targeted methylprednisolone acetate/hyaluronidase/clonidine injection after diagnostic epiduroscopy for chronic sciatica: A prospective, 1-year follow-up study. *Reg Anesth Pain Med* 2002; 27:343-352.
  196. Igarashi T, Hirabayashi Y, Seo N, Saitoh K, Fukuda H, Suzuki H. Lysis of adhesions and epidural injection of steroid/local anaesthetic during epiduroscopy potentially alleviate low back and leg pain in elderly patients with lumbar spinal stenosis. *Br J Anaesth* 2004; 93:181-187.
  197. Takeshima N, Miyakawa H, Okuda K, Hattori S, Hagiwara S, Takatani J, Noguchi T. Evaluation of the therapeutic results of epiduroscopic adhesiolysis for failed back surgery syndrome. *Br J Anaesth* 2009; 102:400-407.
  198. Mavrocordatos P, Cahana A. Minimally invasive procedures for the treatment of failed back surgery syndrome. *Adv Tech Stand Neurosurg* 2011; 31:221-252.
  199. Manchikanti L, Boswell MV, Rivera JJ, Pampati V, Damron KS, McManus CD,

- Brandon DE, Wilson SR. A randomized, controlled trial of spinal endoscopic adhesiolysis in chronic refractory low back and lower extremity pain. *BMC Anesthesiol* 2005; 5:10.
200. Manchikanti L, Pampati V, Bakhit CE, Pakanati RR. Non-endoscopic and endoscopic adhesiolysis in post lumbar laminectomy syndrome: A one-year outcome study and cost effectiveness analysis. *Pain Physician* 1999; 2:52-58.
201. Manchikanti L, Pakanati RR, Pampati V. The value and safety of epidural endoscopic adhesiolysis. *Am J Anesthesiol* 2000; 27:275-279.
202. Murai K, Suzuki H, Igarashi T, Kawaniishi M, Naiki R, Seo N, Sato T, Namiki Y, Hanaoka K, Ogawa S; The Japan Society of Epiduroscopy. Epiduroscopy for intractable low back pain or sciatica in operated and non-operated back patients: Results from the Japan Society of Epiduroscopy. *Pain Clin* 2007; 19:163-169.
203. Kim JD, Jang JH, Jung GH, Kim JY, Jang SJ. Epiduroscopic laser disc and neural decompression. *J Neurosurg Rev* 2011; 1:14-19.
204. Manchikanti L, Singh V. Epidural lysis of adhesions and myelography. *Curr Pain Headache Rep* 2002; 6:427-435.
205. Heavner J, Bosscher H. Complications of lumbosacral epiduroscopy. *Pain Clin* 2007; 19:178-184.
206. Saberski L, Gerena F. Safety of epidural endoscopy. *Reg Anesth Pain Med* 1998; 23:324-325.
207. Manchikanti L, Malla Y, Wargo BW, Cash KA, McManus CD, Damron KS, Jackson SD, Pampati V, Fellows B. A prospective evaluation of bleeding risk of interventional techniques in chronic pain. *Pain Physician* 2011; 14:317-329.
208. Manchikanti L, Malla Y, Wargo BW, Fellows B. Infection control practices (safe injection and medication vial utilization) for interventional techniques: Are they based on relative risk management or evidence? *Pain Physician* 2011; 14:425-434.
209. Manchikanti L, Falco FJE, Benyamin RM, Caraway DL, Helm II, S, Wargo BW, Hansen H, Parr AT, Singh S, Hirsch JA. Assessment of infection control practices for interventional techniques: A best evidence synthesis of safe injection practices and use of single-dose medication vials. *Pain Physician* 2012; 15:E573-E614.
210. 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.
211. Manchikanti L, Benyamin RM, Swicegood JR, Falco FJE, Datta S, Pampati V, Fellows B, Hirsch JA. Assessment of practice patterns of perioperative management of antiplatelet and anticoagulant therapy in interventional pain management. *Pain Physician* 2012; 15:E955-E968.
212. Manchikanti L, Malla Y, Wargo BW, Fellows B. Preoperative fasting before interventional techniques: Is it necessary or evidence-based? *Pain Physician* 2011; 14:459-467.
213. Manchikanti L, Malla Y, Wargo BW, Cash KA, Pampati V, Fellows B. A prospective evaluation of complications of 10,000 fluoroscopically directed epidural injections. *Pain Physician* 2012; 15:131-140.
214. Manchikanti L, Malla Y, Wargo BW, Cash KA, Pampati V, Fellows B. Complications of fluoroscopically directed facet joint nerve blocks: A prospective evaluation of 7,500 episodes with 43,000 nerve blocks. *Pain Physician* 2012; 15:E143-E150.
215. Amirikia A, Scott IU, Murray TG, Halperin LS. Acute bilateral visual loss associated with retinal hemorrhage following epiduroscopy. *Arch Ophthalmol* 2000; 118:287-289.
216. Naseri A, Blumenkranz MS, Horton JC. Terson's syndrome following epidural saline injection. *Neurology* 2001; 57:364.
217. Tabandeh H. Intraocular hemorrhages associated with endoscopic spinal surgery. *Am J Ophthalmol* 2000; 129:688-690.
218. Shah RV, Heavner JE. Recognition of the subarachnoid and subdural compartments during epiduroscopy: Two cases. *Pain Pract* 2003; 3:321-325.
219. Hauck EF, Wittkowski W, Bothe HW. Intradural microanatomy of the nerve roots S1-S5 at their origin from the conus medullaris. *J Neurosurg Spine* 2008; 9:207-212.
220. Arslan M, Cömert A, Açar H, Özdemir M, Elhan A, Tekdemir, Tubbs SR, Attar A, Uur HÇ. Lumbosacral intrathecal nerve roots: an anatomical study. *Acta Neurochirurgica* 2011; 153:1435-1442.
221. Ludwig H, Kruschat T, Knobloch T, Teichmann HO, Rostasy K, Rohde V. First experiences with a 2.0-µm near infrared laser system for neuroendoscopy. *Neurosurg Rev* 2007; 30:195-201.
222. Kang SS, Hwang BM, Son HJ, Cheong IY, Lee SJ, Lee SH, Chung TY. The dosages of corticosteroid in transforaminal epidural steroid injections for lumbar radicular pain due to a herniated disc. *Pain Physician* 2011; 14:361-370.
223. Gazelka HM, Burgher AH, Huntoon MA, Mantilla CB, Hoelzer BC. Determination of the particulate size and aggregation of clonidine and corticosteroids for epidural steroid injection. *Pain Physician* 2012; 15:87-93.
224. Wegener B, Rieskamp K, Büttner A, Habiyambere V, von Schultze-Pellangahr C, Schaffer V, Jansson V, Birkenmaier C. Experimental evaluation of the risk of extradiscal thermal damage in intradiscal electrothermal therapy (IDET). *Pain Physician* 2012; 15:E99-E106.
225. Manchikanti L, Singh V. Corticosteroids. In: Manchikanti L, Christo PJ, Trescot AM, Falco FJE (eds). *Foundations of Pain Medicine and Interventional Pain Management: A Comprehensive Review*. ASIPP Publishing, Paducah, KY, 2011, pp 589-606.
226. Dashfield A, Taylor M. In response to "Spinal endoscopy for chronic sciatica." *Br J Anaesth* 2005; 95:276.
227. Bosscher H, Heavner J. Diagnosis of the vertebral level from which low back or leg pain originates. A comparison of clinical evaluation, MRI and epiduroscopy. *Pain Pract* 2012; 12:506-512.
228. Vanelderden P, van Boxem K, Van Zundert J. Editorial: Epiduroscopy: The missing link connecting diagnosis and treatment. *Pain Pract* 2012; 12:499-501.