Systematic Review

Effectiveness of Spinal Endoscopic Adhesiolysis in Post Lumbar Surgery Syndrome: A Systematic Review

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Background: Post lumbar surgery syndrome with persistent chronic low back and lower extremity pain is common in the United States. Epidural fibrosis may account for as much as 20% to 36% of all cases of failed back surgery syndrome (FBSS). Percutaneous adhesiolysis with a catheter or direct visualization of the spinal canal and the contents with an endoscope are techniques employed in resistant cases when patients fail to respond to conservative modalities of treatment, including fluoroscopically directed epidural injections. Some patients failing to respond to percutaneous adhesiolysis are candidates for spinal endoscopic adhesiolysis. However, literature evaluating the effectiveness of spinal endoscopic adhesiolysis is sparse and discussions continue about its effectiveness, utility, and complications.

Study Design: A systematic review of the available literature.

Objective: To evaluate the effectiveness and safety of spinal endoscopic adhesiolysis in the management of chronic low back and lower extremity pain in post surgical patients with chronic recalcitrant pain, non-responsive to conservative modalities of management and fluoroscopically directed epidural injections.

Methods: A search of relevant resources (PubMed, EMBASE, and the Cochrane database) was accomplished and the resulting publications were examined based on the inclusion/exclusion criteria set forth. Randomized controlled trials and observational studies were included in the search. Two reviewers assessed the studies' methodologies and outcomes. Randomized clinical trials were assessed and scored based on the criteria established by the Cochrane methodological assessment criteria of randomized clinical trials and the observational studies were assessed and scored based on the Agency for Healthcare Research and Quality (AHRQ) criteria.

Clinical relevance was evaluated utilizing Cochrane review criteria.

Analysis was conducted using 5 levels of evidence, ranging from Level I to III, with 3 subcategories in Level II.

Outcome Measures: The primary outcome measure was pain relief (≥ 50%) in follow-up for at least 6 months. Pain relief for longer than 6 months was considered long-term and 6 months or less was considered short-term. The secondary outcome measures were functional and psychological status, return to work, patient satisfaction, and opioid intake.

Results: Of the 13 studies considered for inclusion, one randomized trial and 5 observational studies met inclusion criteria for evidence synthesis based on the inclusion criteria and methodologic quality scores of 50 or more.

The indicated level of evidence for endoscopic adhesiolysis is Level II-1 or II-2 evidence for short- and long-term relief based on the U.S. Preventive Services Task Force (USPSTF) criteria.

Limitations: There was a paucity of literature for randomized trials.

Conclusion: Spinal endoscopic adhesiolysis may be used as an effective treatment modality for chronic refractory low back pain and radiculopathy that is related to epidural adhesions.

Key words: Chronic low back pain, lower extremity pain, lumbar post surgery syndrome, failed back surgery syndrome, percutaneous adhesiolysis, endoscopic adhesiolysis, epidural adhesions, epidural fibrosis

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Failed back surgery syndrome (FBSS), representing a cluster of symptoms following spine surgery, is also described as post lumbar laminectomy syndrome or post surgery syndrome (1-5). Persistent, chronic, disabling pain which is non-responsive to various modalities of conservative and interventional treatments following lumbar spine surgery is common (1-11). Due to an exponential increase in surgical interventions, it appears that the cost of persistent pain following lumbar spine surgery also continues to increase (12-22). In addition, the literature continues to demonstrate an increase in prevalences and care seeking for spinal pain (23,24).

Animal models of post lumbar laminectomy syndrome demonstrate paraspinal muscle spasms, tail contractures, pain behaviors, tactile allodynia, epidural and perineural scarring, and nerve root adherence to the underlying disc and pedicle (25-30). Various causes of post surgery syndrome or FBSS include epidural fibrosis, acquired stenosis, internal disc disruption, recurrent disc herniation, facet joint pain, sacroiliac joint pain, arachnoiditis, segmental instability, and others (1-8,17,31-37). Epidural fibrosis may account for as much as 20% to 36% of all cases of FBSS (6,7,31,33-37). Further, a final common pathway resulting in peripheral and central facilitation potentiated by inflammatory and nerve injury mechanisms has been described (25-30). A correlation between peridural scarring and radicular pain (6,38-40) and poor clinical outcomes (41) have been reported. However, others (42-44) have questioned the role of epidural fibrosis as a causative factor.

While the mechanism of FBSS pain could involve a long list of pathologies, it is accepted that epidural adhesions that develop following surgical manipulation of the space or small hematomas may be an important etiologic factor (6,7,33,34,45,46). Epidural fibrosis could trigger nociceptive activity as it compresses the nerve roots (47). Further, epidural fibrosis restricts the movement of nerves through the nerve sleeves and decreases the flexibility of the nerve roots by tethering them (47).

Epidural procedures for managing chronic low back are one of the most commonly performed interventions in the United States (48-60). However, only a moderate proportion of these patients show improvement in pain and functional level with interventional pain management procedures, including epidural injections and adhesiolysis (1,61-70).

Imaging techniques such as computed tomography (CT) and magnetic resonance imaging (MRI) are not specific and cannot identify epidural fibrosis. Direct visualization of the pathologic changes inside the spinal canal may be necessary to confirm the diagnosis and additionally can be used as a therapeutic tool in dissecting fibrotic tissue and injecting medications. Indeed, instrumentation with epidural endoscopes in patients with chronic back pain has been used for mechanical adhesiolysis (breaking up adhesions by pulling and dissecting), sheer volume adhesiolysis (injecting a relatively large volume of saline), and target-directed delivery of steroids close to the affected nerve root(s).

Spinal endoscopic adhesiolysis has emerged during the 1990s after years of advances in instrumentation. Imaging tools and fiberoptic technology made possible the development of small flexible endoscopes with high image resolution. The historical perspective of spinal endoscopy is well described by Manchikanti et al (36). Current U.S. Food and Drug Administration (FDA) approved indications for the use of spinal endoscopy are as follows: documentation of pathological features, documentation of decompression of structures, direct nerve inspection, inspection of internal fixation, and delivery of therapeutic agents.

Spinal endoscopic adhesiolysis offers potential advantages in the management of chronic refractory low back and leg pain, including direct visualization of spinal structures allowing specific adhesiolysis and targeted deposition of medications. Nonetheless, effective application of this technology warrants evaluation of clinical trials to determine its efficacy in the context of specific clinical conditions and analysis of risks associated with the procedure.

This systematic review is undertaken to evaluate the effectiveness of spinal endoscopic adhesiolysis in treating low back and/or radicular pain in patients with failed low back surgery syndrome.

Methods

Search Strategy

Bibliographic resources such as PubMed, CINAHL, EMBASE, Cochrane Database of Systematic Reviews, and Cochrane Controlled Trials Register were used to search for English language studies published from 1966 until December 2008. Keywords used to search were spinal adhesions, adhesiolysis, epidural adhesiolysis, epiduroscopy, lumbar post surgery syndrome, lumbar post-laminectomy syndrome, and failed back surgery syndrome.

Study Selection

Search results from all databases were combined and duplicates were removed. Reference lists from retrieved articles were also reviewed for additional relevant studies that were not identified in our search. All articles were triaged for inclusion by the first author for suitability prior to review.

Inclusion criteria included all studies evaluating the role of spinal endoscopy as a therapeutic tool for adhesiolysis in managing chronic low back pain with or without lower extremity pain secondary to post lumbar surgery syndrome. All the patients should have tried and failed conservative management, including fluoroscopically directed epidural injections.

Exclusion criteria included non-clinical studies, expert opinions, reports without appropriate diagnosis, non-systematic reviews, book chapters, and case reports.

Outcome Measurements

Significant pain relief (≥ 50%) of short-term (≤ 6 months) and long-term (> 6 months) was the primary outcome measure. Secondary outcomes included functional or psychological improvement, improvement in work status, and complications.

Methodological Quality Assessment

The methodologic quality of each individual article used in this analysis was assessed by the Agency for Healthcare Research and Quality (AHRQ) criteria for assessment of observational studies (71) and modified Cochrane review criteria with weighted scores (72) for randomized trials and with consensus-based weighted scoring developed by the guidelines committee of the American Society of Interventional Pain Physicians (ASIPP). These criteria have been revised and also have been utilized in other publications (68,73-83). A standardized form was used to extract the relevant data on the methods used, participants, interventions, outcome measures used and timing of outcome measurement, reported side effects, and the main results. Studies could earn points for each criterion met with a maximum score of 100 points. The authors independently scored each article using the method described. Only studies scoring 50 or above were used in the analysis. Any discrepancies or conflicts were arbitrated by a third reviewer to either reach a consensus agreement or break a tie. If there was a conflict of interest with the reviewed manuscripts with authorship or any other type of conflict, the involved authors did not review the manuscripts for quality assessment or evidence synthesis.

Observational studies were only included in the evidence synthesis if there were less than 4 randomized trials meeting the inclusion criteria.

Clinical Relevance

Clinical relevance of the included studies was evaluated according to 5 questions recommended by the Cochrane Back Review Group (60,84). Each question was scored positive (+) if the clinical relevance item was met, negative (–) if the item was not met, and unclear (?) if data were not available to answer the question.

In the recent Cochrane review of "Injection Therapy for Subacute and Chronic Low Back Pain" (60) the authors considered a 20% improvement in pain scores (85) and a 10% improvement in functioning outcomes (86) to be clinically important. This study utilized stricter criteria than general systematic reviews and previous systematic reviews. Any relief of 6 months or less was considered as short-term, whereas Cochrane reviews (60) and others have considered 6 weeks as short-term and longer than 6 weeks as long-term. We also utilized very strict methodologic quality assessment criteria (60) to minimize inclusion, thus this systematic review is expected to provide robust results because of the stricter criteria. Further, in contrast to many other systematic reviews, in this systematic review, observational studies with scores of 50 or more on a scale of 0 – 100 based on AHRQ criteria were included. This improves the generalizability of the systematic review as well as the intervention (87-91).

Qualitative Analysis of Evidence

A qualitative analysis was conducted using 5 levels of evidence for effectiveness of spinal endoscopic adhesiolysis as illustrated in Table 1. The levels of evidence range from Level I to Level III, with Level II having 3 subcategories (92).

Recommendations

Qualitative recommendations relative to the quality of evidence for each outcome was judged based on criteria established by Guyatt et al (93) as shown in Table 2.

Outcomes of the Studies

A study was judged to be positive if the endoscopic adhesiolysis was clinically relevant and effec-

Table 1. *Modified quality of evidence developed by USPSTF.*

I:	Evidence obtained from at least one properly randomized controlled trial
II-1:	Evidence obtained from well-designed controlled trials without randomization
II-2:	Evidence obtained from well-designed cohort or case-control analytic studies, preferably from more than one center or research group
II-3:	Evidence obtained from multiple time series with or without the intervention. Dramatic results in uncontrolled experiments (such as the results of the introduction of penicillin treatment in the 1940s) could also be regarded as this type of evidence
III:	Opinions of respected authorities, based on clinical experience descriptive studies and case reports or reports of expert committees

Adapted and modified from the U.S. Preventive Services Task Force (USPSTF) (92).

Table 2. *Grading recommendations.*

Grade of Recommendation/ Description	Benefit vs Risk and Burdens	Methodological Quality of Supporting Evidence	Implications
1A/strong recommendation, high-quality evidence	Benefits clearly outweigh risk and burdens, or vice versa	RCTs without important limitations or overwhelming evidence from observational studies	Strong recommendation, can apply to most patients in most circumstances without reservation
1B/strong recommendation, moderate quality evidence	Benefits clearly outweigh risk and burdens, or vice versa	RCTs with important limitations (inconsistent results, methodological flaws, indirect, or imprecise) or exceptionally strong evidence from observational studies	Strong recommendation, can apply to most patients in most circumstances without reservation
1C/strong recommendation, low-quality or very low-quality evidence	Benefits clearly outweigh risk and burdens, or vice versa	Observational studies or case series	Strong recommendation but may change when higher quality evidence becomes available
2A/weak recommendation, high-quality evidence	Benefits closely balanced with risks and burden	RCTs without important limitations or overwhelming evidence from observational studies	Weak recommendation, best action may differ depending on circumstances or patients' or societal values
2B/weak recommendation, moderate-quality evidence	Benefits closely balanced with risks and burden	RCTs with important limitations (inconsistent results, methodological flaws, indirect, or imprecise) or exceptionally strong evidence from observational studies	Weak recommendation, best action may differ depending on circumstances or patients' or societal values
2C/weak recommendation, low-quality or very low-quality evidence	Uncertainty in the estimates of benefits, risks, and burden; benefits, risk, and burden may be closely balanced	Observational studies or case series	Very weak recommendations; other alternatives may be equally reasonable

Adapted from Guyatt G et al. Grading strength of recommendations and quality of evidence in clinical guidelines. Report from an American College of Chest Physicians task force. *Chest* 2006; 129:174-181 (93).

tive, either with a placebo control or active control in randomized trials. This indicates that the difference in the effect for the primary outcome measure was statistically significant at the conventional 5% level. In a negative study, no difference between the study treatment or no improvement from baseline was reported. Further, the outcomes were judged at the reference point with positive or negative results reported at 3 months, 6 months, and one year.

For observational studies, a study was judged to be positive if the endoscopic adhesiolysis was effective, with outcomes reported at the references point with positive or negative results at 3 months, 6 months, and one year.

Results

A literature search was carried out for endoscopic adhesiolysis as shown in Fig. 1.

Our search strategy yielded multiple studies evaluating the effectiveness of endoscopic adhesiolysis that were considered for inclusion. These included 2 systematic reviews (69,70) and 13 studies (67,94-105). Of these, there were 3 randomized trials (67,96,98), and 11 observational studies (94,95,97,99-106).

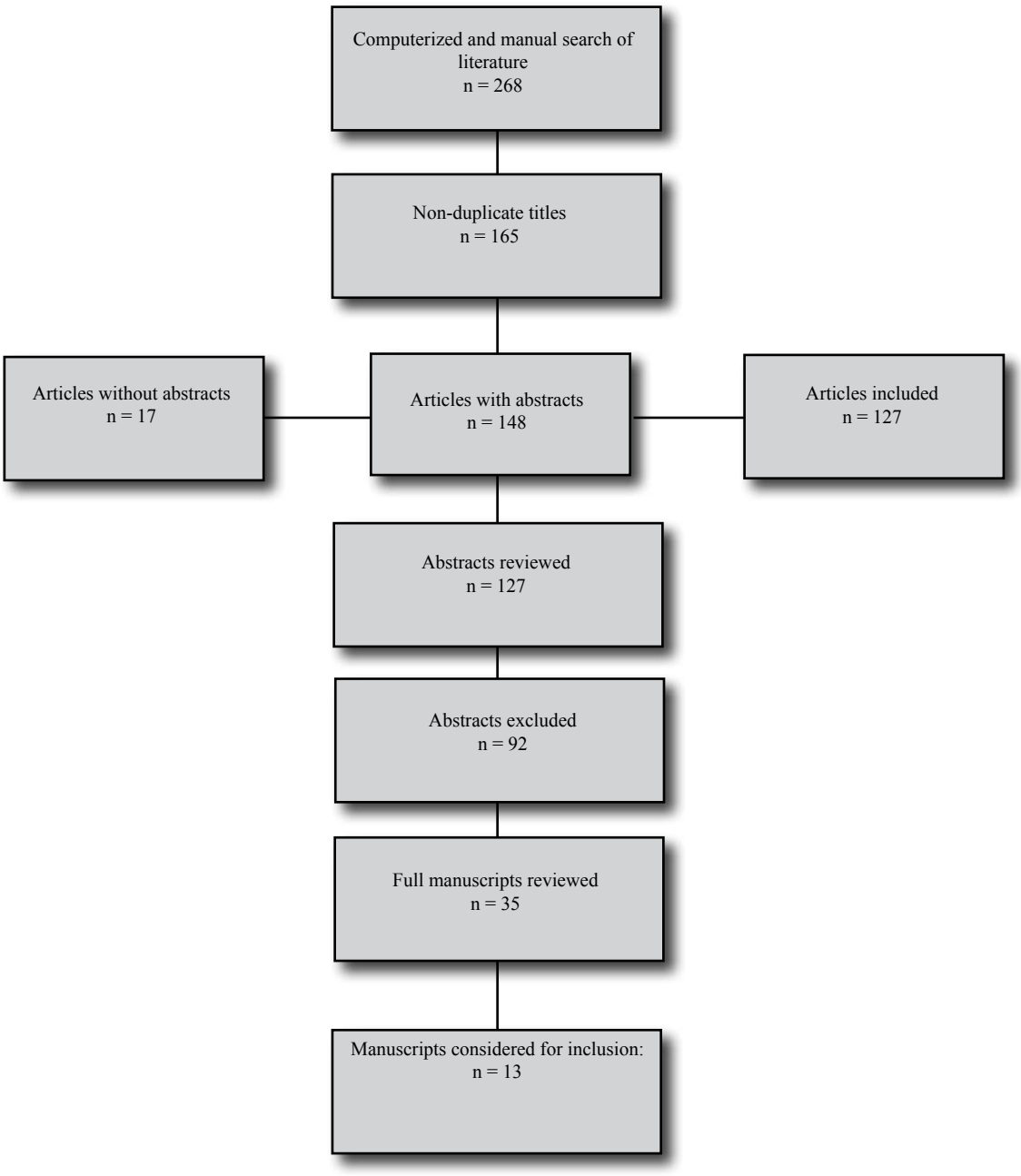

Fig. 1. *The flow diagram illustrating available literature of endoscopic adhesiolysis.*

Randomized Trials

Methodologic Quality Assessment

Of the 3 randomized trials (67,96,98), one was a preliminary report (96). The study by Dashfield et al (98) evaluated patients without surgical intervention and without prior treatment with fluoroscopically directed epidural injections. The indications for spinal endoscopic adhesiolysis in this study were flawed. Thus, it was excluded from methodologic quality assessment.

The sole randomized trial (67) that met the inclusion criteria had a heterogenous population.

Methodologic quality assessment criteria of the one study meeting inclusion criteria are illustrated in Table 3. The quality assessment criteria was 69.

Clinical Relevance Assessment

Table 4 illustrates the clinical relevance of the randomized trial.

Study Characteristics

Manchikanti et al (67) evaluated the effectiveness of spinal endoscopic adhesiolysis in chronic refractory low back and lower extremity pain in a randomized controlled trial. However, this trial was not a placebo-control, but was a randomized, double blind, equivalence or non-inferiority trial utilizing an active control design. These studies are common in interventional pain management and are considered to be ideal (63-65,87-91,107-114). In this study, a total of 83 patients were evaluated, with 33 patients in Group I and 50 pa-

Table 3. *Methodological assessment of randomized clinical trials of therapeutic of spinal endoscopic adhesiolysis.*

CRITERION		WEIGHTED SCORE (points)	Manchikanti et al (67)
1. Study population		35	14
A	Homogeneity	2	2
B	Comparability of relevant baseline characteristics	5	5
C	Randomization procedure adequate	4	4
D	Drop-outs described for each study group separately	3	3
E	< 20% loss for follow-up	2	0
	< 10% loss for follow-up	2	0
F	> 50 subject in the smallest group	8	0
	> 100 subjects in the smallest group	9	0
2. Interventions		25	15
G	Interventions included in protocol and described	10	10
H	Pragmatic study	5	5
I	Co-interventions avoided or similar	5	0
J	Placebo-controlled	5	0
3. Effect		30	30
K	Patients blinded	5	5
L	Outcome measures relevant	10	10
M	Blinded outcome assessments	10	10
N	Follow-up period adequate	5	5
4. Data-presentation and analysis		10	10
O	Intention-to-treat analysis	5	5
P	Frequencies of most important outcomes presented for each treatment group	5	5
	TOTAL SCORE	100	69

Methodological criteria and scoring adapted from Koes BW et al. Efficacy of epidural steroid injections for low-back pain and sciatica: A systematic review of randomized clinical trials. *Pain* 1995; 63:279-288 (72).

Table 4. *Clinical relevance of randomized clinical trials evaluating the effectiveness of spinal endoscopic adhesiolysis.*

	Manchikanti et al (67)
A) Are the patients described in detail so that you can decide whether they are comparable to those that you see in your practice?	+
B) Are the interventions and treatment settings described well enough so that you can provide the same for your patients?	+
C) Were all clinically relevant outcomes measured and reported?	+
D) Is the size of the effect clinically important?	+
E) Are the likely treatment benefits worth the potential harms?	+
TOTAL CRITERIA MET	5/5

+ = positive; - = negative

Scoring adapted from Staal JB et al. Injection therapy for subacute and chronic low-back pain. *Cochrane Database Syst Rev* 2008; 3:CD001824 (60).

tients in Group II. Group I served as an active control, with endoscopy into the sacral level without adhesiolysis, followed by injection of local anesthetic and steroid. In contrast, Group II received spinal endoscopic adhesiolysis, followed by an injection of local anesthetic and steroid. Among the 50 patients in the treatment group receiving spinal endoscopic adhesiolysis, significant improvement without adverse effects were shown in 80% at 2 months, 56% at 6 months, and 48% at 12 months. The control group showed improvement in 33% of patients at one month and none thereafter. Based on the definition that less than 6 months of relief is considered short-term and longer than 6 months of relief is considered long-term, a significant number of patients obtained long-term relief with improvement in pain, functional status, and psychological status. In this study, the authors performed an intention-to-treat analysis. Outcome assessments included visual analog pain scale (VAS), Oswestry Disability Index 2.0 (ODI), work status, opioid intake, range of motion, and psychological evaluation.

The disadvantages of this study include lack of a placebo group; however, placebo control may never be achieved for an intervention such as spinal endoscopic adhesiolysis. The study met methodologic quality assessment and also had 50 patients in the treatment group while there were less than 50 patients in the control group.

Observational Studies

Methodologic Quality Assessment

There were 10 observational studies considered for inclusion (94,95,97,99-105). Of the 10 studies, 5 met criteria for inclusion for methodologic quality assessment (97,99,101,103,104). Methodologic quality assessment criteria are illustrated in Table 5. Methodologic quality assessment showed scores of 53 to 77. Five studies failed to meet the inclusion criteria: One study (100) evaluated the role of endoscopic adhesiolysis in refractory spinal stenosis; the second study (95) evaluated the effectiveness of endoscopic adhesiolysis in radiculitis; 2 studies (94,102) evaluated short-term improvement; and one study (105) was a technical description.

Table 6 illustrates the study characteristics of observational studies.

Descriptive Characteristics

Some studies reported on the proportion of patients with lumbar post-laminectomy syndrome or FBSS (67,97,99,101,103,104). Among those studies, the percentage of patients with FBSS varied with the study from 50% (101) to 100% (97,103). The patients had failed conservative medical management prior to enrolling in all the studies. In the studies by Manchikanti et al (67,103,104), the investigators had additionally ruled out facet and sacroiliac joint pain, important sources of low back pain, prior to enrolling patients. Outcomes measured included, in addition to pain scores, functional outcomes, psychological status, opioid intake, and return to work.

Effectiveness of spinal endoscopic adhesiolysis was investigated based on the following questions:

1 A. Is spinal endoscopic adhesiolysis with or without steroids effective in treating low back and/or radicular pain in patients with and without FBSS?

Table 5. *Methodologic quality assessment criteria for observational studies of spinal endoscopic adhesiolysis.*

CRITERION	Weighted Score (points)	Manchikanti et al (103)	Manchikanti et al (104)	Richardson et al (101)	Geurts et al (99)	Avellanal and Diaz-Reganon (97)
1. Study Question	2	2	1	1	2	1
• Clearly focused and appropriate question	2	2	1	1	2	1
2. Study Population	8	5	4	4	5	3
• Description of study population	5	5	4	4	5	3
• Sample size justification	3	0	0	0	0	0
3. Comparability of Subjects	22	12	11	12	14	14
• Specific inclusion/exclusion criteria for all groups	5	4	5	5	5	5
• Criteria applied equally to all groups	3	3	2	3	3	3
• Comparability of groups at baseline with regard to disease status and prognostic factors	3	2	2	1	3	3
• Study groups comparable to non-participants with regard to confounding factors	3	0	0	0	0	0
• Use of concurrent controls	5	0	0	0	0	0
• Comparability of follow-up among groups at each assessment	3	3	2	3	3	3
4. Exposure or Intervention	11	10	9	11	10	10
• Clear definition of exposure	5	5	5	5	5	5
• Measurement method standard, valid and reliable	3	2	1	3	2	2
• Exposure measured equally in all study groups	3	3	3	3	3	3
5. Outcome measures	20	10	8	15	20	11
• Primary/secondary outcomes clearly defined	5	4	3	5	5	3
• Outcomes assessed blind to exposure or intervention	5	0	0	0	5	0
• Method of outcome assessment standard, valid and reliable	5	1	0	5	5	4
• Length of follow-up adequate for question	5	5	5	5	5	4
6. Statistical Analysis	19	10	14	10	8	5
• Statistical tests appropriate	5	5	5	5	5	5
• Multiple comparisons taken into consideration	3	3	3	3	0	0
• Modeling and multivariate techniques appropriate	2	2	0	2	1	0
• Power calculation provided	2	0	0	0	2	0
• Assessment of confounding	5	0	5	0	0	0
• Dose-response assessment if appropriate	2	0	1	0	0	0
7. Results	8	8	7	8	8	6
• Measure of effect for outcomes and appropriate measure of precision	5	5	4	5	5	4
• Adequacy of follow-up for each study group	3	3	3	3	3	2
8. Discussion	5	5	4	5	5	3
• Conclusions supported by results with possible biases and limitations taken into consideration	5	5	4	5	5	3
9. Funding or Sponsorship	5	0	0	0	5	0
• Type and sources of support for study	5	0	0	0	5	0
TOTAL SCORE =	100	62	58	66	77	53

Adapted and modified from West S et al. *Systems to Rate the Strength of Scientific Evidence,* Evidence Report, Technology Assessment No. 47. AHRQ Publication No. 02-E016 (71).

Table 6. *Summary description of observational studies for spinal endoscopic adhesiolysis.*

Study / Methods	Participants	Intervention	Outcome	Results	Conclusion(s) Short-term ≤6 mos. Long-term > 6 mos.	Complications
Manchikanti et al 1999 (103)	60 FBSS patients - excluded facet and SI joint pain	Epiduroscope to level of pathology, adhesiolysis, 10 mL 1% lidocaine + steroid injection	Pain relief: 1) none 2) <50% 3) 50% (successful) Duration: < 1 month, 1, 2, 3, 6, and 12 months	Initial success (> 50% relief) in 100% of patients declining to 80% at 3 months, 52% at 6 months, and 22% at one year	Safe and possibly cost effective procedure in patients with FBSS (long-term)	Dural puncture in 7 procedures. "Suspected" infection in 8 patients who were given antibiotics but no "obvious" infection was noted
Manchikanti et al 2000 (104)	85 consecutive patients (86% with FBSS) underwent 112 epiduroscopic adhesiolysis procedures (27 patients had a second procedure). Follow up for 1-2 years	Epiduroscopic adhesiolysis and application of 10 mL 1% lidocaine + 6 mg betamethasone	Pain relief: 1) none 2) <50% 3) >50% (significant) Duration: < 1 month, 1, 2, 3, 6, and 12 months	Significant (> 50%) relief for a mean of 19 ± 1.79 weeks. After one procedure, initial relief in 100% of patients, declined to 94% at 1-2 months, 77% at 2-3 months, 52% at 3-6 months, 21% at 6-12 months, and 7% after one year	Relatively safe and possibly cost effective procedure in patients who have failed other modalities of treatment (long-term)	Dural puncture in 8 patients. Subarachnoid block in 4 patients. 2 documented infections (one requiring skin grafting and prolonged antibiotics) and 6 "SUSPECTED" infections.
Richardson et al 2001 (101)	38 patients with lumbar radicular pain who failed analgesics, TENS, and epidural injections were recruited; 19 had FBSS. Procedure. Aborted in 4 patients	34 patients underwent mechanical adhesiolysis + 5 mL bupivacaine 0.25% + 80 mg methyl-prednisolone + 100 mcg clonidine.	VAS + functional activity score at 2, 6, and 12 months post procedure	Preoperative VAS 8.2 →5.6, 6.8, and 6.7 at 2, 6, and 12 months respectively. A similarly significant functional improvement was noted	Epiduroscopic adhesiolysis achieved moderate but sustained reduction in chronic lumbar radicular pain as well as improvement in functional status	Transient low back pain in some and transient lower limb paresthesiae in 2 patients. None required hospital admission.
Geurts et al 2002 (99)	24 patients were recruited: radicular pain below knee + evidence of radiculopathy by exam; leg pain > back pain 2 patients unable to enter caudal space (excluded); 14 of the remaining 22 were FBSS patients	Mechanical adhesiolysis + 120 mg methyl-prednisolone + 600 IU hyaluronidase + 150 mcg clonidine. 2 patients had no injection and were excluded: one with no adhesions and another because of dural puncture	Median VAS score from 12 recordings over a 4 day period one week before intervention and assessment at 3, 6, 9 and 12 months. Global subjective efficacy rating (GSER) at 12 months.	19/20 patients showed adhesions by epiduroscopy vs. 11/20 by MRI Significant pain relief at 3, 6, 9, and 12 months occurred in 55%, 40%, 35% and 35% of patients respectively Similar findings by GSER at 12 months	Epiduroscopy is useful in diagnosing spinal root pathology and targeted application of epidural medications can result in substantial and prolonged pain relief	One accidental dural puncture noted; procedure aborted and patient was excluded from analysis. However, 3 patients had post-dural puncture headache and 2 required epidural blood patches. Transient intra-operative discomfort in some patients.
Avellanal and Diaz-Reganon 2008 (97)	19 patients with h/o FBSS and severe sciatica (VAS ≥ 7) who have failed multiple treatment modalities including adhesiolysis with a Racz catheter. All patients had X-rays, MRI, and EMG within 2 months of enrollment	Interlaminar epiduroscopic adhesiolysis at L5/S1 and occasionally at L4/L5 or L3/L4. 6 mL mixture of triamcinolone, 40 mg, hyaluronidase 600 IU, and bupivacaine 0.0625% was injected	VAS at 1, 2, 3, and 6 months.	Compared to VAS at baseline, there was significant reduction in pain at 1, 2, 3, and 6 months. Six patients had no improvement at 3 months or later, 7 experienced mild improvement, and 6 improved markedly (> 3 points on the VAS)	A 50% smaller diameter endoscope is effective in pain relief through adhesiolysis in patients with FBSS	4 dural punctures (21%), one necessitating admission to the hospital for 5 days; transient headache and hypotension during the procedure lasting < 30 sec; some low back and leg pain relieved spontaneously within 2 days

There were no placebo controlled trials of spinal endoscopic adhesiolysis. However, in the double blind randomized controlled trial by Manchikanti et al (67), patients were included in the study if they had refractory low back pain and lower extremity pain and had failed to have significant response with fluoroscopically guided caudal epidural steroid injections and one-day percutaneous adhesiolysis. Lack of significant response to caudal epidural steroid injections was defined as ≥ 50% pain relief for ≤ one week after a second epidural steroid injection and ≥ 50% pain relief for ≤ 4 weeks after a third epidural steroid injection. Lack of significant response to one-day percutaneous non-endoscopic adhesiolysis was defined as no response to the first adhesiolysis procedure and less than 2 months of pain relief (≥ 50%) following the second or subsequent procedures. Other causes of low back pain such as facet and sacroiliac joint pain were ruled out by diagnostic blocks prior to the patients enrolling in the study. Patients were randomized to spinal endoscopic adhesiolysis or caudal epidural steroid injections once the endoscope reached the level of S3 by fluoroscopy (hence considered to be a control group). Among patients enrolled, 73% in the group randomized to caudal epidural steroid injections had FBSS compared to 84% of the patients randomized to spinal endoscopic adhesiolysis. While data were not stratified according to patients having a history of FBSS or having back vs. leg pain, there was a very significant increase in the duration of pain relief in the spinal endoscopic adhesiolysis group (with targeted steroid injection) compared to the caudal epidural steroid injection group ($P = 0.001$) using an intent-to-treat analysis (67). Similarly, there were significant improvements in the functional and psychological status of patients.

The prospective observational study by Geurts et al (99) recruited patients who had predominantly radicular leg pain. About two-thirds of the patients who underwent spinal endoscopic adhesiolysis had FBSS. Spinal endoscopic adhesiolysis with targeted steroid, hyaluronidase, and clonidine deposition resulted in significant pain relief and an improved Global Subjective Efficacy Rating (GSER) in a significant number of patients at 3, 6, 9, and 12 months after the intervention. Similarly, significant pain relief and functional improvement were noted in the study by Richardson et al (101) where the recruited patients had leg and chronic low back pain. All patients had failed transcutaneous nerve stimulation and 50% of the patients had FBSS. Unfortunately, neither study stratified patients based on a history of FBSS (99,101).

In an earlier observational study by Manchikanti et al (103), 60 consecutive patients with FBSS underwent spinal endoscopic adhesiolysis in 1998. They were compared to 60 consecutive patients with FBSS who underwent non-endoscopic percutaneous adhesiolysis in 1997. The patients had to have failed additional intervening conservative medical management including epidural steroid injections, and other causes of low back pain including facet joint pain and sacroiliac joint pain were excluded. Significant pain relief was defined as greater than 50% pain relief. All patients undergoing either procedure had initial significant pain relief after one procedure which declined to 72% at one month, 25% at 3 months, 10% at 6 months, and 7% at one year for the non-endoscopic adhesiolysis group and 97% at one month, 80% at 3 months, 52% at 6 months, and 22% at one year for the spinal endoscopy group. Duration of pain relief with the first procedure was 12 ± 3.6 weeks for non-endoscopic adhesiolysis compared to 20 ± 2.9 weeks for the endoscopic adhesiolysis group. However, patients in the non-endoscopic group received more repeat procedures than the endoscopic group. With repeat procedures a significantly greater number of patients had significant pain relief at 6 months and one year in the non-endoscopic adhesiolysis group compared to the endoscopic adhesiolysis group (103).

B. In patients with chronic low back and lumbar radicular pain is spinal endoscopic adhesiolysis effective in providing longer duration of symptom relief as compared to placebo or another treatment (such as percutaneous adhesiolysis without endoscopy or caudal epidural steroid injection) and does it improve outcomes?

The double blind placebo controlled study by Manchikanti et al (67) randomized patients to endoscopic adhesiolysis at target nerve roots or to introduction of the epiduroscope to only S3 and performed a caudal epidural steroid injection

(control group). Compared to the control group and to baseline values, a significant proportion of patients in the spinal endoscopic adhesiolysis group experienced pain relief. The duration of significant pain relief (≥ 50%) was 0.7 ± 0.73 months for the caudal group vs. 7.6 ± 4.7 months for the spinal endoscopic adhesiolysis group. Similar significant functional improvements were noted in the ODI and in range of motion evaluations in the endoscopic adhesiolysis group compared to baseline and to the control group. Additionally, there were significant improvements in psychological outcomes of depression, anxiety, and somatization (P-3 scores), decreases in opioid consumption, and improved return to work rates in the endoscopic adhesiolysis group compared to the caudal group and to baseline (67). Of note, all patients recruited in this study had also failed non-endoscopic adhesiolysis. Manchikanti et al (103) also compared 60 consecutive patients with FBSS who underwent spinal endoscopic adhesiolysis in 1998 to 60 consecutive patients with FBSS who underwent non-endoscopic percutaneous adhesiolysis in 1997. Duration of pain relief after one procedure was longer for the spinal endoscopic adhesiolysis than the non-endoscopic adhesiolysis and a greater proportion of patients in the endoscopic group had pain relief than in the non-endoscopic group after one procedure. However, in this retrospective study, more patients in the non-endoscopic group received repeat procedures and as such a greater proportion of those patients had significant pain relief compared to the endoscopic group at 6 months and at one-year timelines after adhesiolysis (103).

Avellanal and Diaz-Reganon (97) using an interlaminar endoscopic adhesiolysis approach in an observational study of 19 patients with FBSS who had failed non-endoscopic adhesiolysis reported significant improvements in VAS scores at one, 2, 3, and 6 months after the intervention.

2. What is the role of medications used with spinal endoscopic adhesiolysis?

   Local anesthetic and glucocorticoid steroid application occurred following mechanical spinal endoscopic adhesiolysis in all studies included in the analysis in this systematic review. Clonidine (100 mcg) was additionally used by Richardson et al (101), bovine hyaluronidase (600 IU) by Avellanal and Diaz-Reganon (97), and clonidine (150 mcg) + bovine hyaluronidase (600 IU) were added to the local anesthetics/steroids by Geurts et al (99). There were no comparative studies evaluating the effectiveness of mechanical adhesiolysis alone to that of adhesiolysis with application of local anesthetics/steroids or evaluating the effectiveness of additional or adjuvant medications.

   The previous evaluations of use of hyaluronidase showed no significant effect (64,65). There is no significant evidence describing the utilization of hyaluronidase in spinal endoscopic adhesiolysis (99). In an experimental evaluation of hyaluronidase activity in combination with specific drugs applied in clinical techniques of interventional pain management and local anesthesia (115), the results showed that there was interaction among the drugs which was related to the activity of hyaluronidase with iodinated contrast media, 10% sodium chloride solution, and the absence of corticosteroids reducing hyaluronidase activity. However, higher activities were detected in sodium chloride concentrations of 0.9% with no influence noted with local anesthetics.

3. Is spinal endoscopic adhesiolysis safe?

   Common complications reported following spinal endoscopic adhesiolysis include pain at the site of the procedure/low back pain, dural puncture headache and cerebrospinal fluid (CSF) leak, infection, paresthesiae, and transient subarachnoid block. However, despite characterization of spinal endoscopic adhesiolysis as a generally safe procedure as noted in the efficacy studies reviewed in this article, several case reports describe serious potential complications (116,117). Severe visual impairment following epiduroscopy has been reported (116,117). Apparently, increases in CSF pressure due to bolus fluid injections during the procedure can result in retinal hemorrhage and blindness with recovery in only 79% of the cases as reported by Gill and Heavner (116) who reviewed 12 cases of visual impairment following epiduroscopy (3 cases) or epidural fluid injection. In another report, intravascular spread of contrast was detected by fluoroscopy during 2 cases of

lumbosacral epiduroscopy (117). Withdrawing or manipulating the endoscope resulted in resolution of the vascular (likely venous) uptake without any negative consequences to the patients (117). Despite the technical difficulty of manipulating an endoscope in the spinal canal, there are no reports in the literature of permanent neurological damage or reports of epidural hematoma or meningitis.

Effectiveness

The single randomized trial evaluating endoscopic adhesiolysis (67) showed positive results for short- and long-term relief. Of the 5 observational studies meeting methodologic quality criteria (97,99,101,103,104), all of them showed positive results for short-term improvement, whereas none of them were positive for long-term relief.

Table 7 illustrates results of effectiveness of endoscopic adhesiolysis.

Level of Evidence

The indicated level of evidence is II-1 or II-2 for short- and long-term relief for endoscopic adhesiolysis in post lumbar laminectomy syndrome, based on one randomized trial.

Recommendations

Based on Guyatt et al's grading strength of recommendations and quality of evidence in clinical guidelines, the recommendation is 1C/strong for endoscopic adhesiolysis in post lumbar laminectomy syndrome.

Complications

The most commonly reported complications of spinal endoscopic adhesiolysis were dural puncture, infection, increase in CSF, and steroid side effects (67,69,94,95,97,99-104,116-118). Intravascular injection, vascular injury, cerebral vascular or pulmonary embolus, reaction to the steroids, hypertonic saline or hyaluronidase, visual impairment, death, and brain damage also may result. Side effects are related to the administration of steroids and are generally attributed to the chemistry or pharmacology of the steroids. However, therapeutic doses of epidural steroids in appropriate dosing were without complications (119,120).

Discussion

The present systematic review of the literature of the effectiveness of spinal endoscopic adhesiolysis in managing chronic intractable pain of post surgery syndrome indicated evidence level II-1 or II-2 based on USPSTF criteria and one randomized trial with a recommendation of 1C/strong recommendation (67,92,93). Even though this systematic review focused only on patients with post lumbar laminectomy syndrome, there was a paucity of evidence and a weak recommendation was obtained. However, the expansion of

Table 7. *Summary results of eligible studies of endoscopic adhesiolysis included in this systematic review.*

Study	Study Characteristics	Methodological Quality Scoring	Number of Participants	Significant Pain Relief		Results	
				≤ 6 mos.	>6 mos.	Short-term ≤ 6 mos.	Long-term > 6 mos.
Manchikanti et al 2005 (67)	RA,DB	69	83	56%*	48%*	P	P
Manchikanti et al 1999 (103)	O	62	60	52%*	22%*	P	N
Manchikanti et al 2000 (104)	O	58	85	21%* 6-12 mos.	7%* >12 mos.	P	N
Richardson et al 2001 (101)	O	67	38	Yes	Yes	P	N
Geurts et al 2002 (99)	O	77	24	Yes	Yes	P	N
Avellanal and Diaz-Reganon 2008 (97)	O	53	19	Yes	N/A	P	N

*Denotes percentage of patients with > 50% pain relief
RA = randomized; DB = double blind; O = observational; P = positive; N = negative; N/A = not applicable.

the definition of short-term relief to 6 months or less and long-term relief to longer than 6 months provides a robust measure.

Complications related to the procedure are usually minor and for the most part can be prevented with careful attention to technique. In patients with persistent low back and/or radicular pain, particularly after having had one or more previous lumbar spinal surgery(ies), spinal endoscopic adhesiolysis offers a reasonable option at pain relief and functional improvement. In patients with FBSS, repeat surgeries typically do not improve the outcome and spinal cord stimulation was found to be a superior modality to reoperation (121). There are, however, no comparative studies evaluating spinal cord stimulation versus spinal endoscopic adhesiolysis. In addition, spinal endoscopic adhesiolysis would be more cost-effective than repeat lumbar spine surgery (103,104). A recent reassessment of evidence by Manchikanti et al (68) emphasized the importance of guidelines and the potential implications of appropriate systematic reviews (122,123).

Selection criteria for spinal endoscopic adhesiolysis includes patients with chronic refractory low back and/or lumbar radicular pain who are suspected of having adhesions contributing to their symptoms. It is believed that adhesiolysis improves the nutrition and mobility of lumbar nerves and facilitates delivery of local anesthetics and steroids to their target areas at the nerve roots that is otherwise made impossible by the presence of adhesions (36,100). In addition, Takeshima et al (106) showed that progressive epidural scarring after epidural adhesiolysis with re-adhesions around the nerve root is responsible for recurrent pain.

The primary author of this systematic review does not perform endoscopic adhesiolysis in his practice, decreasing the likelihood of bias. Future spinal endoscopic adhesiolysis studies are needed to optimize patient selection and improve identification of patients that would benefit from this modality. Patient stratification is essential to identifying proper patient selection criteria. Additionally, studies specifically evaluating adjuvant medications may need to be carried out; a recombinant form of human hyaluronidase is now commercially available but has yet to be tested in spinal endoscopic adhesiolysis. Prospective comparative studies evaluating efficacy and cost effectiveness of spinal endoscopic adhesiolysis to non-endoscopic adhesiolysis or other interventional modalities such as spinal cord stimulation would be valuable and facilitate clinical decision-making.

Conclusion

Spinal adhesions appear to be an important contributor to refractory low back and/or lumbar radicular pain, especially in patients with previous (failed) lumbar spinal surgery. Epidural adhesions may compromise nerve root nutrition and contribute to persistent inflammation. Spinal endoscopic adhesiolysis may allow improved nutrition and mobility of lumbar nerves and would allow delivery of therapeutic medications (local anesthetics and steroids) to target nerve roots.

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