Manipulative and Manual Therapies in the Management of Patients with Prior Lumbar Surgery: A Systematic Review

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SUBJECT AREAS
Orthopedics

KEYWORDS
Postsurgical, Failed back surgery syndrome, Postoperative periods, Spinal manipulation, Manual therapy
Abstract

Background

The purpose was to identify, summarize, and rate scholarly literature that describes manipulative and manual therapy following lumbar surgery.

Methods

The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and was registered with PROSPERO. PubMed, Cochrane Database of Systematic Reviews, ICL, CINAHL, and PEDro were searched through July 2019. Articles were screened independently by at least two reviewers for inclusion. Articles included described the practice, utilization, and/or clinical decision making to post surgical intervention with manipulative and/or manual therapies. Data extraction consisted of principal findings, pain and function/disability, patient satisfaction, opioid/medication consumption, and adverse events. Scottish Intercollegiate Guidelines Network critical appraisal checklists were utilized to assess study quality.

Results

Literature search yielded 1916 articles, 348 duplicates were removed, 109 full-text articles were screened and 50 citations met inclusion criteria. There were 37 case reports/case series, 3 randomized controlled trials, 3 pilot studies, 5 systematic/scoping/narrative reviews, and 2 commentaries.

Conclusion

The findings of this review may help inform practitioners who utilize manipulative and/or manual therapies regarding levels of evidence for patients with prior lumbar surgery. Following lumbar surgery, the evidence indicated inpatient neural mobilization does not improve outcomes. There is inconclusive evidence to recommend for or against most manual therapies after most surgical interventions.

Trial registration

Prospectively registered with PROSPERO (#CRD42020137314). Registered 24 January 2020.

Background
Low back pain is the leading cause of disability worldwide, impacting roughly 540 million people at any given time [1]. Lumbar surgical procedures have become increasingly more widespread over the past several decades. Surgical treatment for lumbar degenerative disc disease increased 2.4-fold from 2000 to 2009 [2], and there were 1,288,496 new posterior lumbar fusion operations reported in the United States alone between 1998 and 2008 [3]. From 2004-2015 the volume of elective lumbar fusion procedures in the United States rose by 62.3% (or 32.1 per 100,000) from 122,679 (60.4 per 100,000) to 199,140 (79.8 per 100,000)[4]. The greatest increase in fusions occurred in adults over 65 years old, and octogenarians saw an increase from 1,144 fusions in 2004 to 2,061 fusions in 2013 [4, 5].

The most frequent condition considered appropriate for lumbar surgery is low back pain and radiculopathy secondary to lumbar disc herniation [6], with discectomy being the most commonly performed lumbar surgical procedure [7]. Recurrence of spinal or radicular symptoms is common following surgical intervention [8-10]. Following lumbar discectomy for symptomatic lumbar disc herniation the 1-year and 3-year recurrence rate for leg symptoms has been estimated to be 20% and 45% and for recurrent low back pain 29% and 65% respectively [11].

Postoperative pain and potential for future operative procedure is common for those undergoing lumbar surgical procedure. Patients that undergo lumbar discectomy procedure are 2.97 times more likely to require a future lumbar fusion than individuals without prior discectomy [12]. Failed back surgery syndrome (FBSS) is a regular indicator for spinal cord stimulator implant/neuromodulation [13], though may only provide pain relief for a portion of individuals undergoing this intervention. Turner et al. reported only 50–60% of failed back surgery patients with implanted neuromodulation reported 50% pain improvement and 40–50% continue to experience pain [13].

Many individuals with chronic pain complaints seek manual and manipulative therapy (MMT) for non-pharmacological pain management from chiropractors, osteopaths, physical therapists and massage therapists [4, 6, 7, 11, 12]. Manual therapy is the application of the practitioner’s hands directly to soft tissues or joints using techniques such as mobilization, stretching, myofascial release, massage, and muscle energy techniques [14]. Manipulation is a type of manual therapy that involves the
practitioner applying a high-velocity, low-amplitude manual force to a perceived hypo-mobile joint to approximate the joint near its end range of motion and to restore its physiological joint ROM [15], or alternatively through a table-assisted approach such as flexion-distraction (FD). MMT may be a potential treatment option to aid in pain reduction and functional preservation in those with a prior history of lumbar surgical intervention.

The authors are unaware of any prior systematic reviews analyzing the literature of MMT for individuals with a history of lumbar surgery. The primary aim of this study was to investigate the current relationship of MMT to the management of pain, function, patient satisfaction, and opioid/medication utilization for patients with prior lumbar operative procedures. A secondary purpose of this study was to assess the adverse events reported in the same body of literature.

Methods
Search strategy
A literature search was performed July 2019 of PubMed, Cochrane Database of Systematic Reviews, Index to Chiropractic Literature, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Physiotherapy Evidence Database (PEDro) from inception of each database through July 2019. We combined numerous MMT search terms, with a variety of terms relevant to surgical interventions (Tables 1 and 2). The list of references of included publications was manually checked for additional studies potentially meeting the inclusion criteria.
Table 1
Search terms related to manipulation, manual therapy and surgical interventions

| Treatment Strategy                      | Prior Procedure          | Condition/Region              |
|-----------------------------------------|--------------------------|-------------------------------|
| Chiropractic                            | Postsurgical             | Failed Back Syndrome          |
| Musculoskeletal Manipulations           | Postoperative            | Spine                         |
| Osteopathic Manipulations               | Post-Surgical            | Spinal                        |
| Orthopedic Manipulations                | Post-Operative           | Low Back                      |
| Manual Therapy                          | Fusion                   | Lumbar                        |
| Manual Therapies                        | Decompression            | Lumbosacral                   |
| Manipulative Therapy                    | Lumbar Spine Surgery     | Back Pain                     |
| Manipulative Therapies                  | Microdisectomy           | Radiculopathy                 |
| Manipulative Rehabilitation             | Spinal Deformation       | Radicular Pain                |
| Joint Manipulation                      | Diskectomy               | Sciatica                      |
| Joint Mobilization                      | Laminecotomy             | Disc Herniation               |
| Mobilization Therapy                    | Laminateomy              | Disk Herniation               |
| Spinal Mobilization                     | Spinal Decompression     | Intervertebral Disc           |
| Flexion-Distraction                     | Disk Replacement          | Intervertebral Disk           |
| Myofascial                              | Spinal Laminectomy       | Disc Degeneration             |
| Active Release                          | Spinal Discectomy        | Disk Degeneration             |
| Graston                                 | Spinal Kyphoplasty       | Spinal Stenosis               |
| Massage                                 | Foraminotomy             | Spondylolisthesis             |
| Stretching Techniques                   | Spinal Interlaminar Implant | Spondylosis                |
| Muscle Stretching                       | Spinal Intrathecal Drug Delivery | Adjacent segment disease     |
| Static Stretching                       | Laser Surgery            | Junction Failure              |
| Passive Stretching                      | Extreme Lateral Interbody | Degenerative Disc Disease     |
| Proprioceptive Neuromuscular Facilitation|                          | Degenerative Disk Disease     |
| PNF Stretching                          |                          | Scoliosis                     |
| Post Isometric Relaxation               |                          |                               |
| Contract-Relax                          |                          |                               |
| Instrument Assisted Soft Tissue         |                          |                               |
| Instrument Assisted Manipulation         |                          |                               |
| Instrument Assisted Adjustment          |                          |                               |
| Instrument Assisted Adjusting           |                          |                               |
| Manipulation Under Anesthesia           |                          |                               |
| Spinal Manipulation                     |                          |                               |

Table 2
Search strategy example

(((postsurgical OR postoperative OR post-surgical OR post-operative) AND (spine OR low back OR lumbar OR lumbosacral OR “back pain” OR radiculopathy OR radicular pain OR sciatica OR disc herniation OR disk herniation OR intervertebral disc OR intervertebral disk OR spinal OR degenerative disc disease OR degenerative disk disease OR disk degeneration OR disk degeneration OR scoliosis OR spinal stenosis OR spondylolisthesis OR spondylosis OR spondylolysis OR failed back syndrome OR adjacent segment disease OR joint failure)) OR (((fusion OR decompression) OR (laser AND surgery)) AND (spine OR low back OR lumbar OR lumbosacral OR “back pain” OR radiculopathy OR radicular pain OR sciatica OR disc herniation OR disk herniation OR intervertebral disc OR intervertebral disk OR spinal OR degenerative disc disease OR degenerative disk disease OR disk degeneration OR disk degeneration OR scoliosis OR spinal stenosis OR spondylolisthesis OR spondylosis OR spondylolysis OR failed back syndrome OR adjacent segment disease OR joint failure))) OR ((failed back surgery syndrome OR lumbar spine surgery OR microdiscectomy OR microdisectomy OR discectomy OR discectomy OR laminecctomy OR laminectomy OR disc replacement OR disk replacement OR verteoplasty OR kyphoplasty OR foraminotomy OR interlaminar implant OR “spinal cord stimulator” OR intrathecal drug delivery OR “extreme lateral interbody fusion”) AND (((spinal manipulation OR chiropractic OR musculoskeletal manipulations OR osteopathic manipulation OR orthopedic manipulation OR manual therapy OR manual therapies) OR (manipulative AND (therapy OR therapies OR rehabilitation))) OR (“joint manipulation” OR “joint mobilization” OR “mobilitation therapy” OR “spinal mobilization” OR “soft tissue mobilization” OR flexion distraction OR myofascial OR “active release” OR Graston OR massage OR stretching techniques OR muscle stretching OR static stretching OR passive stretching OR proprioceptive neuromuscular facilitation OR “PNF stretching” OR “post isometric relaxation” OR contract-relax) OR (instrument assisted AND (soft tissue OR manipulation OR adjusting OR adjustment)) OR (“manipulation under anaesthesia”)) NOT (“Animals”[Mesh] NOT (“Animals”[Mesh] AND “Humans”[Mesh]) AND English)) AND 

Completed studies accepted for publication, but not yet in-print, were identified by searching clinicaltrials.gov and the World Health Organization International Clinical Trials Registry. The literature was searched with the assistance of a health sciences librarian (SW), and titles were screened independently by two different reviewers (CJD, ZAC). The review was conducted in accordance with
the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and was registered with PROSPERO (#CRD42020137314).

Eligibility criteria

The inclusion and exclusion criteria are available in Table 3. All research designs published by peer-reviewed scholarly journals in English were included in the search. Commentaries from non-peer reviewed sources (e.g., trade magazines) and other non-scholarly sources were excluded, as were writings not specific to post-surgical care provided. Case reports and case series were included to inform decision-making when no other higher level of evidence was available [16, 17]. Exclusions included animal studies as done by the method from the Cochrane Handbook for Systematic Reviews of Interventions [18]. Abstracts of conference proceedings were not included due to the high rate of conference presentations that never reach full publication [19]. Articles were considered for final inclusion if they describe the practice, utilization, and/or clinical decision making related to post-surgical intervention with MMT.

| Inclusion                                                                                   | Exclusion                                                                                           |
|---------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| • Human subjects aged 18 or older                                                          | • Non-peer-reviewed publications                                                                     |
| • English language                                                                          | • Conference abstracts                                                                               |
| • Intervention includes manipulation AND/OR manual therapy AND/OR mobilization with or      | • Non-English language                                                                               |
|   without multimodal approach                                                                | • Animal studies                                                                                     |
| • Treatment of status post-surgical low back pain (degenerative or traumatic)               | • Study protocol                                                                                     |
| • Surgery types (fusion, laminectomy, decompression, microdiscectomy, disc replacement,     | • Prior surgery for scoliosis                                                                        |
|   veterbroplasty, spinal stimulators/implants, ...)                                          | • Red flag condition identified which resulted in subsequent surgery                                 |
| • Any study design                                                                          | • Surgical intervention performed as result of adverse event purportedly related to manipulative and/or |
|                                                                                            |   manipulation and/or manual therapy                                                                 |
|                                                                                            | • Unless patient already had a prior lumbar surgery predating manipulative/manual therapy           |
|                                                                                            | • Dry needling/acupuncture                                                                          |
|                                                                                            | • Non-surgical treatments which do not include manipulative OR manual therapies (e.g. physical      |
|                                                                                            |   modalities, medications, braces and other equipment                                                |

P – Participants/population

Adults ≥ 18 years old, prior lumbar surgical procedure for degenerative and/or traumatic condition.

I – Interventions

Manipulation and/or manual therapy; may include multimodal care

C – Comparators

No restrictions

O – Outcomes

Pain and function/disability

Patient satisfaction
Opioid and medication and consumption
Note adverse events
Methods of review
Study selection
The screening process was conducted independently by two authors, and coauthors were asked to contribute citations with which they were familiar but which might be missing from the formal search. Citations were screened by two reviewers by reading the title and abstract for each article. Abstracts of the citations that obviously or possibly met the review criteria were saved. The full papers of each abstract were retrieved and each article was reviewed independently by at least 2 authors to verify that it met the inclusion criteria. Disagreements on eligibility were resolved by discussion and adjudicated by a third author when necessary. Articles that did not meet the criteria were discarded and a note was made as to why they were excluded. Once an article was included, the citation, study design, principal findings, surgical intervention, manual/manipulative therapy, and adverse events were extracted.
Data extraction
Two authors completed data extraction for each of the included studies. One author served as the primary extractor and the second served as a secondary extractor confirming the findings. Any disagreements were resolved through discussions and if necessary, a third reviewer. Data were extracted into Microsoft Word tables grouped by type of study design. Items collected on the data extraction tables included: citation with first author and publication year, surgical history, MMT intervention, principle findings comparison, adverse events, and medication discussion. For randomized controlled trial (RCT) and cohort designs, we separated principle findings into comparison, outcome measures, results, and conclusions. For studies that involved multiple surgical types within an individual patient, we classified the surgical type from least-to-most aggressive or advanced approach in the order of discectomy, laminectomy, fusion, artificial disc replacement, and spinal cord stimulator, respectively. Studies that incorporated multiple surgical types without stratifying results by type were classified as undifferentiated.
Evaluation of risk of bias
Scottish Intercollegiate Guideline Network (SIGN) critical appraisal checklists [20] were utilized to
assess for risk of bias (quality). All RCTs and systematic reviews (SR) included in this study were assessed with the corresponding checklist provided by SIGN, with at least 2 authors performing each quality assessment. Disagreements were resolved with discussion and a third reviewer was incorporated as appropriate. The SIGN checklist rates each article as “high quality, low risk of bias”, “acceptable quality, moderate risk of bias”, and “low quality, high risk of bias”.

For the SR checklist, there are 12 items to score and quality is rated as: high, low risk of bias > 9, acceptable, moderate risk of bias 6–9, and low, high risk of bias < 6 (Table 4). For the RCT checklist, there are 10 items to score and quality is rated as: high, low risk of bias > 8, acceptable, moderate risk of bias 5–8, and low, high risk of bias < 5 (Table 5).

| Table 4 | Modified SIGN systematic review checklist [21] |
|---------|-----------------------------------------------|
| 1.1     | The research question is clearly defined and the inclusion/exclusion criteria must be listed in the paper. (If “No” then reject) |
| 1.2     | A comprehensive literature search is carried out (If “No” then reject) |
| 1.3     | At least two people should have selected studies. |
| 1.4     | At least two people should have extracted data. |
| 1.5     | The status of publication was not used as an inclusion criterion. |
| 1.6     | The excluded studies are listed. |
| 1.7     | The relevant characteristics of the included studies are provided. |
| 1.8     | The scientific quality of included studies was assessed and reported. |
| 1.9     | Was the scientific quality of the included studies used appropriately? |
| 1.10    | Appropriate methods are used to combine the individual study findings. |
| 1.11    | The likelihood of publication bias was assessed appropriately. |
| 1.12    | Conflicts of interest are declared |

| Table 5 | Modified SIGN randomized trial checklist [21] |
|---------|------------------------------------------------|
| 1.1     | The study addresses an appropriate and clearly focused question. |
| 1.2     | The assignment of subjects to treatment groups is randomized |
| 1.3     | An adequate concealment method is used. |
| 1.4     | The design keeps subjects and investigators ‘blind’ about treatment allocation |
| 1.5     | The treatment and control groups are similar at the start of the trial |
| 1.6     | The only difference between groups is the treatment under investigation |
| 1.7     | All relevant outcomes are measured in a standard, valid and reliable way |
| 1.8     | What percentage of the individuals or clusters recruited into each treatment arm of the study dropped out before the study was completed? |
| 1.9     | All the subjects are analyzed in the groups into which they were randomly allocated (often referred to as intention to treat analysis) |
| 1.10    | Where the study is carried out at more than one site, results are comparable for all sites. |

**Strength of evidence**

The strength of evidence for recommendations was based upon the quality and quantity of evidence available and as has been demonstrated elsewhere [21] and modified from the UK evidence report.
The criteria are outlined in Table 6 and describe high, moderate, and inconclusive strength of evidence, and favorable or unfavorable recommendation.

| Quality and quantity of evidence | Rating               |
|---------------------------------|----------------------|
| Consistent results found in at least 2 low risk-of-bias studies | High                 |
| Results of at least 1 low risk-of-bias study or at least 2 low risk-of-bias studies with some inconsistency of results | Moderate             |
| Only acceptable-quality studies with inconsistent results, or only high-risk of bias studies | Inconclusive         |

**Results**

A comprehensive database search identified 1913 citations, and 3 additional citations were added from the grey literature. After 348 duplicates were removed, 1568 citations were screened and 1459 were excluded by title and abstract as irrelevant. A review of the remaining 109 full-text articles resulted in 50 studies meeting inclusion criteria (Fig. 1). Fifty-nine articles were excluded with reasons provided in Table 7.

| Reason                  | Number of citations |
|-------------------------|---------------------|
| Not about MMT           | 30 [84–113]         |
| Not lumbar postsurgical | 11 [114–124]        |
| Lacks relevant specifics| 7 [125–131]         |
| Related to scoliosis    | 3 [132–134]         |
| Not peer-reviewed source| 2 [135–136]        |
| Conference abstract     | 2 [137–138]         |
| Book chapter            | 1 [139]             |
| Not English language    | 1 [140]             |
| Unable to obtain        | 1 [141]             |

The majority of included studies were case reports or case series (n = 37), followed by RCTs (n = 6), SRs (n = 3), scoping review (n = 1), narrative review (n = 1), and commentaries (n = 2). The most common reason for exclusion was due to care not involving MMT (n = 30).

**Systematic reviews**

Three SRs met the inclusion criteria. One of the 3 was high quality [25], 1 was acceptable quality [26], and 1 was low quality [27] (Table 8). Two of the 3 included SRs described physical therapy and rehabilitation intervention in patients with undifferentiated lumbar surgery for degenerative conditions [25, 26], and 1 described care following lumbar fusion surgery [27]. Two of the 3 describe physical therapy (PT) and rehabilitation including, but not specific to, MMT [26, 27], and 1 specifically described neural mobilization techniques [25].
Table 8
Quality (risk-of-bias) assessment of included systematic reviews

| First Author and Year Published | Items on modified SIGN* Checklist | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total | Quality ** |
|--------------------------------|----------------------------------|---|---|---|---|---|---|---|---|---|---|---|---|--------|-----------|
| Basson 2017                    |                                  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 | **      | H         |
| Gilmore 2015                   |                                  | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 8      | A         |
| Madera 2017                    |                                  | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5      | L         |

*SIGN, Scottish Intercollegiate Guideline Network
**Quality: H = High, A = Acceptable, L = Low

The high-quality and acceptable-quality reviews addressed rehabilitation after a variety of lumbar surgical types (e.g. disectomy, laminectomy, fusion). The high-quality SR investigated neural mobilization and included 69 studies, of which only 1 study that was postoperative low back pain [28], and concluded that inpatient neural mobilization in the 3 days following lumbar operation did not add benefit to usual care [25]. The acceptable-quality review analyzed inpatient PT including 4 studies, of which 1 was relevant to MMT [28] and it was the same study identified by the neural mobilization SR [26].

Following lumbar fusion, a low-quality review found insufficient evidence to make an argument for or against the inclusion of joint mobilization, nerve mobilization, or soft-tissue mobilization for lumbar fusion postoperative rehabilitation [27]. Despite insufficient evidence, among other treatments, the study authors recommended joint mobilization of the thoracic spine and hips to maintain posture and increase functional mobility, early neural mobilization to improve ROM by decreasing nerve tension, and soft-tissue mobilization to decrease post-surgical pain and swelling around the incision site.

**Randomized controlled trials**
Table 9 provides the RCTs risk of bias as high, acceptable, and low-quality studies and Table 10 presents the evidence. Of the 6 RCTs, 3 were pilots and were underpowered to make any conclusions regarding efficacy and were not rated for quality. Of the 3 remaining studies, 2 were rated high-quality [28, 29] and 1 was rated acceptable-quality [30].
Table 9
Risk-of-bias assessment of included randomized clinical trials

| First Author and Year Published | Items on SIGN* Checklist | Total | Quality* |
|---------------------------------|--------------------------|-------|----------|
| Mannion 2007                    | 1                       | 9     | H        |
| Scrimshaw 2001                  | 1                       | 9     | H        |
| Timm 1994                       | 1                       | 6     | A        |
| Kim 2015                        | 1                       | 9     | NR       |
| Kim 2016                        | 1                       | 9     | NR       |
| Kim 2017                        | 1                       | 6     | NR       |

*SIGN, Scottish Intercollegiate Guideline Network
**Quality: H = High, A = Acceptable, L = Low, NR = Not Rated

Table 10
Randomized controlled trial evidence table

| Citation and Quality | Participants | Surgical History | Intervention | Comparison | Outcome Measures | Results | Conclusion | Adverse Events | Medication |
|----------------------|--------------|------------------|--------------|------------|------------------|---------|------------|----------------|------------|
| Scrimshaw 2001 High [28] | n = 81 Age: CG = 55 TG = 59 Duration CG(< 6 wks) = 8 CG(6wk-6mo) = 14 CG(> 6 mo) = 2 TG(< 6 wks) = 19 TG(6wk-6mo) = 14 TG(> 6 mo) = 14 | Discectomy, Laminectomy, Fusion | TG: Inpatient Neural Mobilization 2x/day for 3 days with different protocol for laminectomy and discectomy versus fusion | CG; Standard postoperative care | GPE (7-Point) VAS (0-100 mm) McGill QDS RTW | GPE: no difference between groups VAS: no difference between groups McGill: no difference between groups QDS: no difference between groups RTW: no difference between groups | Neural mobilization did not provide additional benefit to standard care | Not Reported | Not reported |
| Mannion 2007 High [29] | n = 151 Age: CG = 66 TG1 = 64 TG2 = 65 Duration LBP: CG = 132 mo TG1 = 94 mo TG2 = 126 mo Duration LP CG = 33 mo TG1 = 34 mo TG2 = 41 mo | Laminotomy Discectomy | Both groups 2 sessions/week up to 12 weeks TG1: Spine Stabilization Exercise TG2: PT-Mixed (among PT techniques included Maitland, Manual Therapy, Spinal Mobilization, Soft Tissue Mobilization) | CG; Self-Management | NPRS (0-10) for LBP and LP RMQ | NPRS: significant reduction in LBP and LP following surgery, no between group differences; slight statistical increase in LP from completion of rehab phase through 12mo post-op RMQ: all scores reduced following surgery, no significant | All groups improved. No significant difference between groups in pain and self-rated disability at 24 months after surgery | 1 TG1 patient dropped out after 2 sessions due to increased pain | Not reported |
| Timm 1994 Acceptable [30] | n = 250 | L5 laminectomy | All groups 3x/week for 8 weeks: TG1: physical agents (hot packs, ultrasound, TENS unit) TG2: joint manipulation (large-amplitude, low-velocity T12-S1 prone (Grade III or IV)) TG3: low-tech exercise (McKenzie and Spine Stabilization) TG4: high tech exercise (Bicycle ergometry followed by isotonic Ex on Cybex TEF and Torso) | CG: No treatment modified-modified Schober (lumbar ROM) Cybex lifttask (strength) ODI modified-modified Schober: low-tech and high-tech Ex increased lumbar flexion and extension ROM Joint manipulation increased extension ROM Cybex lifttask: low-tech and high-tech Ex increased lifting force output, no difference between groups ODI: low-tech and high-tech demonstrated improved ODI, no between group differences | None reported. |
|---|---|---|---|---|---|
| Kim 2015 Not Rated [72] | N = 33; Mean age: TG1 = 46.4 TG2 = 46.6 | Lumbar microdiscectomy | TG1: OMT including soft tissue and joint mobilization, myofascial release, neuromuscular technique, muscle energy technique, craniosacral release and rib raising and mobilization (not including HVLAs) | RMQ VAS Leg Pain VAS LBP Lumbar ROM Use of Medication RDQ: OMT greater reduction in disability VAS leg pain: OMT greater reduction VAS LBP: OMT greater improvements both groups, OMT greater improvement in extension and L side bending improvements both groups, with fewer patients | None Reported |
| Year | Author(s) | N | Age (Mean) | Intervention | Outcome Measures | Comments |
|------|-----------|---|------------|---------------|------------------|----------|
| 2016 | Kim       | 21 | CG: 54.9  |
|      |           |    | TG: 45.7  |
|      |           |    | Open laser microdiscectomy | TG = OMT including joint mobilization, soft tissue release, myofascial release, neuromuscular technique, muscle energy technique (not including HVLA) | CG = active control receiving home exercise booklet and verbal instruction to perform HEP 2x/week for 4 weeks | None Reported |
| 2017 | Kim       | 21 | CG: 54.9  |
|      |           |    | TG: 45.7  |
|      |           |    | Lumbar microdiscectomy | TG = OMT including soft tissue and joint mobilization, counter-strain techniques, neuromuscular technique, muscle energy technique (not including HVLA) | CG = active control receiving home exercise booklet | None reported |

CG = Control Group, CLBP = chronic low back pain, Ex = exercise, GPE = global perceived effect, Grade III = large amplitude rhythmic oscillating mobilization, Grade IV = small amplitude rhythmic oscillating, HEP = home exercise program, HVLA = high-velocity, low-amplitude manipulation, LBP = low back pain, LP = leg pain, McGill = McGill Pain Questionnaire, NPRS = Numerical Pain Rating Scale, ODI = Oswestry Disability Index, OMT = Osteopathic Manipulative Technique, PCS-SF = Physical Component Score of 36-item Short-Form, QDS = Quebec Disability Scale, RMQ = Roland Morris Questionnaire, ROM = Range of Motion, RTW = Return to work, TG = Treatment Group, VAS = Visual Analog Scale for pain.

Following lumbar surgery (undifferentiated), one RCT [29] compared a control group of self-management to 2 PT groups, a “spinal stabilization exercise group” and a “mixed-physical therapy group” including Maitland, manual therapy, spinal mobilization, and soft-tissue mobilization among other PT techniques. They found no between-group differences as measured by the numerical pain
rating scale or Roland-Morris Disability Questionnaire. The study did not control for specific interventions utilized by physical therapists in treatment. This RCT was rated high quality (low-risk-of bias) by the SIGN checklist.

A second high-quality RCT was described above and investigated inpatient use of neural mobilization following undifferentiated lumbar surgery [28]. Their study found no between-group differences for global perceived effect, the visual analog scale for pain, McGill Pain Questionnaire, Quebec Disability Scale, or return-to-work.

The last RCT studied outcomes after L5 laminectomy in a 5-arm trial comparing control (no treatment) to postoperative physical agents, joint mobilization, low-tech exercise, and high-tech exercise [30]. This study was graded acceptable-quality as it did not adequately address group assignment randomization, blinding of the investigators or patients, and handling of missing data (intention-to-treat). In their study, active approaches were the most effective for the improvement of functional measures of chronic low back pain, with low-tech exercise having the longest interval of chronic low back pain relief. Joint mobilization increased lumbar extension ROM but did not impact objective outcomes for spinal function.

**Literature reviews, case reports, and commentaries**

There was a large body of lower-level studies that were not assessed for quality. This included 1 scoping review [31], 1 narrative review [32], 14 case series [33–46], 23 case reports [47–69], and 2 commentaries [70, 71]. Ten of the case reports described 53 cases following discectomy, 16 reports described MMT in 143 cases post-laminectomy, 16 reports described MMT care for 67 cases after fusion, 1 report discussed post-surgical treatment in 8 cases after artificial disc replacement, and 1 report discussed care in 3 cases following implantation of spinal cord stimulators. There were multiple instances where a single report described FBSS cases from following more than 1 surgical intervention. The narrative review discusses lumbar fusion with relevance to chiropractors and the scoping review analyzed rehabilitation protocols directed at the lumbar spine in the perioperative periods. The findings from these studies and case reports are presented in Tables 11–13.

| Table 11 | Summary of included narrative, scoping and systematic reviews |
|----------|-------------------------------------------------------------|
| First Author, Year Published | Design | Quality | Principal Findings |
| Basson 2017 [25] | ISR | High | Systematic review and |
| Reference         | Type | Rating | Summary                                                                                                                                 |
|-------------------|------|--------|-----------------------------------------------------------------------------------------------------------------------------------------|
| Basson 2017[25]   | SR   | High   | Systematic review and meta-analysis of neural mobilization for neuromusculoskeletal conditions  
• 21 included in qualitative analysis, 1 related to post-lumbar surgery  
• Neural mobilization did not provide added benefit to usual medical care |
| Daniels 2016[32]  | NR   | Not Rated | • Describes indications for fusion, common surgical practice, and potential fusion complications  
• Patients with LBP and prior lumbar fusion may benefit with chiropractic manipulation, flexion-distraction, or manipulation under anesthesia.  
• Large-scale RCTs are needed to effectively assess the safety and efficacy of chiropractic care for patients after lumbar fusion |
| Gilmore 2015[26]  | SR   | High   | • Systematic review of physical therapy before and after surgery for lumbar degenerative condition  
• 4 studies met inclusion criteria  
• No clear benefit or risk of harm from performing either prone or side-lying transfers  
• Very-low-quality evidence suggests that physiotherapy may improve pain and function following lumbar surgery  
• Further research into patient mobility, exercise and provision of education is required using outcome measures that allow for comparison of results |
| Madera 2017[27]   | SR   | Acceptable | • Review of existing literature regarding rehabilitation following lumbar fusion surgery  
• 21 articles met the author’s inclusion criteria  
• Few articles offered specific rehabilitation protocols  
• Based on their review, the authors recommended immediate mobilization, followed by formal active rehabilitation 2–3 months post-operatively |
| Marchand 2016[31]  | ScR  | Not Rated | • 28 articles: comparing rehabilitation with placebo, no treatment, or another active treatment, or rehabilitation combined with interventions.  
• Outcomes: VAS, mODI, RMD, SLR, strength and endurance testing.  
• Following discectomy, early passive and active hip and knee flexion exercises were found to reduce time to independent mobility and return to work  
• No mention of MMT for |
• No mention of MMT for fusion, or vertebral decompression
• No conclusion could be drawn but notably multimodal programs including combinations of exercise, education, group exchange, and ergonomics

**Abbreviations:** MMT, manipulative or manual therapy; NR, narrative review; ODI, Oswestry Disability Index; RCT, randomized clinical trial; RMD0 Roland Morris Disability Questionnaire; ScR, scoping review; SLR, straight leg raise; SR, systematic review; VAS, visual analog scale

Table 12
Evidence table for included case series or reports of patients with prior lumbar surgery

| Citation        | Patients (n) | Surgical Intervention | Manual or Manipulative Intervention | Principle Findings                                                                 | Adverse Events          | Medication Discussion |
|-----------------|--------------|-----------------------|-------------------------------------|--------------------------------------------------------------------------------|-----------------------|-----------------------|
| Adams 1959[34]  | 31           | Discectomy and/or fusion | Sciatic nerve MUA                    | • Intraoperative sciatic nerve MUA for 31 lumbar postsurgical patients, 13 with prior fusion and 18 with prior discectomy  
• 22 patients had good outcomes  
• 9 patients were reexplored (revision surgery) | 19 cases increased pain following MUA procedure | Not reported |
| Adams 2004[33]  | 1            | L5/S1 discectomy       | SMT                                 | • FBSS with functional instability following surgery  
• 2 weeks of short-term pain benefit with SMT  
• SMT discontinued in favor of home exercise program | None reported | Not reported |
| Alexander 1993[35] | 1          | Laminectomy            | MUA                                 | • Describes management of FBSS with 5 days of serial MUA  
• Contrast MRI revealed L4-5 recurrent disk herniation and possible epidural fibrosis | None reported | Not reported |
| Aspegren 1997[36] | 1           | L5-S1 discectomy       | FD, MUA plus lumbar ESI             | • Describes management of recurrent lumbar radiculopathy secondary to epidural fibrosis  
• Initially managed with 10 sessions of a combination of chiropractic (flexion-distraction, exercise, hot pack, TENS) and 2 session lumbar ESI | None reported | Not reported |
| Name | Year | Procedure | Modality | Description | Side Effects | Notes |
|------|------|-----------|----------|-------------|-------------|-------|
| Bates 1964[45] | 1 | L5 laminectomy | Massage | Progressed to MUA plus ESI combination with positive outcome | None reported | Muscle relaxant |
| Benningfield 1997[37] | 1 | L5/S1 discectomy with laminotomy | SMT | Describes management of recurrent LE radiation of pain 1 year postoperative | Not reported | Aspirin, Tylenol 3, Ibuprofen with minimal relief; No post-TX reporting |
| Cornelson 2018[61] | 1 | Multiple: fusion and laminectomy at L3-4 and L4-5 | Neural mobilization | Describes successful management of patient with adhesive arachnoiditis following 3 lumbar procedures | None reported | Pre-TX Ibuprofen 400–600 mg per day; No post-TX reporting |
| Coulis 2013[51] | 2 | Case 1 L5 laminectomy with left L4-5 decompression and right L5-S1 decompression; Case 2 discectomy | Case 1 FD, Case 2 FD and SMT | Describes positive benefits of SMT and FD for patients with laminectomy and discectomy | Case 1 none reported; Case 2 mild lumbar spine soreness following initial TX with non subsequent adverse event | Case 1 Diclofenac and Cyclobenzaprine; Case 2 tricyclic antidepressants, acetaminophen, meloxicam, cyclobenzaprine and opioids; No post-TX reporting |
| Reference   | Year | Procedure | Treatment | Outcome                                                                 |
|-------------|------|-----------|-----------|------------------------------------------------------------------------|
| Cox 2009[55] | 2009 | L4-S1 Fusion | FD        | Improvement including walking and driving tolerance                   |
|             |      |           |           | • 20 sessions of FD provided improvement in pain and function (ODI)     |
|             |      |           |           | • LE pain completely relieved and mild LBP with use remained            |
|             |      |           |           | None reported                                                          |
|             |      |           |           | Not reported                                                           |
| Demetrious 2007[54] | 2007 | Fusion, 6 lumbar procedures | FD, manual trigger point therapy | Pre-TX severe compromise of ADLs and total disability status         |
|             |      |           |           | • Improvement reported for ADLs (ODI) and pain (VAS)                    |
|             |      |           |           | • Workers compensation ended trial of chiropractic care despite apparent benefit |
|             |      |           |           | None reported                                                          |
|             |      |           |           | Not reported                                                           |
| Francio 2017[65] | 2017 | Laminectomy | SMT       | Describes successful management post-laminectomy with combination of SMT and McKenzie method exercise |
|             |      |           |           | • Stable functional improvement with no significant pain or disability (ODI) at 3-month follow-up |
|             |      |           |           | None reported                                                          |
|             |      |           |           | Non-responsive to OTC medications, muscle relaxants and pain medicine |
| Gluck 1996[56] | 1996 | Discectomy | FD, manual therapy, SMT | Describes multimodal treatment approach emphasizing active rehabilitation techniques |
|             |      |           |           | • Transitioned from passive therapy after active patient was deemed “permanent and stationary” |
|             |      |           |           | • Improved lumbar ROM, reduced pain (VAS) 6.5 to 3.8, reduced disability (ODI) 82-58% |
|             |      |           |           | • Improved ambulation no longer required assistive device, improved sleep |
|             |      |           |           | None reported                                                          |
|             |      |           |           | Meperidine (Demerol), Motrin; Patient stopped using pain medication during treatment plan |
| Author   | Year | Procedure                                      | Type  | Management                                                                 | Effect                                      | Other                                                   |
|----------|------|-----------------------------------------------|-------|---------------------------------------------------------------------------|---------------------------------------------|---------------------------------------------------------|
| Greenwood| 2012 | Fusion, vertebrectomy, cage reconstruction     | FD    | • Describes successful management of chronic low back pain associated with adjacent segment disease  
• Aviation crash survivor with multilevel lumbar fusion | None reported                               | Not reported                              |
| Gudavalli| 2016 | Discectomy, laminectomy, fusion                | FD    | • Describes FD for patients with history of discectomy (n = 15), laminectomy (n = 20), fusion (n = 29), and other (n = 5)  
• 57/67 (81%) reported > 50% improvement in pain  
• 13/67 (19%) reported < 50% improvement in pain  
• 2 patients lost to follow-up  
• Mean relief (NPS) following initial care 71.6%, 70% at 24-month follow-up  
• 24 patients (43%) did not require any additional care  
• 32 patients sought additional care with 17(53%) seeking SMT, 9 (28%) physical therapy, exercise, injections and/or medications, and 5 (16%) having repeat spinal surgery, and 1 lost to follow-up | None reported                               | 9 cases reported seeking additional physical therapy, exercise regimens, injections, and/or medications at 24-month follow-up; No reporting on Post-TX medication change |
| Hoiriis  | 1989 | Laminectomy L4-S1 and partial discectomy L5-S1 | SMT   | • Describes management of patient with postsurgical LBP radiating to right LE with 18 sessions of upper cervical manipulation  
• Decrease in pain with leg lowering, decrease of pain with cervical ROM, and increase in cervical ROM  
• No reported                                           | Not reported                               | Not reported                              |
| Study          | Treatment                      | Control | Outcomes                                                                                           | Adverse Events |
|---------------|--------------------------------|---------|---------------------------------------------------------------------------------------------------|----------------|
| Keller 2012[68] | L4-5 Laminectomy and Fusion   | Massage | - Describes 7 30-minute massage sessions <br>- Improved disability with measured ODI from 50–36% post-TX, and RDQ from 3/24 to 2/24 <br>- Pain (VAS) and hamstring length improved within each session | Not reported   |
| Kennedy 2016[67] | Lumbosacral fusion            | Curanderismo (massage) | - Describes holistic healing tradition indigenous to Latin America <br>- Treatment consisting of educating patient on connection between mind, body, spirit, aromatherapy, music therapy, and massage of body meridian lines <br>- No quantitative decrease in maximum or average pain levels <br>- Patient reported improved function, mood, sleep and narcotic use <br>- Patient did not refill Percocet prescription | None reported |
| Kruse 201[53]   | Fusion                        | FD      | - Describes successful management of acute postsurgical LBP <br>- 13 sessions FD plus ultrasound and electrical stim over 6 weeks <br>- Resolution of pain, VAS 5/10 to 0/10 <br>- Reduced disability, ODI 18–2% <br>- 2-year follow-up with no symptoms recurrence and expressed patient satisfaction with care | None reported   |
| Study            | Patients | Intervention | FD Details                                                                                                                                  | NPS Change | TX Details |
|------------------|----------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------|------------|------------|
| Kruse 2011[41]   | 32       | FD           | Retrospective analysis describes FD for patients with history of discectomy (n = 13), laminectomy (n = 10), fusion (n = 2), or combination (n = 7) | None reported | Not reported |
|                  |          |              | Heterogeneous sample                                                                                                                        |            |            |
|                  |          |              | TX dose ranged from 6-31 sessions                                                                                                          |            |            |
|                  |          |              | NPS decrease ranged from 0-8.4                                                                                                             |            |            |
| |          |              | Patients with combination                                                                                                                 |            |            |
| Lamb 1997[59]    | 1        | Discectomy   | Describes successful management of patient with post-surgical LBP                                                                        | None reported | Not reported |
|                  |          |              | 10 sessions of SMT (targeting sacroiliac joint) and ultrasound                                                                          |            |            |
| Layton 2009[49]  | 1        | Laminectomy  | Describes management of post-surgical LBP                                                                                                  | None reported | Not reported |
|                  |          |              | 32 visits of SMT of cervical, thoracic, lumbar and sacroiliac regions                                                                     |            |            |
|                  |          |              | Pain (VAS) score improved from 5 to 8, but Borg pain scale (right now, typical/average, worst) was unchanged 5,5,9 to 6,6,8               |            |            |
| Lisi 2004[50]    | 1        | Laminectomy  | Describes management of patient with residual cauda equina symptoms following surgical decompression                                        | None reported | Not reported |
|                  |          |              | Resolution of LBP after 4 sessions of SMT                                                                                                  |            |            |
|                  |          |              | NRS 5/10 to 0/10                                                                                                                          |            |            |
|                  |          |              | No change in chronic residual cauda equina symptoms                                                                                         |            |            |
| Lee 2017[42]     | 102      | SMT (Chuna Manual therapy, form of Korean SMT)                                                                                            | Describes management of patients with post-surgical back pain or LE (spinal) pain including laminectomy (n | None reported | Analgesics and muscle relaxants; no reporting post-TX |
|                  |          |              | 1 case increased LBP, 32 cases mild GI issues (related to herbal medicine component)                                                    |            |            |
| Study-Year | Case Count | Procedure Details | Treatment Description | Medication | Pain Relief Details |
|------------|------------|-------------------|-----------------------|------------|--------------------|
| Maddalozzo 2018[47] | 1 | Discectomy, Fusion, Hemilaminotomy | SMT • Describes successful management of post-surgical LBP • Treatment consisted of 52 visits over 8 months with SMT with active rehabilitation (with functional decompression) • Pain (NRS) reduced from 8/10 to 1/10 • Disability (ODI) reduced from 50–8% | None reported | Hydrocodone-acetominophen 10/325 Fentanyl 50 mcg/hr Transdermal Patch; pain medication use decreased through course of tx; 41-month follow-up patient denied use of medication for LBP |
| McGregor 1983[44] | 3 | Case 1 L5/S1 fusion; Case 2 Laminectomy; Case 3 L4-S1 laminectomy | SMT • Describes management of lumbar post-surgical sacroiliac joint syndrome • Case 1 reported significant relief following SMT to sacroiliac joint daily for 2 weeks followed by “regular follow-up” for 1 month • Case 2 reported SMT to sacroiliac joint daily for 3 weeks, then “frequently” for a month and a half, tapering over 10 months until no longer symptomatic | None reported | Not reported |
| Morningstar[43] 2012 | Fusion and L4 or L5 laminectomy | MUA, myofascial trigger point therapy, massage | • Case 3 describes sacroiliac SMT for 2 weeks with leg pain completely relieved |
|---------------------|----------------------------------|-----------------------------------------------|----------------------------------------------------------------------------------|
| Oakley 2007[48]     | L4-5 laminectomy                 | SMT and static posturing                       | None reported Case 1: 2 Vicodin 7.5/750 mg; no reporting post-TX |
| O'Shaughnessy 2010[39] | Total disc replacement L5/S1 (7) and/or L4/L5 (4) | SMT                                            | None reported Vicodin; patient no longer required analgesic narcotic pain medications |
| Study          | #   | Treatment  | Outcome                                                                 | Notes |
|---------------|-----|------------|-------------------------------------------------------------------------|-------|
| Paris 2017[62]| 1   | T12/L2 fusion post-trauma | SMT, drop table assisted SMT, spinal mobilization                      | None reported |
|               |     |            | • Describes successful management with SMT<br>• 13 sessions over 4 months<br>• Patient self-discharged and missed re-examination<br>• Phone follow-up patient indicated he felt great and didn’t need ongoing care | Not reported |
| Perrucci 2017[40] | 3 | SCS | SMT, FD, myofascial release | None reported |
|               |     |            | • Describes chiropractic management of patients with SCS<br>• Case 1 L5/S1 fusion with SCS implant treated 6x over 3 months and experienced durable LBP relief and increased tolerance to standing and lying down<br>• Case 2 received 2 treatment, reported no benefit and discontinued care<br>• Case 3 presented with cLBP and right LE pain<br>• Poor tolerance to pre-manipulation positioning so SMT not performed, was treated 4x over 4 weeks with FD and myofascial release<br>• Temporary relief of LBP with no change of LE symptoms and care discontinued | Opioid medications prescribed, but not impacted by manual therapy |
| Peterson 1    | 1   | L2-5       | Spinal                                                                 | None reported |
|               |     |            | • Describes                                                                 | 22 medications |
| Year | Authors | Study Design | Intervention | Outcome |
|------|---------|--------------|--------------|---------|
| 2016 | Peterson | L2-5 laminectomy with partial facetomy and IPD implantation | Mobilization with McKenzie method lateral shift correction | Successful management of subacute to chronic lumbar radiculopathy. At discharge no leg pain or antalgia, improved and pain-free lumbar ROM, improved hip abduction muscle test, and improved LBP (NRS) 9/10 to 1/10. Improved disability (ODI) 52% to 40%. Global rating of change 6+.

- None reported included narcotics for pain management; no reporting post-TX.

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| Year | Authors | Study Design | Intervention | Outcome |
|------|---------|--------------|--------------|---------|
| 1995 | Stern | Undifferentiated SMT, massage, mobilization | | Case series of 3531 patient files with n = 71 having LBP and LE pain with diagnosis of disc herniation, of those 7 had history of low back surgery. History of lumbar surgery more common in negative (non-response) outcome group (p = 0.007). Previous operation tended to predict poor outcome: adjusted odds ratio 46.6 (CI 2.4–90.0).

- None reported.

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| Year | Authors | Study Design | Intervention | Outcome |
|------|---------|--------------|--------------|---------|
| 1996 | Shaw | L4-5 discectomy and laminectomy | SMT | Describes response to new LBP with right S1 radicular pain after slip and fall with prior low back surgery. Reduced disability (ODI) from 84% to < 10%. Treatment consisted of SMT, passive physiotherapy, and active and passive home care with definitive treatment dosage described.

- None reported.

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| Year | Authors | Study Design | Intervention | Outcome |
|------|---------|--------------|--------------|---------|
| 2007 | Taylor | L4-5 decompression with laminectomy and cyst | FD | Describes care of patient with LBP and bilateral LE symptoms, and

- None reported.

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| Vaillancourt 1983[69] | L4-S1 fusion | SMT | • Describes of patient with cLBP, bilateral LE pain and L4 hypoesthesia  
• Treatment consisted of 14 upper cervical manipulations over 166 days  
• No valid outcomes were available other than reported LE pain reduction and medication reduction | None reported |Switched from Carbamazepine to Aspirin at Psychiatrist direction |
| Vulfsons 2011[63] | Hemilaminectomy and discectomy with revision 2x | OMT (oscillatory) | • Returned to work as a surgeon at 4-month follow-up  
• Without pain | None reported | Not reported |
| Welk 2012[52] | Lumbar discectomy | FD, manual therapy | • Describes management of acute on chronic LBP with right gluteal pain  
• MRI revealed recurrent L5/S1 disc herniation and epidural fibrosis and patient declined surgical revision  
• Care consisted of 27 visits over 12 weeks, then every other week for 9 visits  
• Disability (ODI) reduced from 50–17.7% | None reported | Flexeril, Naprosyn, Percocet as needed; no reporting Post-TX |
from 50–17.7% in 10 weeks

- Other outcomes included pain intensity, orthopedic tests, lumbar ROM and DTRs

| Citation and Quality | Design | Surgical Intervention | Manual or Manipulative Therapy | Principle Findings | Adverse Events | Medication Discussion |
|----------------------|--------|-----------------------|--------------------------------|--------------------|---------------|-----------------------|
| Walker 1992[70]      | CO     | Undifferentiated      | SMT                            | • Explanations of possible reasons for FBSS | Not applicable | Not applicable         |
| Shapiro 2014[71]     | CO     | Microdiscectomy, discectomy, microlaminectomy, laminectomy, PLIF, ALIF, TLIF | SMT and focused PT | • Short-term relief can be afforded with manipulation and focused physical therapy but recurrent and persistent pain, spasm, and limited range of motion is common. • Remainder of article described interventional and pharmacological procedures. | Majority of the paper discusses adverse events (FBSS) | Discussed use of 1. NSAIDs or acetaminophen; 2. Muscle relaxants; 3. True antispastic medications; 4. Antidepressants; 5. Gabapentinoids; 6. Tramadol; 7. Opioids |

**Strength Of Evidence**

The strength of evidence is rated and grouped by prior surgical type and criteria are described in Table 6.

**Discectomy**

Evidence was inconclusive because of a scarcity of studies and is insufficient to recommend or discourage application of MMT in treatment plans following lumbar discectomy.

**Laminectomy**

Evidence was inconclusive regarding spinal mobilization (Grade III or IV Maitland) following L5 laminectomy but is favorable for improving lumbar extension ROM without improving pain and function outcome measures. Evidence is insufficient to recommend or discourage application of MMT in treatment plans following lumbar laminectomy.
Fusion
Evidence was inconclusive because of a scarcity of studies and is insufficient to recommend or
discourage application of MMT in treatment plans following lumbar fusion.

Disc replacement
Evidence was inconclusive because of a scarcity of studies and is insufficient to recommend or
discourage application of MMT in treatment plans following lumbar total disc replacement.

Spinal cord stimulator
Evidence was inconclusive because of a scarcity of studies and is insufficient to recommend or
discourage application of MMT in treatment plans following spinal cord stimulator implantation.

Undifferentiated postsurgical (lumbar discectomy, laminectomy, or fusion)
Moderate evidence indicates that mixed technique PT (which may include MMT) does not improve
outcomes compared with control or standard PT techniques. Moderate evidence indicates adding
neural mobilization to immediate postoperative care does not improve outcomes.

Discussion
This review evaluated the state of literature, assessed RCT and SR quality, and graded the strength of
evidence for MMT for individuals with history of lumbar surgical procedures. We organized the
findings and graded the strength of evidence by surgical type. Very few MMT clinical trials have been
completed for this population and thus the interested clinician is forced to rely heavily on case reports
and series for literature guidance.

Discectomy
We found no trials that specifically investigated MMT following discectomy. There were 3 pilot studies
published by Kim et al. investigated OMT versus active control following microdiscectomy [72–74].
Two of these studies were of the same patient data (short- and long-term follow-up), and all 3
described greater improvements in pain and disability following OMT. There were 10 case reports and
series describing the care of 54 patients following discectomy. All but one intraoperative report [34]
involved care provided by chiropractors. Favorable responses were reported with spinal manipulation
[33, 37, 51, 59], FD manipulation [38, 41, 51, 52], manual therapy [52, 56], and manipulation under
anesthesia of the sciatic nerve [34] or spinal joints [36]. Following discectomy, a scoping review
suggested early passive and active hip and knee flexion exercises to reduce time to independent
Laminectomy
One randomized controlled trial with acceptable quality met inclusion criteria. Relevant to MMT this trial found that lumbar mobilization increased lumbar extension ROM after laminectomy. Grade III and IV mobilization did not significantly improve functional measures for lower back pain. As this was the only study specific to laminectomy and it was of acceptable quality, there is inconclusive evidence for or against using MMT. We identified 16 case reports or series describing 143 patients after lumbar laminectomy. Two reports from the medical profession [42, 63], 1 from physical therapy [60], 1 from an athletic trainer [45] and the rest were chiropractic specific. Favorable responses were described with spinal manipulation [42, 44, 48-50, 57, 64, 65], spinal manipulation under anesthesia [35], spinal mobilization with or without McKenzie method [60], FD manipulation [38, 41, 51, 66], and massage [45].

Fusion
We found no trials that specifically investigated MMT following discectomy. We identified 16 case reports or series describing MMT for 67 patients with history of lumbar fusion. Three of these reports were from the medical profession [34, 42, 67], 1 from massage [68] and the rest were chiropractic specific. Favorable response to care was noted following spinal manipulation [42, 44, 47, 62, 69], FD manipulation [38, 41, 53-55, 58], massage [67, 68], neural mobilization both post- [61] and intra-operative [34], and spinal manipulation under anesthesia [43]. A literature review outlined types of lumbar fusion operation, common adverse events, and described chiropractic fusion related literature while calling for clinical trials to assess the safety and efficacy of care [32].

Disc Replacement
No trials and only 1 case described MMT following lumbar total disc replacement [39]. O’Shaughnessy et al. described management of 8 cases with spinal manipulation. As a safety measure, the authors incorporated flexion-extension radiographs to ensure intersegmental stability and patients were positioned in a preloaded manipulative setup to determine tolerance. Disability and fear-avoidance was improved in 75% (6/8) and 63% (5/8) of cases respectively.

Spinal cord stimulator
No trials and only 1 case report described MMT following spinal cord stimulator [40]. This report outlined chiropractic management of 3 cases through a combination of spinal manipulation, FD, and myofascial release. One of the patients could not tolerate positioning for spinal manipulation and as a result, was not performed. Two of the 3 cases reported favorable outcomes and one had no benefit from care.

**Postsurgical undifferentiated (lumbar discectomy, laminectomy, or fusion)**

Two of the 3 randomized controlled trials enrolled patients following a variety of different lumbar surgical procedures (discectomy, laminectomy, and fusion) and did not breakdown their results by surgical type [28, 29]. The studies were both early postoperative, and neither study found significant improvement by incorporating MMT. The study by Mannion et al. did not specifically require MMT as part of the intervention group [29]. In a scoping review of lumbar surgery perioperative rehabilitation, Marchand et al. found that passive and active hip and knee flexion exercises reduced time to independent mobility and return-to-work. Commentaries by Walker [70] and Shapiro [71] discussed complications related to, and the role of manipulation for, individuals with FBSS.

**Adverse events**

None of the clinical trials reported patient dropout in any treatment groups including MMT. Each of the pilot trials reported patients lost to outcome, but no side effects or complications were reported [72–74]. None of the case reports or series reported any serious adverse events such as loss of bowel or bladder function, stroke, fracture or hospitalization [75]. The case series describing intraoperative neural mobilization reported 61% (19/31) patients noted increased pain post MMT and 29% (9/31) required additional exploratory surgery [34]. Mild lumbar soreness was reported by several case reports for various MMTs and surgical types [39, 42, 51]; however, mild soreness is commonly reported following manual therapy in patients without history of surgery [76–78]. One study reported increased lower extremity pain in 2 of 8 patients being treated with spinal manipulation following lumbar total disc replacement [39].

**Medications**

None of the adequately powered trials used pharmacologic prescription or utilization as an outcome, thus no conclusions or recommendations can be determined regarding the ability of MMT to reduce or
impact patient usage of medication. One pilot trial assessed anti-inflammatory, analgesic, and muscle relaxant medication usage as a secondary outcome and found that patients assigned to osteopathic manipulative rehabilitation after microdiscectomy used less medication than the control group [72]. A few case reports similarly described patient medication reduction or elimination through the utilization of MMT [47, 48, 56, 67], but most did not comment on any change in medication. A recent systematic review and meta-analysis revealed an inverse association between chiropractic care and opioid receipt in veterans with spinal pain [79] and multiple cohort studies of health insurance claims data displayed a significantly lower likelihood of filling opioid prescriptions for recipients of chiropractic care than nonrecipients [80, 81]. Although promising, it is not clear if this relationship persists in the post-surgical population.

Limitations
This review is limited by the evidence that is available and underscores the knowledge gap and the need for high-quality trials to allow for recommendations for or against MMT following a variety of lumbar surgeries. Although numerous case reports describe favorable outcomes with MMT, the limited number of RCTs and the absence of cohort studies with comparison make it impractical to make recommendations for most MMT. There is insufficient evidence to make any recommendations following most surgical procedures. Two of the 3 sufficiently powered RCTs included multimodal care, were heterogeneous of design, and all 3 were perioperative, making the findings impossible to pool and challenging to generalize to outpatient settings with patients presenting months to years post-procedure. Further, none of these trials specifically investigated or included spinal manipulation as an intervention. The current literature to guide clinicians relies heavily on case reports, with which there is a strong prospect of positive publication bias and likely under-reporting of adverse events [82]. The increased utilization of surgical intervention to address lumbar degenerative conditions and high rate of spine pain recurrence necessitate the need for studying MMT as a non-pharmacological treatment option post-operatively. Further study is needed which emphasizes pragmatic application of MMT within study designs. RCTs and longitudinal cohorts with comparison or control groups could shed light on the relative safety or dosage of MMT that is appropriate to reach maximum therapeutic
benefit. There is a need to assess the impact of MMT on prescription medication utilization. Lastly, there is a need for studies that stratify the response to MMT by surgical type. There may be between-group differences for treatments depending on surgical-type history. Although low-level studies suggest favorable outcomes associated with MMT in the postsurgical patient, no conclusions can be drawn from the evidence related to timing, dosage, tolerance, or safety of MMT after lumbar surgery.

Conclusions
The findings of this review will help to inform practitioners of MMT (chiropractors, physical therapists, osteopaths, massage therapists and other manual therapy providers) about existing literature for managing patients with prior lumbar surgeries. Following lumbar surgery, current evidence indicated that inpatient neural mobilization does not improve outcomes. There is inconclusive evidence to recommend for or against most MMT after most surgical interventions. The overall body of evidence is primarily limited to low-level studies including case reports and series. The results of this study suggest that MMT may have a positive effect in individuals with low back pain with a history of lumbar surgery, however, caution should be used in generalizing the findings of these results to clinical practice, considering the low-quality of the evidence available for synthesis. High-quality studies, including RCTs are needed to gain further understanding of the effectiveness and safety profile of MMT for patients with prior lumbar surgery.

Abbreviations
Flexion-distraction (FD), Manual and manipulative therapy (MMT), osteopathic manipulative therapy (OMT), randomized controlled trial (RCT), Scottish Intercollegiate Guidelines Network (SIGN), systematic review (SR)

Declarations
Ethics approval and consent to participate
Since our study is a systematic review, an ethical review is not required.

Consent for publish
Not applicable

Availability of data and materials
Not applicable. The data used for analysis was retrieved from published studies listed in our manuscript.
Competing interests
The authors declare they have no competing interests.

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Authors’ contributions
CD and CH developed the study concept. CD, JG, ZC, SW and CH designed study methodology. CD, ZC and SW performed literature search and data collection. CD, JG, ZC, NH, DG, and AS analyzed and interpreted the data. All authors read and approved the final manuscript.

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References
1. GBD 2017 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018 10;392(10159):1789-1858.
2. Yoshihara H, Yoneoka D. National trends in the surgical treatment for lumbar degenerative disc disease: United States, 2000 to 2009. Spine J. 2015;15(2):265–71.
3. Pumberger M, Chiu Y-L, Ma Y, Girardi FP, Mazumdar M, Memtsoudis SG. National in-hospital morbidity and mortality trends after lumbar fusion surgery between 1998 and 2008. J Bone Joint Surg Br. 2012;94(3):359–64.
4. Martin BI, Mirza SK, Spina N, Spiker WR, Lawrence B, Brodke DS. Trends in Lumbar Fusion Procedure Rates and Associated Hospital Costs for Degenerative Spinal Diseases in the United States, 2004 to 2015. Spine. 2019;44(5):369-76.
5. Kha ST, Ilyas H, Tanenbaum JE, et al. Trends in Lumbar Fusion Surgery Among Octogenarians: A Nationwide Inpatient Sample Study From 2004 to 2013. Global Spine J -. 2018;8(6):593–9.

6. Ruan W, Feng F, Liu Z, Xie J, Cai L, Ping A. Comparison of percutaneous endoscopic lumbar discectomy versus open lumbar microdiscectomy for lumbar disc herniation: A meta-analysis. Int J Surg. 2016;31:86–92.

7. Yadav RI, Long L, Yanming C. Comparison of the effectiveness and outcome of microendoscopic and open discectomy in patients suffering from lumbar disc herniation. Med (Baltim). 2019;98(50):e16627.

8. Carragee EJ, Han MY, Suen PW, Kim D. Clinical outcomes after lumbar discectomy for sciatica: the effects of fragment type and anular competence. J Bone Joint Surg Am. 2003;85(1):102–8.

9. Maigne JY, Planchon CA. Sacroiliac joint pain after lumbar fusion. A study with anesthetic blocks. Eur Spine J. 2005;14(7):654–8.

10. Fritsch EW, 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(5):626–33.

11. Suri P, Pearson AM, Zhao W, et al. Pain Recurrence After Discectomy for Symptomatic Lumbar Disc Herniation. Spine (Phila Pa 1976). 2017;42(10):755–63.

12. Castillo H, Chintapalli RTV, Boyajian HH, Cruz SA, Morgan VK, Shi LL, et al. Lumbar discectomy is associated with higher rates of lumbar fusion. Spine J. 2019;19(3):487–92.

13. Turner JA, Loeser JD, Deyo RA, Sanders SB. Spinal cord stimulation for patients with failed back surgery syndrome or complex regional pain syndrome: a systematic review of effectiveness and complications. Pain. 2004;108(1-2):137–47.
14. Kim C-G, Mun S-J, Kim K-N, Shin B-C, Kim N-K, Lee D-H, et al. Economic evaluation of manual therapy for musculoskeletal diseases: a protocol for a systematic review and narrative synthesis of evidence. BMJ Open. 2016;6(5).

15. Smith MS, Olivas J, Smith K. Manipulative Therapies: What Works. Am Fam Physician. 2019;99(4):248-52.

16. Brantingham JW, Cassa TK, Bonnefin D, Pribicevic M, Robb A, Pollard H, et al. Manipulative and multimodal therapy for upper extremity and temporomandibular disorders: a systematic review. J Manipulative Physiol Ther. 2013;36(3):143-201.

17. Murad MH, Sultan S, Haffar S, Bazerbachi F. Methodological quality and synthesis of case series and case reports. BMJ Evid-Based Med. 2018;23(2):60-3.

18. Crumpston M, Li T, Page MJ, et al. Updated guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for Systematic Reviews of Interventions. Cochrane Database Syst Rev. 2019;10:ED000142.

19. Scherer RW, Meerpohl JJ, Pfeifer N, Schmucker C, Schwarzer G, von Elm E. Full publication of results initially presented in abstracts. Cochrane Database Syst Rev. 2018;11:MR000005.

20. Scottish Intercollegiate Guidelines Network. Critical appraisal and notes checklists. https://www.sign.ac.uk/checklists-and-notes Accessed 1 March 2020.

21. Hawk C, Minkalis AL, Khorsan R, Daniels CJ, Homack D, Gliedt JA, et al. Systematic Review of Nondrug, Nonsurgical Treatment of Shoulder Conditions. J Manipulative Physiol Ther. 2017;40(5):293-319.

22. Bronfort G, Haas M, Evans R, Leininger B, Triano J. Effectiveness of manual therapies: the UK evidence report. Chiropr Osteopat. 2010;18:3.

23. Clar C, Tsertsvadze A, Court R, Hundt GL, Clarke A, Sutcliffe P. Clinical effectiveness of manual therapy for the management of musculoskeletal and non-musculoskeletal
conditions: systematic review and update of UK evidence report. Chiropr Man Ther. 2014;22(1):12.

24. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009 Jul;21(7):e1000097. 6().

25. Basson A, Olivier B, Ellis R, Coppieters M, Stewart A, Mudzi W. The Effectiveness of Neural Mobilization for Neuromusculoskeletal Conditions: A Systematic Review and Meta-analysis. J Orthop Sports Phys Ther. 2017;47(9):593–615.

26. Gilmore SJ, McClelland JA, Davison M. Physiotherapeutic interventions before and after surgery for degenerative lumbar conditions: a systematic review. Physiotherapy. 2015;101(2):111–8.

27. Madera M, Brady J, Deily S, et al. The role of physical therapy and rehabilitation after lumbar fusion surgery for degenerative disease: a systematic review. J Neurosurg Spine. 2017;26(6):694-704.

28. Scrimshaw SV, Maher CG. Randomized controlled trial of neural mobilization after spinal surgery. Spine. 2001;26(24):2647–52.

29. Mannion AF, Denzler R, Dvorak J, Müntener M, Grob D. A randomised controlled trial of post-operative rehabilitation after surgical decompression of the lumbar spine. Eur Spine J. 2007;16(8):1101-17.

30. Timm KE. A randomized-control study of active and passive treatments for chronic low back pain following L5 laminectomy. J Orthop Sports Phys Ther. 1994;20(6):276–86.

31. Marchand AA, O'Shaughnessy J, Châtillon C, et al. Practices in Lumbar Surgery Perioperative Rehabilitation: A Scoping Review. J Manipulative Physiol Ther. 2016;39(9):668-92.
32. Daniels CJ, Wakefield PJ, Bub GA, Toombs JD. A narrative review of lumbar fusion surgery with relevance to chiropractic practice. J Chiropr Med. 2016;15(4):259-71.

33. Adams V. The rehabilitation of a patient with functional instability associated with failed back surgery. J Am Chiropr Assoc. 2004;41(12):31-9.

34. Adams JE, Inman VT. Stretching of the Sciatic Nerve. California Medicine. 1959;91(1):24-6.

35. Alexander GK. Manipulation under anaesthesia of lumbar post-laminectomy syndrome patients with epidural fibrosis and recurrent HNP. J Chiropr. 1993;30(6a):79-82.

36. Aspergren DD, Hemler DE, Wright RE. Manipulation under epidural anesthesia with corticosteroid injection: two case reports. J Manipulative Physiol Ther. 1997;20:4:263-266.

37. Benningfield RC. Conservative treatment and back-strengthening exercises to prevent recurrent surgery. J Sports Chiropr Rehabil. 1997;11(2):52-6.

38. Gudavalli MR, Oding K, Joachim G, Cox JM. Chiropractic Distraction Spinal Manipulation on Postsurgical Continued Low Back and Radicular Pain Patients: A Retrospective Case Series. J Chiropr Med. 2016;15(2):121-8.

39. O’Shaughnessy J, Drolet M, Roy J-F, Descarreaux M. Chiropractic management of patients post-disc arthroplasty: eight case reports. Chiropr Osteopat. 2010;18(1):7.

40. Perrucci RM, Coulis CM. Chiropractic management of post spinal cord stimulator spine pain: a case report. Chiropr Man Ther. 2017;25(1):5.

41. Kruse RA, Cambron J. Chiropractic Management of Postsurgical Lumbar Spine Pain: A Retrospective Study of 32 Cases. J Manipulative Physiol Ther. 2011;34(6):408-12.

42. Lee J, Shin J-S, Lee YJ, Kim M, Choi A, Lee J-H, et al. Long-Term Course of Failed Back Surgery Syndrome (FBSS) Patients Receiving Integrative Korean Medicine Treatment: A 1 Year Prospective Observational Multicenter Study. PLOS ONE.
43. Morningstar MW, Strauchman MN. Manipulation under anesthesia for patients with failed back surgery: retrospective report of 3 cases with 1-year follow-up. J Chiropr Med. 2012;11(1):30-5.

44. McGregor M, Cassidy JD. Post-surgical sacroiliac joint syndrome. J Manipulative Physiol Ther. 1983;6(1):1-11.

45. Bates WT. Postoperative Disk Management in Sports. Phys Ther. 1964;44(11):997-8.

46. Stern PJ, Cote P, Cassidy JD. A series of consecutive cases of low back pain with radiating leg pain treated by chiropractors. J Manipulative Physiol Ther. 1995;18(6):335-42.

47. Maddalozzo GF, Aikenhead K, Sheth V, Perisic MN. A novel treatment combination for failed back surgery syndrome, with a 41-month follow-up: a retrospective case report. J Chiropr Med. 2018;17(4):256-63.

48. Oakley PA, Berry RH, Harrison DE. A structural approach to post-surgical laminectomy: a case study. J Vert Sublux Res. 2007;19:1-7.

49. Layton PD. Chiropractic care for a patient with subluxation & unsuccessful surgery of the lumbar spine. J Vert Sublux Res. 2009;10:1-5.

50. Lisi AJ, Bhardwaj MK. Chiropractic high-velocity low-amplitude spinal manipulation in the treatment of a case of postsurgical chronic cauda equina syndrome. J Manipulative Physiol Ther. Nov;27(9):574-8.

51. Coulis CM, Lisi AJ. Chiropractic management of postoperative spine pain: a report of 3 cases. J Chiropr Med. 2013;12(3):168-75.

52. Welk AB, Werdehausen DN, Kettner NW. Conservative management of recurrent lumbar disk herniation with epidural fibrosis: a case report. J Chiropr Med. 2012;11(4):249-53.
53. Kruse RA, Cambron JA. Cox decompression chiropractic manipulation of a patient with postsurgical lumbar fusion: a case report. J Chiropr Med. 2011;10(4):255–60.

54. Demetrious J. Clinical imaging pearls. Posterior lumbar interbody fusion failure: a brief case presentation. J Acad Chiropr Orthoped. 2007;4(4):3–7.

55. Cox JM. Failed Back Surgical Syndrome - L1-2 and L5-S1 Disc Herniations Following L4- S1 Spinal Fusion: A Case Report. J Acad Chiropr Orthoped. 2009;6(3):17.

56. Gluck NI. Passive care and active rehabilitation in a patient with failed back surgery syndrome. J Manipulative Physiol Ther. 1996;19(1):41–7.

57. Hoiriis KT. Case report: management of post-surgical chronic back pain with upper cervical adjustment. Chiropr Res J. 1989;1(3):37–42.

58. Greenwood DM. Improvement in chronic low back pain in an aviation crash survivor with adjacent segment disease following flexion distraction therapy: a case study. J Chiropr Med. 2012;11(4):300–5.

59. Lamb KL. Sacroiliac joint dysfunction with associated piriformis syndrome mimicking intervertebral disc syndrome resulting in failed low back surgery. Chiropr Tech. 1997;9(3):128–32.

60. Peterson S, Hodges C. Lumbar lateral shift in a patient with interspinous device implantation: a case report. J Man Manip Ther. 2016;24(4):215–22.

61. Cornelson SM, Johnnie ED, Kettner NW. Neural mobilization in a 54-year-old woman with postoperative spinal adhesive arachnoiditis. J Chiropr Med. 2018;17(4):283–8.

62. Paris DJ, Schielke AL. Resolution of post-surgical low back pain in a patient with chronic cauda equina syndrome: a case study. J Acad Chiropr Assoc. 2017;14(4):43–9.

63. Eisenberg E by Vulfsons E, Waldman S M. Persistent Back Pain after Multiple Operations: Case Presentation From Israel With Commentaries From Austria and The
64. Shaw TW. Chiropractic rehabilitation of the retraumatized postsurgical lumbar spine with radiculopathy. J Am Chiropr Assoc. 1996;33(3):71-4.

65. Francio V, Towery C, Davani S, Brown T. Spinal manipulation and therapeutic exercises in treating post-surgical resurgent lumbar radiculopathy. Oxf Med Case Rep. 2017;10:omx062.

66. Taylor DN. Spinal synovial cysts and intersegmental instability: a chiropractic case. J Manipulative Physiol Ther. 2007;30(2):152–7.

67. Kennedy L, Gonzales E, Corbin L. The effect of Curanderismo on chronic non-malignant pain: a case report. EXPLORE. 2016;12(4):263–7.

68. Keller G. The effects of massage therapy after decompression and fusion surgery of the lumbar spine: a case study. Int J Ther Massage Bodyw. 2012;5(4):3-8.

69. Vaillancourt PJ, Collins KF. Case report: management of post-surgical low back syndrome with upper cervical adjustment. Chiropr Res J. 1993;2(3):1-15.

70. Walker BF. Failed back surgery syndrome. COMSIG Rev. 1992;1(1):3-6.

71. Shapiro CM. The failed back surgery syndrome: pitfalls surrounding evaluation and treatment. Phys Med Rehabil Clin N Am. 2014;25(2):319–40.

72. Kim BJ, Ahn J, Cho H, et al. Rehabilitation with osteopathic manipulative treatment after lumbar disc surgery: A randomised, controlled pilot study. Int J Osteo Med. 2015;18(3):181–8.

73. Kim BJ, Kim T, Ahn J, Cho H, Kim D, Yoon B. Manipulative rehabilitation applied soon after lumbar disc surgery improves late post-operative functional disability: A preliminary 2-year follow-up study. J Back Musculoskelet Rehabil. 2017;30(5):999–1004.

74. Kim BJ, Ahn J, Cho H, Kim D, Kim T, Yoon B. Early individualised manipulative
rehabilitation following lumbar open laser microdiscectomy improves early post-operative functional disability: A randomized, controlled pilot study. J Back Musculoskelet Rehabil. 2016;29(1):23-9.

75. Paanalahti K, Holm LW, Nordin M, Asker M, Lyander J, Skillgate E. Adverse events after manual therapy among patients seeking care for neck and/or back pain: a randomized controlled trial. BMC Musculoskelet Disord. 2014;15:77.

76. Walker BF, Hebert JJ, Stomski NJ, Clarke BR, Bowden RS, Losco B, et al. Outcomes of usual chiropractic. The OUCH randomized controlled trial of adverse events. Spine. 2013;38(20):1723-9.

77. Yin P, Gao N, Wu J, Litscher G, Xu S. Adverse Events of Massage Therapy in Pain-Related Conditions: A Systematic Review. Evid-Based Complement Altern Med. 2014;2014:480956.

78. Boyd C, Crawford C, Paat CF, Price A, Xenakis L, Zhang W. The impact of massage therapy on function in pain populations—a systematic review and meta-analysis of randomized controlled trials: Part I, patients experiencing pain in the general population. Pain Med. 2016;17(7):1353–75.

79. Corcoran KL, Bastian LA, Gunderson CG, Steffens C, Brackett A, Lisi AJ. Association between chiropractic use and opioid receipt among patients with spinal pain: a systematic review and meta-analysis. Pain Med. 2020;21(2):e139-45.

80. Whedon JM, Toler AWJ, Kazal LA, Bezdjian S, Goehl JM, Greenstein J. Impact of Chiropractic Care on Use of Prescription Opioids in Patients with Spinal Pain. Pain Med. 2020 pii:pnaa014.[epub ahead of print].

81. Whedon JM, Toler AWJ, Goehl JM, Kazal LA. Association Between Utilization of Chiropractic Services for Treatment of Low-Back Pain and Use of Prescription Opioids. J Altern Complement Med. 2018;24(6):552–6.
82. Nissen T, Wynn R. The clinical case report: a review of its merits and limitations. BMC Res Notes. 2004;7:264.

83. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6(7):e1000097.

84. Rathmell JP. A 50-Year-Old Man With Chronic Low Back Pain. JAMA. 2008 May 7;299(17):2066.

85. McGregor AH, Henley A, Morris TP, Doré CJ. An Evaluation of a Postoperative Rehabilitation Program After Spinal Surgery and Its Impact on Outcome: Spine. 2012 Apr;37(7):E417–22.

86. Aspegren DD, Burt AL. A study of postspinal surgery cases in chiropractic offices. J Manipulative Physiol Ther. 1994;17(2):88–92.

87. Oğutluлер Ozkara G, Ozgen M, Ozkara E, Armagan O, Arslantas A, Atasoy MA. Effectiveness of physical therapy and rehabilitation programs starting immediately after lumbar disc surgery. Turk Neurosurg. 2015;25(3):372–9.

88. Estadt GM. Chiropractic/rehabilitative management of post-surgical disc herniation: a retrospective case report. J Chiropr Med. 2004;3(3):108–15.

89. Owers C, Wessely M. Chronic low back pain in a 24-year-old rugby player: Case discussion. Clin Chiropr. 2012;15(3-4):203-12.

90. Johansson A-C, Linton SJ, Bergkvist L, Nilsson O, Cornefjord M. Clinic-based training in comparison to home-based training after first-time lumbar disc surgery: a randomised controlled trial. Eur Spine J. 2009;18(3):398-409.

91. Abbott AD, Tyni-Lenné R, Hedlund R. Early rehabilitation targeting cognition, behavior, and motor function after lumbar fusion: a randomized controlled trial. Spine. 2010;35(8):848-57.
92. Teixeira MJ, Yeng LT, Garcia OG, Fonoff ET, Paiva WS, Araujo JO. Failed back surgery pain syndrome: therapeutic approach descriptive study in 56 patients. Rev Assoc Med Bras. 2011;57(3):282–7.

93. Demetrious J. Clinical pearl. Functional lumbar stenosis due to posterior lumbar interbody fusion. J Acad Chiropr Orthoped. 2008;5(2):12–6.

94. Greenwood J, McGregor A, Jones F, et al. Rehabilitation following lumbar fusion surgery: A systematic review and meta-analysis. Spine (Phila Pa. 1976;41(1):E28–36.

95. Picelli A, Buzzi MG, Cisari C, Gandolfi M, Porru D, Bonadiman S, et al. Headache, low back pain, other nociceptive and mixed pain conditions in neurorehabilitation. Eur J Phys Rehabil Med. 2016;52(6):14.

96. Ingber S. Iliopsoas myofascial dysfunction: a treatable cause of “failed” low back syndrome. Arch Phys Med Rehabil. 1989;70(5):382–6.

97. Chou R, Loeser JD, Owens DK, Rosenquist RW, Atlas SJ, Baisden J, et al. Interventional therapies, surgery, and interdisciplinary rehabilitation for low back pain: An evidence-based clinical practice guideline from the American Pain Society. Spine. 2009;34(10):1066–77.

98. Kjellby-Wendt G, Styf J. Early active training after lumbar discectomy. A prospective randomized, and controlled study. Spine (Phila Pa 1976). 1998;23(21):2345–51.

99. Soegaard R, Christensen FB, Lauersen I, Bünger CE. Lumbar spinal fusion patients’ demands to the primary health sector: evaluation of three rehabilitation protocols. A prospective randomized study. Eur Spine J. 2006;15(5):648–56.

100. Reife MD, Coulis CM. Peroneal neuropathy misdiagnosed as L5 radiculopathy: a case report. Chiropr Man Ther. 2013;21(1):12.

101. Philadelphia Panel. Philadelphia Panel evidence-based clinical practice guidelines on selected rehabilitation interventions for low back pain. Phys Ther. 2001;81(10):1641–
102. Snowdon M, Peiris CL. Physiotherapy Commenced Within the First Four Weeks Post-Spinal Surgery Is Safe and Effective: A Systematic Review and Meta-Analysis. Arch Phys Med Rehabil. 2016;97(2):292–301.

103. Rushton A, Heneghan NR, Calvert M, Heap A, White L, Goodwin PC. Physiotherapy post lumbar discectomy: Prospective feasibility and pilot randomised controlled trial. PLOS ONE. 2015;10(11):e0142013.

104. Rushton A, Eveleigh G, Petherick E-J, Heneghan N, Bennett R, James G, et al. Physiotherapy rehabilitation following lumbar spinal fusion: a systematic review and meta-analysis of randomised controlled trials. BMJ Open. 2012;2(4):e000829.

105. Rushton A, Wright C, Goodwin P, Calvert M, Freemantle N. Physiotherapy rehabilitation post first lumbar discectomy: A systematic review and meta-analysis of randomized controlled trials. Spine. 2011;36(14):E961–72.

106. Erdogmus CB, Resch K-L, Sabitzer R, Müller H, Nuhr M, Schöggl A, et al. Physiotherapy-based rehabilitation following disc herniation operation: Results of a randomized clinical trial. Spine. 2007;32(19):2041–9.

107. Huysmans E, Goudman L, Van Belleghem G, De Jaeger M, Moens M, Nijs J, et al. Re: Return to work following surgery for lumbar radiculopathy—is there a need for postoperative rehabilitation? Spine J. 2018;18(12):2376–7.

108. Oosterhuis T, Costa LO, Maher CG, de Vet HC, van Tulder MW, Ostelo RW. Rehabilitation after lumbar disc surgery. Cochrane Database Syst Rev. 2014;14(3):CD003007.

109. McGregor AH, Probyn K, Cro S, Doré CJ, Burton AK, Balagué F, et al. Rehabilitation following surgery for lumbar spinal stenosis. A Cochrane review. Cochrane Database Syst Rev. 2014;39(13):1044–54.
110. Rosomoff HL, Rosomoff RS. Comprehensive multidisciplinary pain center approach to the treatment of low back pain. Neurosurg Clin N Am. 1991;2(4):877-90.

111. Neblett R, Mayer TG, Brede E, Gatchel RJ. The effect of prior lumbar surgeries on the flexion relaxation phenomenon and its responsiveness to rehabilitative treatment. Spine J. 2014;14(6):892-902.

112. Ebenbichler GR, Inschlag S, Pflüger V, Stemberger R, Wiesinger G, Novak K, et al. Twelve-year follow-up of a randomized controlled trial of comprehensive physiotherapy following disc herniation operation. Clin Rehabil. 2015;29(6):548-60.

113. Monticone M, Giovanazzi E. Usefulness of a cognitive behavioural and rehabilitative approach to enhance long lasting benefit after lumbar spinal stenosis and degenerative spondylolisthesis surgery. A case report. Eur J Phys Rehabil Med. 2008;44(4):467-71.

114. Daley J. A 45-Year-Old Man With Low Back Pain and a Numb Left Foot, 1 Year Later. JAMA. 1999;281(16):1540.

115. Dellamonte NA. Alteration of spinal biomechanics after laminectomy with fusion. Chiropr Tech. 1997;9(2):62–6.

116. Gerwin R. Differential diagnosis of trigger points. J Musculoskelet Pain. 2004;12(3–4):23–8.

117. Johnson HH, Lamb KL. Thoracic disk herniation: A case report. J Manipulative Physiol Ther. 2001;24(5):367–8.

118. Jorgenson D, Confait H. Post-surgical back pain. BJC Case Studies. 1997;1(1):6-7.

119. McMorland G, Suter E, Casha S, du Plessis SJ, Hurlbert RJ. Manipulation or Microdiskectomy for Sciatica? A Prospective Randomized Clinical Study. J Manipulative Physiol Ther. 2010;33(8):576-84.

120. Marin GA. Lumbar disk protrusion. Evaluation and study of 600 diskectomeies with
one to ten years followup. Internation surgery. 1974;59(3):154-5.

121. Miake-Lye IM, Mak S, Lee J, Luger T, Taylor SL, Shanman R, et al. Massage for Pain: An Evidence Map. J Altern Complement Med. 2019;25(5):475-502.

122. Puentedura EJ, Brooksby CL, Wallmann HW, Landers MR. Rehabilitation Following Lumbosacral Percutaneous Nucleoplasty: A Case Report. J Orthop Sports Phys Ther. 2010;40(4):214-24.

123. Ammendolia C, Côté P, Rampersaud YR, Southerst D, Budgell B, Bombardier C, et al. The boot camp program for lumbar spinal stenosis: a protocol for a randomized controlled trial. Chiropr Man Ther. 2016;24(1):25.

124. Fujii K, Abe T, Kubota S, Marushima A, Kawamoto H, Ueno T, et al. The voluntary driven exoskeleton Hybrid Assistive Limb (HAL) for postoperative training of thoracic ossification of the posterior longitudinal ligament: a case report. J Spinal Cord Med. 2017;40(3):361-7.

125. Ostelo RWJG, Köke AJA, Beurskens AJHM, de Vet HCW, Kerckhoffs MR, Vlaeyen JWS, et al. Behavioral-graded activity compared with usual care after first-time disk surgery: Considerations of the design of a randomized clinical trial. J Manipulative Physiol Ther. 2000;23(5):312-9.

126. Lewit K, Olsanska S. Clinical importance of active scars: Abnormal scars as a cause of myofascial pain. J Manipulative Physiol Ther. 2004;27(6):399-402.

127. Ammendolia C, Chow N. Clinical outcomes for neurogenic claudication using a multimodal program for lumbar spinal stenosis: A retrospective study. J Manipulative Physiol Ther. 2015;38(3):188-94.

128. Herman PM, Hurwitz EL, Shekelle PG, Whitley MD, Coulter ID. Clinical scenarios for which spinal mobilization and manipulation are considered by an expert panel to be inappropriate (and appropriate) for patients with chronic low back pain. Med Care.
2019;57(5):391–8.

129. Snider K, Snider E, DeGooyer B, Bukowski A, Fleming R, Johnson J. Retrospective medical record review of an osteopathic manipulative medicine hospital consultation service. J Am Osteopath Assoc. 2013;113(10):754–67.

130. Cupler ZA, Anderson MT, Stancik TJ. Thoracic spondylodiscitis epidural abscess in an afebrile Navy veteran: A case report. J Chiropr Med. 2017;16(3):246–51.

131. Kumar K, Malik S, Demeria D. Treatment of Chronic Pain with Spinal Cord Stimulation versus Alternative Therapies: Cost-effectiveness Analysis. Neurosurgery. 2002;51(1):106-16.

132. Colloca CJ, Polkinghorn BS. Chiropractic management of ehlers-danlos syndrome: a report of two cases. J Manipulative Physiol Ther. 2003;26(7):448-59.

133. Lewis DD, Summers GK. Osteopathic manipulative treatment for the management of adjacent segment pathology. J Am Osteopath Assoc. 2017;117(12):782.

134. Cuka C, McDevitt AW, Porter-Hoke A, Karas S. Spinal manipulation after multiple fusions in an adult with scoliosis: a case report. J Man Manip Ther. 2019;27(2):115-24.

135. J Am Chiropr Assoc. Conservative management or surgery: The team approach. J Am Chiropr Assoc. 2003;40(2):8-14.

136. Forcum TL. Post disc herniation surgery rehab: A case study using Trigenics Applied Functional Neurology. Am Chiropr 2011:45-46.

137. Griffée SR, Prideaux C. Poster board 414: Acute pain management in rehabilitation unit: An exploratory study on the use of integrative medicine. Am J Phys Med Rehabil 2014;93(3 Suppl).

138. Imamura S. Efficacy of myofascial therapy in failed back surgery. Acupunct Electrother Res. 2006;31:157-92.
139. Stoll ST, Simmons SL. Inpatient rehabilitation and manual medicine. Phys Med Rehab. 2000;14(1):85–106.

140. Maffei P. Intérêt du massage dans le traitement de douleurs postopératoires précoces: étude contrôlée randomisée. Kinésithérapie Rev. 2014;14(145):16–25.

141. Lapham-Yaun R, Castro K. Improved spinal alignment, chronic low back pain and improved quality of life in a 62-year-old patient undergoing chiropractic care following failed surgical syndrome: a case study & review of the literature. Ann Vert Subluxation Res 2019:10–21.

Figures
Figure 1

PRISMA Flow Diagram[83]