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

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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 32.1per 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	Microdiskectomy	Radiculopathy
Manipulative Rehabilitation	Microdiscectomy	Radicular Pain
Joint Manipulation	Discectomy	Sciatica
Joint Mobilization	Diskectomy	Disc Herniation
Mobilization Therapy	Laminectomy	Disk Herniation
Spinal Mobilization	Laminotomy	Intervertebral Disc
Soft Tissue Mobilization	Disc Replacement	Intervertebral Disk
Flexion-Distraction	Disk Replacement	Disc Degeneration
Myofascial	Vertebroplasty	Disk Degeneration
Active Release	Kyphoplasty	Spinal Stenosis
Graston	Foraminotomy	Spondylolisthesis
Massage	Interlaminar Implant	Spondylosis
Stretching Techniques	Spinal Cord Stimulator	Spondylolysis
Muscle Stretching	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 disc 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 or surgeries))) 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 disc 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 microdiskectomy OR diskectomy OR discectomy OR laminectomy OR laminotomy OR disc replacement OR disk replacement OR vertebroplasty 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 “mobilization 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 anesthesia”)) NOT ("Animals"[Mesh] NOT ("Animals"[Mesh] AND "Humans"[Mesh])) AND English[la]

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.

Table 3
Eligibility criteria

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 without multimodal approach	• Non-English language
• Treatment of status post-surgical low back pain (degenerative or traumatic)	• Animal studies
• Surgery types (fusion, laminectomy, decompression, microdiscectomy, disc replacement, veterbroplasty, spinal stimulators/implants, ...)	• Study protocol
• Any study design	• Prior surgery for scoliosis
	• Red flag condition identified which resulted in subsequent surgery
	• Surgical intervention performed as result of adverse event purportedly related to manipulative 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 [22, 23]. The criteria are outlined in Table 6 and describe high, moderate, and inconclusive strength of evidence, and favorable or unfavorable recommendation.

Table 6
Rating of evidence from randomized controlled trials and systematic reviews [21–23]

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)[24]. Fifty-nine articles were excluded with reasons provided in Table 7.

Table 7
Reasons for excluded articles from this review

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	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. discectomy, 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											
	1	2	3	4	5	6	7	8	9	10	Total	Quality**
Mannion 2007	1	1	1	0	1	1	1	1	1	1	9	H
Scrimshaw 2001	1	1	1	0	1	1	1	1	1	1	9	H
Timm 1994	1	0	1	0	0	1	1	1	1	0	6	A
Kim 2015	Pilot Study – Not Powered											NR
Kim 2016	Pilot Study – Not Powered											NR
Kim 2017	Pilot Study – Not Powered											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	M
Scrimshaw 2001 High [28]	n = 81; mean 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	N
Mannion 2007 High [29]	n = 151 Mean age: CG = 66 TG1 = 64 TG2 = 65 Duration LBP: CG = 132 mo TG1 = 94mo TG2 = 126mo 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 differences between groups	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	N

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

Citation and Quality	Participants	Surgical History	Intervention	Comparison	Outcome Measures	Results	Conclusion	Adverse Events	M
Timm 1994 Acceptable [30]	n = 250 mean age CG = 45 TG1 = 42 TG2 = 42 TG3 = 44 TG4 = 43 duration cLBP before surgery(years): CG = 1.8 TG1 = 2.1 TG2 = 1.8 TG3 = 2.2 TG4 = 1.9 surgery to tx (years): CG = 1.2 TG1 = 1.3 TG2 = 1.5 TG3 = 1.5 TG4 = 1.6	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 Large-amplitude (Bicycle ergometry followed by Isotonic Ex on Cybex TEF and Torso)	CG: No treatment	modified-modified Schober (lumbar ROM) Cybex liftask (strength) ODI	modified-modified Schober: low-tech and high-tech Ex increased lumbar flexion and extension ROM, Joint manipulation increased extension ROM Cybex liftask: 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.	N

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

Citation and Quality	Participants	Surgical History	Intervention	Comparison	Outcome Measures	Results	Conclusion	Adverse Events	N
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 HVLA)	TG2: Exercise (1 week back and abdominal stretching, next 2 weeks isometric strengthening back and hips, final week back and stability exercise using Pilates apparatus)	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 needing medication in OMT group	Pilot study shows the feasibility of a future RCT to investigate OMT rehabilitation for post-operative management after lumbar microdiscectomy	None Reported	A b w p s a i n a a r s
Kim 2016 Not Rated [74]	N = 21; Mean age: 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	RMQ VAS LBP VAS legs PCS-SF	RDQ: greater improvement with OMT VAS LBP: Both groups improved, no between group differences VAS legs: Greater decrease with OMT PCS-SF: both groups slightly improved, greater with OMT	Pilot study supports the feasibility of a future RCT and indicates OMT rehabilitation may be important part of post-operative care after open laser discectomy.	None Reported	A b w p a i n a a r t
Kim 2017 Not Rated [73]	N = 21; Mean age: 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	RMQ VAS LBP VAS legs	RMQ: OMT group improved and CG worsened VAS LBP: OMT group improved and CG worsened VAS legs: OMT group improved and CG worsened	Demonstrated potential of manipulative rehabilitation to post-operative management after lumbar disc surgery. Definitive trials with large same sizes needed to confirm feasibility and potential therapeutic effect.	None reported	E w p s a i n a a r

CG = Control Group, cLBP = chronic low back pain, Ex = exercise, GPE = global perceived effect, Grade III = large amplitude rhythmic oscillating mobilization, Gr small amplitude rhythmic oscillating, HEP = home exercise program, HVLA = high-velocity, low-amplitude manipulation, LBP = low back pain, LP = leg pain, Mc Pain Questionnaire, NPRS = Numerical Pain Rating Scale, ODI = Oswestry Disability Index, OMT = Osteopathic Manipulative Technique, PCS-SF = Physical Cor Score of 36-item Short-Form, QDS = Quebec Disability Scale, RMQ = Roland Morris Questionnaire, ROM = Range of Motion, RTW = Return to work, TG = Treatm 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]	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 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 • Progressed to MUA plus ESI combination with positive outcome	None reported	Not reported
Bates 1964[45]	1	L5 laminectomy	Massage	• Describes successful return to professional sport following surgery • Postoperative program consisted of heat, massage, exercise and progressive exercise	None reported	Muscle relaxant

Abbreviations: ADL, activity of daily living; bid, bis in die (two times per day); cLBP, chronic low back pain; DTR, deep tendon reflexes; ESI, epidural steroid injection; FABQ, Fear-Avoidance Belief Questionnaire; FBSS, failed back surgery syndrome; FD, flexion distraction technique; FRI, Functional Rating Index; LBP, low back pain; LE, lower extremity; MUA, manipulation under anesthesia; NPS, numerical pain scale; NRS, numerical rating scale; NSAID, non-steroidal anti-inflammatory drug; ODI, Oswestry Disability Index; OMT, osteopathic manipulative therapy; OTC, over-the-counter; ROM, range of motion; RDQ, Roland-Morris Disability Questionnaire; SCS, spinal cord stimulator; SMT, spinal manipulative therapy (Grade V Maitland); TX, treatment

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
Benningfield 1997[37]	1	L5/S1 discectomy with laminotomy	SMT	• Describes management of recurrent LE radiation of pain 1 year postoperative • TX consisted of SMT and lumbar MedX lumbar-extension machine • 2x week 6 weeks, followed by 1x week 6 weeks • 30% improvement in strength	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 • 3 weeks of neural mobilization • VAS reduced by 2 points, straight leg raise pain free, ODI reduced from 63–44%, and increased tolerance for exercise	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 reduced VAS 6/10 to 4/10 and improvements in function and ADLs without exacerbation • Case 2 no change in VAS, but functional improvement including walking and driving tolerance	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
Cox 2009[55]	1	L4-S1 Fusion	FD	• 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

Abbreviations: ADL, activity of daily living; bid, bis in die (two times per day); cLBP, chronic low back pain; DTR, deep tendon reflexes; ESI, epidural steroid injection; FABQ, Fear-Avoidance Belief Questionnaire; FBSS, failed back surgery syndrome; FD, flexion distraction technique; FRI, Functional Rating Index; LBP, low back pain; LE, lower extremity; MUA, manipulation under anesthesia; NPS, numerical pain scale; NRS, numerical rating scale; NSAID, non-steroidal anti-inflammatory drug; ODI, Oswestry Disability Index; OMT, osteopathic manipulative therapy; OTC, over-the-counter; ROM, range of motion; RDQ, Roland-Morris Disability Questionnaire; SCS, spinal cord stimulator; SMT, spinal manipulative therapy (Grade V Maitland); TX, treatment

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
Demetrious 2007[54]	1	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]	1	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]	1	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 quality	None reported	Meperidine (Demerol), Motrin; Patient stopped using pain medication during treatment plan
Greenwood 2012[58]	1	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

Abbreviations: ADL, activity of daily living; bid, bis in die (two times per day); cLBP, chronic low back pain; DTR, deep tendon reflexes; ESI, epidural steroid injection; FABQ, Fear-Avoidance Belief Questionnaire; FBSS, failed back surgery syndrome; FD, flexion distraction technique; FRI, Functional Rating Index; LBP, low back pain; LE, lower extremity; MUA, manipulation under anesthesia; NPS, numerical pain scale; NRS, numerical rating scale; NSAID, non-steroidal anti-inflammatory drug; ODI, Oswestry Disability Index; OMT, osteopathic manipulative therapy; OTC, over-the-counter; ROM, range of motion; RDQ, Roland-Morris Disability Questionnaire; SCS, spinal cord stimulator; SMT, spinal manipulative therapy (Grade V Maitland); TX, treatment

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
Gudavalli 2016[38]	69	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[57]	1	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 outcomes related to LBP complaint	Not reported	Not reported
Keller 2012[68]	1	L4-5 Laminectomy and Fusion	Massage	• Describes 7 30-minute massage sessions • Improved disability with measured ODI from 50–36% post-TX, and RDQ from 3/24 to 2/24 • Pain (VAS) and hamstring length improved within each session	Not reported	Tylenol as needed

Abbreviations: ADL, activity of daily living; bid, bis in die (two times per day); cLBP, chronic low back pain; DTR, deep tendon reflexes; ESI, epidural steroid injection; FABQ, Fear-Avoidance Belief Questionnaire; FBSS, failed back surgery syndrome; FD, flexion distraction technique; FRI, Functional Rating Index; LBP, low back pain; LE, lower extremity; MUA, manipulation under anesthesia; NPS, numerical pain scale; NRS, numerical rating scale; NSAID, non-steroidal anti-inflammatory drug; ODI, Oswestry Disability Index; OMT, osteopathic manipulative therapy; OTC, over-the-counter; ROM, range of motion; RDQ, Roland-Morris Disability Questionnaire; SCS, spinal cord stimulator; SMT, spinal manipulative therapy (Grade V Maitland); TX, treatment

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
Kennedy 2016[67]	1	Lumbosacral fusion	Curanderismo (massage)	• Describes holistic healing tradition indigenous to Latin America • Treatment consisting of educating patient on connection between mind, body, spirit, aromatherapy, music therapy, and massage of body meridian lines • No quantitative decrease in maximum or average pain levels • Patient reported improved function, mood, sleep and narcotic use • Patient did not refill Percocet prescription	None reported	Lisinopril/ hydrochloro-thiazide, zolpidem, clonazepam, diclofenac 75 mg bid, and oxycodone/ acetaminophen 5 mg/ 325 mg bid; patient reported reduced need for opioid pain medication
Kruse 201[53]	1	Fusion	FD	• Describes successful management of acute postsurgical LBP • 13 sessions FD plus ultrasound and electrical stim over 6 weeks • Resolution of pain, VAS 5/10 to 0/10 • Reduced disability, ODI 18–2% • 2-year follow-up with no symptoms recurrence and expressed patient satisfaction with care	None reported	OTC anti-inflammatory; no reporting post-TX
Kruse 2011[41]	32	Discectomy, laminectomy, fusion, or combination	FD	• Retrospective analysis describes FD for patients with history of discectomy (n = 13), laminectomy (n = 10), fusion (n = 2), or combination (n = 7) • Heterogeneous sample • TX dose ranged from 6–31 sessions • NPS decrease ranged from 0-8.4 • Patients with combination	None reported	Not reported
Lamb 1997[59]	1	Discectomy	SMT	• Describes successful management of patient with post-surgical LBP • 10 sessions of SMT (targeting sacroiliac joint) and ultrasound	None reported	Not reported

Abbreviations: ADL, activity of daily living; bid, bis in die (two times per day); cLBP, chronic low back pain; DTR, deep tendon reflexes; ESI, epidural steroid injection; FABQ, Fear-Avoidance Belief Questionnaire; FBSS, failed back surgery syndrome; FD, flexion distraction technique; FRI, Functional Rating Index; LBP, low back pain; LE, lower extremity; MUA, manipulation under anesthesia; NPS, numerical pain scale; NRS, numerical rating scale; NSAID, non-steroidal anti-inflammatory drug; ODI, Oswestry Disability Index; OMT, osteopathic manipulative therapy; OTC, over-the-counter; ROM, range of motion; RDQ, Roland-Morris Disability Questionnaire; SCS, spinal cord stimulator; SMT, spinal manipulative therapy (Grade V Maitland); TX, treatment

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
Layton 2009[49]	1	Laminectomy	SMT	• Describes management of post-surgical LBP • 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	None reported	Not reported
Lisi 2004[50]	1	Laminectomy	SMT	• Describes management of patient with residual cauda equina symptoms following surgical decompression • Resolution of LBP after 4 sessions of SMT • NRS 5/10 to 0/10 • No change in chronic residual cauda equina symptoms	None reported	Not reported
Lee 2017[42]	102	Discectomy, laminectomy, fusion, or combination	SMT (Chuna Manual therapy, form of Korean SMT)	• Describes management of patients with post-surgical back pain or LE (spinal) pain including laminectomy (n = 99) and/or fusion (n = 9) • Treatment consisted of 16 weekly sessions of Chuna manual therapy (Korean SMT), bee venom, acupuncture, and herbal supplementation • 102 completed 1-year follow-up • LBP (VAS) improved from 6.1 to 2.9 • LE pain (VAS) improved from 5.4 to 2.5 • Disability (ODI) reduced from 41.3 to 23.6 at 6-months • 79.2% sustained improvement at 1-year	1 case increased LBP, 32 cases mild GI issues (related to herbal medicine component)	Analgesics and muscle relaxants; no reporting post-TX

Abbreviations: ADL, activity of daily living; bid, bis in die (two times per day); cLBP, chronic low back pain; DTR, deep tendon reflexes; ESI, epidural steroid injection; FABQ, Fear-Avoidance Belief Questionnaire; FBSS, failed back surgery syndrome; FD, flexion distraction technique; FRI, Functional Rating Index; LBP, low back pain; LE, lower extremity; MUA, manipulation under anesthesia; NPS, numerical pain scale; NRS, numerical rating scale; NSAID, non-steroidal anti-inflammatory drug; ODI, Oswestry Disability Index; OMT, osteopathic manipulative therapy; OTC, over-the-counter; ROM, range of motion; RDQ, Roland-Morris Disability Questionnaire; SCS, spinal cord stimulator; SMT, spinal manipulative therapy (Grade V Maitland); TX, treatment

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
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-acetominaphen 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 • Case 3 describes sacroiliac SMT for 2 weeks with leg pain completely relieved	None reported	Not reported
Morningstar[43] 2012	3	Fusion and L4 or L5 laminectomy	MUA, myofascial trigger point therapy, massage	• Describes successful management of 3 cases of FBSS • Case 1 reduced pain (NPRS) 77 to 53, and improved function (FRI) from 31 to 22 • Case 2 reduced pain (NPRS) 67 to 43, and improved function (FRI) from 26 to 18 • Case 3 reduced pain (NPRS) 53 to 27, and improved function (FRI) from 19 to 7	None reported	Case 1: 2 Vicodin 7.5/750 mg; no reporting post-TX

Abbreviations: ADL, activity of daily living; bid, bis in die (two times per day); cLBP, chronic low back pain; DTR, deep tendon reflexes; ESI, epidural steroid injection; FABQ, Fear-Avoidance Belief Questionnaire; FBSS, failed back surgery syndrome; FD, flexion distraction technique; FRI, Functional Rating Index; LBP, low back pain; LE, lower extremity; MUA, manipulation under anesthesia; NPS, numerical pain scale; NRS, numerical rating scale; NSAID, non-steroidal anti-inflammatory drug; ODI, Oswestry Disability Index; OMT, osteopathic manipulative therapy; OTC, over-the-counter; ROM, range of motion; RDQ, Roland-Morris Disability Questionnaire; SCS, spinal cord stimulator; SMT, spinal manipulative therapy (Grade V Maitland); TX, treatment

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
Oakley 2007[48]	1	L4-5 laminectomy	SMT and static posturing	• Describes successful management of patient 6-months post laminectomy with LBP and LE pain • Initial treatment consisted of 36 visits over 12 weeks with SMT and static posturing • Pain (NRS) reduced 8/10 to 2/10, disability (ODI) reduced 76–40%, repeat radiographs reported improved cervical lordosis • Following additional 72 treatments reported pain (NRS) 0/10, disability (ODI) 24%, and normal ROM	None reported	Vicodin; patient no longer required analgesic narcotic pain medications
O'Shaughnessy 2010[39]	8	Total disc replacement L5/S1 (7) and/or L4/L5 (4)	SMT	• Total disc replacement determined stable by radiographs at 8 weeks and lateral flexion-extension radiographs at 12 weeks • Preload in sidelying was performed to ensure tolerance and if tolerated received 2x/week for 8–10 visits • Disability (ODI) reduced in 6/8 patients • FABQ I reduced in 4/8 patients • FABQ II reduced in 5/8 patients	Slight increase in LBP < 12 hours following almost half of TX; 2 patients reported severe LBP and LE pain after first TX; light to moderate soreness common post-TX; for 5/8 LE paresthesia exacerbated for 24–48 hours post-TX	Not reported
Paris 2017[62]	1	T12/L2 fusion post-trauma	SMT, drop table assisted SMT, spinal mobilization	• Describes successful management with SMT • 13 sessions over 4 months • Patient self-discharged and missed re-examination • Phone follow-up patient indicated he felt great and didn't need ongoing care	None reported	Not reported

Abbreviations: ADL, activity of daily living; bid, bis in die (two times per day); cLBP, chronic low back pain; DTR, deep tendon reflexes; ESI, epidural steroid injection; FABQ, Fear-Avoidance Belief Questionnaire; FBSS, failed back surgery syndrome; FD, flexion distraction technique; FRI, Functional Rating Index; LBP, low back pain; LE, lower extremity; MUA, manipulation under anesthesia; NPS, numerical pain scale; NRS, numerical rating scale; NSAID, non-steroidal anti-inflammatory drug; ODI, Oswestry Disability Index; OMT, osteopathic manipulative therapy; OTC, over-the-counter; ROM, range of motion; RDQ, Roland-Morris Disability Questionnaire; SCS, spinal cord stimulator; SMT, spinal manipulative therapy (Grade V Maitland); TX, treatment

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
Perrucci 2017[40]	3	SCS	SMT, FD, myofascial release	• Describes chiropractic management of patients with SCS • 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 • Case 2 received 2 treatment, reported no benefit and discontinued care • Case 3 presented with cLBP and right LE pain • Poor tolerance to pre-manipulation positioning so SMT not performed, was treated 4x over 4 weeks with FD and myofascial release • Temporary relief of LBP with no change of LE symptoms and care discontinued	None reported	Opioid medications prescribed, but not impacted by manual therapy
Peterson 2016[60]	1	L2-5 laminectomy with partial facetomy and IPD implantation	Spinal mobilization with McKenzie method lateral shift correction	• Describes 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	22 medications included narcotics for pain management; no reporting post-TX

Abbreviations: ADL, activity of daily living; bid, bis in die (two times per day); cLBP, chronic low back pain; DTR, deep tendon reflexes; ESI, epidural steroid injection; FABQ, Fear-Avoidance Belief Questionnaire; FBSS, failed back surgery syndrome; FD, flexion distraction technique; FRI, Functional Rating Index; LBP, low back pain; LE, lower extremity; MUA, manipulation under anesthesia; NPS, numerical pain scale; NRS, numerical rating scale; NSAID, non-steroidal anti-inflammatory drug; ODI, Oswestry Disability Index; OMT, osteopathic manipulative therapy; OTC, over-the-counter; ROM, range of motion; RDQ, Roland-Morris Disability Questionnaire; SCS, spinal cord stimulator; SMT, spinal manipulative therapy (Grade V Maitland); TX, treatment

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
Stern 1995[46]	7	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	Not reported
Shaw 1996[64]	1	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	Prozac and Advil; no reporting post-TX
Taylor 2007[66]	1	L4-5 decompression with laminectomy and cyst excision	FD	• Describes care of patient with LBP and bilateral LE symptoms, and similar symptoms resolved 3-years prior with surgery • Treatment with FD provided limited relief and updated MRI revealed L4-5 synovial cyst with progression of Grade 1 L4 spondylolisthesis • Lumbar stability exercise initiated with palliative effect and patient progressed to self-management • Disability (ODI) reduced from 30–12.5% at 2.5-year follow-up	None reported	Not reported
Vaillancourt 1983[69]	1	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

Abbreviations: ADL, activity of daily living; bid, bis in die (two times per day); cLBP, chronic low back pain; DTR, deep tendon reflexes; ESI, epidural steroid injection; FABQ, Fear-Avoidance Belief Questionnaire; FBSS, failed back surgery syndrome; FD, flexion distraction technique; FRI, Functional Rating Index; LBP, low back pain; LE, lower extremity; MUA, manipulation under anesthesia; NPS, numerical pain scale; NRS, numerical rating scale; NSAID, non-steroidal anti-inflammatory drug; ODI, Oswestry Disability Index; OMT, osteopathic manipulative therapy; OTC, over-the-counter; ROM, range of motion; RDQ, Roland-Morris Disability Questionnaire; SCS, spinal cord stimulator; SMT, spinal manipulative therapy (Grade V Maitland); TX, treatment

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
Vulfsons 2011[63]	1	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]	1	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% in 10 weeks • Other outcomes included pain intensity, orthopedic tests, lumbar ROM and DTRs	None reported	Flexeril, Naprosyn, Percocet as needed; no reporting Post-TX

Abbreviations: ADL, activity of daily living; bid, bis in die (two times per day); cLBP, chronic low back pain; DTR, deep tendon reflexes; ESI, epidural steroid injection; FABQ, Fear-Avoidance Belief Questionnaire; FBSS, failed back surgery syndrome; FD, flexion distraction technique; FRI, Functional Rating Index; LBP, low back pain; LE, lower extremity; MUA, manipulation under anesthesia; NPS, numerical pain scale; NRS, numerical rating scale; NSAID, non-steroidal anti-inflammatory drug; ODI, Oswestry Disability Index; OMT, osteopathic manipulative therapy; OTC, over-the-counter; ROM, range of motion; RDQ, Roland-Morris Disability Questionnaire; SCS, spinal cord stimulator; SMT, spinal manipulative therapy (Grade V Maitland); TX, treatment

Table 13
Evidence table for consensus studies, guidelines, and commentaries

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 of 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

Abbreviations: ALIF, anterior lumbar interbody fusion; CO, commentary; FBSS, failed back surgery syndrome; PLIF, posterior lumbar interbody fusion; NSAID, nonsteroidal anti-inflammatory drugs; PT, physical therapy; TCA, tricyclic antidepressants; TLIF, transforaminal lumbar interbody fusion;

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 mobility and return-to-work [31].

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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Figures

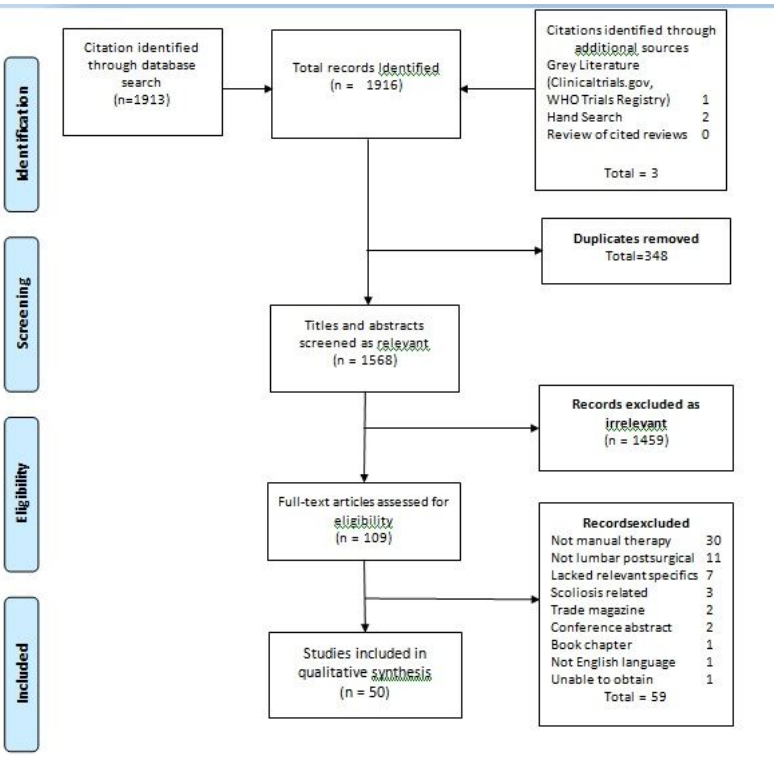

Figure 1

PRISMA Flow Diagram[83]