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Manipulative and manual therapies in the management of patients with prior lumbar surgery: A systematic review

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ABSTRACT

Background and Purpose: Pain and disability may persist following lumbar spine surgery and patients may subsequently seek providers trained in manipulative and manual therapy (MMT). This systematic review investigates the effectiveness of MMT after lumbar surgery through identifying, summarizing, assessing quality, and grading the strength of available evidence. Secondarily, we synthesized the impact on medication utilization, and reports on adverse events.
Methods: Databases and grey literature were searched from inception through August 2020. Article extraction consisted of principal findings, pain and function/disability, medication consumption, and adverse events.
Results: Literature search yielded 2025 articles,117 full-text articles were screened and 51 citations met inclusion criteria.
Conclusion: There is moderate evidence to recommend neural mobilization and myofascial release after lumbar fusion, but inconclusive evidence to recommend for or against most manual therapies after most surgical interventions. The literature is primarily limited to low-level studies. More high-quality studies are needed to make recommendations.

1. Introduction

Low back pain (LBP) 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 [2]. Surgical treatment for lumbar degenerative disc disease increased 2.4-fold from 2000 to 2009 [3]. From 2004 to 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), with the greatest increase in fusions occurring in adults over 65 years old [4,5].

The most frequent condition considered appropriate for lumbar surgery is LBP and radiculopathy secondary to lumbar disc herniation [6], with discectomy being the most common [7]. These surgeries are generally considered following the failure of conservative care. Recurrence of spinal or radicular symptoms is common following surgical intervention with symptom reoccurrence rates reaching between 20% and 65% [8–11].

Postoperative pain and surgical revision are common following a 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

Abbreviations: FD, Flexion-distraction; LBP, low back pain; MMT, manual and manipulative therapy; OMT, osteopathic manipulative therapy; RCT, randomized controlled trial; SIGN, Scottish Intercollegiate Guidelines Network; SR, systematic review.

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Table 1
Search terms related to manipulation, manual therapy and surgical interventions.

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

PNF=Proprioceptive Neuromuscular Facilitation.

a portion of individuals undergoing this intervention. Only 50–60% of FBSS 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 [5–7,11,12]. Manual therapy is the application of the practitioner's hands directly to soft tissues or joints using techniques such as mobilization, manipulation, 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 painful or perceived hypo-mobile joint to approximate the joint near its end range of motion and to restore its physiological joint range of motion (ROM) [15], or alternatively through a table-assisted approach such as flexion-distraction (FD) [16]. Most guidelines for non-specific LBP recommend MMT [17,18], however there is a paucity of literature to guide clinicians following surgical intervention. It is conceivable that MMT might be an effective management option for individuals with a prior history of lumbar surgery.

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 effectiveness of MMT to impact pain and function for patients with prior lumbar operative procedures. A secondary purpose of this study was to assess the opioid/medication utilization and adverse events reported in the same body of literature.

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]

MeSH = Medical Subject Headings, PNF=Proprioceptive Neuromuscular Facilitation.

Table 3
Eligibility criteria.

Inclusion	Exclusion
• Human subjects aged 18 or older • English language • Intervention includes manipulation AND/OR manual therapy AND/OR mobilization with or without multimodal approach • Treatment of status post-surgical low back pain • All surgery types (i.e. fusion, laminectomy, decompression, microdiscectomy, disc replacement, vertebroplasty, kyphoplasty, spinal stimulators/implants, laser surgery)	• Non-peer-reviewed publications • Commentaries • Conference abstracts • Non-English language • Animal studies • Study protocol • 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 o 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)

2. Methods

2.1. Search strategy

A literature search was initially performed July 2019 of PubMed, Cochrane Database of Systematic Reviews, Index to Chiropractic Literature, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Allied and Complementary Medicine database (AMED) and Physiotherapy Evidence Database (PEDro) from inception of each database through July 2019. The search was then updated to include new publications through August 2020. Medical Subject Headings were combined with keywords and searched as free text. Exclusions included

Table 4
Rating of evidence from randomized controlled trials and systematic reviews [17,24,27].

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

animal studies as done by the filter created for Cochrane Systematic Reviews of Interventions [19]. Tables 1 and 2 provide the search terms and strategy. The list of references of included publications were manually checked for studies potentially meeting the inclusion criteria. Completed studies accepted for publication, but not yet in-print, were identified at 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 and abstracts were screened independently by two 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).

2.2. Eligibility criteria

The inclusion and exclusion criteria are available in Table 3. We included case reports and case series to inform clinical decision-making due to the anticipated paucity of higher-level evidence [20,21]. In accordance with the Cochrane Handbook for Systematic Reviews of Interventions, we excluded animal studies [22]. Articles were considered for final inclusion if they describe the practice, utilization, and/or clinical decision making related to post-surgical intervention with MMT.

2.3. Methods of review

2.3.1. Study selection

Citation titles and abstracts were screened independently by two reviewers. Abstracts of the citations that met 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. 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.

2.3.2. Data extraction

Two authors completed data extraction for each of the included studies. One author served as the primary extractor and the other served as a secondary extractor confirming the findings [23–25]. Any disagreements were resolved through discussions and if necessary, with 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), 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.

2.3.3. Evaluation of risk of bias

Scottish Intercollegiate Guideline Network (SIGN) critical appraisal checklists [26] were utilized to assess for risk of bias (quality). All RCTs and systematic reviews (SR) included were assessed with the corresponding checklist provided by SIGN, with 3 authors performing each quality assessment. Disagreements were resolved with discussion. 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" (Appendix 1 and 2).

2.3.4. 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 [24] and modified from the UK evidence report [17,27] (Table 4).

3. Results

A comprehensive database search identified 2022 citations, and 3 additional citations were added from the grey literature. After 348 duplicates were removed, 1687 citations were screened and 1570 were excluded by title and abstract as irrelevant according to our exclusion criteria. A review of the remaining 117 full-text articles resulted in 51 studies meeting inclusion criteria (Fig. 1) [28]. Sixty-six articles were excluded with reasons provided in Table 5.

The majority of included studies were case reports or case series (n = 38), followed by RCTs (n = 7), SRs (n = 3), scoping review (n = 1), narrative review (n = 1) and a cross-sectional survey (n = 1). The most common reason for exclusion was due to care not involving MMT (n = 35).

3.1. Systematic reviews

Three SRs met the inclusion criteria. One of the 3 was high quality [29], 1 was acceptable-quality [30], and 1 was low quality [31] (Table 6). Two of the 3 included SRs described physical therapy and rehabilitation intervention in patients with undifferentiated lumbar surgery for degenerative conditions [29,30], and 1 described care following lumbar fusion surgery [31]. Two of the 3 described physical therapy (PT) and rehabilitation including, but not specific to, MMT [30, 31], and 1 specifically described neural mobilization techniques [29].

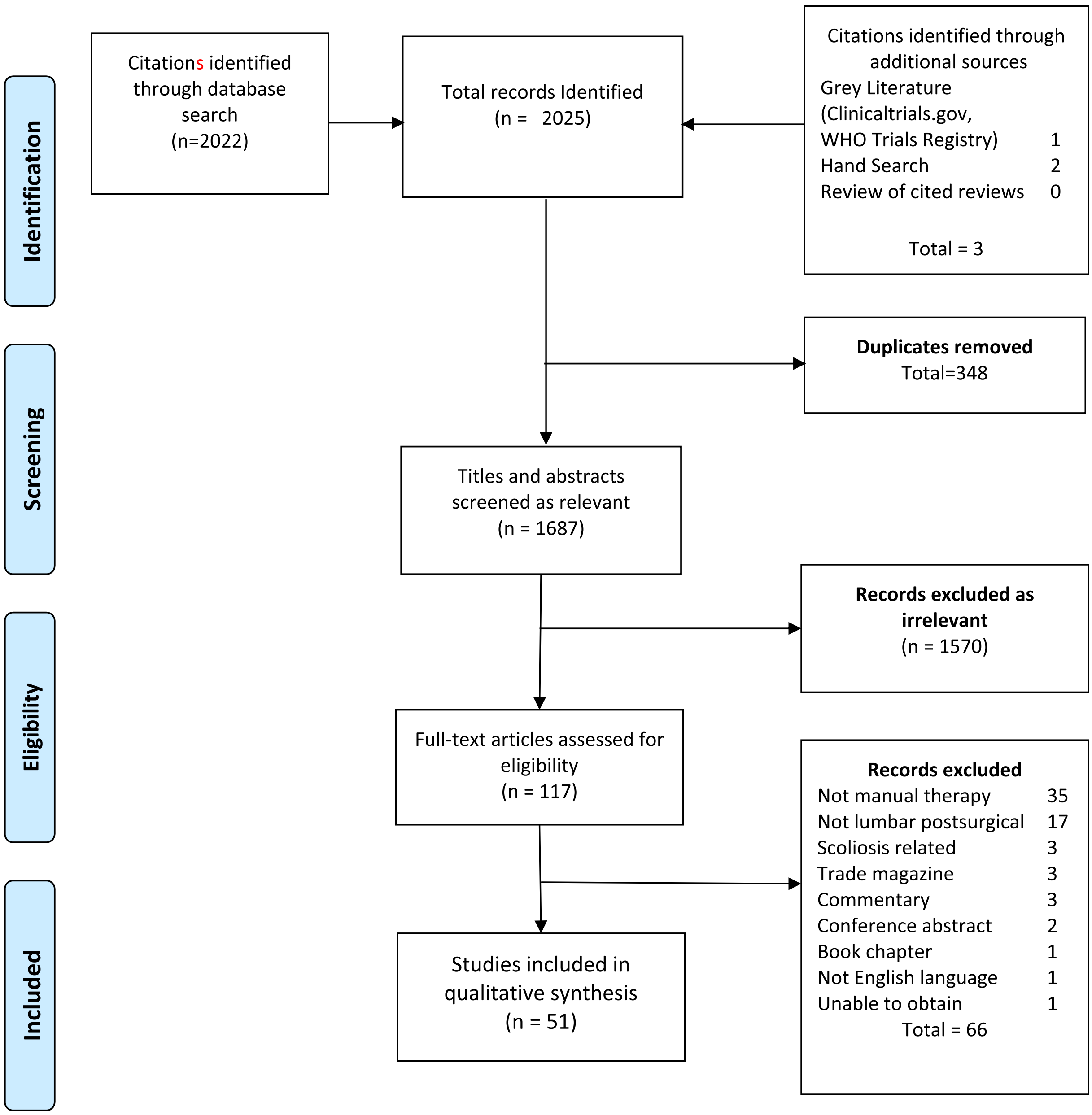
The high-quality and acceptable-quality reviews addressed rehabilitation after a variety of lumbar surgical types. The high-quality SR investigated neural mobilization and included 69 studies, of which only 1 study that was postoperative LBP [32], and concluded that inpatient neural mobilization in the 3 days following lumbar operation did not add benefit to usual care [29]. The acceptable-quality review analyzed inpatient PT including 4 studies, of which 1 was relevant to MMT [32] and it was the same study identified by the neural mobilization SR [30].

Following lumbar fusion, a low-quality review found insufficient evidence to make an argument for or against the inclusion of MMT during lumbar fusion postoperative rehabilitation [31]. 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.

3.2. Randomized controlled trials

Table 7 provides the RCTs risk of bias and Table 8 presents the evidence. Of the 7 RCTs, 3 were pilots and were underpowered to make any conclusions regarding efficacy and were not rated for quality. Of the 4 remaining studies, 3 were rated high-quality [32–34] and 1 was rated acceptable-quality [35].

Following lumbar surgery (undifferentiated), one RCT [33] compared a control group of self-management to 2 PT groups, a "spinal stabilization exercise group" and a "mixed-physical therapy group"



PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses, WHO= World Health Organization

Fig. 1. PRISMA flow diagram [28].

Table 5
Reasons for excluded articles from this review.

Reason
Not about MMT [89–123]
Not lumbar postsurgical [124–140]
Related to scoliosis [141–143]
Not peer-reviewed source [144–146]
Commentary [147–149]
Conference abstract [150,151]
Book chapter [152]
Not English language [153]
Unable to obtain [154]

MMT = manual and manipulative therapy.

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 investigated 3-days of inpatient physical therapy with and without the addition of neural mobilization following undifferentiated lumbar surgery [32]. 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.

Another RCT graded as high quality examined the addition of 4-weeks of neural mobilization or myofascial release to stabilization

Table 6
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

A = Acceptable, H=High, L = Low, SIGN=Scottish Intercollegiate Guideline Network.

Table 7
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
Elsayyad 2020	1	1	1	1	0	1	1	1	1	1	9	H
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

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

exercise versus stabilization exercise alone after lumbar fusion [34]. Contrary to Scrimshaw et al. this study found a favorable response to neural mobilization and to be superior to myofascial release or stabilization exercise in terms of pain and disability.

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 [35]. 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 LBP, with low-tech exercise having the longest interval of chronic LBP relief. Joint mobilization increased lumbar extension ROM but did not impact objective outcomes for spinal function.

3.3. *Literature reviews, case series and case reports*

There was a large body of lower-level studies that were not assessed for quality. This included 1 scoping review [36], 1 narrative review [37], 1 survey [38], 14 case series [39–52], and 24 case reports [53–76]. The findings from these studies and case reports are presented in Tables 9–11.

3.4. *Strength of evidence*

The strength of evidence is rated and grouped by prior surgical type and criteria are described in Table 4.

3.4.1. *Discectomy*

We found no trials that specifically investigated MMT following discectomy. There were 3 pilot studies published by Kim et al. that demonstrated the feasibility of investigating osteopathic manipulative therapy (OMT) versus active control following microdiscectomy [77–79]. There were 10 case reports and series describing the care of 54 patients following discectomy. All but one intraoperative report [39] involved care provided by chiropractors. Favorable responses were reported with spinal manipulation [46,47,57,69], FD manipulation [49,51,68,69], manual therapy [62,68], and manipulation under anesthesia of the sciatic nerve [39] or spinal joints [45]. 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 [36].

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.

3.4.2. *Laminectomy*

One RCT with acceptable-quality met inclusion criteria [35]. 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 17 case reports or series describing 144 patients after lumbar laminectomy. Two reports from the medical profession [52,64], 1 from physical therapy [71], 1 from an athletic trainer [40] and the rest were chiropractic specific. Favorable responses were described with spinal manipulation [41,52,54,56,58,60,63,72,76], spinal manipulation under anesthesia [42], spinal mobilization with or without McKenzie method [71], FD manipulation [49,51,61,69,76], and massage [40].

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.

3.4.3. *Fusion*

One RCT with high quality met inclusion criteria [34]. This was 3-arm trial where each group received treatments 3 times a week for 4 weeks consisting of stabilization exercise, 1 group additionally received myofascial release, and 1 group additionally received neural mobilization. All 3 groups improved, with the neural mobilization group demonstrating the greatest improvement followed by the myofascial group. 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 [39,52,70], 1 from massage [67] and the rest were chiropractic specific. Favorable response to care was noted following spinal manipulation [41,43,52,73,75], FD manipulation [49,51,59,62,65,66], massage [67,70], neural mobilization both post- [74] and intra-operative [39], and spinal manipulation under anesthesia [50]. 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

Table 8
Evidence for included Randomized controlled trials of manipulation and manual therapy.

Citation and Quality	Participants	Surgical History	Intervention	Comparison	Outcome Measures	Results	Conclusion	Adverse Events	Medication
Elsayyad 2020 High	n = 60; mean age: TG1 = 42.05 TG2 = 43.55 TG3 = 43.2 Duration: TG1 = 3.0mo TG2 = 2.95mo TG3 = 2.98mo	Fusion	TG1: Neural mobilization plus stabilization exercise TG2: Myofascial release plus stabilization exercise	TG3: Stabilization exercise alone	ODI VAS Back ROM	All groups improved. NM improved the most, followed by myofascial release All groups improved. NM greater improvement than myofascial release or stabilization exercise alone No between group differences. All groups improved, except for with left rotation ROM	Adding NM or myofascial release to stabilization program had better improvement, favoring NM, regarding pain and disability than stabilization exercise alone	Not reported	Not reported
Mannion 2007 High	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	Not reported
Scrimshaw 2001 High	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 NM 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	NM did not provide additional benefit to standard care	Not Reported	Not reported
Timm 1994 Acceptable	N = 250 mean age CG = 45 TG1 = 42 TG2 = 42 TG3 = 44 TG4 = 43	L5 laminectomy	All groups 3x/ week for 8 weeks TG1: physical agents (hot packs, ultrasound,	CG: No treatment	modified-modified Schober (lumbar ROM) Cybex liftask	modified-modified Schober: low-tech and high-tech Ex increased lumbar flexion	Active approaches were effective for improvement of functional measures of cLBP; low-tech	None reported.	None reported

(continued on next page)

Table 8 (*continued*)

Citation and Quality	Participants	Surgical History	Intervention	Comparison	Outcome Measures	Results	Conclusion	Adverse Events	Medication
	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		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)		(strength) ODI	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	EX provides longest interval of cLBP relief; joint manipulation increased lumbar extension, but did not produce significant improvement in objective measures of spinal function		
Kim 2015 Not Rated	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	RMQ: 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	All patients in both groups were prescribed supplementary anti-inflammatory medication, analgesics, and a muscle relaxant by surgeon
Kim 2016 Not Rated	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	All patients in both groups were prescribed anti-inflammatory medication, analgesics, and muscle relaxants by their surgeons
Kim 2017 Not Rated	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	None reported	Both groups were prescribed supplementary anti-inflammatory medication, analgesics, and muscle relaxants

(*continued on next page*)

Table 8 (*continued*)

Citation and Quality	Participants	Surgical History	Intervention	Comparison	Outcome Measures	Results	Conclusion	Adverse Events	Medication
							potential therapeutic effect.		

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, N=Number, NM= Neural Mobilization, NPRS=Numerical Pain Rating Scale, ODI=Oswestry Disability Index, OMT = Osteopathic Manipulative Technique, PCS-SF= Physical Component Score of 36-item Short-Form, PT=Physical Therapy, QDS = Quebec Disability Scale, RMQ = Roland Morris Disability Questionnaire, ROM = Range of Motion, RTW = Return to work, TG = Treatment Group, VAS=Visual Analog Scale for pain.

Table 9
Summary of included narrative, scoping and systematic reviews.

First Author, Year Published	Design	Quality	Principal Findings
Basson 2017	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	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	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	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	ScR	Not Rated	• 28 articles: comparing rehabilitation with placebo, no treatment, or another active treatment, or rehabilitation combined with interventions. • Outcomes: VAS, mODI, RMQ, 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: LBP = low back pain, mODI = Modified Oswestry Disability Index, MMT = manipulative or manual therapy; NR = narrative review, RCT = randomized clinical trial, RMQ = Roland Morris Disability Questionnaire, ScR = scoping review, SLR = straight leg raise, SR = systematic review, VAS = visual analog scale.

of care [37]. A survey provided preliminary data on United States Veterans Affairs health system chiropractors attitudes, beliefs, and management of patients with prior lumbar fusion [38].

Moderate evidence indicates that after lumbar fusion the use of neural mobilization plus stabilization exercise is more effective than myofascial release plus stabilization exercise, or stabilization exercise alone.

3.4.4. *Disc replacement*

No trials and only 1 case described MMT following lumbar total disc replacement [48]. 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 were improved in

Table 10
Evidence for included survey studies.

Citation	Participants (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
Daniels 2020	62/134 (46.3%)	Lumbar Fusion	SMT, FD, table-assisted SMT, MFR	• Described practice behavior of US chiropractors in an integrated hospital setting for the management of post surgical lumbar fusion. • 93.5% surveyed report 12 or less visits was necessary to reach maximum therapeutic benefit. • Two thirds of respondents considered thrust manipulation to the lumbar spine a reasonable intervention consideration 1 year postop. • Manual therapy, lumbar mobilization, and flexion-distraction manipulation were commonly considered interventions for treating post fusion low back pain.	Not Applicable	Not Applicable

Abbreviations: FD=Flexion Distraction, MFR = Myofascial Release, SMT=Spinal Manipulative Therapy, US=United States.

Table 11
Findings for included case series or reports of patients with prior lumbar surgery received MMT.

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
Adams 1959	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	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	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	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	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
Benningfield 1997	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
Cole 2020	1	Lumbar laminectomy	SMT, FD, myofascial release, drop table assisted SMT	• Describes management with chiropractic care while patient is being tapered from opioid medications • BBQ decreased by 18 points (37.5%), and VAS reduced by 3 points	None reports	Pre-TX Hydrocodone 30–40 mg per day Post-TX tapered off of Hydrocodone
Cornelson 2018	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% to 44%, and increased tolerance for exercise	None reported	Pre-TX Ibuprofen 400–600 mg per day; No post-TX reporting
Coulis 2013	2	Case 1 L5 laminectomy with left L4-5	Case 1 FD, case 2 FD and SMT		Case 1 none reported; Case 2 mild lumbar spine	Case 1 Diclofenac and Cyclobenzaprine; Case 2

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Table 11 (*continued*)

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
		decompression and right L5-S1 decompression; Case 2 discectomy		• 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	soreness following initial TX with non subsequent adverse event	tricyclic antidepressants, acetaminophen, meloxicam, cyclobenzaprine and opioids; No post-TX reporting
Cox 2009	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
Demetrious 2007	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	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	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	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
Gudavalli 2016	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	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

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Table 11 (*continued*)

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
				and/or medications, and 5 (16%) having repeat spinal surgery, and 1 lost to follow-up		
Hoiriis 1989	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	1	L4-5 Laminectomy and Fusion	Massage	• Describes 7 30-min massage sessions • Improved disability with measured ODI from 50% to 36% post-TX, and RMQ from 3/24 to 2/24 • Pain (VAS) and hamstring length improved within each session	Not reported	Tylenol as needed
Kennedy 2016	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/hydrochlorothiazide, zolpidem, clonazepam, diclofenac 75 mg bid, and oxycodone/acetaminophen 5 mg/325 mg bid; patient reported reduced need for opioid pain medication
Kruse 2011	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 to 31 sessions • NPS decrease ranged from 0 to 8.4 • Patients with combination	None reported	Not reported
Kruse 2011	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
Lamb 1997	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
Layton 2009	1	Laminectomy	SMT		None reported	Not reported

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Table 11 (*continued*)

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
				• 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		
Lisi 2004	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	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
Maddalozzo 2018	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% to 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	3	Case 1 L5/S1 fusion; Case 2 laminectomy; Case 3 L4-S1 laminectomy	SMT	• Describes management of lumbar post-surgical sacro-iliac 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 2012	3	Fusion and L4 or L5 laminectomy	MUA, myofascial trigger point therapy, massage	• Describes successful management of 3 cases of FBSS	None reported	Case 1: 2 Vicodin 7.5/750 mg; no reporting post-TX

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Table 11 (*continued*)

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
				• 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		
Oakley 2007	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	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 h 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 L E paresthesia exacerbated for 24–48 h post-TX	Not reported
Paris 2017	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
Perrucci 2017	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	1	L2-5 laminectomy with partial facetomy and IPD implantation	Spinal mobilization with McKenzie method	• Describes successful management of subacute to	None reported	22 medications included narcotics for pain

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Table 11 (*continued*)

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
			lateral shift correction	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+		management; no reporting post-TX
Shaw 1996	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
Stern 1995	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
Taylor 2007	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% to 12.5% at 2.5-year follow-up	None reported	Not reported
Vaillancourt 1983	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
Vulfsons 2011	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	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	None reported	Flexeril, Naprosyn, Percocet as needed; no reporting Post-TX

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Table 11 (*continued*)

Citation	Patients (n)	Surgical Intervention	Manual or Manipulative Intervention	Principle Findings	Adverse Events	Medication Discussion
				• Care consisted of 27 visits over 12 weeks, then every other week for 9 visits • Disability (ODI) reduced from 50% to 17.7% in 10 weeks • Other outcomes included pain intensity, orthopedic tests, lumbar ROM and DTRs		

Abbreviations: ADL = activity of daily living, bid = bis in die (two times per day), BBQ= Back Bournemouth Questionnaire, CI= Confidence Intervals, 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, GI = Gastrointestinal, LBP = low back pain, LE = lower extremity, MMT = manipulative and manual therapy, MRI = Magnetic Resonance Imaging, MUA = manipulation under anesthesia, NPS = numerical pain scale, NRS = numerical rating scale, ODI= Oswestry Disability Index, OMT = osteopathic manipulative therapy, OTC = over-the-counter, ROM = range of motion, RMQ = Roland-Morris Disability Questionnaire, SCS = spinal cord stimulator, SMT = spinal manipulative therapy (Grade V Maitland), TENS = Transcutaneous Electrical Nerve Stimulation, TX = treatment, VAS = verbal analog scale.

75% (6/8) and 63% (5/8) of cases respectively.

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.

3.4.5. Spinal cord stimulator

No trials and only 1 case report described MMT following spinal cord stimulator [53]. 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, and thus only myofascial release and FD were performed. Two of the 3 cases reported favorable outcomes and one had no benefit from care.

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.

3.4.6. Undifferentiated postsurgical (lumbar discectomy, laminectomy, or fusion)

Two of the 3 RCTs enrolled patients following a variety of different lumbar surgical procedures (discectomy, laminectomy, and fusion) and did not breakdown their results by surgical type [32,33]. 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 [33]. 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 [36].

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.

4. Discussion

Very few MMT clinical trials have been completed for this growing subpopulation of LBP sufferers and thus the interested clinician is forced to rely heavily on case reports and series for literature guidance. This review 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.

4.1. 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 [77–79]. None of the case reports or series reported any serious adverse events, such as loss of bowel or bladder function, stroke, fracture or hospitalization [80]. 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 [39]. Mild lumbar soreness was reported by several case reports for various MMTs and surgical types [48,52,69]; however, mild soreness is commonly reported following manual therapy in patients without history of surgery [81–83]. One study reported increased lower extremity pain in 2 of 8 patients being treated with spinal manipulation following lumbar total disc replacement [48].

4.2. 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. While under powered to form any conclusions, one pilot trial investigating the feasibility of studying OMT after microdiscectomy assessed medication usage as a secondary outcome [77]. A few case reports described patient medication reduction or elimination through the utilization of MMT, however this cannot be generalized to other cases [55,60,70,75]. A recent SR and meta-analysis revealed an inverse association between chiropractic care, which is known for delivery of MMT in a majority of care [84], and opioid receipt in veterans with non-cancer spinal pain [85]. Multiple cohort studies of health insurance claims data displayed a significantly lower likelihood of filling opioid prescriptions for recipients of chiropractic care than nonrecipients [86,87]. Although promising, a causal relationship between chiropractic care and reduced opioid medication utilization cannot be inferred and further it is not clear if this relationship persists in the post-surgical population.

4.3. 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. In attempt to inform researchers and clinicians of all the available relevant literature, we included a wide array of articles, including pragmatic approaches and case reports. Case reports are inherently anecdotal in nature which cannot be used to draw conclusions. Two of the RCTs included manipulation or manual therapy in at least one trial arm, however we did not require any data be specific to MMT, and thus results from these studies cannot be specifically related to MMT. Two of the 4 sufficiently powered RCTs included pragmatic care, all were clinically heterogeneous in design, and most were perioperative, making the findings inappropriate 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 retrospective case reports, with which there is a strong prospect of positive publication bias and likely under-reporting of adverse events [88].

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.

5. Conclusion

The findings of this review will help to inform practitioners of MMT 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 LBP 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 of MMT for patients after lumbar surgery.

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Systematic review registration

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Author contributions

CD, JG, CH, and SW conceptualized the study and contributed to study design and methodology. SW, CD and ZC managed the data collection. CD and ZC screened titles and abstracts. CD, ZC, JG, NH, AL, and DG evaluated full-text for eligibility, extracted and analyzed qualitative data, and assessed for publication bias. CD drafted the first draft of the manuscript. CD, ZC, JG, SW, AS, NH, DG, and CH all provided feedback and then CD finalized the manuscript for publication. CH was the primary advisor for all parts of the study process.

Declaration of competing interest

None of the authors have any conflicts of interest to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ctcp.2020.101261.

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