The role of physical therapy and rehabilitation after lumbar fusion surgery for degenerative disease: a systematic review

Marcella Madera, MD,1 Jeremy Brady, DPT,2 Sylvia Deily, DC,2 Trent McGinty, DPT,2 Lee Moroz, MD,3 Devender Singh, PhD,4 George Tipton, MD,5 and Eric Truumees, MD,1 for the Seton Spine Rehabilitation Study Group

1Department of Surgery and Perioperative Care, The University of Texas Dell Medical School; 2Rehabilitation Service and Orthopaedic Spine Surgery, Seton Spine & Rehabilitation; and 3Physical Medicine & Rehabilitation and 4Research, Seton Spine & Scoliosis Center, Austin, Texas

OBJECTIVE The purpose of this study was to provide a systematic and comprehensive review of the existing literature regarding postfusion rehabilitation.

METHODS Using thePreferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, the authors conducted an exhaustive review of multiple electronic databases. Potential articles were screened using inclusion/exclusion criteria. Two authors independently analyzed these studies using predefined data fields, including study quality indicators such as level of evidence and availability of accepted patient-reported outcomes measures. These findings were synthesized in a narrative format. A third author resolved disagreements regarding the inclusion of a study.

RESULTS Twenty-one articles with I or II levels of evidence were included in the review. The authors divided the findings of the literature review into several groups: rehabilitation terminology, timing and duration of postfusion rehabilitation, the need for rehabilitation relative to surgery-related morbidity, rehabilitation’s relationship to outcomes, and cognitive and psychosocial aspects of postsurgical rehabilitation. Current evidence generally supports formal rehabilitation after lumbar fusion surgery. Starting physical therapy at the 12-week postoperative mark results in better outcomes at lower cost than an earlier, 6-week start. Where available, psychosocial support improves outcomes. However, a number of the questions could not be answered with high-grade evidence. In these cases, the authors used “best evidence available” to make recommendations. There are many cases in which different types of caregivers use clinical terminology differently. The data supporting an optimal protocol for postfusion rehabilitation remains elusive but, using the data available, the authors have crafted recommendations and a model protocol, which is currently undergoing prospective study.

CONCLUSIONS Rehabilitation has long been a common feature in the postoperative management of patients undergoing spinal fusion. Although caregivers from multiple disciplines agree that the majority of their patients will benefit from this effort, the supporting data remain sparse. In creating a model protocol for postlumbar fusion rehabilitation, the authors hope to share a starting point for future postoperative lumbar fusion rehabilitation research.

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KEY WORDS rehabilitation; physical therapy; lumbar fusion surgery; outcome; systematic review; PRISMA; degenerative

Lumbar degenerative disease is nearly universal in the aging spine. Typically, associated symptoms may be successfully managed nonoperatively. In patients with continued pain and functional limitations despite appropriate conservative modalities, operative intervention is considered. In patients with degenerative spinal instability, such as scoliosis or spondylolisthesis, a fusion is often offered. The limitations of fusion procedures are well known and include the muscle dissection required to carry out the approach and the impact segmen-

ABBREVIATIONS CBT = cognitive behavioral therapy; LOE = level of evidence; LOS = length of stay; NASS = North American Spine Society; ODI = Oswestry Disability Index; ROM = range of motion.


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Rehabilitation after lumbar fusion will have on overall spinal kinematics. Postoperatively, physical therapy and other rehabilitative modalities have been frequently used to improve patients’ activity level, range of motion (ROM), and core strength.

Recently the costs of spine care have been questioned. Deyo and Mirza reported that, over a decade, there was a 629% increase in Medicare spending for epidural steroid injections, a 423% increase in spending for opiate medications, and a 307% increase in the number of lumbar MRI studies ordered in Medicare patients. Cowan et al. studied the Nationwide Inpatient Sample from 1993 to 2001 and found that overall use of lumbar fusion increased by 356% in that time frame. Kepler et al. studied the American Orthopedic Surgery database from 1999 to 2011 and found that the number of fusion procedures doubled during that period.

Coordinated, multidisciplinary care using evidence-based guidelines has been suggested as a way to deliver the best outcomes while curbing costs. In the course of our own multidisciplinary group’s meetings to address quality and costs of spine care in our patient population, we realized that common terms concerning postoperative rehabilitation carried different meanings for the specialists involved. We also noted a wide divergence among practitioners in the rates of utilization of physical therapy and other rehabilitative services, the modalities requested, and the timing of such treatments relative to surgery. As we sought to coordinate care, we wanted to establish an evidence base for our recommended rehabilitation regimen.

Rehabilitation as a primary treatment for back pain (i.e., without surgery) has been shown to be effective in several randomized controlled trials for patients with degenerative disc disease and back pain, with success rates as high as 60%. Several of these seminal papers compared outcomes of rehabilitation versus fusion surgery for degenerative disease.

There are far fewer studies examining the role of postoperative rehabilitation after lumbar fusion. In the postoperative setting, much of the rehabilitation literature focuses on postdiscectomy patients. The aim of this study was to conduct a systematic and comprehensive review of the existing literature regarding postfusion rehabilitation.

Methods

Study Design

A systematic review was conducted in accordance to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement for Reporting Systematic Reviews. The study was exempt from review of the institutional review board.

Search Criteria

We conducted a comprehensive computerized literature search through multiple electronic databases without date limits up until November 2014 by using combinations of key search terms. MEDLINE was searched using PubMed and OvidSP search engines; Cochrane Controlled Trials Register and EMBASE were also searched for any potential studies. The OvidSP included the following: Ovid MEDLINE without revisions (1996–Nov 2014); Books @Ovid (25th Nov, 2014); Ovid MEDLINE (1946–Nov 2014); Ovid MEDLINE without revisions (1946–1995); Ovid MEDLINE In-Process & Other Non-Indexed Citations and Ovid MEDLINE (1946–present); Ovid MEDLINE In Process & Other Non-Indexed Citations (3rd Nov, 2014); Ovid OLDMEDLINE (1946–1965); Seton Healthcare Family Journals @Ovid; and Journals @Ovid Full Text (3rd Nov, 2014). The search strategy used for PubMed is shown in the Appendix (see online-only content). Other databases followed the same search strategy.

Search Terms

Our search strategy focused on the combinations of the following key terms: “Lumbar fusion,” “Spinal fusion,” “Physical therapy,” “Rehabilitation,” “Spinal surgery,” “Brace,” “Posture correction,” “Patient education,” “Joint mobilization,” “Soft tissue manipulation,” “Therapeutic exercise,” “Extensor strength,” “Muscle endurance,” “Mobility,” “Quality of life (QOL),” and “Cognitive behavioral therapy (CBT).”

Inclusion and Exclusion Criteria

Articles for potential selection were screened using inclusion and exclusion criteria. Inclusion criteria include studies published in peer-reviewed journals in English or translated into English and studies with postoperative rehabilitation after spinal fusion for degenerative spinal conditions in adults in which a clear description of the rehabilitative strategy was provided.

Studies with the following criteria were excluded: 1) non-English; 2) no spinal fusion surgery; 3) no postoperative rehabilitation after spinal surgery; 4) no clear description of postoperative rehabilitative strategy; 5) basic science studies; 6) not a full-text article (editorials or letters); 6) insufficient sample size; 7) no well-defined outcome measures used; 8) papers that could not be found; or 9) didn’t meet the minimum level of evidence (LOE) (i.e., I or II).

Data Extraction

Two research librarians and 1 of the authors (D.S.) performed the electronic database search. Two authors (E.T. and T.M.) independently reviewed these studies to be potentially included in the systematic review by using predefined data fields, including study quality indicators such as LOE and availability of accepted patient-reported outcomes measures. These findings were synthesized in a narrative format. Disagreements on the inclusion of a study were resolved by a third author (M.M.). In addition, we also performed manual searches of review bibliographies and reference lists of primary studies not captured by the electronic searches. To further avoid missing studies not referenced in our original papers’ bibliographies or our literature searches, we sought additional recommendations from prominent researchers in the field. Additional full-text references were then obtained and analyzed for inclusion.
Results

Our initial search resulted in 1850 articles. Of these, we excluded those identified as duplicate articles, editorials, letters, or basic science studies, and identified 210 full-text articles. With detailed analysis, we excluded 61 full-text articles (13 non-English; 14 could not be found; 21 with no well-defined outcome measures, and 13 with insufficient patient samples). A total of 149 full-text articles were found to be relevant for the systematic review. Of these 149 articles, 123 did not meet the minimum LOE (i.e., II) and were excluded from the review. The remaining 26 articles with I or II LOEs were included in the review. On further review, 5 of these articles were found to be irrelevant and were excluded from the current study (Fig. 1). Articles included in the final review are listed with their LOEs in Table 1.

We divided the findings of the literature review into several groups: general rehabilitation terminology, timing and duration of postfusion rehabilitation, the need for rehabilitation relative to surgery-related morbidity, rehabilitation’s relationship to outcomes, and cognitive and psychosocial aspects of postsurgical rehabilitation.

We encountered a variety of terms that carried different meanings for different care provider classes. To proceed further, therefore, we sought to establish some common definitions for the components of rehabilitation.

To establish a standardized postlumbar fusion rehabilitation protocol, we next queried the literature for optimal timing and duration of postoperative rehabilitation. Other primary questions included the following: how does the extent of surgery relate to postoperative rehabilitation needs, what is the impact of postoperative rehabilitation on treatment outcomes, and how do psychosocial diagnoses or support systems impact these outcomes?

We used standard North American Spine Society (NASS) grades of recommendation for summaries or review studies, as shown in Table 2. These findings are summarized in Table 3.

Definitions

Only a few papers offered specific and detailed rehabilitation protocols. In that there were insufficient data to assess individual elements of these protocols, they were studied “as one.” That said, most authors favored specific rehabilitation techniques as part of a multidisciplinary approach. For instance, Tarnanen et al. emphasize the...
TABLE 1. Articles included in the final review, with LOEs

<table>
<thead>
<tr>
<th>LOE</th>
<th>Relevant Papers</th>
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<tbody>
<tr>
<td>II</td>
<td>Biering-Sørensen, 1984</td>
</tr>
<tr>
<td>II</td>
<td>Moffett et al., 1999</td>
</tr>
<tr>
<td>I</td>
<td>Mannion et al., 2001</td>
</tr>
<tr>
<td>II</td>
<td>Scrimshaw &amp; Maher, 2001</td>
</tr>
<tr>
<td>I</td>
<td>Christensen et al., 2003</td>
</tr>
<tr>
<td>II</td>
<td>Brox et al., 2003</td>
</tr>
<tr>
<td>II</td>
<td>Fairbank et al., 2005</td>
</tr>
<tr>
<td>II</td>
<td>Keller et al., 2004</td>
</tr>
<tr>
<td>I</td>
<td>Håkkinen et al., 2005</td>
</tr>
<tr>
<td>II</td>
<td>Rosenberger et al., 2005</td>
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<tr>
<td>II</td>
<td>Brox et al., 2006</td>
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<tr>
<td>I</td>
<td>Mannion et al., 2007</td>
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<td>II</td>
<td>Andersen et al., 2009</td>
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<td>II</td>
<td>Nielsen et al., 2010</td>
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<td>I</td>
<td>Brox et al., 2010</td>
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<td>I</td>
<td>Froholdt et al., 2011</td>
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<tr>
<td>I</td>
<td>Froholdt et al., 2012</td>
</tr>
<tr>
<td>II</td>
<td>Oestergaard et al., 2012</td>
</tr>
<tr>
<td>I</td>
<td>Willems, 2013</td>
</tr>
<tr>
<td>II</td>
<td>Oestergaard et al., 2013^6</td>
</tr>
<tr>
<td>II</td>
<td>Oestergaard et al., 2013^4</td>
</tr>
</tbody>
</table>

TABLE 2. Grades of recommendation for summaries or review studies

<table>
<thead>
<tr>
<th>NASS Grade for LOE</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Good evidence (Level I studies w/ consistent findings) for or against recommending intervention</td>
</tr>
<tr>
<td>B</td>
<td>Fair evidence (Level II or III studies w/ consistent findings) for or against recommending intervention</td>
</tr>
<tr>
<td>C</td>
<td>Poor-quality evidence (Level IV or V studies) for or against recommending intervention</td>
</tr>
<tr>
<td>I</td>
<td>Insufficient or conflicting evidence that does not allow a recommendation for or against intervention</td>
</tr>
</tbody>
</table>

Evidence for or against recommending an intervention is listed as A = good evidence (Level I study with a consistent finding); B = fair evidence (Level II or III study with a consistent finding); C = poor-quality evidence (Level IV or V study); I = inconsistent or conflicting evidence that does not warrant recommending for or against an intervention. [https://www.spine.org/Research/ClinicalCare/Research/GradesofRecommendation.aspx]

importance of maintaining neutral spine position while strengthening core muscles,^6^ while Oestergaard et al.^[54–56] model their rehabilitation after Christensen et al.’s biopsychosocial “Back Café” model.^6^ In most of the studies analyzed, postfusion rehabilitation was poorly defined. Where physical therapy is mentioned, it often falls into several categories: generalized cardiovascular exercise (including aerobic work on bicycle or walking), generalized strength training, motor control/stability training, soft-tissue and nerve mobility, joint mobility/stretching, patient education, and psychosocial interventions. Literature support for passive modalities such as ultrasound, electrical stimulation, thermal agents, and other modalities has been decreasing over the past 2 decades.^[4,66] Although descriptions of the components of postoperative rehabilitation programs were rarely offered, a few common themes emerged. Most authors recommend customizing a program based on individual patient needs. Many authors also emphasize the identification and treatment of any psychosocial barriers to recovery. The most common components of these programs are defined below.

Specific Components of Postfusion Rehabilitation

Cardiovascular Exercise

Generalized, aerobic exercise is often a major element of postoperative rehabilitation. Brennan and colleagues suggest that increasing aerobic capacity positively impacts long-term health without increasing back pain symptoms after lumbar surgery.^[9] A number of other studies support the short-term benefits of generalized exercise in terms of decreased pain and increased function.^[2,4,32,48,63] However, such aerobic exercise therapy is a primary focus in only a few of the reviewed studies, and where it is defined, those definitions vary greatly.

An emphasis on cardiovascular exercise, typically walking, is common in rehabilitation for lumbar surgeries, both preoperatively and postoperatively. Evidence suggests that regular cardiovascular exercise performed preoperatively decreases length of stay (LOS) and improves Roland-Morris scores postoperatively.^[52] A recumbent bike can be useful to increase cardiovascular health preoperatively, if a patient’s walking tolerance is limited by his/her symptoms. Aquatic exercise may also be effective in increasing cardiovascular health, and has the benefits of buoyant lumbar traction as well as lower-extremity compression to fight swelling. However, it lacks weight bearing, which is an important component of bone health and functional strengthening of the extensor musculature against gravity.

With modern, rigid spinal instrumentation, patients undergoing fusion for degenerative disease are believed to leave the operating room with adequate stability for immediate mobilization. Early mobility (transfer training and supervised gait training) in the acute care setting has been suggested to reduce adverse events, pain, and LOS.

Upon discharge, there is an expectation of gradual in-crease in distance and frequency of walking, as symptoms allow. We recommend that care providers include cardiovascular exercise in both pre- and postoperative fusion rehabilitation programs (Table 3).

Soft-Tissue Mobilization

Massage therapy is often used postoperatively to reduce inflammation, decrease pain, and facilitate patient recovery. Pressure and touch are thought to encourage these changes by restoring lymphatic drainage, improving...
TABLE 3. The NASS strategy for grading of evidence and recommendations for various components of postfusion rehabilitation

<table>
<thead>
<tr>
<th>Components of Rehabilitation</th>
<th>Clinical Question</th>
<th>Guideline/Recommendation</th>
<th>NASS Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular exercise</td>
<td>Should cardiovascular exercise be included in lumbar fusion postop rehabilitation?</td>
<td>Cardiovascular exercise is recommended to be included in lumbar fusion postop rehabilitation programs to positively impact long-term health</td>
<td>B</td>
</tr>
<tr>
<td>Soft-tissue mobilization</td>
<td>Should soft-tissue mobilization be included in lumbar fusion postop rehabilitation?</td>
<td>There is insufficient evidence to make an argument for or against soft-tissue mobilization's inclusion in lumbar fusion postop rehabilitation programs</td>
<td>I</td>
</tr>
<tr>
<td>Nerve mobilization</td>
<td>Should nerve mobilization be included in lumbar fusion postop rehabilitation?</td>
<td>There is insufficient evidence to make an argument for or against nerve mobilization's inclusion in lumbar fusion postop rehabilitation programs</td>
<td>I</td>
</tr>
<tr>
<td>Motor control &amp; strengthening</td>
<td>Should motor control &amp; strengthening exercises be included in lumbar fusion postop rehabilitation?</td>
<td>Neutral spine control exercises are recommended to be considered as part of postop fusion rehabilitation to increase core strength &amp; improve disability scores</td>
<td>B</td>
</tr>
<tr>
<td>Joint mobilization</td>
<td>Should joint mobilization be included in lumbar fusion postop rehabilitation?</td>
<td>There is insufficient evidence to make an argument for or against joint mobilization's inclusion in lumbar fusion postop rehabilitation programs</td>
<td>I</td>
</tr>
<tr>
<td>Patient education</td>
<td>Should patient education be included in lumbar fusion postop rehabilitation?</td>
<td>Patient education is recommended as part of both pre &amp; postop fusion rehabilitation to facilitate clear communication b/wn patients &amp; care providers, to prepare patients for the postop rehabilitation regimen, &amp; to improve outcomes while decreasing pain, complications, &amp; LOS</td>
<td>A</td>
</tr>
<tr>
<td>Timing &amp; duration of</td>
<td>What is the optimal timing &amp; duration of lumbar fusion postop rehabilitation?</td>
<td>Postop fusion rehabilitation is recommended to begin immediately, &amp; to include education &amp; a walking program</td>
<td>B</td>
</tr>
<tr>
<td>postfusion rehabilitation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Need for rehabilitation</td>
<td>How does the magnitude of surgery relate to postop rehabilitation needs?</td>
<td>Postop fusion rehabilitation is recommended after both minimally invasive &amp; open lumbar fusion surgeries</td>
<td>C</td>
</tr>
<tr>
<td>relative to surgery-related</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>morbidity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rehabilitation's relationship</td>
<td>What is the impact of postop rehabilitation on treatment outcomes?</td>
<td>Postop rehabilitation is recommended after lumbar fusion to improve function &amp; pain in the months after surgery, &amp; to allow return to work</td>
<td>C</td>
</tr>
<tr>
<td>to outcomes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psychosocial considerations</td>
<td>How do psychosocial diagnoses or support systems impact clinical outcomes?</td>
<td>Preop psychological testing prior to lumbar fusion &amp; postop psychological coping techniques in rehabilitation should be considered to optimize outcomes</td>
<td>B</td>
</tr>
</tbody>
</table>

blood circulation, lengthening short or tight connective tissue, relaxing tense muscles, and soothing the nervous system. To date, no studies have assessed the effects of massage therapy on patients who have undergone lumbar fusion.

To some degree, the utility of these modalities may be extrapolated from other surgical milieux. Massage therapy administered postsurgically has been shown to decrease patients' pain and need for analgesics after colectomy and cesarean section. Patients who received massage therapy after cardiovascular surgery also had significant decreases in postsurgical pain as well as a reduction in anxiety and tension compared with those who received standard care. There is insufficient evidence to make an argument for or against soft-tissue mobilization's inclusion in lumbar fusion postoperative rehabilitation programs. Nevertheless, we recommend that care providers consider soft-tissue mobilization as a treatment option in postoperative fusion rehabilitation to provide a decrease in postsurgical pain and a reduction in anxiety and tension (Table 3). Soft-tissue mobilization may be most important for patients who are experiencing pain and swelling specifically around the incision site, as well as patients who are experiencing more anxiety or distress during their recovery.

Nerve Mobilization

Postoperative pain has occasionally been attributed to nerve root adherence to scar tissue around the decompresed thecal sac. Cadaver studies demonstrate nerve mobilization through the neuroforaminae. In the lower extremity, ultrasound measurements demonstrate 5.22 and 6.62 mm of longitudinal and lateral movement, respectively.

The benefit of formal nerve mobilization procedures after lumbar fusion surgery remains contested, however. Scrimshaw and Maher reported a randomized controlled trial in which there was no difference in McGill Pain Questionnaire findings and the Quebec Disability Scale outcomes of lumbar surgery at 1 year between groups undergoing nerve mobilization and controls. On the other hand, a pilot study of healthy male soccer players showed improved ROM, as measured by the straight leg raise test in patients randomized to nerve mobilization.

Although there is insufficient evidence to make an argument for or against the inclusion of nerve mobilization...
in lumbar fusion postoperative rehabilitation programs, we believe that mobilization techniques are safe in the postlumbar fusion population. We recommend that care providers consider early nerve mobilization as a treatment option in postoperative fusion rehabilitation to improve ROM by decreasing postoperative nerve tension and decreasing scar tissue adherence to the nerve (Table 3).

**Motor Control and Strengthening**

Another common element in the studies analyzed is proper strengthening of trunk extensors and balancing of core musculature. Strengthening has long been a cornerstone of physical therapy. A number of studies have shown adverse effects of lumbar fusion on lumbar extensor function and density. Waschke and colleagues showed adverse effects of lumbar fusion on lumbar extensor muscle activation and increased intraabdominal pressures, and they showed that measured isokinetic strength gains of 184 Nm and improved Biering-Sørensen positional holding times in patients randomized to an exercise program for disc degeneration or postlaminectomy syndrome. 35

Cocontraction of abdominal and extensor muscles provides a splinting effect that may be protective to the spine. Although it is a controversial claim, some have argued that core strengthening may even decrease a patient’s risk for adjacent-segment pathologies. 67

Less controversially, fusion of one or more weight-bearing segments of the spine will benefit from spinal motor control through functional, loading activities such as transfers, lifting, bending, and upright exercise. Proper neuromuscular reeducation for timing associated with muscle activation and increased intraabdominal pressures during these loaded movements should also be addressed. 21,65 Tarnanen and colleagues found “neutral spine control exercises” to be safe and effective during the rehabilitation of the postfusion population. 65 These authors described each exercise and reported how electromyography findings support the exercise’s effectiveness on activation of particular muscles, and they showed that measured increases in core strength correlated to lower Oswestry Disability Index (ODI) scores. 64 Most of these exercises should be central to core stability efforts for patients with lumbar fusion, despite surgical intervention, and are commonly used by our coauthors from the rehabilitation departments. We recommend that care providers consider neutral spine control exercises as part of postoperative fusion rehabilitation to increase core strength and improve disability scores (Table 3).

**Joint Mobilization**

Joint mobilization and manipulation techniques have been shown to be effective in the treatment of low-back pain. Efficient movement requires optimization of not only lumbar ROM, but also those musculoskeletal units cranial and caudal to the spine. The available data support rehabilitation program strategies for thoracic spine and hip mobilization in maintaining proper posture, functional mobility, and decreasing stress on the healing fusion.

In 1999, Moffett et al. reported 1-year outcomes of a progressive exercise program in patients with low-back pain. 49 One hundred eighty-seven patients were randomized into either CBT rehabilitation or the usual primary care management. The rehabilitation program included Oxford strengthening exercises consisting of a physical therapy evaluation followed by eight 1-hour group classes. A CBT component encouraged self-reliance and normal movement of the spine. At 1 year, significantly greater improvements in disability and back pain scores were reported. In that the rehabilitation patients missed far less work and used fewer health care resources, the authors concluded that this approach was more cost-effective.

Specifically, thoracic rotation training may assist patients’ return to activities requiring seated rotation. It may also thereby decrease torsional stress on the healing lumbar spine and, perhaps, decrease nerve tension. One Italian study found that such manipulation was more beneficial than education and traditional therapy for pain and Roland-Morris scores. 15 Although there is insufficient evidence to make an argument for or against joint mobilization’s inclusion in lumbar fusion postoperative rehabilitation programs, we recommend that care providers consider thoracic spine and hip mobilization as a treatment option in postoperative fusion rehabilitation to maintain proper posture, increase functional mobility, and decrease stress on the healing fusion (Table 3).

**Patient Education**

The indications for lumbar surgery are clear in patients with progressive weakness or loss of function. However, when presented with chronic pain alone, patient selection can be daunting. Predicting the outcome of lumbar fusion surgery in the population with chronic low-back pain has proven difficult. Preoperative consultation with an experienced spine rehabilitation specialist to conduct biomechanical screening, improve compliance, and prepare the patient physically and mentally for surgical intervention could prove invaluable in these cases. Exercises such as low-impact aerobics have been shown to reduce pain in these patients. 46

Patient education can be the cornerstone of rehabilitation, reducing anxiety and increasing patient empowerment, gratitude, and satisfaction. Building patient rapport is important for all members of the patient’s care team and improves outcomes. 20,25,60

Rosenberger et al. measured physician and patient preoperative expectations and compared them with postoperative outcomes in anterior cruciate ligament repairs. They found that physicians underestimated postoperative pain and overestimated function, yet were still better predictors of postoperative function and pain than were patients. This research calls for good preoperative communication between physicians and patients. The researchers have observed therapists’ integral role in helping bridge this gap. Answering routine questions and helping prioritize more challenging questions for their surgeon can help patients feel more prepared. Setting up realistic expectations...
of how a surgery can be a part of the overall solution to chronic back pain may facilitate better outcomes. This scenario works best in the context of a multidisciplinary center where all providers stay in close communication and develop a level of trust for delivery of these services.

The education process begins preoperatively and involves several members of the care team. Ideally, each team member should give a consistent and cohesive message at each stage in the process. Preoperative education classes and written materials can be helpful in getting patients’ questions and concerns addressed before surgery. Ideally, these sessions would include physical prehabilitation efforts to ready patients for the postoperative rehabilitation regimen before surgical pain and weakness are major factors. These efforts appear to improve outcomes while decreasing complications and LOS.\textsuperscript{53} We recommend that care providers include patient education as part of both pre- and postoperative fusion rehabilitation to facilitate clear communication between patients and care providers, to ready patients for the postoperative rehabilitation regimen, and to improve outcomes while decreasing pain, complications, and LOS (Table 3).

**Timing and Duration of Postfusion Rehabilitation**

Few studies have examined the timing of initiation of postoperative rehabilitation. Oestergaard and colleagues randomized 2 groups of patients who underwent lumbar fusion to start rehabilitation at either 6 or 12 weeks postoperatively. The group starting at 12 weeks showed improved outcomes over the 6-week group in pain, activities of daily living, ODI, and Dallas Pain Questionnaire scores, even at 6-month follow-up.\textsuperscript{54–56} This protocol advocates a group setting of four 2-hour group sessions, which is modeled after the “Back Café” format proposed by Christensen et al.\textsuperscript{16} The exercises are outlined, but are not specifically detailed by individual exercise.\textsuperscript{55}

Duration of rehabilitation postfusion has several variables that should be considered. Patient comorbidities, preoperative deconditioning, age, disability, smoking, secondary orthopedic problems, psychosocial barriers (such as fear avoidance and/or depression), the patient’s commitment and ability to exercise safely and independently, and pain control are factors that could require a patient to warrant closer monitoring from a rehabilitation specialist, to facilitate clear communication between patients and care providers, to ready patients for the postoperative rehabilitation regimen, and to improve outcomes while decreasing pain, complications, and LOS (Table 3).

**The Need for Rehabilitation Relative to Surgery-Related Morbidity**

We are not aware of any studies comparing the role of rehabilitation after 1-level versus multilevel lumbar fusion procedures; the impact of these surgeries on the extensor musculature is likely to be very different. These patients may also arrive at surgery with very different functional states. A similar assessment could be made comparing surgeries undertaken with a less invasive approach over more traditional, open surgeries.

Minimally invasive fusion approaches offer less tissue disruption than traditional open fusion procedures. Compared with patients who undergo open fusion, those who have the minimally invasive procedures may be able to start rehabilitation sooner, leading to a shorter LOS and earlier return to work.\textsuperscript{32}

At this point, however, data for the influence of the extent of surgery on an appropriate rehabilitation protocol are not available. In those papers that more thoroughly examine rehabilitation after lumbar surgery, we find that the majority of them focus on microdiscectomies rather than lumbar fusions, with good evidence in favor of physical therapy for increased recovery. Although microdiscectomies and fusions are not identical and require different recovery time frames, there is enough correlation between the two that we can consider extrapolating from discectomy to fusion.\textsuperscript{50} We recommend that care providers order postoperative fusion rehabilitation after both minimally invasive and open lumbar fusion surgeries (Table 3).

**Rehabilitation’s Relationship to Outcomes**

Most studies find that early rehabilitation in the 3- to 6-month time frame increases early function and symptom control; however, ultimate function at 1–2 years continues to require higher-LOE research, because current studies do not show good evidence for or against therapy.\textsuperscript{28,32,45,48,52,54,63} In lumbar degenerative disease, long-term, randomized outcomes studies tend to show regression to the mean. That is, even when comparing operative versus nonoperative treatment strategies, longer-term follow-up suggests
similar outcomes.10–12,24,29 Recently, Lurie and others published the 8-year results of the Spine Patient Outcomes Research Trial for lumbar spinal stenosis. Whereas outcomes remained stable in the observational cohort, the benefits of surgery diminished in the randomized group.43

Tarnanen et al.'s 2013 study does show a correlation between weak trunk extensor strength and increased disability as measured by the ODI, but it is limited by its short-term follow-up.64 Oestergaard et al. demonstrate that the timing is important because beginning skilled therapy at 6 versus 12 weeks leads to a higher usage of health care services without a measurable increase in the overall quality of life.54 Yet they are unable to suggest an optimal initiation time frame at this point within their study’s parameters. However, if rehabilitation at the 3-month time frame can show an earlier return to functional movement to enable regular work and activities of daily living in conjunction with improved psychological and psychosocial variables when compared with lack of skilled therapy, then skilled therapy services are warranted. Evaluating prehabilitation and outcome measures, Nielsen et al.’s study shows good evidence of improved outcomes and shortened hospital stay without increase in disability, pain, dissatisfaction, or complications after 1- to 2-level lumbar fusions.52

**Psychosocial Considerations**

In a 2010 review, Abbott et al. noted the interdependent nature of physical and psychological therapy during rehabilitation.2 Candidates for lumbar fusion surgery have probably had symptoms and compromised function for months to years. Over that time the episodic and/or chronic pain will have had an effect on these patients’ psychological status, including fear/avoidance behavior, transitioning from an internal locus of control to an external locus of control, anxiety, catastrophizing, and depression. Patients who undergo lumbar fusion have been shown to have significant fear of movement and (re)injury. Abbott et al. showed that approximately 80% of the study’s patients who underwent lumbar spinal fusion had comorbid anxiety and/or depression. These patients also had lower health-related quality of life (HRQOL) and higher levels of pain.3 When neuroticism, anxiety, depression, fear/avoidance beliefs, catastrophizing, or kinesiophobia are present in a patient who undergoes lumbar fusion, a worse outcome is predicted.5,6,30,31,40 Smoking and off-work status for more than 13 weeks prior to surgery also predict a worse outcome.5

Even psychologically healthy patients will endure psychological stress during the perioperative period. Stressors include the following: the financial costs of treatment, the potential loss of income while off from work, and the individual’s compromised function, which may tax relationships and/or family dynamics.

Strategies used to address these issues are varied. Some studies have explored incorporating CBT, others include teaching relaxation and coping techniques along with rehabilitation, and still others have used patient-led group meetings along with a video of home exercises in replacement of traditional physical therapy.2,3,16,35,49,51 All of these have shown increased benefit to the patient in comparison with rehabilitation administered without these techniques, although there are no studies comparing one technique or approach against another.

Current data are inadequate to compare various forms of psychosocial support with others. Preoperative psychological testing has been shown to be effective in several studies.26,40,62 We recommend that care providers consider preoperative psychological testing prior to lumbar fusion; providers should consider including psychological coping techniques in postoperative rehabilitation.

**Discussion**

Postoperative rehabilitation means different things to different people. For some, it’s a pamphlet and a recommendation that the patient walk. In European centers, a “Back Café” approach with psychosocial support in addition to exercise is often offered. Others recommend an aggressive program of isometric strengthening exercises. We have analyzed the limited literature specifically pertaining to postfusion rehabilitation and have extrapolated recommendations, where necessary and appropriate, from the literature concerning rehabilitation after other spine procedures—most notably discectomy. Where high-grade evidence is not available we identified this deficit but made recommendations based on our group’s extensive, multidisciplinary experience with these patients.

Based on our analysis of these studies and on our experience, we have listed a set of definitions for the components of rehabilitation that we propose should be addressed in planning postoperative rehabilitation for patients who undergo lumbar fusion. These are as follows: 1) cardiovascular exercise; 2) soft-tissue mobilization; 3) nerve mobilization; 4) motor control and strengthening; 5) joint mobilization; and 6) patient education.

We examined the optimal timing and duration of postfusion rehabilitation, and we advocate immediate mobilization followed by formal, outpatient rehabilitation at 2–3 months postoperatively. We also evaluated postfusion rehabilitation’s relationship to the extent of surgery and whether it is known if postfusion rehabilitation improves outcome. Although there are no direct data addressing this concept, we recommend rehabilitation after fusion regardless of number of levels or degree of invasiveness of the operation. We also analyzed the importance of psychosocial considerations when planning both surgery and postfusion rehabilitation. When possible, psychological testing and teaching of coping strategies should be considered by care providers.

We graded recommendations very conservatively because many of the papers reviewed did not directly address postlumbar fusion rehabilitation. Even where there was insufficient evidence, we made recommendations in which we extrapolated from the evidence available and our clinical practices to the postfusion scenario. Our review is chiefly limited by the data available. We have designed a protocol for postoperative rehabilitation and are studying this program prospectively. So far, we have not been able to identify any harm from the program in total or in any of its components. The relative benefits from the program or its constituent parts are the focus of...
our ongoing study. Additionally, we seek to identify those subgroups of patients with lumbar fusion who are most likely to benefit from formal postoperative rehabilitation, and to perform cost utility analyses.

Conclusions

Rehabilitation has long been a common feature in the postoperative management of patients with spinal fusion, but without a clear understanding by many providers of what that rehabilitation should include and why. Although most caregivers agree that most patients will benefit from this effort, the supportive data remain sparse. In this review we have provided a list of and have made evidence-based recommendations for components that should be included in postlumber fusion rehabilitation. We have also discussed the optimal timing and duration, and we advocate immediate mobilization followed by formal, outpatient rehabilitation at 2–3 months postoperatively. At this point, although much additional research is required, we have begun to construct from the data an active, patient-driven rehabilitation protocol. This protocol is undergoing prospective study to examine its cost per quality-adjusted life year features and its impact on patient-reported function.

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Disclosures
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Author Contributions
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Correspondence
Eeric Truumees, Seton Spine and Scoliosis Center, 1600 West 38th St., Ste. 200, Austin, TX 78731-6400. email: etruumees@seton.org.