Rehabilitation Following Lumbosacral Percutaneous Nucleoplasty: A Case Report

Surgery for symptomatic lumbar degenerative disc disease (DDD) continues to increase in the United States. Although many patients with low back pain (LBP) do not need surgery, a small number do seek surgery as an option. The most common surgical option for this population has been fusion of the affected vertebral motion segment. However, the success of lumbar fusion surgery is often complicated by the acceleration of adjacent-level disc degeneration, which is thought to be triggered by the loss of motion at the fused segment. This has led to the advancement of spine arthroplasty technology, or motion-sparing procedures, as a means to relieve pain while restoring function and, theoretically, protecting adjacent levels. However, the success rates remain less than optimal, and, to date, no study has shown disc replacement to be superior to spinal fusion in terms of clinical outcome. This has led to a shift in focus from total disc replacement to less-invasive procedures, such as nucleoplasty.

Nucleoplasty, which involves replacement of the nucleus pulposus, is considered a form of partial disc replacement and is proposed to provide advantages over total disc replacement, in that it is minimally invasive and allows for multiple surgical approaches (anterior retroperitoneal, lateral, and posterior). Furthermore, the limited surgical exposure and annulotomy allows for several revision options, including total disc replacement and fusion. Nucleoplasty is purported to provide a surgical solution that decreases recalcitrant mechanical LBP in patients with early or moderate DDD by directly addressing the presumed source of symptoms (in this case, the diseased nucleus through its effects on the innervated annulus fibrosus) and replacing it with a device that will maintain functional motion. It is important to note that nucleoplasty is recommended as a surgical intervention for early to moderate DDD, as it requires that the annulus be intact to contain the prosthetic nucleus device.

One of many nucleoplasty devices currently being investigated is the Dascor disc arthroplasty device, which is an in situ-cured, balloon-contained, injectable polyurethane device. In a recent case report, this patient’s Oswestry Disability Index decreased from 56% to 4% over 6 weeks of treatment. When contacted at 6, 12, 18, and 24 months posttherapy, his Oswestry Disability Index was 2%, 2%, 0%, and 0%, respectively, and he had returned to all previous activities without recurrence of symptoms.

**STUDY DESIGN:** Case report.

**BACKGROUND:** Lumbar spine nucleoplasty is a new surgical option for patients with disc pathology. There are no reports in the literature describing the role of physical therapy in postoperative lumbar nucleoplasty management. The purpose of this case is to describe the postoperative physical therapy management of a patient who underwent this procedure.

**CASE DESCRIPTION:** A 50-year-old male, 7 weeks following a L5/S1 lumbar nucleus replacement, completed 6 weeks of rehabilitation. The focus of the treatment was controlled reloading of the spine through a spinal stabilization progression in weight-bearing and non-weight-bearing activities. In addition, education, spinal manual therapy techniques, and a home exercise program were also incorporated.

**OUTCOMES:** The patient’s Oswestry Disability Index decreased from 56% to 4% over 6 weeks of treatment. When contacted at 6, 12, 18, and 24 months posttherapy, his Oswestry Disability Index was 2%, 2%, 0%, and 0%, respectively, and he had returned to all previous activities without recurrence of symptoms.

**DISCUSSION:** This case report outlines the clinical decision-making process during the postoperative management of an individual who had undergone a single-level lumbar nucleoplasty. A postoperative regimen of education, segmental spinal stabilization, and a home exercise program might have contributed to the observed improvement in pain and disability levels in this patient. The role of these postoperative interventions warrants further research.


**KEY WORDS:** manual therapy, nucleus replacement, pain science education, physical therapy, postoperative rehabilitation, spinal segmental stabilization

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In the Ahrens et al study, the role of physical therapy following single-level lumbar nucleoplasty is not described, and there are currently no data to inform and guide practitioners on appropriate management strategies for patients who have undergone this relatively new surgery. Early results of lumbar nucleoplasty will likely result in an increased availability of this procedure to the general public. Thus there is a growing need for research on the postoperative management of this surgical procedure. The purpose of this case is to describe the postoperative physical therapy management of a patient who underwent an L5/S1 nucleoplasty procedure.

CASE DESCRIPTION

Preoperative Condition

Prior to surgery, a 50-year-old male patient described a history of insidious chronic and recurrent LBP, for which he received several successful bouts of physical therapy. His previous physical therapy for LBP had included manual therapy (both thrust and nonthrust), as well as exercises focusing on strengthening and stabilization. He reported frustration with the increasing frequency of the recurring episodes of his LBP. DDD was noted on radiographs at the L5/S1 segment.

The patient owned and operated an air-conditioning contracting business and was unable to perform his regular duties. Additionally, he was unable to ride his motorcycle, which had been a regular hobby for him. At the time of his surgery, his visual analog scale for pain and ODI scores were quite high (7.2 and 64%, respectively), with approximately 95% of his pain being in his lower back and the remaining 5% in his left lower extremity.

Operative Procedure

While seeking a second surgical opinion for a single-level lumbar fusion, he learned about the nucleoplasty procedure. He decided to participate in the limited nationwide clinical trial of the Dascor device, which was underway at the time. A single-level (L5/S1) lumbar nucleus replacement surgery, using the Dascor disc arthroplasty device, with an anterior retroperitoneal approach, was performed. The procedure (Figure 1) involved endoscopic evacuation of the nucleus (total nucleus removal) via a 5.5-mm annulotomy, while maintaining the integrity of the annulus, and then insertion of a polyurethane balloon into the space previously occupied by the nucleus. A curable polymer was then injected into the balloon under controlled pressure, causing the balloon to expand to contour and fill the entire nucleus space left by the total nucleus removal procedure. The annular wall was then sealed.

The patient was able to resume his regular activities, including riding his motorcycle, within 6 weeks after surgery.

FIGURE 1. Percutaneous nucleoplasty using the Dascor Disc Arthroplasty Device. Although this graphic demonstrates an anterior retroperitoneal surgical approach, the Dascor device can also be inserted via a lateral or posterior endoscopic approach. (A) Total nucleus removal is achieved through a 5.5-mm annulotomy. (B) The annulus of the disc is left intact. (C) A polyurethane balloon is inserted and fluid volume calculated. (D) Balloon is emptied of fluid and prepared for injection of the final polymer. (E) Final polymer injected into the polyurethane balloon. (F) Disc height is maintained to the 2-part cured polyurethane device. (G) The cured polyurethane forms the prosthetic nucleus as shown. From Disc Dynamics, Inc, with permission.
Postoperative Findings

The patient’s back pain had decreased postoperatively to the point where he felt he had experienced an increase in functional mobility and the left lower extremity pain had resolved. He reported that he had been prescribed pain medications (Hydrocodone APAP), but had only taken them for the first 3 to 4 weeks, at which time he no longer felt he needed them. Per the clinical trial guidelines, no postoperative rehabilitation was prescribed in the acute postoperative phase.

Per the discretion of the surgeon and in accordance with patient’s request, an initial physical therapy examination was conducted 7 weeks postoperatively, at which time he was still experiencing some difficulties with bending, crouching, prolonged sitting, rising from sitting, prolonged standing, and walking. His initial ODI was 56%, and he reported intermittent back pain. He reported that his current pain level was 3 out of 10, where 0 represented no pain and 10 represented worst possible pain. His best level had been 0, and his worst was 6 with activity, which gave him an average of 3 on the numeric pain rating scale (NPRS). He described his current pain as “stiff” and “achy”; he denied any pain radiating into his lower extremity. He reported that he felt worse in the early mornings and expressed concerns about the appropriate level of physical activity following his surgery.

A screen of the gastrointestinal, genitourinary, and cardiovascular systems revealed no abnormalities. He demonstrated a normal gait pattern without use of an assistive device. Postural inspection was performed in standing and revealed slight loss of the normal lumbar lordosis, without lateral shift to either side. The patient reported no pain at rest in standing, and, therefore, active range of motion (ROM) of the lumbar spine was tested in this position to pain onset. Active ROM was visually rated by the examiner using the patient’s fingertip reach along his lower extremities. This is a modified version of the fingertip-to-floor test, which has been shown to have an intrarater reliability of 0.98 in 73 subjects with LBP. The patient was limited to the knee level for flexion and the lower third of the lateral thigh for lateral flexion left and right. Extension was visually estimated to be approximately 15°. Onset of his LBP was reported at end of available range in flexion and extension, but no onset in LBP was reported at the end of available range in lateral flexion (stiffness was the limiting factor). Repeated flexion and extension movements (5 times each) in standing had no effect on his resting symptoms.

A lower extremity neurological screening examination was unremarkable for deep tendon reflexes, manual muscle testing (hip flexors, knee extensors, ankle dorsiflexors, great toe extensors, and plantar flexors), and light touch and sharp/dull perception for each dermatomal area (L2 through S1). Passive ROM in both hips appeared to be within normal limits and did not elicit any symptoms. Passive straight leg raise test in supine was limited to approximately 45° of hip flexion. The patient reported feeling hamstring muscle stretching with the straight leg raise test and reported that it did not change his baseline LBP. Manual palpation (tested in prone) revealed normal temperature and moderate tenderness over the lower lumbar levels L3/4, L4/5, and L5/S1. Passive accessory-movement testing revealed hypomobility and familiar pain provocation with posterior-to-anterior (PA) vertebral pressure at L3/4, L4/5, and L5/S1. Seffinger et al, in a systematic review, found the reliability of motion palpation for diagnostic purposes to be poor and pain provocation tests to be more reliable. In addition, Fritz et al were able to demonstrate that a physical therapist’s assessment of hypomobility or hypermobility could be effectively used to determine appropriate treatment strategies for patients with LBP.

Lastly, a pressure biofeedback unit (Stabilizer), as described by Richardson et al, was used to assess for the appropriate activation of the isolated cocontraction of transversus abdominis and lumbar multifidus. The voluntary cocontraction of transversus abdominis and lumbar multifidus is referred to in the literature as the deep corset contraction (DCC). The between-sessions intrarater reliability of the pressure biofeedback unit has been reported as moderate, with an intraclass correlation coefficient (ICC) of 0.58 and a 95% confidence interval (CI) of 0.28 to 0.78, in a study involving 29 asymptomatic subjects. In addition, the use of the pressure biofeedback unit has been correlated with laboratory electromyographic tests for activation of the transverse abdominis. Hodges et al found a significant relationship between the 2 tests and an associated high level of agreement between the 2 measures in 15 subjects with and without LBP.

The patient was given instruction in performance of the skill (“Slowly draw up and in, the lower part of your abdomen towards your spine without movement of your trunk or pelvis”) and was then placed in prone, with the biofeedback device placed under his lower abdomen and inflated to 70 mmHg. Despite coaching and repeated trials, the patient was not able to perform the correct action, which would normally result in a 6- to 10-mmHg drop in pressure, suggesting that the transverse abdominis was not cocontracting appropriately. The fact that the patient was unable to correctly perform the DCC action led us to hypothesize that there was loss of the normal motor control afforded by the deep abdominal musculature.

Clinical Impression

The patient appeared to be experiencing continued impairments attributable to a combination of decreased lumbar spine mobility (decreased active ROM in standing and palpable hypomobility) and decreased motor control (inability to correctly perform the DCC) when loading the spine through its available ROM. This seemed to be consistent with his
complaints of difficulty with moving his lumbar spine during bending, crouching, prolonged sitting, rising from sitting, prolonged standing, and walking. Recent research into the motor control aspects of lumbopelvic stability has highlighted the importance and interdependence of 3 subsystems: the osseoligamentous (passive), muscular (active), and nervous (neural) subsystems.\textsuperscript{23,25,26,68} It is postulated that injury or degenerative changes may affect 1 or more of these subsystems which may lead to compensatory changes in the others.\textsuperscript{23} The patient had confirmed degenerative changes at the L5-S1 intervertebral motion segment, and it could be argued that his presurgery symptoms may have been an indication of failure of the neural and active subsystems to adequately compensate for these deficits in the passive subsystem.

The intent of the surgical procedure was to restore the integrity of the passive subsystem by establishing dynamic stabilization and restoring lost height at the affected intervertebral segment. It was reasoned by the therapist that the supporting ligamentous tissues of the vertebral motion segment might have been stretched or tightened by the implanted semirigid prosthetic device, and this, along with the wound healing and scar tissue formation, might have contributed to the patient’s complaints of stiffness and aching in his low back following his surgery. It was further reasoned that because of the patient’s history of recurrent LBP episodes, he had compromised neural and active subsystems (inefficient motor control), and these were yet to be reeducated or reestablished following the surgery.

Based on the patient’s history of recurrent LBP, it would be reasonable to assume that multifidus firing patterns\textsuperscript{45} and deep corset actions were adversely affected, as has been shown in several studies in patients with LBP.\textsuperscript{26,35,37,39,43} Because deep multifidus activity is critical for normal spinal control,\textsuperscript{9,10,29,30,37}\textsuperscript{7} the retraining for this deep muscle function was, therefore, going to be a priority in his rehabilitation program. Additionally, segmental spinal stabilization exercises to specifically address DCCs would also be incorporated into the program. The stabilization exercise approach would also follow a specific progression (un-loaded to loaded, non-weight bearing to weight bearing, and closed chain to open chain), as defined by Richardson et al.\textsuperscript{59} This particular approach was viewed as the most appropriate because of the patient’s noted impairments in loaded postures.

The basic goals for therapy were, therefore, to increase his spinal mobility and to help him regain control of the motion. Manual therapy or passive joint mobilization to the operated segment would be used later in the program, if it became necessary. It was also viewed as a conservative precaution secondary to lack of evidence for manual therapy as an intervention in the acute stages following spinal surgery. This, however, does not preclude the use of mobilization at segments remote to the surgery site.

Although no formal assessment of the patient’s psychological status was undertaken, the therapist reasoned that the patient did exhibit some concerns about how much movement or activity he felt would be safe for him to perform, given his novel surgical procedure. This is not an uncommon presentation following surgery of this nature. Therefore, it was reasoned that education about the surgery and future expectations was necessary. In addition, a pain science education approach, as described by Moseley,\textsuperscript{46} was also deemed appropriate in light of his history of chronic LBP.

Although the patient reported a high level of functional limitation and disability at the initial physical therapy examination, the therapist felt that his prognosis for functional recovery was good. He was motivated and in relatively good health. The original plan of care was to see the patient for 8 weeks; this duration of treatment was based upon previous studies involving spinal stabilization programs.\textsuperscript{7,26,42} He was initially scheduled for physical therapy sessions twice a week. This frequency was chosen because a significant portion of the rehabilitation would involve repeated practice at home, and attendance twice weekly was felt to be appropriate to check his progress and advance his exercises as needed. The frequency of treatment also matched the schedule followed by previous studies on stabilization programs.\textsuperscript{7,26,42}

**Physical Therapy Intervention**

For convenience, the rehabilitation program can be broken down into 3 distinct phases based on time frames: phase 1 (0-2 weeks), phase 2 (3-5 weeks), and phase 3 (6-8 weeks).

**Phase 1 (0-2 weeks)**

A combination of education, gentle ROM exercises, specific exercises for segmental spinal stabilization training, and a home exercise program was deemed to be the most appropriate course of action for the first phase of postoperative rehabilitation (APPENDIX).

The patient’s education focused on postoperative safety precautions and what activities were appropriate given the nature of his surgery. Expectations about future functioning and compliance were also addressed. He was given a detailed description of the anatomy and biomechanics of the lumbar spine, an explanation of the surgical procedure and its proposed effects, and information on the importance of the active stabilizing mechanism afforded by the deep muscle system of the lumbar spine. A major emphasis of his education was the pain science education approach, which was based on the work of Butler and Moseley (TABLE).\textsuperscript{6} This approach emphasizes explaining the patient’s pain, so that perceived threats can be minimized and the patient can be empowered to more adequately manage his or her condition. Each therapy session in this phase included at least 15 minutes of discussion, in which the patient was given detailed explanation and discourse on the current concepts about pain science.\textsuperscript{46} Ultimately,
the focus of this education was to provide the patient with a deeper understanding of current pain sciences, which would provide him with tools to progress and regain functional mobility.

Gentle active ROM exercises for the lumbar spine (pelvic tilts, bridging, and single knee to chest) were used to allow the patient to experience graded movement and, in addition, to facilitate appropriate somatosensory input within a ROM.

An exercise program to regain local segmental control, as described by Richardson et al.,66-68 was also initiated. This approach has been shown to be efficacious in 2 previous studies.29,34 Isolated DCC, characterized by cocontraction of transverse abdominis and lumbar multifidus muscles, was initially started in 4-point kneeling. This was then progressed to prone over a pillow, side-lying, and finally supine hook-lying (FIGURE 2A and 2D). In each position, the patient was instructed to repeat these DCCs 10 times, with a 10-second hold for each repetition.

His home exercise program consisted of the following: rehearsal of the DCC training in each of the 4 unloaded postures, pelvic tilts, bridging, and single knee to chest. All exercises and activities were to be performed 10 to 15 times, with 10-second holds as necessary. He was also instructed to continue the usual activities that he was participating in prior to attending physical therapy and was encouraged to push himself a little by extending his time in sitting, standing, and walking.

**Phase 2 (3-5 Weeks)**
The main focus of this phase of the treatment program was to progressively improve his ROM and to challenge his ability to perform and maintain the DCC in weight bearing and closed kinetic chain activities (APPENDIX).60 We define closed kinetic chain activities as those in which the distal end of the extremity is fixed to an immovable surface (eg, wall, foot plate of a total gym) or a movable surface (eg, bike pedal, moving foot plate). Under these conditions, there is joint compression during the movement, and studies have demonstrated that this tends to preferentially activate 1-joint muscles or local stabilizers of the joints undergoing movement and compression.5,66

Lumbar rotation in supine hook-lying was added to the ROM exercises that were carried over from phase 1. Prone extensions were added to improve mobility in the sagittal plane. During this phase, the patient reported that he was feeling continued stiffness in his lower lumbar spine. PA vertebral pressures revealed only minimal tenderness but persistent hypomobility at the L3/4, L4/5, and L5/S1 levels. His trunk active ROM had improved overall but remained slightly limited in extension and flexion. The stiffness reported by the patient might have been from muscle soreness associated with exercising, as he had been relatively inactive since his surgery. However, an alternative clinical thought was that he may have had some residual joint stiffness that was now becoming more evident with his greater demand for motion, and, therefore, a trial of manual therapy was conducted. Graded PA mobilizations (Maitland grade III progressing to IV)46 applied to the L3, L4, and L5 spinous processes appeared to improve his active ROM into extension (FIGURE 2E). These were performed for 30 to 45 seconds by the therapist, followed by reassessment of extension with active ROM. Range and comfort, as reported by the patient, appeared to improve with each bout of mobilization and, subsequently, these interventions were repeated 3 times. Side-lying lumbar rotation nonthrust mobilizations (Maitland grade III progressing to IV) were added to the treatment (FIGURE 2F).

These were also performed for 30 to 45 seconds by the therapist, with reassessment of active extension in standing taking place after each bout of mobilization. The strength of the mobilizations was increased as both range and comfort with movement appeared to improve. Following the manual therapy, the patient reported subjective improvements in both stiffness, and active range of trunk extension and flexion appeared to have improved when visually estimated with the fingertip reach method. These non-thrust manual therapy techniques were continued throughout the rest of the treatment program.

For DCC in this phase, the actual choice of a particular exercise was considered less important than the fact that the emphasis of each was controlled...
loading of the lumbar spine while also promoting appropriate activation and function of the 1-joint antigravity weight-bearing muscles in their proposed role of lumbopelvic joint protection. Upper body ergometry and recumbent bicycling were introduced, with a focus on DCC. The intent of these exercises was to have the patient focus on maintaining the DCC while actively moving his upper limbs (upper body ergometry) and lower limbs (bike). Several studies have shown that limb motions cause perturbations in the spine and in subjects without LBP, the deep muscle system is able to afford segmental control and stability. The exercises were seen as reeducation for control and stability at the spinal segmental level during perturbations caused by limb motions.

Following this concept, the patient then began to incorporate some upper body pulley work (lateral pull-downs, seated rowing), with emphasis on slow, smooth movement, while controlling and maintaining DCC throughout. The goal of these specific exercises was to allow the patient to activate global muscles and move his extremities during these activities, while maintaining a tonic stabilizing function of the local, deep muscle system (DCC).

Other activities included dynamic neuromuscular reeducation via balance and proprioceptive work on a wobble board and mini-trampoline. This was done to incorporate some balance and sway aspects into the upright antigravity function of the stabilizing musculature of the lumbopelvic region. In other words, the activities required him to maintain segmental stability with the deep muscle system while using the more superficial muscle groups to control lumbopelvic orientation and whole-body equilibrium. Work-specific activities, such as walking up and down a 3-m ladder with 3.2-kg cuff weights around the wrists, were also included as the patient had returned to work on modified duties after his third therapy visit.

**Phase 3 (6-8 weeks)**

The final phase consisted of advanced DCC in weight-bearing, closed-chain environments but also began to introduce some open-chain activities. We define open kinetic chain activities as those where the distal end of the extremity is moving freely through space. Under these conditions, there is less joint compression during the movement and there may be joint distraction. Studies have demonstrated that this tends to preferentially activate multijoint muscles or global mobilizers of the joints undergoing movement. The addition of open-chain exercises and activities was thought prudent because many of the patient’s ADLs, hobbies, and work-specific activities would involve open-chain environments (eg, dressing, lifting groceries,

![Figure 2](image-url)

**FIGURE 2.** Isolated cocontraction of transverse abdominis and lumbar multifidus muscles (DCC) was first performed in 4-point kneeling (A), in prone (B). Instructions given to the patient were to “Slowly draw up and in, the lower part of your abdomen towards your spine, without movement of your trunk or pelvis, while breathing normally,” and “Swell or gently tighten the muscles along your lower spine.” The DCC was then practiced in supine leg press with feet against the wall (C), and then progressed to loaded weight bearing, while seated on the edge of the treatment table with single upper extremity support (D). Manual therapy interventions applied during the second phase of therapy included graded PA mobilizations to L3-L5 (E) and nonthrust mobilization (grades III and IV) into rotation localized to L3-L5 levels (F).
raising, and holding a flow meter over air-conditioning vents).

During this phase, the patient reported that he had helped to lift a heavy piece of equipment while at work and was pleased that it had not caused any return of his back pain. However, the patient did express concern that his lower back had felt “fatigued” after the effort. The patient was educated regarding loading through the spine during lifting and the importance of correct lumbar posture to distribute the loads optimally throughout his spine. Squat lifts and weight work were also incorporated into his program.

The last session was primarily a review and summary of what he had learned and what he had done throughout the rehabilitation program. He was encouraged to remain motivated and continue with his home exercise program even though formal therapy sessions were to be discontinued.

OUTCOMES

Prior to surgery, the patient had a 64% on the ODI. This dropped to a 56% by the initial postoperative physical therapy examination. At this time, his pain was 3/10 on the NPRS. By the end of the first phase of treatment (third week), the patient’s ODI was 24% and NPRS was 1 (FIGURE 3). Trunk active ROM had improved and stiffness rather than pain was reported at end range. The patient felt he was still limited to 1 hour of walking prior to the onset of pain, his driving tolerance was limited to 2 hours without pain, his sitting tolerance was limited to 2 hours without pain, and his standing tolerance was limited to 1 hour without pain. The patient was also unable to successfully perform the DCC during clinical testing with the pressure biofeedback device.

At the end of phase 2 of the program (5 weeks of treatment), his ODI was 4% and he was reporting no pain (NPRS, 0). He had overcome most of his perceived limitations in walking, driving, and sitting. The patient only needed 2 sessions during phase 3 (6 weeks total treatment) to reach the point where he felt he was ready to discontinue formal therapy. His ODI and pain scores remained stable at 4% ODI and 0, his trunk active ROM also remained improved, he had returned to most of his regular duties at work without problems, and he had also resumed his recreational activities (motorcycle riding).

At his last treatment session, he was able to successfully and repetitively (over 6 trials, with 10-second holds) achieve a 6- to 10-mmHg drop in pressure using the pressure biofeedback device. This suggested that the transverse abdominis and lumbar multifidus were cocontracting appropriately.

The patient was contacted at 6, 12, 18, and 24 months following the conclusion of formal therapy. His ODI was 2% at 6 and 12 months, and 0% at 18 and 24 months. The patient reported that he had not experienced any recurrence of his LBP, he was now managing all of his presurgery work duties without restrictions or concerns, and he was regularly riding his motorcycle on weekend trips with his friends. He reported being very satisfied with his outcome.

DISCUSSION

To our knowledge, this is the first published report on postoperative rehabilitation following a single-level lumbar nucleoplasty. The data from this case suggest that a postoperative regimen of education, ROM, segmental spinal stabilization, and a home exercise program may lead to a marked improvement in function, decreased disability, and increased pain-free ROM. In this case, continued impairment and disability (ODI, 56%; NPRS, 3) were noted 7 weeks after surgery. After a 6-week postoperative rehabilitation program, the patient reported a decrease of 52% for the ODI and 3 points for NPRS, both exceeding the minimum clinically important change of 20% for the ODI and 2 points for the NPRS.

Although care should be taken when interpreting the results from a case report, the current findings indicate that postoperative rehabilitation may be of value to patients who have undergone a single-level lumbar nucleus replacement. Our findings are consistent with studies showing the benefit of postoperative rehabilitation following lumbar surgery.
the improvements noted in this case were considerable, we cannot rule out the possibility that this recovery may have been natural history and may have occurred to a certain degree without the postoperative intervention. However, in comparison to the European trials for patients undergoing the same procedure, the change in ODI and pain scores observed in this case were considerably greater than the change in mean scores that occurred in those patients that may not have had postoperative rehabilitation.1 In the present case, ODI scores decreased from a preoperative 64% to 2% at 12 months (96.9% change) (FIGURE 3), whereas the mean ODI scores for the European trials were 57.5% preoperatively and 25.2% at 12 months (56.2% change). In addition, the pain scores in the patient case decreased from a preoperative value of 7 to 0 at 12 months, whereas the mean visual analog scale for the European trials were 7.6 preoperatively and 3.3 at 12 months.

A recent Cochrane review of rehabilitation following first-time lumbar discectomy found that exercise programs starting 4 to 6 weeks postsurgery led to a faster decrease in pain and disability than no treatment. In this particular case, the patient was not started on an active exercise program until 7 weeks postsurgery; however, he did demonstrate significant improvement after only 3 weeks of treatment, as evidenced by the greater than 50% decrease in his initial ODI. While his treatment was initiated after 7 weeks, it is possible that a quicker return to full activity might have been achieved if rehabilitation had been initiated earlier in the acute stage. Further research is needed to determine the most appropriate timing of such rehabilitation interventions.

It is important to note that the interventions utilized (education, ROM and stabilization exercises, and manual therapy) in this case did not result in any adverse reaction. These results concur with the conclusions of the Cochrane review that demonstrated that postoperative active exercise programs are safe and do not increase the reoperation rate after first-time lumbar surgery.49 Also in this case, the addition of manual therapy techniques did not cause any adverse events, but in fact might have contributed to the improved outcomes. It is interesting to note that in the European trials1 47% of the patients experienced some kind of adverse event during the 2-year follow-up and 16.4% had serious adverse events, with 7 patients requiring explants of the device.

A significant feature of the intervention provided was the emphasis on patient education. Every therapy session in phase 1 included at least 15 minutes of education, including safety issues, appropriate and inappropriate activities, pain science, spinal anatomy and biomechanics, and motor control. Initially, the patient expressed concerns about the effects of physical activity on his spine. Such concerns are common following surgeries of this nature; therefore, it is imperative to make education an important focus of any postoperative rehabilitation program. It is possible that his concern might have risen to the level of fear, which, in turn, might have led to a high level of fear-avoidance behavior. However, this was not specifically addressed and is recognized as a weakness of this case report. In light of this, the authors recommend more formal assessment of fear-avoidance behavior by using the Fear-Avoidance Beliefs Questionnaire or the Tampa Scale for Kinesiophobia.

The choice of active stabilization exercises was supported by previous studies that found improved outcomes when investigating the effect of spinal stabilization exercises following disc surgery.50,51,52 Filiz et al randomized 60 patients who had undergone a single-level discectomy to an intensive exercise program and back school education, a home exercise program and back school education, and a control group that did not receive education or exercise. The authors found superior clinical outcomes for the 2 groups doing exercises, when compared to the control group. They also reported that the intensive exercise program group performed better than the home exercise program group. Dolan et al randomized 20 patients who had undergone lumbar microdiscectomy into an exercise group and a control group. Both groups received standard postoperative care for the first 6 weeks, and then the exercise group began a 4-week program concentrating on strength and endurance of back and abdominal muscles and mobility of the spine and hips. The authors found improved outcome measures in both groups at 6-weeks postsurgery. At 10 weeks, the exercise group showed further improvements, whereas the control group did not, and the difference between groups was maintained at 26 and 52 weeks. Kulig et al randomized 98 patients following single-level lumbar microdiscectomy into an education-only group or an intensive, progressive exercise program and education. Despite some problems with adherence to group assignment, the data showed a significantly greater reduction in ODI scores in the group receiving exercise and education compared with those in groups receiving either education alone or education and usual physical therapy.

The progression of the segmental spinal stabilization program used in this study was based upon recent research highlighting the specific role of the deep muscles of the spine (ie, transversus abdominis, multifidus) in support for weight-bearing activities against gravity.50,51,54 The approach targeted specific muscles (retraining the DCC) but also followed a specific progression (unloaded to loaded, non-weight bearing to weight bearing, and closed chain to open chain). This particular approach was viewed as the most appropriate, because of the patient’s noted impairments in loaded postures.

Additionally, the treatment approach followed in this case report incorporated manual therapy. While the evidence for adding manual therapy to rehabilitation after lumbar disc surgery is currently lacking, there is evidence that it is safe and does not increase reoperation rates.49
However, Ostelo et al in their systematic reviews\(^6\) found no strong evidence for the effectiveness of any specific intervention when added to an exercise program. Further research is needed to identify the most effective intervention strategies for patients following single-level lumbar nucleoplasty.

**Limitations**

As previously noted, our patient expressed concerns about the effects of physical activity on his spine, and it is possible that his concern could have risen to the level of fear that, in turn, may might lead to a high level of fear-avoidance behavior. We did not formally assess for fear-avoidance behavior in our patient by using either of the Fear-Avoidance Beliefs Questionnaire or the Tampa Scale for Kinesiophobia, which have been shown to be reliable and valid measures of fear-avoidance behaviors.\(^3,12,15\) A further limitation noted in this case report was that ROM should have been measured using more precise methodology. This would have allowed for a more quantitative analysis of the observed improvements in ROM. Finally, the measurement of performance of the DCC with the pressure biofeedback device was only undertaken at 2 occasions, at the initial evaluation and at discharge.

**CONCLUSION**

This case is of interest because it describes the postoperative rehabilitation of a patient who underwent a novel surgical procedure. Recurrent LBP from DDD continues to be prevalent in our society and much of the research and innovation into management of this problem has focused on advancing surgical solutions. In the case presented, education, ROM exercises, specific segmental stabilization exercises, manual therapy and home exercises appeared to facilitate decrease in pain, functional improvement, and a full return to occupational and recreational activities post-surgery.


36. Hodges PW, Richardson CA. Feedforward contraction of transversus abdominis is not influenced by the direction of arm movement. Exp Brain Res. 1997;114:362-370.


SUMMARY OF INTERVENTIONS

**Phase 1: 0 to 2 Weeks, 4 Total Visits**

**Interventions**

**Education**
- Safety precautions and rehabilitation expectations
- Pain Science

**Gentle range of motion (ROM) exercises**
- Giving the patient opportunities to experience symptom-free movement and exercises

**Local segmental control multifidus and transversus abdominis activation**
- Isolated deep corset contraction (DCC)
  - Four-point kneeling, prone, side-lying, and supine hook-lying
  - Reducing contribution of global muscles
  - Weight of the body minimized to allow patient to focus on specific skill

**Home exercise program**
- Rehearsal of DCC training in unloaded postures
- Pelvic tilts, bridging and single knee-to-chest exercises

**Criteria to Progress to Next Phase**
- Demonstration of understanding of neurophysiology of pain
- Independent performance of gentle ROM exercises
- Demonstration of ability to perform isolated DCC in unloaded postures
- Compliance in home exercise program

**Phase 2: 3 to 5 Weeks, 6 Total Visits**

**Interventions**

**ROM exercises**
- Advance further into end ranges without provocation of symptoms
- Manual therapy as needed to promote increased ROM

**Closed-chain segmental control**
- DCC progressed to loaded, weight-bearing, and closed-chain environments
  - Supine hook-lying with feet braced against wall; in sitting with arm support; standing with back against wall (minimal wall squat);
  - Upper body ergometer and recumbent bike
  - Seated lateral pull-downs and rows
  - Maintain steady standing on a balance board
  - Walking/stepping on a mini-tramp
  - Backwards/forwards resisted gait

**Home exercise program progression**
- Independent performance of all ROM exercises
- Ability to maintain isolated DCC in loaded, weight-bearing and closed-chain postures
- Continued compliance in home exercise program

**Phase 3: 6 to 8 Weeks, 2 Total Visits**

**Interventions**

**Open-chain segmental control**
- DCC progressed to open-chain tasks; aim to continue to maintain local segmental control (DCC) while load added to the spine through open kinetic chain movement of adjacent segments
- Activities of daily living (lifting, carrying, pushing, pulling)
- Alternate arm and leg lifts in all positions
- Simulated work tasks (eg, prolonged overhead reach/activity, floor-to-waist lift, floor-to-overhead lift, weighted carry)

**Education review**
- Pain science
- Safety precautions and return to full activity guidelines

**Criteria for Discharge**
- Independent performance of all exercises
- Demonstration of ability to maintain local segmental control (DCC) during high-load open-chain tasks in a smooth and coordinated fashion