Functional Restoration for a Chronic Lumbar Disk Extrusion With Associated Radiculopathy
Andrew J Hahne and Jon J Ford
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Functional Restoration for a Chronic Lumbar Disk Extrusion With Associated Radiculopathy

Background and Purpose. The effectiveness of functional restoration (FR) for patients with lumbar disk herniation with associated radiculopathy (LDHR) is unclear. This case report describes how an FR program was used to rehabilitate a patient with such an injury. Case Description. The patient was a 26-year-old female child care worker with a 12-month history of back pain and a 4-month history of unremitting left leg symptoms. She had clinical and radiological evidence of an L5–S1 disk extrusion with associated left S1 radiculopathy. Interventions. The patient completed a 9-week FR program supervised by a physical therapist. Exercises were continued more independently for a 2-year period at a public gymnasium. Outcomes. Following 9 weeks of supervised FR, the patient demonstrated marked improvement in symptoms and functional ability, and resolution of neurological signs. Fourteen months after commencing FR, a follow-up magnetic resonance imaging scan demonstrated resolution of the L5–S1 disk extrusion and relief of S1 nerve root compression. Functional improvements continued and were maintained 2 years following the start of intervention. Discussion. A patient with chronic LDHR who underwent FR made significant improvements. Research is needed to determine the efficacy of an FR approach for treating such patients. [Hahne AJ, Ford JJ. Functional restoration for a chronic lumbar disk extrusion with associated radiculopathy. Phys Ther. 2006;86:1668–1680.]

Key Words: Back pain, Exercise therapy, Intervertebral disk displacement, Radiculopathy, Rehabilitation.

Andrew J Hahne, Jon J Ford
The annual incidence of lumbar disk herniation (LDH) has been estimated to be 1% of the population.\(^1\) When an LDH results in clinical evidence of radiculopathy, and if conservative treatment such as medication and physical therapy fails, discectomy often is recommended.\(^1,2\) There is no consensus, however, as to the most effective conservative treatment for lumbar disk herniation with associated radiculopathy (LDHR). One systematic review indicated some support for the use of epidural steroids for LDHR, but insufficient evidence to support the use of non-steroidal anti-inflammatory medication, traction, or intramuscular steroids.\(^3\) The use of bed rest for LDHR appears to be ineffective.\(^4\) A study involving 250 patients with acute radiculopathy showed no difference in outcomes among bed rest, physical therapy, and continuing with daily activities.\(^5\)

The current evidence to support exercise-based rehabilitation of patients with LDHR is limited to nonrandomized outcome studies. A case series of 62 patients with chronic (mean=4.6 months) LDHR who underwent exercise rehabilitation and epidural steroid injections reported a 90% success rate and a 92% return-to-work rate at an average follow-up of 31 months.\(^6\) A subsequent magnetic resonance imaging (MRI) study on 11 of the conservatively managed patients with extruded disks showed that 82% of the disk extrusions had reduced in size at a median follow-up of 25 months, and all of the patients appeared to have reduced neural impingement.\(^7\) Another case series of 22 patients with extruded or sequestered lumbar disks (median duration=4.5 weeks) who received conservative management including active exercise, back school, and epidural steroid injections reported a 77% successful clinical outcome at a mean follow-up of 6.9 months.\(^8\) Other case series and cohort studies have revealed similar clinical or radiological success rates between 70% and 90% for patients with LDH who received various conservative treatments that were often poorly described and not standardized.\(^9\)–\(^15\)

In contrast to the favorable prognosis described in these studies, other reports of patients with sciatica and potential LDH (without radiological confirmation in all subjects) described less favorable outcomes. Tubach et al\(^16\) followed 622 patients with sciatica and found ongoing leg symptoms in 55% of the patients at a 2-year follow-up and in 53% of the patients at a 4-year follow-up. Similar results were reported by Balague et al,\(^17\) with only 29% of patients reporting a full recovery from sciatica after 12 months, and by Nykvist et al,\(^18\) who reported that 82% of conservatively treated patients still had sciatica after 5 years. Variability in recovery rates among the studies cited may be attributable to differences in outcome measures and definitions of successful outcome\(^16\) as well as to differences in the treatment interventions used in the studies.

Another large cohort study involving 507 patients with sciatica showed that 56% of conservatively treated patients reported reduced leg pain at a 1-year follow-up,\(^19\) 60% reported reduced leg pain after 5 years,\(^20\) and 64% reported a reduction after 10 years.\(^21\) These results suggest that the number of patients improving with conservative management slows over time, with the majority of improvement occurring during the first year. The results of other studies\(^11,17,22\) suggest that the majority of clinical and radiological improvement occurs during the first 3 months after onset of symptoms, with fewer patients recovering after this time frame.

In addition to cohort studies and case series, numerous case reports have been published describing excellent clinical or radiological outcomes in patients with LDH. Notably, however, patients in these studies typically had
acute symptoms,23–28 and studies involving large cohorts of subjects such as those cited above already confirm that the prognosis is often good in such patients regardless of the intervention. Other case reports on patients with a longer duration of symptoms do not provide convincing clinical or radiological evidence that the patient had LDHR.29–31

The scarcity of research into the use of exercise-based interventions such as functional restoration (FR) for LDHR is surprising, given the good evidence demonstrating that such interventions can be effective for the management of nonspecific low back pain (NSLBP).32,33 In particular, patients with LDHR typically are excluded from randomized controlled trials (RCTs) investigating exercise-based interventions such as FR. Functional restoration has been defined as “a multimodal pain management program that employs a comprehensive cognitive-behavioural treatment orientation to help patients better cope with, and manage, their pain . . . while undergoing the sports medicine physical approach to correct functional deficits.”34(p483) Although there is significant variation in the precise content of different described FR programs, they typically include aerobic and strengthening exercises (for the trunk, upper limbs, and lower limbs) specific to the patient’s daily activity and work demands. A cognitive-behavioral approach is utilized in FR to address the psychosocial aspects of chronic injury. Functional restoration programs have been shown to be effective for people with chronic NSLBP32 and subacute NSLBP35 when conducted by multidisciplinary teams32 or when supervised by a sole physical therapist.33,36 Advantages of single-discipline FR programs may include lower costs and wider accessibility for patients.

The purpose of this case report is to describe the management and outcomes of a patient with clinical and radiological evidence of a chronic L5–S1 disk extrusion with associated S1 radiculopathy who completed an FR program supervised by a physical therapist.

Description

History
The patient was a 26-year-old female child care worker from Melbourne, Victoria, Australia. Although she had worked in this capacity for 7 years, she reported a slow onset of low back pain (LBP) and stiffness, which she attributed to additional vacuuming, cleaning, and lifting required of her during renovations taking place at her workplace. She continued working but commenced periodic chiropractic manipulation, which provided temporary symptom relief.

Eight months following the onset of her symptoms, the patient’s LBP had increased in intensity, and a gradual onset of left posterolateral leg pain was noted. An MRI scan was performed that demonstrated significant T2 signal loss involving the T12–L1, L4–5, and L5–S1 disks. In addition, a 5-mm left posterolateral extrusion of the L5–S1 disk was identified, with significant displacement and compression of the left S1 nerve root. The patient’s physician certified her as unfit for work and prescribed 15 mg/d of meloxicam (Mobic*), a COX-2–inhibiting nonsteroidal anti-inflammatory drug. She commenced Bowen therapy, an alternative form of massage developed by Tom Bowen (1916–1982) in Geelong, Australia, which consists of “rolling the thumbs and forefingers over a muscle or tendon at precise locations triggering a relaxation response.”37(p32) She also increased her chiropractic treatment to 3 sessions per week. This treatment consisted of application of ice to the lumbar area and massage to the lumbar spine and left leg. She said that she did not receive any manipulative treatment at this time. An exercise regimen of spinal flexion and lateral flexion stretches, hip abduction exercises, and general abdominal bracing without attempting to localize the contraction to a particular muscle group also was prescribed by the chiropractor. This treatment continued for 4 months (ie, 12 months after the initial onset of her LBP). In the final month of this treatment, she noticed a progressive increase in left leg pain and onset of peripheral paresthesia. The patient was examined at that time by a neurosurgeon, who recommended an L5–S1 diskectomy, which she declined because she preferred non-surgical treatment. She then was referred for physical therapy by an occupational rehabilitation provider acting on behalf of the compensable insurer to facilitate recovery and return to work.

Reported Symptoms
The initial physical therapy assessment was 1 year following the onset of LBP (4 months following the onset of her left leg symptoms). Her presenting symptoms are illustrated in the pain drawing completed during the initial assessment (Fig. 1). Questioning revealed increased symptoms each morning for up to 3 hours and waking 3 times per night due to lumbar and leg pain. Some authors38,39 have suggested that such symptoms may be indicative of a chemical or inflammatory component to the pathology. Her symptoms were aggravated by sitting or standing (limited to a maximum of 20 minutes), walking (limited to 30 minutes), coughing or sneezing, and forward-bending activities such as putting on shoes and socks.

* Boehringer Ingelheim Pharmaceuticals Inc, a subsidiary of Boehringer Ingelheim Corp, 900 Ridgebury Rd, PO Box 368, Ridgefield, CT 06877-0368.
Examination

Visual estimates of lumbar active range of motion (ROM) revealed flexion and lateral flexion (left and right) limited to reaching two thirds down the length of the thigh and extension limited to 15 degrees. All movements were limited by lumbar and leg pain. Straight leg raise was limited to 60 degrees on the left by leg pain, compared with 90 degrees on the right by hamstring muscle resistance. Moderate-intensity palpation centrally and to the left of the L4–5 and L5–S1 vertebral segments reproduced pain and muscle guarding. Neurological examination of the lower limbs revealed normal sensation, an absent left ankle jerk reflex, and decreased strength (force-generating capacity) of the left gastrocnemius muscle, with the patient unable to perform a left leg heel raise while standing.

The patient’s ability to perform a localized contraction of the transversus abdominis muscle was assessed visually with the patient in standing and side-lying positions. Some authors have reported that more localized activation of the transversus abdominis muscle relative to superficial abdominal muscles is characterized by an inward movement of the lower abdominal wall. The patient demonstrated a technique of global abdominal wall bracing and was unable to isolate the inward movement to the inferior abdomen. Concurrent palpation bilaterally and immediately adjacent to the L4 and L5 spinous processes revealed a poor ability to actively generate tension in the deep fibers of the lumbar multifidus muscle. Evidence exists that these muscles are involved in normal spinal control and are commonly found to be dysfunctional in individuals with LBP. Furthermore, retraining these muscles has been shown to be efficacious in patients with acute and chronic LBP.

The patient scored 48% on the Oswestry Low Back Pain Disability Questionnaire, indicating a moderate level of perceived pain and disability. This is a valid, reliable, and responsive outcome measure for patients with LBP and has been used extensively on patients with sciatica or LDH.

Measures of psychosocial status included a pain drawing, nonorganic signs tests, and the Fear-Avoidance Beliefs Questionnaire (FABQ). The results of the nonorganic signs tests, when scored according to reliable and valid protocols, did not reveal evidence of significant psychosocial distress or elevated pain behavior. However, out of a possible 6 symptom descriptors were used when completing the pain drawing (Fig. 1) indicating a possible influence of psychosocial distress on her reported symptoms and prognosis. In addition, a score of 46/60 on the FABQ indicated a moderate level of fear-avoidance beliefs, which in previous studies on patients with LBP was shown to be predictive of poorer outcomes.

Diagnosis

The patient’s symptoms and examination findings were consistent with an L5–S1 disk extrusion with resultant compression and potential inflammation of the left S1 nerve root. Despite 12 months of conservative treatment, deteriorating leg symptoms, and a moderate degree of perceived pain and disability, she expressed a strong preference to avoid surgery. In addition to her physical injury, she had a moderate degree of fear-avoidance beliefs and a pain drawing indicative of some psychosocial distress. After detailed explanation and discussion, the patient agreed to cease chiropractic treatment and commence an FR program supervised by a physical therapist.

Intervention

The physical therapist (AJH) who treated the patient had graduated from La Trobe University, Victoria, Australia, with a Bachelor of Physical Therapy with Honours degree 3 years earlier. He had worked for 3 years in private practice at a clinic specializing in exercise-based management of recalcitrant LBP. He had received approximately 100 hours of clinical mentoring from a senior physical therapist (JJF) with 15 years of experience treating patients with LBP and a master’s degree in musculoskeletal physical therapy. A second mentor with 7 years of experience had provided a further 100 hours of training. The mentoring provided training in clinical...
reasoning, clinical assessment, and management of LBP from a biopsychosocial perspective, including the implementation of basic cognitive-behavioral strategies. The treating therapist also had attended several conferences and short professional development courses relating to LBP, including one by Peter O’Sullivan on assessment and management of lumbopelvic instability using a motor skill learning approach (16 hours).

The exercise component of the patient’s program consisted of 3 main phases, which are summarized in Table 1. The phases of management and time frames of key events in the patient’s history are presented in a time line in Figure 2.

**Phase 1**
In phase 1, the patient attended 2 sessions per week for 4 weeks. She first was educated regarding her injury. A diagram was drawn to demonstrate her L5–S1 disk extrusion. Her left leg symptoms and neurological findings were described in terms of inflammation and mechanical compression of the left S1 nerve root. Reassurance was provided regarding the potential to improve with appropriate management, given the evidence regarding the importance of a positive patient outlook.

The patient was taught self-management strategies aimed at minimizing therapist dependence and empowering the patient to gain control over symptoms. These strategies included self-application of heat to the lumbar spine using a microwave-heated wheat bag with the aim of producing an analgesic affect and reduction of muscle spasm at the depth of the skin and superficial muscles. It is unlikely that the heat could penetrate to the depth of the disk where inflammation may have been active. Inflammation potentially present in and around the disk and nerve root was controlled by continuing with Mobic medication throughout the program (15 mg/d). Although continuing with daily activity was encouraged, she was advised to minimize activities that have been shown to increase intradiskal pressure such as forward flexion activities and flexed sitting. Such caution may not be necessary for all patients, but given the serious nature of the pathology, the avoidance of potentially provocative postures was

<table>
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<tr>
<th>Table 1. The 3 Phases of Management</th>
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<tr>
<td><strong>Phase 1</strong></td>
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<tr>
<td>Duration</td>
</tr>
<tr>
<td>No. of physical therapy consultations</td>
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<td>Content</td>
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</table>

**Figure 2.** Key events and phases of management. MRI=magnetic resonance imaging.
justified. This was facilitated initially by the application of rigid strapping tape to the patient’s lumbar spine area to discourage excessive lumbar flexion. Following 3 weeks of consistent taping, self-management of symptoms by avoidance of provocative postures had been learned and the taping was no longer required. Lumbar spine taping has received little attention in the literature, but has been briefly described previously.\textsuperscript{58,59}

In addition to implementing educational and self-management strategies, retraining of the transversus abdominis, lumbar multifidus, and pelvic-floor muscles commenced during phase 1. After education regarding the importance of these muscles, retraining commenced in side-lying and 4-point-kneeling positions. The patient was instructed to relax all lumbar, abdominal, and pelvic muscle groups and then slowly and gently elevate the anterior aspect of her pelvic floor. To activate the transversus abdominis muscle, a slow and gentle inward movement of the lower abdominal wall muscles was performed, while discouraging any significant movement of the upper abdominal wall, spine, and pelvis.\textsuperscript{40,41}

A submaximal contraction was sustained for 5 seconds initially, while normal and continuous breathing was maintained. Both therapist observation and palpation of the abdominal wall were used to distinguish optimal transversus abdominis muscle activations from substitution strategies indicative of excessive activation of other muscle groups.\textsuperscript{40} The desired visual appearance of the patient’s abdominal wall while performing a pelvic-floor and transversus abdominis muscle contraction is demonstrated in Figure 3.

The coactivation of the lumbar multifidus muscle was checked via bilateral palpation immediately adjacent to the L4 and L5 spinous processes.\textsuperscript{40} Concurrent activation of the pelvic-floor, transversus abdominis, and lumbar multifidus muscles is referred to as the patient’s “stabilizing pattern” for the purposes of this case report. Initially, the patient practiced the stabilizing pattern at home 3 times per day in a side-lying or 4-point-kneeling position, performing 5 to 10 repetitions of 5-second holds during each session. The therapist reviewed her 3 times over the first 2 weeks to provide feedback regarding her technique, as well as to implement the other educational and self-management strategies described above. After 2 weeks, the patient could perform the stabilizing pattern precisely in these initial positions and was progressed to a standing position for 1 week (2 review sessions). Visual feedback was provided by standing next to a mirror. Dosage was initially the same as for the side-lying and 4-point-kneeling positions, before progressing to 20 second holds. Finally, the patient began to perform the stabilizing pattern while walking for 1 week, holding for up to 20 to 30 seconds.

Phase 2

The next stage of rehabilitation consisted of integrating the stabilizing pattern into a clinic-based, supervised FR program. The patient attended the clinic 3 times per week for a 5-week period, and she completed 2 additional exercise sessions each week at home. Exercises included walking on a treadmill, step-ups onto a 15-cm-high step, and lifting upper-limb dumbbells (bicep curls, forward raises, and bilateral side raises). The patient was instructed to maintain the stabilizing pattern learned during phase 1 while performing all exercises, and the abdominal wall was observed and palpated periodically by the therapist to ensure that optimal transversus abdominis muscle activation was maintained. Upright cervicothoracic posture also was encouraged. Exercises were separated into 3 sets of short duration activities to avoid excessive fatigue of the stabilizing muscles. Program dosage is outlined in Table 2 for each phase of the FR program. The rate of exercise progression was determined by the therapist at the beginning of each session and was based on multiple factors such as response to the previous exercise session, current status of symptoms, and treatment goals. The patient continued with weekly Bowen therapy during phases 1 and 2 of the program because this therapy appeared to provide short-term symptom relief. She then was encouraged to cease...
the Bowen therapy in light of her improved ability to control her symptoms via self-management strategies and active exercise.

**Phase 3**

Following phase 2 of the FR program, the patient was reexamined and had demonstrated substantial improvement (see “Outcomes” section). She then commenced phase 3 of management, consisting of a relatively independent exercise program at a public gymnasium. The program was designed by the physical therapist, who attended the gymnasium with her on the first occasion to orientate her to the facilities, introduce her to staff, and demonstrate the appropriate exercises. The patient then attended the gym 3 or 4 times per week independently and was reviewed in the physical therapy clinic periodically for guidance regarding appropriate increases in exercise intensity and addition of new exercises and to review goals. During the first month of the gym program, the physical therapy review sessions occurred weekly, with the frequency then reduced to fortnightly, then monthly, and then once every 6 weeks prior to discharge. Exercises that were added included lateral pull-downs, triceps push-downs, stepper machine, upright stationary bicycle, squats, and lunges. Intensive erector spinae muscle exercises also were added with the patient lying prone on a Swiss ball and lifting her trunk to horizontal. Strengthening of the erector spinae muscle with such exercises has been shown to be effective for managing chronic LBP.60,61 Exercises for abdominal muscles more superficial to the transversus abdominis muscle also were added, including straight and oblique crunches, with the patient lifting her head and shoulders from a supine position with knees flexed to 90 degrees and feet flat on the floor. The patient maintained her stabilizing pattern while performing all exercises. As the strength and endurance of the patient’s stabilizing pattern improved, increases were made in the duration of aerobic exercise and the weight of resistance exercises (Tab. 2).

**Goal Setting**

Throughout all phases of management, the patient’s personal and lifestyle goals were reviewed, which assisted with exercise progression. Initial goals negotiated with the patient for the first 9 weeks of her program included avoiding surgery, achieving a noticeable relief of leg symptoms, improving the activation technique of her stabilizing function, improving her understanding and self-management of her condition, improving sitting and standing tolerances to 30 minutes, and improving walking tolerance to 60 minutes. Establishing return-to-work goals was delayed until the completion of phase 2 of the program, because this was dependent on her clinical progress. Exercise dosage goals also were established and written in an exercise diary kept by the patient. The initial exercise goals set at the start of intervention had been achieved as planned by the end of phase 2 (Tab. 2).

During phase 3, goal setting targeted remaining functional limitations reported by the patient. For example, she reported unresolved LBP while lifting bowls located in the middle of the dining table. Aiming to address this functional limitation, bicep curls and straight-arm forward raises were commenced in varying degrees of

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**Table 2.**

<table>
<thead>
<tr>
<th>Exercise Dosage and Progression at Key Stages of Management</th>
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<tbody>
<tr>
<td><strong>Commencement of</strong></td>
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<tr>
<td><strong>Phase 2</strong></td>
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<tr>
<td>Aerobic training</td>
</tr>
<tr>
<td>Treadmill</td>
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<tr>
<td>Steps</td>
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<tr>
<td>Stepper machine</td>
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<tr>
<td>Stationary bicycle</td>
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<tr>
<td>Resistance training</td>
</tr>
<tr>
<td>Dumbbells</td>
</tr>
<tr>
<td>Bicep curls</td>
</tr>
<tr>
<td>Forward raises</td>
</tr>
<tr>
<td>Side raises</td>
</tr>
<tr>
<td>Lunges</td>
</tr>
<tr>
<td>Lateral pull-down</td>
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<tr>
<td>Tricep push-down</td>
</tr>
<tr>
<td>Lunges</td>
</tr>
<tr>
<td>Abdominal crunches</td>
</tr>
<tr>
<td>Erector spinae muscle exercise</td>
</tr>
<tr>
<td>Swiss ball squats against wall</td>
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<tr>
<td>Classes</td>
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</table>
been found to improve outcomes. Cognitive-behavioral strategies were used by the physical therapist and patient’s physician decided at each review. She continued to improve on each subsequent reassessment and had maintained her improvements 2 years after commencing her FR program.

The patient’s adherence to attending physical therapy sessions was excellent, as she missed no scheduled session in the first year. She did forget to attend on 2 occasions during the second year, resulting in an overall attendance rate of 95%. Her adherence to attending the gym appeared to average 3 sessions per week when her gym program card was cited at follow-up physical therapy consultations.

A subsequent MRI scan was performed 14 months after intervention (ie, 18 months following her initial MRI). This MRI scan showed that the L5–S1 disk extrusion had resolved, with no remaining evidence of S1 nerve root compression. Her preintervention and postintervention MRI scans are presented in Figure 4.
Table 3.
Examples of the Application of Cognitive-Behavioral Strategies

<table>
<thead>
<tr>
<th>Context</th>
<th>Strategy Applied</th>
<th>Purpose of Strategy</th>
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<tbody>
<tr>
<td>After 3 treatment sessions, the patient expressed concern regarding ongoing back and leg pain (the pain had not increased, but had not improved).</td>
<td>The counterproductive belief regarding unrealistic recovery time frames was challenged (eg, “It is too early to expect improvement yet. For your injury, it will likely take several weeks of exercise before you will notice much change in your symptoms.”).</td>
<td>Assist the patient in gaining appropriate beliefs regarding realistic recovery time frames and reduce anxiety regarding lack of improvement to date.</td>
</tr>
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<td>At the beginning of phase 2, the patient reported some depression following breaking up with her partner. This had the potential to distract her from the program and reduce motivation and adherence.</td>
<td>The patient’s positive progress to date with her exercise program was reinforced, and she was encouraged to maintain her focus on the goals set at the beginning of the program. The patient was encouraged to seek social support from family and friends to assist with this difficult time.</td>
<td>Attempt to maintain focus on rehabilitation and avoid distraction or loss of motivation by a social situation. Ensure appropriate management strategies for the normal emotions associated with her relationship breakup. This would ensure that the patient’s rehabilitation time was used for exercise rather than regular discussion with the physical therapist about the issue.</td>
</tr>
<tr>
<td>During phase 2 of her program, the patient asked if it was safe for her to visit the beach with friends on the weekend.</td>
<td>The physical therapist advised, “You are managing well with your exercise program, so you should manage well with a trip to the beach. Some walking in the water may be a beneficial exercise for you, but I wouldn’t recommend surfing or more strenuous beach games at this stage.” When the patient later reported that she had gone to the beach without any increase in symptoms, this was positively reinforced by praise and conversation regarding her enjoyment of this activity.</td>
<td>Positively reinforce engagement in appropriate physical and social activities (eg, going to the beach), while maintaining appropriate pacing strategies (eg, avoiding more strenuous activities).</td>
</tr>
<tr>
<td>After 8 weeks of intervention, the patient was involved in a motor car accident and demonstrated anxiety regarding potential exacerbation of her back injury.</td>
<td>The patient was fully re-examined by the physical therapist on the day of her accident and found to have sustained no serious injuries. Her examination findings in relation to baseline had actually improved, and this was used to reassure the patient that no exacerbation was apparent to her back injury. She was advised to continue with her exercise program the following day, and this wellness behavior was positively re-enforced by praise and social contact during her exercise program.</td>
<td>Reassessment of the patient’s condition after a potential aggravation provided reassurance to the therapist and patient that the injury had not been aggravated. This allowed the program to continue without unnecessary interruption and minimized the patient’s anxiety regarding her accident.</td>
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</table>

Discussion
This case report has shown how an FR program supervised by a physical therapist was used to rehabilitate a 26-year-old female with a 1-year history of back symptoms and a 4-month history of worsening leg symptoms, with clinical and radiological evidence of an L5–S1 disk extrusion compressing the left S1 nerve root. Functional restoration has been shown to be an efficacious conservative management option for patients with subacute or chronic LBP,32,33,35 but its effectiveness for LDHR is unclear.

While the principles of the patient’s rehabilitation were consistent with a traditional FR approach, some key deviations were considered necessary based on the severity of the pathology. Functional restoration does not typically place a strong emphasis on the diagnosis or management of each patient’s specific pathology. Indeed, an assumption often is made that the pathology has largely resolved and that the remaining pain and disability are attributable to psychosocial factors and deconditioning due to inactivity. This traditional approach may explain the large number of FR studies that exclude patients with specific pathologies such as LDHR. Although the patient’s improvement may well have been due, in part, to the management of psychosocial factors (Tab. 3) and reversing the effects of deconditioning, appropriate diagnosis and management of the primary pathology using evidence-based principles was an additional focus that may have increased effectiveness. The specific diagnosis was used to provide the patient with accurate education regarding her injury, to justify avoidance of potentially provocative activities and postures, to guide the rate of exercise progression, to encourage adherence to Mobic medication aimed at controlling inflammation, and to place an appropriate
emphasis on developing precise activation of her stabilizing pattern.

The therapist considered that optimal function of the transversus abdominis, lumbar multifidus, and pelvic-floor muscles would provide dynamic spinal support for the injured L5–S1 disk. Recent evidence supports the validity of the method of muscular activation used for the patient described in this case report. Some studies have demonstrated the physical benefits of specific retraining of these muscle groups in patients with low back injuries. The phases and progression of our program were derived from the motor skill learning approach of retraining these muscles. This approach commences with learning to perform a specific and selective contraction of the transversus abdominis, lumbar multifidus, and pelvic-floor muscles in low-load, static positions (phase 1 of our treatment protocol). This muscular activation is incorporated into progressively more functional positions and exercises (phase 2) and then is regularly integrated into all of the patient’s exercise and daily activities (phase 3). The ultimate rehabilitation goal is to reach an autonomous stage whereby the skill of activating the stabilizing muscles becomes automatic without conscious attention. Although most FR programs typically include some form of trunk strengthening exercises, the precise activation of the transversus abdominis, lumbar multifidus, and

<table>
<thead>
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<th>Table 4.</th>
<th>Assessment Findings at Key Stages of Management</th>
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<tr>
<td><strong>Initial Assessment</strong></td>
<td><strong>End of Phase 2 (9 Weeks Postassessment)</strong></td>
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<tr>
<td><strong>Symptoms</strong></td>
<td>Constant lumbar and left leg ache</td>
</tr>
<tr>
<td><strong>Inflammation</strong></td>
<td>Waking at night: 3x/night</td>
</tr>
<tr>
<td><strong>Medication</strong></td>
<td>Mobic: 1 × 15 mg/d</td>
</tr>
<tr>
<td><strong>Function reports</strong></td>
<td>Sitting time: 20 min (P2)</td>
</tr>
<tr>
<td><strong>Range of motion</strong></td>
<td>Flexion: Reaching two thirds length of thigh</td>
</tr>
<tr>
<td><strong>Neurological</strong></td>
<td>Reflexes: Absent ankle jerk L</td>
</tr>
<tr>
<td></td>
<td>Myotomes: L heel raise very difficult</td>
</tr>
<tr>
<td></td>
<td>Dermatomes: Normal</td>
</tr>
<tr>
<td></td>
<td>Straight leg raise: L=60° R=90°</td>
</tr>
<tr>
<td></td>
<td>Stabilization pattern: Poor</td>
</tr>
<tr>
<td></td>
<td>Oswestry: 48%</td>
</tr>
<tr>
<td></td>
<td>Work status: Off work</td>
</tr>
<tr>
<td></td>
<td>FABQ: 46/60</td>
</tr>
</tbody>
</table>

*P2=maximum possible due to pain, L=left, R=right, Oswestry=Oswestry Low Back Pain Disability Questionnaire, FABQ=Fear-Avoidance Beliefs Questionnaire.
pelvic-floor muscles followed by a gradual transition of this muscle activation into an FR program has not been commonly described. Gaining optimal control of these muscles before progressing to higher-intensity functional exercises was fundamental to the management of our patient with LDHR and has been shown to be effective in an RCT involving patients with spondylolisthesis.45 The patient described in the case report demonstrated marked improvement both clinically and radiologically. This report adds to the existing studies that showed favorable outcomes in patients with LDHR undergoing exercise-based intervention.6,8 In those studies, however, patients may have also received epidural steroid injections, which have been shown to be effective as a stand-alone treatment,3 whereas our patient did not receive such injections. Other case reports have focused on patients with acute LDHR for whom the prognosis was good23–28 or on patients with chronic conditions without convincing clinical or radiological evidence of LDHR.29–31 Several studies11,17,19,20,22 have suggested that the majority of patients undergoing conservative treatment for LDHR demonstrate most improvement during the first 3 months following symptom onset, after which time surgery is often the recommended option.1,2 Our patient had reported worsening radicular symptoms for 4 months prior to commencing her FR program, but she began to report substantial improvement 4 to 6 weeks after commencing the FR program. It is unlikely that resolution of the patient’s disk extrusion commenced until her symptoms began to improve during her FR program, because studies11,14,66 have shown that morphologic changes in disk herniations seen on imaging typically lag behind improvements in patients’ symptoms.

At the time of entry to our treatment program, the patient was a surgical candidate based on descriptions of inclusion criteria for diskectomy.1,2 Due to the absence of RCTs investigating FR for LDHR or comparing surgery with FR, the relative value of these interventions for such patients is currently unclear. The patient described in this case report chose conservative management primarily due to her preference to avoid surgery. Other patients with LDHR may potentially benefit from a similar FR management approach outlined here prior to surgical intervention, but it is unlikely that all patients with LDHR would attain an outcome similar to that achieved by our patient. Research is needed to determine the proportion of patients with LDHR who would benefit from FR as opposed to surgery, as well as to identify factors that predict a given patient’s likely response to each of these respective interventions. Inves-

Figure 4.
T2-weighted magnetic resonance imaging images taken of the patient at onset of leg symptoms (left) and 18 months later following 12 months of functional restoration intervention (right). Sections shown are midsagittal slices (upper) and axial slices through the L5–S1 disk (lower).
tigations into such questions would requireRCTsthat involve patients with LDHR.

A limitation of our examination procedures relates to the use of visual measurements of ROM, straight leg raise, and stabilizing muscle function by the therapist. There is presumably a large margin for error in visual estimates, so the reported values should be considered estimates only. Despite large margins for measurement error, it is plausible that improvement did occur in these values throughout the intervention period given the large magnitude of improvement recorded in these variables. In addition, impairment measurements such as ROM were only one of several outcomes followed, with validated measures such as the Oswestry Low Back Disability Questionnaire also demonstrating marked improvement. The changes recorded in the patient’s Oswestry scores (Tab. 4) were considerably greater than the 10 percentage points required to be 90% confident that a real change had occurred (minimum detectable change). Other standard clinical and radiological measures such as neurological examination findings, work status, medication dosage, and MRI findings provide further evidence of significant improvement in the patient’s status.

### Conclusion

Several case series, cohort studies, and case studies suggest that the prognosis for patients with LDHR receiving conservative management is good, although studies focusing on exercise-based management of patients with chronic LDHR are scarce. This case report adds to the current literature by reporting a detailed description of an FR approach to managing a patient with a chronic L5–S1 disk extrusion and associated S1 radiculopathy that was confirmed by clinical and radiological examination. Research is needed to determine the efficacy of FR approaches for managing patients with LDHR.

### References


Functional Restoration for a Chronic Lumbar Disk Extrusion With Associated Radiculopathy
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