Cuff Repair for a Patient With Postpolio Syndrome

Mary Carlson and Tana Hadlock

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Physical Therapist Management Following Rotator Cuff Repair for a Patient With Postpolio Syndrome

Mary Carlson, Tana Hadlock

Background and Purpose
Postpoliomyelitis sequelae, such as gait instability and progressive weakness, predispose people with postpolio syndrome to secondary disabilities. With aging, people who depend on their upper extremities to accommodate lower-extremity deficits may anticipate overuse injuries. The purpose of this case report is to describe the use of mobilization and exercise in postoperative rehabilitation of rotator cuff surgery on a patient with postpolio syndrome.

Case Description
A 48-year-old woman with postpolio syndrome had rotator cuff surgical repair followed by physical therapy intervention. Maitland mobilization and mild functional exercises were chosen to avoid triggering fatigue.

Outcomes
Measurements taken preoperatively, before and after physical therapy intervention, and 2 years after intervention showed return to independent status with excellent retention.

Discussion
No fatigue or overuse weakness was encountered. This is the first case report to document physical therapy following rotator cuff repair in a patient with postpolio syndrome.
Patient With Postpolio Syndrome and Rotator Cuff Repair

Polioymelitis is an enterovirus, appearing in 3 strains (types I, II, and III), that attacks the anterior horn cells, brain stem, and reticular activating system in people with the disease. Although the virus infects about 95% of the motoneurons in the spinal cord, many motoneurons will survive without apparent dysfunction, other motoneurons will recover but will show pathological changes, and still others will die. After poliomyelitis, the remaining motoneurons sprout additional terminal axons and adopt “orphaned” muscle cells to create very large motor units, resulting in varying degrees of recovery from paralysis in individual patients.

A 1995 National Health Interview Survey by the National Center for Health Statistics of the Centers for Disease Control and Prevention reported that 1 million US residents have survived poliomyelitis, 450,000 of whom had paralytic poliomyelitis. Estimates of the percentage of this group who will experience postpolio syndrome (PPS) vary widely, but the National Institute of Neurological Disorders and Stroke (NINDS) estimated that 25% to 50% of people with a history of paralytic poliomyelitis will be affected.

The NINDS defined postpolio syndrome as “a condition that affects polio survivors years after recovery from an initial acute attack of the poliomyelitis virus.” The hallmark criteria for the diagnosis are a confirmed prior history of paralytic poliomyelitis; evidence of residual functional deficits, specifically muscle weakness or atrophy, and signs of denervation on electromyography (EMG); a stable period (usually 15 years or more) after recovery from the acute illness; and “the gradual or sudden onset of progressive and persistent new muscle weakness or abnormal muscle fatiguability (decreased endurance).” Generalized fatigue, muscle or joint pain, cold (and, more rarely, heat) intolerance, and sleep disorders are other frequently reported symptoms, but are not necessary to establish the diagnosis.

Halstead’s diagnostic criteria appear to be most widely accepted. However, Halstead and Silver, along with other authors, have recently questioned the appropriateness of paralytic poliomyelitis history as a diagnostic criterion for PPS, noting that histology and autopsy studies have demonstrated significant central nervous system damage in virtually all survivors of acute poliovirus infection and that some people with a history of nonparalytic poliovirus infection show clear symptoms of PPS. Post-Polio Health International noted that “a period of inactivity, or trauma or surgery” may cause the new muscle weakness to develop suddenly. Furthermore, in order to make a diagnosis, symptoms should persist for at least a year, and other medical conditions that might cause similar symptoms should be excluded.

Common functional problems reported in conjunction with these symptoms include new difficulties with personal and instrumental activities of daily living (ADL) such as walking, stair climbing, dressing and bathing, housework, cooking, indoor and outdoor mobility, employment, and, less commonly, breathing and swallowing. Halstead and Grimby noted that “the pathogenesis of PPS remains elusive.” They speculated that it may ultimately develop that the syndrome actually represents several clinical and pathological subgroups.

Various studies have suggested a number of possible etiologies, or pathophysiological factors, that may contribute to the development of PPS in individuals with a prior history of paralytic poliomyelitis. There is some evidence to suggest that an autoimmune process may be a factor, and there is conflicting evidence regarding the presence and effect of poliovirus in the central nervous system of patients with PPS.

Several studies have demonstrated abnormalities of muscle structure and function and reduced muscle capillarization in muscles affected by poliomyelitis, including both clinically weakened and clinically normal muscles. A detailed discussion of these studies is beyond the scope of this article; however, Sunnerhagen and Grimby, Gors, and Grimby and Stalberg have provided excellent summaries. Among the findings reported are: reduced muscular capillary supply; a significant increase in the ratio of type I to type II fibers; a neuromuscular transmitter deficit; and EMG findings, including muscle fiber hypertrophy, neuromuscular jitter, impulse blocking, fibrillation potentials in some muscles, and increased motor unit potentials. Overuse weakness, as evidenced by elevated creatine kinase levels and EMG studies, also is implicated.

The progressive decreases in neuromuscular force, endurance, and general function associated with PPS appear to be caused by a combination of these and other factors. Individuals with PPS have a large number of enlarged motor units, which typically work near maximum capacity as they engage in their daily activities over decades. They typically possess limited reserves of capacity, which may be overwhelmed by small increases in demand or by small losses in neurons with aging and chronic overuse. This mecha-
nism is supported by the evidence that the new muscle weakness of PPS may be precipitated suddenly in some cases by a single incident of trauma, surgery, or a period of inactivity. Eventually, the loss of motor units cannot be compensated for, and clinical symptoms become evident. Other contributing factors may include weight gain and disuse weakness, which may develop as people age and become more sedentary, or responses to secondary conditions such as arthritic pain or soft tissue injuries.

The most frequently noted risk factors for the development of PPS include an older age at the time of initial poliomyelitis infection (>10 years of age) and a more severe level of paralysis during the acute phase, including the need for hospitalization, ventilator use, and paralysis in all 4 limbs. People with greater weakness and EMG evidence of muscle dysfunction, people who experienced a greater extent of recovery, and people with weakness of the lower extremities (LEs), as opposed to the upper extremities (UEs), also are more likely to develop PPS.

In addition to the symptoms directly associated with PPS, people with the condition may develop comorbidities and secondary conditions that further impair their functional status and interfere with participation in daily life. Deficits associated with postpolio sequelae, such as gait instability, progressive weakness, and long-term postural deformity, predispose these patients to such secondary disabilities. However, although PPS itself is well documented in the literature over the past 50 years, secondary disability and comorbidity among people with PPS are poorly addressed in the professional literature. In addition, most of the literature focuses on the LE, ambulation, and mobility impairments. Smith briefly discussed UE repetitive stress injuries secondary to cane and wheelchair use by people who have had poliomyelitis. Klein and colleagues studied the relationship between late effects of poliomyelitis and musculoskeletal pain conditions or development of secondary problems affecting the UEs. However, these authors did not address postoperative rehabilitation for those injuries.

Patients who are experiencing late postpolio problems most typically complain of 3 new symptoms: excessive fatigue, pain, and new muscle weakness in both clinically weakened and clinically normal muscles. An unresolved concern for researchers, clinicians, and patients is the effect of overexertion, from either daily activities or exercise programs, on the motor units. Agre, reviewing a number of studies, showed that patients with substantial postpolio weakness perform activities at a much higher relative level of effort because of the loss of innervated muscle fiber and have a “significantly diminished endurance capacity.”

In addition, muscles weakened by poliomyelitis require 2 to 3 times as long as normal muscles to recover from exhausting effort. Minimum losses of strength (force-generating capacity) in muscles already working at or near their capacity can have profound effects on the functional status of a patient following poliomyelitis. Agre and other authors have recommended that exercise programs for patients with PPS use gentle exercises at only 20% to 40% of perceived “maximum” exertion and include frequent intervals of rest (“pacing”) to prevent overuse fatigue.

The issue of fatigue in PPS is quite complex. Agre and associated found that individuals with new symptoms of PPS (whom they called “unstable post-polio subjects”) recovered strength much more slowly after fatiguing exercise than either a control group or a group of people who did not demonstrate new symptoms of PPS. They also found that people with new symptoms of PPS had weaker muscles, a lower capacity for muscular work, and a history of more severe initial involvement during the acute phase of poliomyelitis. Additionally, when research participants were asked to rate their level of perceived exertion (RPE) during exercise, all 3 groups’ RPEs were well related to the electrophysiologic measures of muscle function. The researchers concluded that individuals with PPS were able to accurately rate their level of muscular fatigue, and they recommended patient self-monitoring as a reliable measure of tolerance in designing exercise programs for patients with PPS.

Agre and Rodriguez and other authors recommended that exercise programs for people with PPS should be characterized by “pacing” (intermittent periods of exercise and rest) with rest periods of 1 to 5 minutes between sets of exercise repetitions. Gawne and Halstead cautioned against exercising severely weakened muscles (manual muscle test [MMT] grades of <3/5) muscles or those demonstrating unstable new weakness or fasciculations. In contrast to Agre, Chan et al demonstrated that the people with PPS could significantly improve their voluntary thenar muscle strength and that the moderate load training program did not have a deleterious effect on the viability of the surviving motoneurons.

In a creative approach to the problem, Klein et al hypothesized that postpolio shoulder pain was a result of overdependence on the UEs for gait and transfers and could be improved with LE exercise, lifestyle modification, or a combination of the 2 interventions. The researchers
found that the exercise-only and lifestyle modification–only groups showed significant decreases in shoulder symptom severity. Only one group (exercise-only) showed a significant decrease (68%) in the number of shoulder symptoms from 3.5 to 1.1). The researchers found no significant differences among the 3 groups.

In a search of MEDLINE and CINAHL as far back as the mid-1980s, we were unable to find research addressing rehabilitation following surgical correction of repetitive-use injuries in the UEs of people with PPS. In all of the postpolio exercise studies, no one has described intervention in a patient with PPS after surgery for a rotator cuff tear resulting from extended use due to postpolio sequelae. With the aging of the population with PPS, finding rehabilitation protocols to address the specific problems endemic to this population becomes increasingly important. The primary issues that we found to be important in the rehabilitation of a person with PPS following surgery for a rotator cuff injury were monitoring and avoiding fatigue. Although we found the patient described in this case report to be adept at monitoring her fatigue, the physical therapist was challenged to establish a fatigue-conserving rehabilitation protocol. The purpose of this case report is to describe the use of mobilization and exercise in rotator cuff postoperative rehabilitation in a person with PPS without setbacks from fatigue or overuse weakness.

Case Description

Patient History

The patient was a 48-year-old woman with right shoulder and anterosuperior brachial pain. She had poliomyelitis at age 18 months with resulting bilateral LE paresis and weakened anterior neck muscles. She made good recovery after several years of rehabilitation and multiple LE surgeries, and since adolescence has used a right knee-ankle-foot orthosis and left forearm crutch for ambulation. At the age of 32 years, the patient was diagnosed with PPS after approximately 2 years of increasing fatigue and a 3-day episode of transient severe weakness of the right UE following a heavy lifting activity with that limb. Electromyographic testing detected enlarged motor units in the muscles of both UEs, as well as both LEs, consistent with the diagnosis of PPS. At this point, the patient was advised to limit heavy use of her UEs and to retire from work, but she chose to continue full-time employment. Modifications of lifestyle, including use of an electric scooter for ambulation of more than 91.4 m (300 ft), increased rest times, and changes in professional duties, were successful in maintaining the patient’s independence. The patient lived alone and worked full-time as an instructor of occupational therapy at a university.

The patient reported that, in the year following the diagnosis of PPS, she sustained a fall in which she injured the right shoulder, experiencing acute pain around the acromion lasting 3 days. The pain resolved without intervention or residual symptoms. About 5 years later, the patient noticed gradual onset of pain in the same area, becoming sufficiently severe that functional use of the shoulder was impaired. The symptoms lasted approximately 8 months and were resolved with a regimen of oral anti-inflammatory medication, ice, and Codman pendulum exercises. About 7 years after the resolution of symptoms, the patient again noticed gradual onset of chronic, moderate pain without precipitating incident; however, this episode did not interfere with function and gradually resolved.

Three years later, the patient reported a rapidly developing onset of pain originating distal to the acromion and proceeding along the anterolateral aspect of the humerus to the elbow. Initially, the pain was present only during flexion or abduction of the arm, but after several days the pain also was present at rest. A mild increase of weakness in the shoulder accompanied the pain, but symptoms did not respond to heat or icing, nonsteroidal anti-inflammatory drugs, or rest, and the patient sought medical advice approximately 8 weeks later. She was unable to identify any precipitating factor or incident preceding the onset of symptoms in any episode other than the initial injury. The patient reported constant pain rated at 7 to 9 on a 10-point scale with any abduction or flexion and frequent pain of 5/10 at rest. She reported occasionally dropping objects due to the pain. Due to the pain and loss of shoulder movement, she had moderate difficulty locking her LE orthosis and severe difficulty styling her hair, carrying groceries, or driving, and she was unable to reach objects at head height or above. She could not don pullover sweaters or don her usual surgical-weight stockings. She sought evaluation and recommendations from her physiatrist and was referred to an orthopedic surgeon, who recommended surgery.

As an experienced occupational therapist, the patient was knowledgeable about PPS and anticipated possible complications with the recovery and rehabilitation process. Due to the LE paresis, she was unable to rise from a seated position; to complete dressing, bathing, bed mobility, or instrumental ADL; or to manage a variety of household and vocational tasks without the use of both UEs. She relied on the right UE to carry objects, open doors, and lock leg braces because she constantly used a forearm crutch with the dominant (left) UE, and she used...
hand controls for driving. Therefore, the patient expected to be almost totally dependent during the 8-week surgical recovery and rehabilitation period.

She was aware that forced inactivity, trauma, or surgery can precipitate new weakness in both clinically weakened and clinically spared muscles, and she was aware of the risks associated with excessive exercise in PPS. These concerns were included in the presurgical consultations as well as the postoperative initial assessment visit with the treating physical therapist. The patient provided PPS-related information to the surgeons and to the physical therapist. A family member living in another state arranged to take 2 months off work to provide personal care for the patient. An occupational therapist provided presurgical family education regarding transfer and personal ADL assistance. A temporary bed rail, gait belt, and elevations to chairs were secured to assist with bed mobility and transfers. The patient’s home was already equipped with bathroom modifications, and her electric wheelchair was equipped with a left-handed joystick control.

Preoperative Examination

According to the medical notes, radiography of the patient’s right shoulder revealed a rotator cuff tear with 2+ clavicular spur and narrowing of the acromial space. A magnetic resonance imaging (MRI) review suggested supraspinatus tendon tear with a 1.5-cm retraction; a superior labral anterior-to-posterior (SLAP) tear, which indicated that the biceps tendon might be totally avulsed from its origin; and a tear of the anterior inferior labrum. The physical examination revealed no obvious joint effusion, ecchymosis, or edema. The presurgical diagnosis was “rotator cuff tear.”

The preoperative physical therapist examination revealed tenderness to palpation at the posterior cuff, supraspinatus, and proximal biceps tendon (long head). In comparison with the contralateral side, the appearance of the right biceps muscle (Fig. 1) indicated a possible detachment of the long head at its origin. The right biceps muscle belly was more pronounced and at a more inferior position on the brachium than the left biceps muscle belly. Additionally, no movement of the long head tendon in the area of the bicipital groove was palpated during muscle contraction.

The right acromioclavicular joint showed a 1-cm step-down deformity (Fig. 2), measured by standard ruler, that may have been from a previous fall. The sulcus sign test for shoulder instability was positive with approximately 1-cm drop that was measured with a standard ruler. Tzannes and Murrell found that a 1-cm sulcus had a sensitivity of 72% and a specificity of 85%, whereas a 2-cm sulcus dropped to a 28% sensitivity with an increase to a 97% specificity. The Yergason test for stability of the long head tendon of the biceps muscle,52,53 empty can test for supraspinatus function,55 and O’Brien test (or SLAP prehension test) for presence of a SLAP lesion52,53 were all positive. Itoi et al54 found the empty can test to be 87% sensitive and 43% specific for a supraspinatus lesion. Holtby and Razmjou55 reported similar sensitivity (88%) but higher specificity (70%). Recent research53,54 has demonstrated sensitivity values of 12% and 43% and specificity values of 96% and 79% for the Yergason test. Sensitivity values of 47% to 63% and specificity values of 47% to 73% have been reported for the O’Brien test.53,56,57 (In the current case report, the clinical tests indicating a SLAP lesion were confirmed by the results of the MRI but refuted by the surgical report, which stated that all of the labrum was stable when probed.)
The patient had difficulty due to pain in abducting the right shoulder in an antigravity position. Visible substitution of scapular motion for glenohumeral motion was present during right shoulder abduction (Fig. 3).

Passive range of motion (PROM) and active range of motion (AROM) of the right shoulder in a supine position revealed 155 degrees of flexion, 95 degrees of abduction, 100 degrees of medial rotation, and 40 degrees of lateral rotation. Passive and active ROM showed 5 degrees or less difference per movement; therefore, only AROM was reported. Shoulder AROM in a sitting position revealed the same rotational values, but abduction was limited to 70 degrees and flexion was limited to 90 degrees. Intraclass correlation coefficients for intratester reliability of measurements of shoulder PROM and AROM have been reported to be between .87 and .99.58,59

Manual muscle testing through a limited range of motion (ROM) showed MMT grades of 4/5 for flexion, 4/5 for horizontal abduction, 5/5 for extension, and 3/5 for abduction. Although MMT has been shown to have sensitivity ranging from 62.9% to 72.3% and specificity ranging from 89.2% to 76% when compared with a dynamometer,60 it has primarily been used to measure muscle strength in knee extension, and it has not been used in patients with PPS.

A Jamar handheld dynamometer measured 31 lb (1 lb = 0.4536 kg) of grasp force, and a Jamar pinch gauge* measured 7.5 lb of key pinch force and 3.2 lb of tip pinch force. Jamar dynamometers have been reported to yield valid measurements ($r = .9994$).61 The BTE Quest dynamometer† provided quantitative measures of functional strength of both UEs and then compared the differences as percent differences. The percent difference in strength between the 2 extremities becomes smaller as the strength of the operative extremity increases. Evaluation of maximum strength using the BTE dynamometer revealed an average percent difference of 49.5% in abduction (Fig. 4) and 57.7% in flexion (Fig. 5) of the right shoulder (measured in inch-pounds) as compared with the left shoulder. Shechtman et al62 compared the hand testing portion of the BTE grip tool with the Jamar dynamometer and found reliability ($r$) values of .97 to .98 and validity ($r$) values of .95 to .96 for the BTE grip tool.

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* JA Preston Corp, 2010 E High St, Jackson, MI 49203.
† Baltimore Therapeutic Equipment Co, 7455-L New Ridge Rd, Hanover, MD 21076.
Operative Findings
Arthroscopic surgery was performed with no complications. The long head of the biceps tendon was avulsed and stable in the avulsed position, so it was not retrieved. The labrum was stable, and the glenoid and humeral head surfaces were essentially normal. Diffuse synovitis was debrided from the anterior and posterior aspects of the joint. The instruments were removed, and the subacromial space was entered through a lateral incision. Extensive subacromial bursitis was debrided. Visual inspection revealed a smooth undersurface of the acromion with no osteophyte. The edges of the rotator cuff were debrided, and drill holes were placed through the greater tuberosity to secure the reattachment of the supraspinatus tendon. The patient was placed in a shoulder immobilizer with her right arm at her side.

Physical Therapist
Postoperative Examination
History
At the first physical therapy outpatient appointment 5 weeks after surgery, the patient’s pain estimate was 6/10, with her goal stated as 3/10. The patient was dependent on her relative for most ADL such as applying her brace, transferring in and out of bed, and donning her stockings.

Initial Postoperative Physical Examination
The patient had approximately 30% of normal active movement in the involved shoulder (Tab. 1). Resistance was not applied for strength testing, but the patient was able to elevate her arm through limited AROM in an antigravity position in flexion, extension, and lateral rotation. The specific impairments and functional limitations were decreased ROM, decreased strength, pain, and loss of independent lifestyle.

Intervention
The patient was not required to sign the Health Insurance Portability Administration Act (HIPAA) forms because physical therapy was provided prior to the HIPAA taking effect. The Internal Review Board of the University of Texas at El Paso exempted the case report because the patient was one of the authors. In accordance with the patient’s goals, postoperative rehabilitation was initiated to improve strength and ROM, to decrease pain, and to restore independent function of the right UE so the patient could return to her independent lifestyle. The
treated physical therapist was not one of the authors.

Treatment consisted of application of moist heat packs to the superior aspect of the right shoulder to promote circulation and reduce pain, application of continuous ultrasound for 1 minute at 1.5 W/cm² to the inferior axillary fold of the joint capsule to increase tissue extensibility, mobilization of the glenohumeral joint to reduce inferior capsular tightness and decrease pain, and therapeutic exercises to improve strength and AROM (Tab. 2). Modalities and mobilizations were administered in the clinic 3 times each week for 6 weeks.

**Modalities**
Ultrasound, applied at 1.5 to 2.0 W/cm² for 1 minute to the inferior axilla, was used throughout the 6 weeks of intervention to increase tissue extensibility. There are variable reports of the heating and mechanical effects as well as effectiveness of ultrasound in the literature. One report in 2001 purported that there is not enough evidence to support the clinical use of ultrasound for management of pain and soft tissue injury. Another study comparing ultrasound and knee ligament stretching with a placebo ultrasound and stretching of the knee on volunteers who were healthy demonstrated only 13% change between conditions. The researchers concluded that stretching with ultrasound might not increase the extensibility of the tissue more than stretching without ultrasound.

Additionally, ultrasound devices from different manufacturers may not have the same calibration. Due to those differences, the effects on the human tissue among devices may not be equivalent. Another source reported that the heating effect appears to be greater in poorly vascularized structures such as ligament.

### Table 2.
Physical Therapist Treatment by Week

<table>
<thead>
<tr>
<th>Mobilization*</th>
<th>Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Week 1</strong></td>
<td><strong>Patient's sister did passive range of motion in flexion and abduction</strong></td>
</tr>
<tr>
<td>Grade III+ mobilizations</td>
<td>At end of week, yellow Thera-Band tubing used for gross patterned movement</td>
</tr>
<tr>
<td>Supine, right hand behind back, anteroposterior glides to head of humerus grade III</td>
<td></td>
</tr>
<tr>
<td><strong>Week 2</strong></td>
<td><strong>At end of week, progressed to red Thera-Band tubing</strong></td>
</tr>
<tr>
<td>Grade IV+</td>
<td></td>
</tr>
<tr>
<td>Grade IV</td>
<td></td>
</tr>
<tr>
<td><strong>Week 3</strong></td>
<td><strong>Yellow Thera-Band for elbow strengthening flexion and extension</strong></td>
</tr>
<tr>
<td>Remained IV+</td>
<td></td>
</tr>
<tr>
<td>Grade III+ to IV+ and discontinued</td>
<td></td>
</tr>
<tr>
<td>Began prone inferior glides to head of humerus grade IV</td>
<td></td>
</tr>
<tr>
<td><strong>Week 4</strong></td>
<td><strong>Progressed to green Thera-Band tubing</strong></td>
</tr>
<tr>
<td>Grade IV++</td>
<td></td>
</tr>
<tr>
<td>Grade III++</td>
<td></td>
</tr>
<tr>
<td>Began prone, hand behind back and extension with mobilization to inferior angle of scapula grade III</td>
<td></td>
</tr>
<tr>
<td><strong>Week 5</strong></td>
<td><strong>Serratus anterior muscle wall push-ups, standing airplane 5 × 15 s</strong></td>
</tr>
<tr>
<td>Grade IV+++</td>
<td></td>
</tr>
<tr>
<td>Grade IV++</td>
<td></td>
</tr>
<tr>
<td>Grade IV+</td>
<td></td>
</tr>
<tr>
<td><strong>Week 6</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Table 1.</strong></td>
<td><strong>Pain-Free Active Range of Motion (in Degrees) of Right Shoulder in Supine Position at 4 Points in Time</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Preoperative</th>
<th>Initial Physical Therapy</th>
<th>End of Physical Therapy</th>
<th>2 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abduction</td>
<td>70</td>
<td>55</td>
<td>160</td>
<td>175</td>
</tr>
<tr>
<td>Flexion</td>
<td>90</td>
<td>65</td>
<td>150</td>
<td>170</td>
</tr>
<tr>
<td>Lateral rotation</td>
<td>100</td>
<td>80*</td>
<td>100</td>
<td>105</td>
</tr>
<tr>
<td>Medial rotation</td>
<td>40</td>
<td>45*</td>
<td>60</td>
<td>70</td>
</tr>
</tbody>
</table>

*Measured during second week of physical therapy.

*All Maitland mobilization techniques were performed in 3 sets with a rate of 60 oscillations per minute for each set. A mobilization grade without a plus sign means that the mobilization moved the joint to 50% of the resistance to the movement. A single plus sign following the grade indicates that the mobilization moved the joint to 75% of the resistance to the movement or 75% of the distance to the end-range expected in a person who is healthy, and a double plus sign indicates that the mobilization moved the joint to the maximum resistance or to the end-range expected in a person who is healthy.

*Sixth postoperative week.
tous tissue and decreased in highly vascularized structures such as muscle. The structure targeted in the patient in this case report was the inferior joint capsule, which is a ligamentous structure that also has a small area; therefore, the application time was limited to just 1 minute to avoid overheating the structure.

Hot packs were applied to the patient’s shoulder for the first 3 weeks to promote circulation and reduce pain. The hot packs were discontinued in the third week when the patient reported that her pain was reduced to 2/10.

**Mobilization Technique**

The treating physical therapist, who holds an orthopedic certified specialization, studied the Australian approach to manual therapy, commonly known as the Maitland technique, while earning his master’s degree at the University of South Australia. The physical therapist chose the Maitland approach for mobilizations because it allows for both pain reduction and joint capsule stretching without the patient providing any exertion. This approach uses the patient’s verbal treatment responses to guide each subsequent treatment.

Only 2 grades of mobilization, III and IV, were used during the intervention period. Maitland grade III is a large-amplitude movement that goes up to the point of limitation in the range of movement. Grade IV is a small-amplitude movement that begins at the very end of the available ROM. The larger-amplitude mobilizations are preferred when there is tissue resistance through a larger ROM, and the smaller-amplitude movement is preferred when the tissue resistance is concentrated in a smaller area. In this case, the mobilization was adjusted at each physical therapy session according to the patient’s pain responses to the mobilization. The specific levels of mobilization are documented in Table 2. In that table, a mobilization grade without a plus sign means that the mobilization moved the joint to 50% of the resistance to the movement. Therefore, if a shoulder joint were limited to 150 degrees of abduction, the grade III or grade IV mobilization would move the joint to 100 to 165 degrees of abduction. A single plus sign following the grade indicates that the mobilization moved the joint to 75% of the resistance to the movement or 75% of the distance to the end range expected in a person who is healthy, and a double plus sign indicates that the mobilization moved the joint to the maximum resistance or to the end-range expected in a person who is healthy. If the patient reported pain with a grade III+ mobilization, the mobilization was reduced to grade III and rechecked for pain response. Although research has shown variance among people in the amount of pressure applied for each grade during mobilizations, the most important factor appears to be the constant verbal interaction between patient and practitioner to guide the practitioner in making the necessary pressure adjustments to deliver mobilization within the pain-free range. Mobilizations were performed with the patient in supine and prone positions and with varying positions of the UE as needed to stretch the capsule. As the ROM increases, the resistance is felt later in the joint’s range of movement.

**Exercise**

Exercise was started with PROM, and the patient’s sister was taught to administer the PROM at home. Then AROM was initiated at the next visit with no ill effects. At the end of the first week of intervention (6 weeks postoperatively), the patient performed 2 proprioceptive neuromuscular facilitation (PNF) patterns (D1 and D2, 5 repetitions each) actively with no pain until the pattern was correctly executed. The patient learned abbreviated ROM patterns when PNF was first introduced due to ROM and strength limitations.

As the patient progressed, the physical therapist made minor corrections of her performance, and home program adjustments were made to progress the home exercise program. The physical therapist chose PNF patterns because the dynamic incorporation of movement patterns in PNF mimics functional movement much better than isolated muscle actions do and because multiple planar movements can be addressed in each multiplanar pattern. The PNF exercises are believed to stimulate weaker muscles to act by linking them to the stronger muscles participating in the patterned movement. The patient performed 2 sets, 8 repetitions per set, of each movement pattern twice daily. When the patient could perform 12 repetitions each time without pain or fatigue, the resistance (Thera-Band tubing) was increased. Yellow tubing was introduced with the patterns in the clinic with no pain reported by the patient. The PNF patterns with yellow tubing then were added as a daily home program, with instructions to the patient to cease the exercise if she encountered pain.

The physical therapist checked the patient’s technique at the start of each clinic appointment and asked the patient questions regarding pain, fatigue, or difficulty with the exercises. The D1 pattern for the UE incorporates shoulder motions of flexion, adduction, and medial rotation in one smooth pattern of movement in the upward direction, with the opposite motions incorporated in the return or downward pattern. The D2 pattern incorporates shoul-

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1 The Hygenic Corp, 1245 Home Ave, Akron, OH 44310-2575.
der flexion, abduction, and lateral rotation in one smooth movement pattern in the upward direction, with the opposing movements incorporated in the return or downward pattern.75

Fatigue Monitoring
An important part of the intervention was to control fatigue during exercise. The patient was an experienced occupational therapist who was able to self-report fatigue. From the first day, she was a part of the rehabilitation team with a primary responsibility of monitoring her own fatigue level, reporting it to the physical therapist, and stopping exercise if she felt fatigue. Agre4 found that the RPEs of patients with PPS correlate well with electrophysiological measurements of muscle fatigue and can reliably be used to monitor fatigue. The patient monitored both local muscle and general fatigue immediately and several hours after exercising. If she noticed local muscle fatigue during exercise, she reduced the number of exercise sets during the current exercise session and during the following 24-hour period. The exercise sets were changed from 2 sets of 8 exercises twice daily to 1 set of 8 exercises 3 times daily only on 3 occurrences during the rehabilitation. Each case of fatigue occurred when the resistance (Thera-Band tubing) was increased. The repetitions never had to be reduced below 8 exercises per set. The patient reported all signs of fatigue to the physical therapist, who made appropriate changes to the rehabilitation.

Outcomes
Outcomes were evaluated after 6 weeks of physical therapy and 2 years after surgery. The patient’s AROM in flexion decreased from 70 degrees preoperatively to 55 degrees at the initial physical therapist evaluation but then increased to 160 degrees at physical therapy discharge and to 175 degrees at the 2-year mark (Fig. 6). A similar pattern developed in flexion and medial rotation (Tab. 2). However, lateral rotation increased from 80 to 100 degrees by the fourth week of physical therapy and thereafter showed a consistent value between 100 and 105 degrees.

Maximum strength and percent difference between the right and left shoulders, as measured by BTE evaluation, are reported in Figure 4 for shoulder abduction and in Figure 5 for shoulder flexion. The percent differences decreased from 49.5% in abduction preoperatively to 21.5% 4 months after surgery and then to 18.3% at the 2-year mark. In flexion, the differences decreased from 57.7% preoperatively to 17.4% 4 months after surgery and then to 9.8% at the 2-year mark. The patient was able to elevate the right UE in abduction with visibly less scapular muscle substitution after 6 weeks of physical therapy as evidenced by the visual differences in the scapular position between Figure 3 and Figure 7. Interestingly, for all testing times, the grip strength of the involved extremity did not vary more than 1 lb from the original measure of 30 lb of force while pinch (key and tip) strength varied between 0.5 lb and 0.3 lb, respectively, from their original values of 7.5 lb for key pinch strength and 3.2 lb for tip pinch strength reported in the preoperative examination.

Manual muscle testing through limited ROM: (1) showed grades of 4+/5 for flexion, 4/5 for horizontal abduction, 5/5 for extension, and 3/5 for abduction on preoperative testing; (2) was antigravity (no resistance tested) through limited ROM at the initial physical therapist examination; and (3) improved to 5/5 for flexion, horizontal abduction, extension, and abduction at physical therapy discharge and at the 2-year mark. Sulcus sign43,51 and O’Brien test (SLAP prehension test)52,53 were positive preoperatively but were negative at physical therapy discharge and at the 2-year mark. Yergason test52–54 and the empty can
test\textsuperscript{5} were positive preoperatively, but the patient reported only a very slight sensation of discomfort with both tests at physical therapy discharge and at the 2-year mark.

Pain
At 2 years after surgery, the patient reported that she no longer had pain except for “an occasional twinge” but that she had to be cautious with some activities such as carrying groceries, which she believed was due to her biceps tendon loss. The patient was very pleased with the outcome of surgery and rehabilitation, reporting that all of her goals had been met.

Function
At 1 month postoperatively, the patient was given medical clearance to return to work part-time for light duty but was not allowed to drive. At 2 months postoperatively, she was released to drive her hand-controlled van and return to full duty at work. In addition, at the 2-month mark, the patient’s relative returned to her own home, and the patient returned to independent living and working with a permanent medical restriction not to lift more than 10 lb with her right UE due to the loss of the long head of the biceps muscle. She was able to perform, without pain or difficulty, those ADL tasks, such as hairdressing and donning stockings, that she previously had difficulty doing. At the 2-year mark, the patient was able to accept a job overseas, making the transition to the new environment with continued independent function. Although she had been concerned about possible permanent functional loss, at the 2-year postoperative mark, she had recovered the same level of function and absence of pain that she had experienced prior to the onset of symptoms.

Discussion
The overuse injuries of individuals with PPS challenge our profession to address the rehabilitation of combined diagnoses while maintaining the caveat not to fatigue these patients. Although research is needed to address this challenge, this case report describes one rehabilitation approach.

As people age, their number of motor units decreases.\textsuperscript{1} Klein et al\textsuperscript{76} found that the rate of annual decline of strength in people with PPS was significantly higher than the decline associated with normal aging. Additionally, the recovery from paralytic poliomyelitis has been attributed to the sprouting of axons that innervate the muscle fibers left orphaned by the disease. The resultant large motor units control a large number of muscle fibers and greatly affect muscle function when they die.\textsuperscript{1}

This aging population has the issues of PPS combined with the orthopedic and neurological problems seen in normal aging.\textsuperscript{76} Physical therapists may work with patients who have combined diagnoses of PPS and other problems seen in the aging population such as arthritis, overuse injuries, and cerebrovascular accidents. Additionally, the potential for overuse injuries in this population may exceed the general population’s overuse injuries due to the UEs taking on extra duties to compensate for the paralyzed LEs as well as the overuse of the surviving motor units of an affected limb.\textsuperscript{76}

The last case of poliomyelitis in the United States was diagnosed in 1998, and the disease is considered eradicated in this country. However, the Centers for Disease Control and Prevention conducted the 1994–1995 National Health Interview Survey, which estimated that there were 433,000 people in the United States who had survived paralytic poliomyelitis.\textsuperscript{7} Additionally, the March of Dimes estimated that, in 2000, there were 250,000 people with PPS in the United States.\textsuperscript{77} People who survived the disease during the last epidemic to sweep the country in the 1950s would now be at least 50 years of age and among the aging population with potential orthopedic problems. This patient with PPS in this case report showed a full return to her...
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independent lifestyle following physical therapy intervention. The research literature lacks articles on postoperative orthopedic rehabilitation of people with PPS, even though this population is aging and would be expected to have onset of disabilities due to overuse and other etiologies. Physical therapists may be hesitant to perform a progressive exercise program on people who have had poliomyelitis due to the documented deleterious effects of exercise on people who have PPS.16,18,32,34,35

In summary, this is the first case report to document the effects of physical therapy in a patient with PPS who had a rotator cuff tear resulting from extended use due to postpolio sequelae. The physical therapist used a Maitland technique with functional active exercises for the patient. The physical therapist additionally emphasized communication and used the patient responses to adjust treatment. The patient was knowledgeable about her condition and was able to be an active partner of the rehabilitation team, monitor fatigue, and modify her exercises and activities as needed. Additionally, the change between her status immediately following rehabilitation and 2 years later showed continued progress in strength and ROM. We believe that the combination of good practitioner/patient communication, use of the Maitland technique to increase joint ROM without patient effort, and careful selection of a few functionally important active and resistive exercises contributed to the success of this patient’s rehabilitation.

Future research might use a single-subject research design for multiple individuals with PPS who have rehabilitation following orthopedic surgery. A standardized functional survey would strengthen the design, and a handheld dynamometer could be used to quantify muscle strength in lieu of the BTE device. The single-subject design is stronger than the case report and can infer an effect of the intervention on the outcome.7,8(p15)

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Cuff Repair for a Patient With Postpolio Syndrome
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