Rehabilitation Strategies After Shoulder Arthroplasty in Young and Active Patients

Devon T. Brameier, BS[a,*], Alicia Hirscht, DPT, SCS[b,c], Marc S. Kowalsky, MD, MBA[a], Paul M. Sethi, MD[a]

KEYWORDS

• Shoulder arthroplasty rehabilitation • Rehabilitation protocol
• Anatomic shoulder arthroplasty • Active patient • Young patient • Shoulder arthritis

KEY POINTS

- Well-designed, progressed, and executed rehabilitation programs are vital to successful functional outcomes after shoulder arthroplasty.
- Early protection of the subscapularis repair is required for implant longevity and success.
- Young and active patients will likely progress more quickly through the rehabilitation protocol than older patients and will require more challenging exercises to regain the strength and mobility required for activity and sport.
- In young and active patients, the final phases of rehabilitation should incorporate full-body training to prevent placing undue stress on the repair or arthroplasty on returning to activity.

INTRODUCTION

The successful outcomes associated with shoulder arthroplasty are predicated on meticulous postoperative rehabilitation.[1] Postoperative therapy and rehabilitation are among the most important factors in shoulder arthroplasty success, facilitating the process of regaining normal shoulder function by promoting soft tissue healing,

Disclosure Statement: No commercial company has any direct financial interest in the subject matter or materials discussed in this article.
[a] The ONS Sports and Shoulder Service, Orthopaedic and Neurosurgery Specialists (ONS), The ONS Foundation for Clinical Research and Education (ONSF), 6 Greenwich Office Park, 40 Valley Drive, Greenwich, CT 06831, USA; [b] Physical Therapy, Orthopaedic and Neurosurgery Specialists (ONS), ONS Stamford, The ONS Foundation for Clinical Research and Education (ONSF), 5 High Ridge Park, Stamford, CT 06905, USA; [c] Physical Therapy, Orthopaedic and Neurosurgery Specialists (ONS), ONS Stamford, The ONS Foundation for Clinical Research and Education (ONSF), 6 Greenwich Office Park, Greenwich, CT 06831, USA
* Corresponding author.
E-mail address: dbrameier@onsmd.com

Clin Sports Med 37 (2018) 569–583
https://doi.org/10.1016/j.csm.2018.05.007 **sportsmed.theclinics.com**

managing pain and swelling, and restoring joint range of motion (ROM), strength, and neuromuscular control.[2,3] The uninjured glenohumeral (GH) joint has great ROM but has little bony stability, relying on the deltoid, periscapular, and rotator cuff muscles and the joint capsule for dynamic stabilization. This makes rehabilitation of the joint more difficult, requiring reestablishment of normal ROM, dynamic stability, and joint strength to achieve a functional outcome.[4] Achieving this goal requires a well-designed and appropriately executed physical therapy program that is both adaptive and progressive to protect anatomic structures in the early recovery phase and to maximize ROM and strength development once healing has occurred.[4–6]

Available literature specific to the topic of post–shoulder arthroplasty rehabilitation is limited, with most information predating 2005.[2,3,6,7] Most rehabilitation protocols currently in use follow the guidelines set out by Hughes and Neer,[5] Brems,[6] and Boardman and colleagues,[7] and in 1975, 1994, and 2001, respectively, with minor adjustments to the criteria for patient progression through the rehabilitation phases as outlined by Wilcox and colleagues[3] in 2005. However, these protocols are based on traditionally older populations of patients undergoing total shoulder arthroplasty (TSA) procedures at the time and do not address the changing demographic of patients undergoing shoulder arthroplasty procedures today. Following recent improvements in implant functionality and survival rates, shoulder replacement procedures are now being used to treat younger patients with higher levels of sports activity.[8–10] These younger patients, younger than 65, place different stresses on shoulder arthroplasties because of their desire to remain active and return to sport participation, and therefore raise concerns for decreased implant survivability and functional outcomes. However, these patients are likely in the prime of their careers and thus need dependable, successful results.[9] This article provides an updated protocol for rehabilitation after shoulder arthroplasty, specifically targeting these young and active patients, focusing on protection of the subscapularis repair and later advanced strengthening, and treating the entire body in preparation for an active postsurgical life.

SHOULDER PATHOLOGY, ARTHROPLASTY TECHNIQUES, AND THEIR EFFECTS ON POSTOPERATIVE SUCCESS

The success of shoulder arthroplasty depends on the underlying shoulder pathology, implant design, surgical techniques, postsurgical rehabilitation, and patient involvement and compliance. To achieve maximal pain relief and functional restoration, surgeons and clinicians must consider the preoperative, intraoperative, and postoperative factors of each case when designing the patient's postoperative rehabilitation protocol.[3]

Shoulder Pathology

Anatomic shoulder arthroplasty is most commonly used to treat patients with a diagnosis of osteoarthritis (OA), rheumatoid arthritis (RA), or proximal humerus fracture (PHF) who complain of consistent pain, limited ROM, and impaired function despite conservative management.[3–5,11] The postsurgical functional outcomes of these patients can be predicted in part by their initial bone stock quality and soft tissue integrity.[3]

Patients with OA who undergo TSA can achieve long-term pain relief with very predictable results, with most studies reporting 90% to 95% of patients eventually being pain-free once fully recovered.[3] These patients often have significant stiffness

preoperatively, thus an emphasis on early ROM and stretching is important throughout their rehabilitation to achieve successful results.[3,4] As these individuals typically have low reported incidences of rotator cuff pathology, they should anticipate an easy transition from the passive ROM-focused phase I of the rehabilitation protocol described in the section "Introduction to the postoperative protocol for the young and active patient," to the active ROM-focused and advanced strengthening–focused phases II, III, and IV, ultimately achieving fully functional overhead ROM with forward flexion of greater than 140°.[3,4]

Arthroplasty Surgical Techniques

The 3 options used for shoulder arthroplasty in the young patient include the anatomic TSA, the humeral hemiarthroplasty (HHA), and the reverse total shoulder arthroplasty (RTSA). These decisions are based on numerous factors and are discussed in this issue. The focus of this article is on rehabilitation following TSA or HHA, which mirror one another. Although RTSA is a viable option in younger patients, its use is much more limited for this patient population and is beyond the scope of this article. TSA is the treatment of choice for patients presenting with OA and RA with an intact rotator cuff.[3,12] This procedure replicates anatomic structure and function, and therefore relies on adequate bone stock to support the implant and sufficient rotator cuff function for motion and strength to achieve a successful outcome. Successful repair and healing of the subscapularis, and intraoperative restoration of soft tissue balance, are vital for good functional outcomes after TSA.[3] Studies have shown that the rate of return to sports such as swimming, cycling, tennis, golf, and downhill skiing is higher with TSA than with RTSA or HHA.[12]

TSA may be used for fracture sequelae of the proximal humerus following when the rotator cuff is intact and the deformity is not severe. Using a TSA to treat fracture sequelae is successful in managing pain but achieves inferior functional motion gains compared with the use of TSA to treat primary OA. Those who undergo TSA or HHA as a primary treatment for PHF sequelae with intact rotator cuffs can be managed like patients with OA.[3] Full recovery may take 6 months to a year postoperatively because of the additional time required to allow for mobilization of the posttraumatic soft tissue envelope.[4]

Subscapularis Repair Techniques

Most surgeons will use a deltopectoral approach to visualize the GH joint. This approach requires the release of the subscapularis (SSc) and the anterior capsule to gain access to the shoulder joint.[11] Proper repair of the SSc is necessary for postoperative joint mobilization, function, and stability. There are 4 key SSc management options: SSc tenotomy, lesser tuberosity osteotomy (LTO), SSc tendon peel, and SSc-sparing approaches.[13] SSc tenotomy is typically repaired with heavy, nonabsorbable sutures through drill holes and around the humeral stem, with additional side-to-side suture and requires more extensive early postoperative limitations of passive external rotation (ER) and active internal rotation (IR) to allow for adequate soft tissue healing.[13–15] LTO techniques maintain the native tendon-to-bone insertion and use heavy, nonabsorbable sutures through drill holes to achieve the repair. The main advantage of repairing the SSc via an LTO is the opportunity for bone-to-bone healing; however, this technique also risks malunion or nonunion of the bone if the repair is stressed before adequate bony healing.[13,15] As repair of an LTO may arguably provide better initial fixation, early rehabilitation can be more aggressive, with allowed immediate passive ROM (PROM) and assisted active

ROM (AAROM) with no limitations from day 0. SSc tendon peeling involves removing the entire SSc insertion off the bone then reattaching the tendon using nonabsorbable suture fixation through bone tunnels and may be used in cases of severe preoperative restriction of ER. SSc-sparing techniques, which are described in detail in this issue, preserve the SSc attachment, requiring that procedure be performed through the rotator cuff interval; however, this approach is technically very challenging.[13] Randomized studies of these techniques have found that no one option is superior to the others.[16]

As this article is focused on the rehabilitation of young, active patients undergoing shoulder arthroplasty procedures to treat shoulder arthritis with the intent of returning to activity, the protocol described is tailored to rehabilitation after TSA or HHA in young patients with OA. The described protocol reflects a tenotomy approach with more strict limitation of early ROM due to the method of repair, but may be altered to fit an LTO approach. Importantly, the surgeon should document the amount of ER achieved preoperatively and the amount achieved intraoperatively. This information can aid in determining the limits of early postoperative ROM to protect the SSc repair. Surgeons also should document the degree of preoperative posterior subluxation and note any procedures, such as capsule plication or glenoid augmentation, to address this subluxation. These observations should be added by the surgeon to their postoperative dictation so that they may be easily accessible at any time during the postoperative recovery process.

We also believe that the rehabilitative therapist should have a firm understanding of the preoperative and intraoperative ER. This information, coupled with an understanding of the preoperative degree of subluxation, can guide and individualize treatment specific to the individual and their degree of pathology to prevent jeopardizing the subscapularis or causing reoccurrence of subluxation.

PROTECTIVE PRECAUTIONS AND CONSIDERATIONS OF THE REHABILITATION PROCESS

All clinicians should have a complete understanding of the local anatomy of the shoulder when treating a postoperative patient with shoulder arthroplasty. They should also have a working understanding of the surgical anatomy and the necessary precautions that are required to preserve the structures affected by the procedure. An understanding of the physiology of healing, the factors that can contribute to more expedient healing, and those that can impede the healing process also can be helpful. Clinicians' expertise in the use of manual treatments, mobilizations, and other modalities serves to optimize motion and minimize risk to the healing shoulder. They must appreciate the appropriate progression of rehabilitation exercises from passive motion, to active assisted motion, to active motion, and culminating in resisted motion.

Early Joint Mobilization to Prevent Joint Stiffness and Adhesions

As the joint capsule of the shoulder may develop adhesions postoperatively, early movement and mobilization of the joint is encouraged to minimize scarring and adhesions between muscle groups and thus prevent stiffness.[6] Previous series have shown that early passive ROM exercises are important to avoid stiffening of the GH joint, which can result from delayed physical therapy.[1] Gentle exercises and stretching as described in this article's protocol can and should be initiated on postoperative day 1, particularly passive shoulder pendulums. Although Denard and Lädermann[17] suggest that immediate and delayed motion following TSA results in similar results

1 year after surgery, the immediate PROM group experienced a more rapid return of function, which would benefit the young patient eager to make progress and return to activity.

Pain and Swelling Management

To allow for the greatest progress to be made with each session, patients may consider a nonopiate analgesic at least 30 minutes before planned physical therapy to control pain levels and diminish the perception of stiffness. After 2 weeks, patients also may use moist heat 30 minutes before physical therapy to reduce stiffness followed by stretching and ice after therapy.[6] Routine cryotherapy is also extremely effective at reducing the intensity and frequency of pain. Cryotherapy should be administered at least 4 to 6 times daily for 20 to 30 minutes at a time during the first 14 days postsurgery to reduce swelling and control pain. Use of ice should be continued intermittently throughout the entire rehabilitation process, especially during periods of increased discomfort after therapy or at night.[18] As an alternative to simple ice, patients may use commercially available continuous cryotherapy devices. Studies have shown that the consistent use of cryotherapy improves patients' ability to sleep and reduces the frequency of perceived need to use pain medications. It also enhances rehabilitative efforts by reducing swelling and minimizing pain associated with shoulder movement during therapy.[18]

Protection of the Subscapularis

Both the surgeon's and therapist's greatest concern during the early rehabilitation process should be the protection of the subscapularis repair. Inadequate or failed healing of SSc tenotomy repairs has been correlated with significantly inferior functional outcomes.[15] The SSc acts as an internal rotator and abductor of the humerus and as an anterior restraint, balancing the forces of the posterior rotator cuff, and thereby providing GH joint compression and stability.[13,19] SSc failure increases the risk of anterior instability, which could lead to anterior humeral head subluxation, pain, and stress on the glenoid component, which can then in turn lead to premature loosening and decreased survivorship of the replacement.[13,14]

Electromyogram studies of subscapularis activity during PROM in forward flexion have shown that limiting passive flexion to 90° reduces SSc activity by half.[20] A randomized study of the effect of early passive exercise on rotator cuff tendon repair healing rates found that aggressive early motion may increase the risk of anatomic failure of the repaired tendon, while limited early motion does not impact the amount of ROM regained postoperatively; therefore, to minimize risk to the SSc repair, passive flexion and scaption is limited to 100° for the first 3 to 4 weeks postoperatively while initial tendon healing occurs.[21] Abduction, active and passive ER, and active IR are known to directly strain SSc repairs.[19,22] As such, abduction should be avoided completely while all ER and active IR should be controlled for the first 6 weeks postoperatively to allow for physiologic healing. Intraoperative assessment of passive ER by the surgeon after subscapularis repair is used to determine the ER limit for each patient. Most patients should be limited to 0° to 30° of passive ER, which may be progressively increased after 6 weeks. If intraoperative passive ER exhibits low SSc tension, then the patient may be allowed to passively rotate to 45° during the first 6 weeks. If there is increased SSc tension when measured intraoperatively, the limits placed on the patient should be more restrictive. Strengthening of the subscapularis should

be addressed in a slow, progressive fashion, after physiologic healing has occurred.

Patients should wear a sling and avoid weight bearing for the first 4 weeks postoperatively, although they may remove the sling to perform their therapeutic exercises after 7 to 10 days postoperatively. They should begin to wean use of the sling at home during postoperative weeks 2 to 3, starting with a few hours in the morning and night and can progressively decrease its use over time; however, they should continue to wear the sling when out in public for 4 weeks postoperatively to protect the repair.

Engaging the Patient as a Partner

Clinicians should be clear and realistic in managing patients' rehabilitation expectation and goals. Therapists and surgeons should emphasize to the patient that they should serve as an active agent in their rehabilitation program rather than a passive recipient if they wish to gain the maximal benefit from therapy. They should be encouraged to perform multiple short periods of stretching and exercise throughout the day, approximately 5 minutes per session 3 to 4 times per day on their own, in addition to planned therapy visits to achieve maximal functional outcomes.[5,6] Patients who avoid early active use of the shoulder and do not perform the prescribed exercises or who overuse their shoulders and strain the repair before soft tissue healing risk inferior results and thus may require additional supervision and direction.[5,14]

INTRODUCTION TO THE POSTOPERATIVE PROTOCOL FOR THE YOUNG AND ACTIVE PATIENT

This TSA postoperative protocol is intended to serve as a guide. It was designed by the authors as a specialized version of the protocols proposed by Wilcox and colleagues,[3] Hughes and Neer,[5] Brems,[6] Basti,[4] and Payne and colleagues[2] targeting the rehabilitation needs of the young and active shoulder arthroplasty patient population. Each patient should be examined by a licensed physical therapist who can adjust his or her clinical decisions based on the patient's presentation; including, but not limited to, the individual's underlying pathology, presurgical level of function, postsurgical goals, and the specific surgical technique used. Regular communication between the surgeon and the therapist is ideal, with progress reports supplied on average at least every 3 to 4 weeks, with additional communication as necessary.

Time frames for each phase are based on normal physiologic healing but should be adjusted for each patient accordingly. Clinicians should remember that every patient's pain threshold and anatomy are different, and thus each protocol and its progression should be individualized to that patient as guided by the patient's pain, tolerance, impairments, desires, and goals, in addition to the original pathology and initial functional level previously mentioned. Patient physiology in part dictates the amount of stress placed on the healing shoulder, and when. This information is coupled with the available metrics taken clinically: ROM, manual muscle testing, and stability testing. As the physiologic healing progresses and the clinical metrics improve, a slow integration of motion, stretching, and eventually strengthening can be introduced.

Achieving pain-free active ROM (AROM) and PROM is crucial before progressing the patient to advanced strengthening and before allowing the patient to return to sport training. Advanced strengthening exercises, including weights, should be added

to the patient's rehabilitation program only once full normal AROM and PROM have been established in phase II. Patients should exhibit proper neuromuscular control, most importantly scapular kinesia and proper posture, with exercises specific to each phase before moving on to the next phase. For example, a patient in phase I should be able to achieve forward flexion to 120° without pain and with proper scapular kinesia before being allowed to progress to phase II. It should be noted that the progression of a patient who underwent TSA for the treatment of OA with an intact rotator cuff who was a high-functioning athlete before surgery will be slightly different from that of a patient of the same age with a diagnosis of RA who was not active previously.

Manual resistance exercises are crucial throughout all phases of rehabilitation to maximize proper neuromuscular patterns and scapular kinesia. These exercises are first performed in the supine position during phase I, then standing in phase II, followed by resistance exercises in phase III, and finally advanced sport-specific and goal-specific strengthening in phase IV. Therapists may challenge the patient's stability while cueing the patient to have proper positioning with the exercises to increase proprioceptive control and recruitment of the rotator cuff. Strengthening must be done with proper scapular position and mechanics to avoid postoperative rotator cuff impingement. During later phases, therapists should encourage active movement of the rotator cuff and deltoid to enhance recruitment of these dynamic stabilizers to enhance GH joint stability with movement.[2]

Phase I: Immediate Postoperative Phase

Phase I, the immediate postoperative phase, spans postoperative weeks 0 to 3. Goals during this period include minimizing pain and edema, specifically in the periscapular and cervical muscles; maintaining wound healing; preventing adhesions and joint stiffening; and educating the patient regarding proper use of the sling, sleep positioning, and modification in activities of daily living (ADLs).

This phase focuses on gentle, restricted PROM aimed at initiating joint mobilization with maximal protection of the subscapularis repair, strictly avoiding active IR and aggressive stretching into ER. Starting postoperative day 1, patients may perform gentle pendulum exercises to initiate joint movement. Patients are encouraged begin formal physical therapy 7 to 10 days postoperatively, at which time the therapists should work with them to achieve passive flexion and scaption to 100° and IR to the belt line. ER is restricted to 0° to 30° in the scapular plane with a rolled towel or pillow supporting the humerus in the supine position. Early cervical PROM is encouraged to minimize upper trapezius guarding.

Soft tissue effleurage (circular stroking–based massage) and petrissage (kneading-based massage) by the therapist is recommended at this time to control edema and pain. Electrical stimulation and cryotherapy are also useful to reduce swelling and inflammation. Once the wound heals, scar mobilization may commence to break up myofascial adhesions and relax muscle tension.

Gentle supine, submaximal shoulder and elbow isometrics and rhythmic stabilization with the humerus supported on a rolled towel and the elbow bent to 90° also may begin during phase I. Additional standing scapular isometrics, such as scapular clocks against a ball on a wall or standing retractions, are encouraged to focus on early redevelopment of proper scapular positioning. Elbow flexion and extension, supination and pronation, wrist circles, and grip exercises can begin immediately in seated or standing positions to maintain elbow and wrist AROM.

Phase II: Early Strengthening Phase

Phase II, the early strengthening phase, spans postoperative weeks 3 to 6. Patients continue with phase I PROM, including flexion and scaption to tolerance, IR to 70° with humerus at 45° of scaption, and ER to 30° to 60° with humerus at 45° of scaption. The goal is to achieve full, pain-free AROM and PROM in all planes by 12 weeks with proper scapular kinesia and neuromuscular control of the shoulder blade.

This phase introduces minimal protection AROM, beginning with AAROM. These exercises should be performed to a sub-pain threshold, taking care not to overstretch into any ROM. Patients should begin supine with the hand of the unaffected arm lifting the surgical arm overhead. They may then progress to supine wand exercises, including flexion, scaption, and horizontal adduction. Patients may start light closed chain AAROM with table slides in flexion or scaption in a seated position with a towel, then progress to standing flexion table slides with a Swissball for increased neuromuscular return from stabilizing the ball. Toward the end of phase 2, during weeks 5 and 6, wall slides may be incorporated as tolerated.

Gentle AROM flexion and scaption to 70° is allowed at this point so long as scapular posterior tilt is present. Patients can stand with their back against the wall if needed for proprioceptive cues. Light strengthening exercises are incorporated during phase II, not in the third week but before the sixth week. Isometric shoulder exercises can progress to Theraband ER and IR walkouts. Prone work on elbows is encouraged at this stage to initiate closed chain proprioceptive return to the periscapular muscles and rotator cuff. Prone scapular strengthening through retraction and extension to neutral and standing 4-way (adduction, abduction, flexion, extension) movement into a ball against a wall are also recommended for light strengthening. Young, formerly active patients with good preoperative strength and control may progress more quickly than the typical older patient through the isometric strengthening phase of rehabilitation due to prior experience with isolated muscle contraction through strength training.[4] As the intensity of exercise is increased, patients may experience additional muscle soreness or swelling. This can be managed with continued cryotherapy and use of analgesics/nonsteroidal anti-inflammatory drugs.

Phase III: Resistance Strengthening and Proprioception Phase

Phase III, the resistance strengthening and proprioception phase, spans postoperative weeks 6 to 12. Patients should continue developing PROM in all planes of motion, including passive IR and ER at 70° to 90° of scaption, and continue increasing AROM/AAROM in flexion and scaption as tolerated, with the goal of achieving greater than 140°. To progress to advanced strengthening in phases III and IV, patients should have pain-free AROM and PROM, including 140° of elevation, and $\geq$60° in ER and $\geq$70° in IR at 70° to 90° of scaption.

This phase continues the concept of minimal protection AROM with lightly weighted, supine AROM punch outs and abduction/adduction exercises. It continues with prone AROM and lightly weighted exercises for the periscapular muscles focusing on retraction, extension, and depression. Standing exercises can be progressed to flexion and scaption with light weight, scapular retraction with Theraband resistance, and adduction with extension AAROM. Resistance motion in IR and ER can be introduced, performed in the scapular plane with a Theraband. Sidelying ER AROM can be performed at this point with light weight.

Light closed chain exercises are important during this phase to improve the patient's functional outcome. These include prone-on-elbows exercises, wall push-ups and planks, and rhythmic stabilization with 2# ball on the wall. Exercises that

target the core also may be introduced, including supine or seated thoracic mobilization and trunk rotation exercises, hip extension strengthening with bridge exercises, and core progressions. These exercises are especially important for those patients seeking to return to a specific sport after recovery, particularly tennis and golf.

Twelve weeks after surgery, patients should have full, pain-free AROM and PROM with enough strength to perform basic ADLs, such as getting a plate down from a kitchen cabinet, sitting at a computer, and getting dressed. At this point, guided physical therapy may be reduced to 1 visit per week during which their strength is progressed further as tolerated. Emphasis on a daily home exercise program is essential.

Phase IV: Advanced Sport-Specific and Goal-Specific Strengthening and Proprioception Phase

Phase IV, the advanced sport-specific and goal-specific strengthening and proprioception phase, spans postoperative weeks 12 to 16+. It focuses on strengthening and endurance training, in addition to specific return to work and sport training as dictated by the needs of the patient's lifestyle and goals. The main objective is to ensure the rotator cuff is engaging at all angles of motion and that the scapula maintains proper position during advanced and heavier exercise. Rotator cuff and periscapular strength are crucial to optimize the longevity of the arthroplasty.

Patients should be instructed to perform basic Theraband and light weight exercises from phase III with changes in their body positioning or the surface on which they are performed to create a more dynamic activity. Examples include performing prone exercises on a ball or IR and ER Theraband work in a single leg stance or lunge position. Patients can begin performing exercises overhead, progressively adding heavier weights when they can perform at least 10 repetitions at the previous weight without fatigue or pain. Closed chain exercises can be progressed to wall walks, planks, and further work with the Swissball. Plyometric exercises may be introduced as needed, in addition to progressive sport-specific exercises catered to each patient after 16 weeks postoperatively.

If the goal is to return to sport within 4 to 6 months, therapists should begin building up to that level of activity at 3 months postsurgery. Phase IV and the final home program should address core and lower extremity strength and mobility to maximize potential for sport performance. Tightness in the hamstrings or hip flexors, along with thoracolumbar spine stiffness, can limit the amount of power produced by the legs and core, adding more stress on the shoulder to produce an overhead force for activities such as the tennis serve. With all young and active patients undergoing a TSA, it is crucial to address the whole body for a return to sport program, being sure to address the other muscle groups involved in the intended activity with full-body training programs to avoid placing undue stress on the affected arm on return to activity. Before returning to sport, the entire kinetic chain should be assessed for strength, stability, and mobility to maximize performance and reduce risk of reinjury.

Advanced Rehabilitative Exercises for the Active Patient

Most of the exercises listed in the protocol in **Fig. 1**, particularly those for phases I, II, and III, are basic shoulder rehabilitation exercises that have been previously demonstrated and described in the literature.[2–4,19,23] The clinical therapist author (AH) emphasizes 5 subsets of strengthening exercises (**Figs. 2–6**) targeted at challenging the young and active patient during phases III and IV to develop the

Patient Name:

_____

Surgeon Name:

_____

Date of Surgery:

____/____/_____

Duration of Sling:

_____ weeks

Subscap Repair Technique:

- ☐ Tenotomy
- ☐ LT Osteotomy
- ☐ Tendon Peel
- ☐ Tendon Sparing
- ☐ Other _____

Pre-Op ER: _____°

Intra-Op ER: _____°

Degree of Posterior Subluxation:

_____

	weeks post-op														
Phase I: Immediate Postoperative Phase Maximal Protection Passive Range of Motion (PROM)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**13**	**17**	**21**	**25**
Scapular Clocks (retraction-depression)																
Passive Cervical Stretching																
Elbow/Hand/Wrist ROM Exercises																
Light Bicep and Tricep Exercises																
Pendulums																
Effleurage and Petrissage																
Cryotherapy																
PROM																
Restricted External Rotation (ER) in Scapular Neutral				30°	30°	30°	30°									
Forward Elevation and Scaption	100°	100°	100°													
Abduction																
Internal Rotation (IR) to Belt Line																
Internal Rotation																
Phase II: Early Strengthening Phase Minimal Protection Active Range of Motion (AROM)		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**13**	**17**	**21**	**25**
Assisted AROM (AAROM)																
IR and ER (using dowel)																
Forward Elevation and Scaption (using dowel)																
Closed Chain AAROM (sliding on ball in flexion/scaption)																
Sub-maximal Isometrics (Rhythmic Stabilization)																
IR and ER																
Abduction/Flexion/Extension (into ball against wall)																
AROM																
Sidelying External Rotation																
Forward Elevation and Scaption (lawn chair progression)																
Prone Scapular Retraction/Extension to Neutral																
Prone Horizontal Abduction and Extensions with ER																
Prone Lower Traps																
Open Chain Proprioception																
Low Load Prolonged Stretches																
Door Jam/Wall Series																
Towel IR																
Cross Arm Stretch																
90/90 ER Stretch																
Activities of Daily Living (ADL's)																
Eating/Drinking (elbow movement allowed)	Using non-surgical arm only															
Dressing																
Washing/Showering																
Computer/Personal Device use (with arm support)																
Driving																
Lifting up to 5 lbs.																
Overhead Activity																
Lifting greater than 5 lbs.																
Phase III/IV: Resistance Strengthening &Proprioception Minimal Protection Active Range of Motion (AROM)		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**13**	**17**	**21**	**25**
Arm-focused Cardio (upper body ergometer)																
ER and IR																
Punches with a Plus																
Sport Cord Rows																
Prone Lower Traps with weights																
Prone Scapular Retraction/Extension with weights																
Prone Horizontal Abduction and Extensions with weights																
Bicep and Tricep Exercises																
Initial Push-up Plus																
Initial Closed Chain Stability																
ER at 45° and 90°																
Advanced Push-Up Plus																
Advanced Closed Chain Stability																
Proprioceptive Neuromuscular Facilitation with Resistance																

Fig. 1. Suggested shoulder arthroplasty rehabilitation protocol form for the young and active patient. This form illustrates the recommended progression through the phases and provides space to document patient-specific sling duration, SSc repair technique, preoperative and postoperative ER, and degree of posterior subluxation to be shared with postoperative clinicians. Colored boxes indicate the exercise allowed at that time. This protocol is a guide, and patients are to be progressed at the therapist's discretion based on ROM, strength, and pain tolerance. The design of the ONS protocol was inspired by that of the Howard Hughes Medical Institute.

advanced shoulder strength, stability, and scapular kinesia required to return to activity.

All of the exercises shown in Figs. 2–6 have been demonstrated in the literature to maximize posterior cuff and scapular muscle activity for proper GH

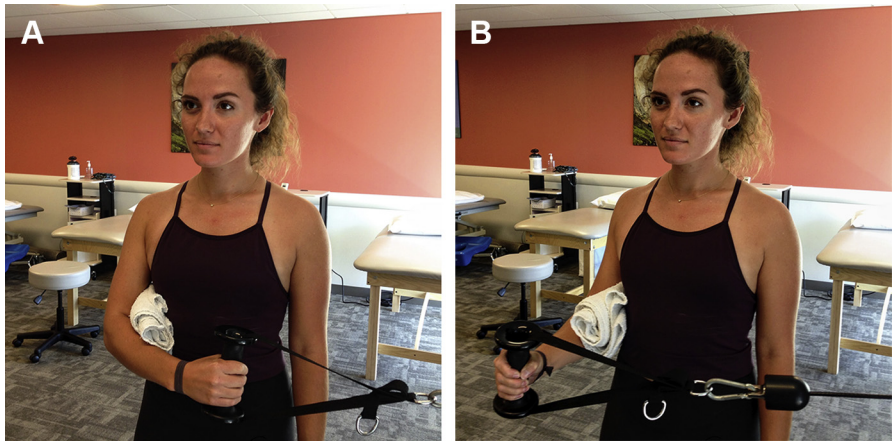

Fig. 2. Shoulder ER with cable column. (*A*) Stand with a rolled towel at your elbow, holding onto the handle with your arm at your belly. (*B*) Rotate your forearm out against the resistance. Return to start position slowly. Complete 2 sets of 15 reps, increasing the weight once the patient can successfully complete one set without pause and fatigue.

stability.[4,19,23] When instructing a patient in these exercises, clinicians should take care to watch the patient's scapular position and cervical spine. The scapula should be retracted while depressed, avoiding an anterior tilt that can lead to rotator cuff impingement. Whenever possible, keep the cervical spine in a retracted, neutral position.

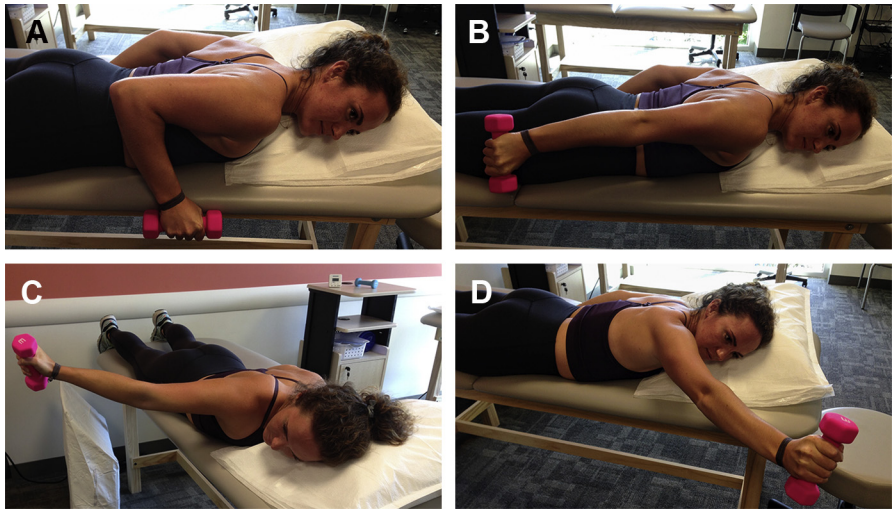

Fig. 3. Prone scapular exercises. Begin each exercise lying face down with a weight in your hand. Finish each exercise with your shoulder blade retracted down and in toward your spine then slowly release the weighted hand back toward the ground. (*A*) *Scapular Rows*. Lift the elbow up to a 90° angle, keeping the upper arm at your side. (*B*) *Extension*. Raise your arm straight back, palm inwards. (*C*) *Horizontal Abduction*. Lift your arm out to the side, elbow extended, with your thumb turned slightly up toward the ceiling. (*D*) *Scaption*. Lift your arm up overhead at a 45° angle off the corner of the table.

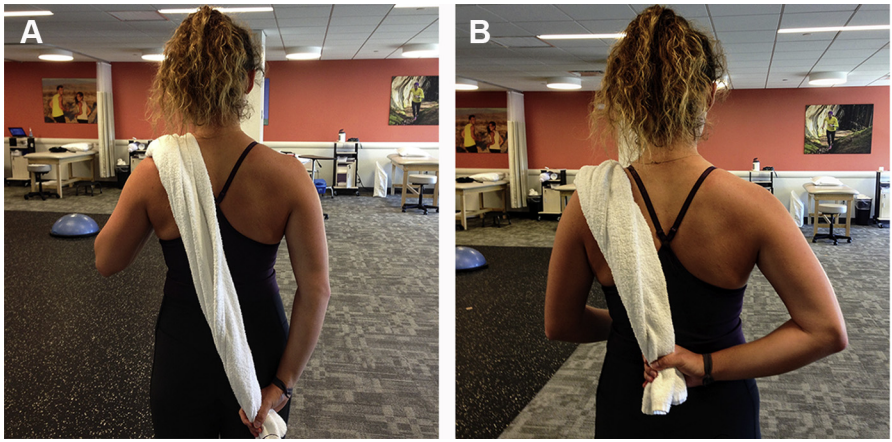

Fig. 4. Towel IR stretch. (*A*) Hold onto a towel with your nonsurgical hand in front of you and the towel draped over your shoulder. Place your surgical arm behind your back and hold onto the draped end of the towel. (*B*) Gently pull the towel down in front with the nonsurgical hand until you feel a stretch in the back of the shoulder. Be careful to keep your shoulder blade down and back toward your spine, do not let your shoulder tilt forward.

Fig. 5. Closed chain stability. Place a 2# ball against the wall at shoulder height, palm on the ball, elbow straight, shoulder blade retracted and depressed. Instruct the patient "Do not let me move you" while you give gentle, then more aggressive perturbations to the patient's arm. (*A*, *B*) Perform for 30 seconds, 4 reps. Progressions can include a heavier ball, an overhead position, or a plank position (demonstrated in *C*, *D*). The advanced modification shown in (*C*) and (*D*) are targeted for the young, active patient, thus they may be too challenging for older patient with shoulder arthroplasty and should be attempted at the therapist's discretion.

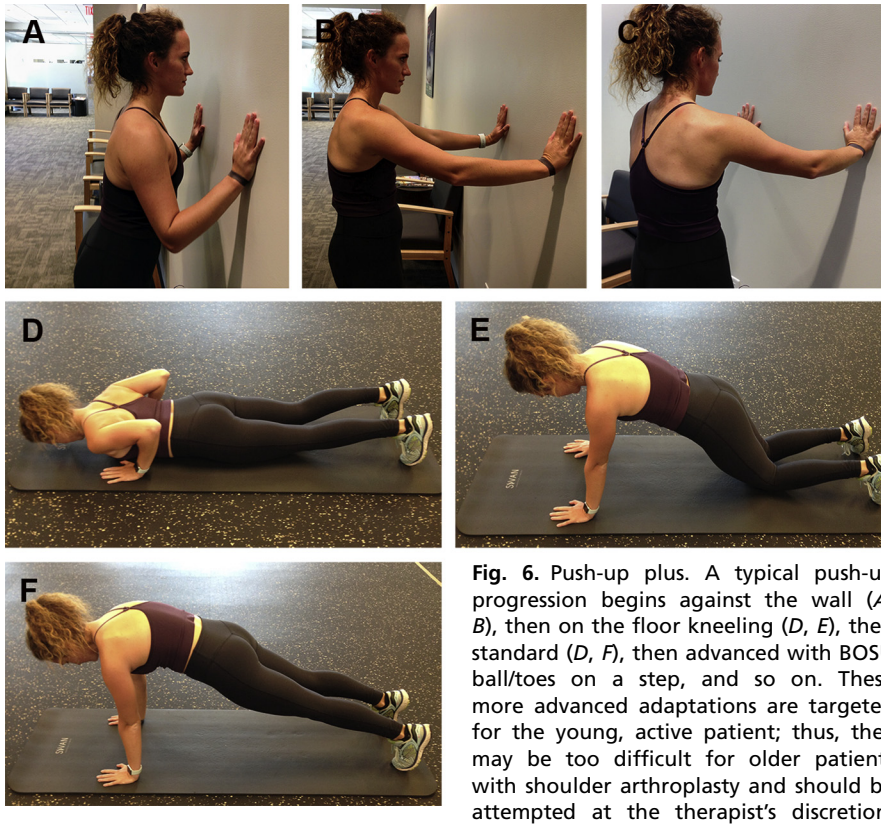

Fig. 6. Push-up plus. A typical push-up progression begins against the wall (*A*, *B*), then on the floor kneeling (*D*, *E*), then standard (*D*, *F*), then advanced with BOSU ball/toes on a step, and so on. These more advanced adaptations are targeted for the young, active patient; thus, they may be too difficult for older patients with shoulder arthroplasty and should be attempted at the therapist's discretion. For a push-up plus, begin with hands directly underneath the shoulders and elbows tucked down along the sides. (*A*, *D*) Push up, then separate the shoulders at the top of the range (*C*), pull back in, and return to start position.

SUMMARY

A well-designed, progressed, and executed rehabilitation program is vital to successful functional outcomes after shoulder arthroplasty. These programs require early protection of the subscapularis repair to encourage implant longevity and success. This article describes the suggested rehabilitation protocol used by the clinical therapists and surgeons at ONS to treat the more recent young and active patient population undergoing anatomic shoulder arthroplasty for arthritis. This is a 4-phase protocol following an immediate postoperative phase I, early strengthening phase II, resistance strengthening and proprioceptive phase III, and advanced sport- and goal-specific strengthening and proprioception phase IV. The exercises and stretches performed in each phase must be sensibly controlled and progressed based on the patient's ROM, strength, and pain tolerance. The provided protocol takes into consideration the likelihood that young, active patients will progress more quickly through the rehabilitation protocol than older patients and provides more challenging exercises specific to the younger patient aimed at regaining the strength and mobility required for activity and sport, including an emphasis on incorporated full-body training to prevent placing undue stress on the repair on return to activity.

ACKNOWLEDGMENTS

The authors acknowledge Dr Peter A. Philip, PT, ScD, COMT, PRPC, of Philip Physical Therapy in New Canaan, CT, for his insight and contribution to this article.

REFERENCES

1. Compito C, Self E, Bigliani L. Arthroplasty and acute shoulder trauma. Clin Orthop Relat Res 1994;307:26–37.
2. Payne C, Jaggi A, Leu L, et al. Rehabilitation for shoulder arthroplasty. Orthop Trauma 2015;29(5):313–23.
3. Wilcox RB III, Arslanian LE, Millett PJ. Rehabilitation following total shoulder arthroplasty. J Orthop Sports Phys Ther 2005;35(12):821–36.
4. Basti J. Rehabilitation of shoulder arthroplasty. In: Bigliani LU, Flatow EL, editors. Shoulder arthroplasty. New York: Springer; 2005. p. 167–207.
5. Hughes M, Neer C. Glenohumeral joint replacement and postoperative rehabilitation. Phys Ther 1975;55(8):850–8.
6. Brems J. Rehabilitation following total shoulder arthroplasty. Clin Ortho Relat Res 1994;307:70–85.
7. Boardman ND III, Cofield RH, Bengston KA, et al. Rehabilitation after total shoulder arthroplasty. J Arthroplasty 2001;16(4):483–6.
8. Schumann K, Flury MP, Schwyzer HK, et al. Sports activity after anatomical total shoulder arthroplasty. Am J Sports Med 2010;38(10):2097–105.
9. Roberson TA, Bentley JC, Griscom JT, et al. Outcomes of total shoulder arthroplasty in patients younger than 65 years: a systematic review. J Shoulder Elbow Surg 2017;26:1298–306.
10. McCarty EC, Marx RG, Maerz D, et al. Sport participation after shoulder replacement surgery. Am J Sports Med 2008;36(8):1577–81.
11. Hawkins R, Bell R, Jallay B. Total shoulder arthroplasty. Clin Ortho Relat Res 1989;242:188–94.
12. Liu JN, Carcia GH, Mahony G, et al. Sports after shoulder arthroplasty: a comparative analysis of hemiarthroplasty and reverse total shoulder replacement. J Shoulder Elbow Surg 2016;25:920–6.
13. Shields E, Ho A, Wiater J. Management of the subscapularis tendon during total shoulder arthroplasty. J Shoulder Elbow Surg 2017;26:723–31.
14. Caplan J, Whitfield B, Nevasier R. Subscapularis function after primary tendon to tendon repair in patients after replacement arthroplasty of the shoulder. J Shoulder Elbow Surg 2009;18:193–6.
15. Buckley T, Miller R, Nicandri G, et al. Analysis of subscapularis integrity and function after lesser tuberosity osteotomy versus subscapularis tenotomy in total shoulder arthroplasty using ultrasound and validated clinical outcome measures. J Shoulder Elbow Surg 2014;23(9):1309–17.
16. Lapner PLC, Sabri E, Rakhra K, et al. Comparison of lesser tuberosity osteotomy to subscapularis peel in shoulder arthroplasty: a randomized controlled trial. J Bone Joint Surg Am 2012;94(24):2239–46.
17. Denard P, Lädermann A. Immediate versus delayed passive range of motion following total shoulder arthroplasty. J Shoulder Elbow Surg 2016;25:1918–24.
18. Speer K, Warren R, Horowitz L. The efficacy of cryotherapy in the postoperative shoulder. J Shoulder Elbow Surg 1996;5(1):62–8.
19. Escamilla RF, Yamashiro K, Paulos L, et al. Shoulder muscle activity and function in common shoulder rehabilitation exercises. Sports Med 2009;39(8):663–85.

20. Jung M-C, Kim S-J, Rhee J-J, et al. Electromyographic activities of the subscapularis, supraspinatus and infraspinatus muscles during passive shoulder and active elbow exercises. Knee Surg Sports Traumatol Arthrosc 2016;24:2238–43.
21. Lee BG, Cho NS, Rhee YG. Effect of two rehabilitation protocols on range of motion and healing rates after arthroscopic rotator cuff repair: aggressive versus limited early passive exercises. Arthroscopy 2012;28(1):34–42.
22. Wright T, Easley T, Bennett J, et al. Shoulder arthroplasty and its effect on strain in the subscapularis muscle. Clin Biomech (Bristol, Avon) 2015;30(4):373–6.
23. McCann P, Wootten M, Kadaba M, et al. A kinematic and electromyographic study of shoulder rehabilitation exercises. Clin Ortho Relat Res 1993;288:179–88.