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CLINICAL COMMENTARY

EXERCISE REHABILITATION IN THE NON-OPERATIVE MANAGEMENT OF ROTATOR CUFF TEARS: A REVIEW OF THE LITERATURE

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ABSTRACT

The incidence of rotator cuff tears increases with age, with full-thickness rotator cuff tears present in approximately 25% of individuals in their sixties, and more than 50% of those in their eighties. While surgery is considered an effective treatment, recurrent tears at the insertion site are common, especially with degenerative tears, which are frequent in the older population. More recently, there has been increasing interest in exercise rehabilitation and physical therapy as a means to manage partial and full thickness tears of the rotator cuff by addressing weakness and functional deficits. Recent studies have suggested that patients opting for physical therapy have demonstrated high satisfaction, an improvement in function, and success in avoiding surgery. When considering the increasing rate of shoulder surgery and the associated economic and social burden rotator cuff surgery places on both the patient and the health care system, non-surgical management such as physical therapy and exercise may, in selected cases, be a treatment alternative to surgical repair. The purpose of this clinical commentary is to provide an overview of rotator cuff pathology and pathogenesis, and to present an evidence-based case for the role of conservative rehabilitation in the management of rotator cuff injuries.

Level of Evidence: Level 5

Keywords: Conservative management; exercise rehabilitation; physical therapy; rotator cuff tear

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INTRODUCTION

Full thickness tears of the rotator cuff are among the most frequently encountered causes of pain and dysfunction in the shoulder complex, becoming more prevalent due to an ageing population and the increased functional demands in older people.[1] Chronic rotator cuff pathology has attracted attention due to the considerable disability, poor quality of life and expensive utilization of health care resources.[2] In the United States alone, tears of the rotator cuff affect at least 10% of those over the age of 60, equating to over 5.7 million people and resulting in an estimated 75,000–250,000 rotator cuff surgeries performed per year.[3] In Australia, this figure is approximately 14,000 annually, with direct medical expenses for rotator cuff repair estimated at $250 million per year.[4] Therefore, it is important to investigate possible solutions to reduce the increasing economic and social burden that rotator cuff repair places on patients and health care systems around the world.

To date, evidence regarding the management of rotator cuff tears has produced conflicting results. Some authors consider that surgery for rotator cuff tears offers better outcomes than non-operative treatments;[5] while others have argued that non-operative interventions produce equivalent outcomes to surgery.[6,7] Those advocating operative treatment suggest that repair of the rotator cuff tendon (especially early in the disease process) may alter the pathogenesis of rotator cuff disease and protect and/or prevent tear progression, tissue degeneration, biceps involvement and glenohumeral joint (GHJ) degeneration.[8] Those in favor of non-operative interventions argue that for selected patients, addressing the clinical and functional deficits via conservative management may be effective in reducing pain and symptoms, providing a worthy alternative to surgery. The purpose of this clinical commentary is to provide an overview of rotator cuff pathology and pathogenesis, and to present an evidence-based case for the role of conservative rehabilitation in the management of rotator cuff injuries.

EPIDEMIOLOGY

Shoulder pain is the third most common musculoskeletal complaint reported to general practitioners in primary care settings.[9] In developed countries, approximately 1% of the adult population is expected to visit a general practitioner annually for shoulder pain. While it is estimated that 65–70% of all shoulder pain involves the rotator cuff tendon,[10] it has been estimated that 5 to 40% of people without shoulder pain have full-thickness tears of the rotator cuff.[11] Rotator cuff tears can be classified by the mechanism of injury: acute, chronic or a combination of both (acute on chronic). An acute rotator cuff tear has been defined as a tear involving an injury or trauma, typically appearing in patients with no previous history of shoulder symptoms, and presenting with pseudoparalysis of the shoulder. Chronic rotator cuff tears often occur due to progressive degeneration of the tendon, developing over time and typically due to multiple factors such as overuse, a lack of blood supply and other physiological factors. Additionally, chronic cuff tears that may be asymptomatic may be aggravated by trauma, which is known as acute on chronic. Irrespective of the mechanism of the injury, rotator cuff tears can be classified into two broad types: partial-thickness or full-thickness. Partial-thickness tears are generally more frequent than full-thickness tears, with a prevalence of 13% versus 7%.[12]

Rotator cuff tears are generally considered a normal, age-related degenerative disorder, which can be symptomatic, or asymptomatic. Little information is available as to why some rotator cuff tears are painful while others are completely asymptomatic. Symptomatic tears are generally seen in the dominant shoulder (only 28% of patients in the non-dominant shoulder only), with bilateral tears present in 36% of patients.[13] In a cadaveric study, full-thickness tearing of the rotator cuff was observed in 6% of cadaver specimens under 60 years of age, and 30% in those older than 60.[14] Other authors have used magnetic resonance imaging (MRI) and ultrasound in an attempt to determine the presence of rotator cuff tears in asymptomatic shoulders. Sher et al[15] observed tears in 34% of asymptomatic individuals, with 15% of those classified as full-thickness tears and 20% as partial thickness. No individuals under 40 years of age displayed full-thickness tears, and only 4% had partial-thickness tears. In patients between 40-60 years of age, full-thickness and partial-thickness tears were observed in 4% and 24% of individuals, respectively; and in individuals older than 60 years of age, this increased to 28% and 26%, respectively.

Tempelhof et al[16] reported an overall prevalence of full-thickness rotator cuff tears in asymptomatic individuals to be 23%, with 51% of individuals over 80 years of age displaying tears. A limitation of this study was that the authors only evaluated asymptomatic shoulders. Interestingly, rotator cuff disease appears to be a bilateral condition. Yamaguchi et al[13] reported that if patients had a symptomatic rotator cuff tear, there was a 35% chance of a cuff tear on the opposite side which increased to 50% if the patient was 66 years of age or older. Despite not being painful, asymptomatic rotator cuff tears are at risk of becoming symptomatic over time. The average size of a symptomatic tear has been shown to be 30% greater than that of an asymptomatic tear.[13] Yamaguchi et al[8] followed asymptomatic rotator cuff tears over a five-year period to assess the risk for development of symptoms and tear progression using ultrasound and clinical assessment. 51% of these tears progressed to symptomatic tears at a mean of 2.8 years after initial examination. Furthermore, 50% of those who became symptomatic demonstrated tear progression compared with 22% of those who remained asymptomatic.

RELEVANT ANATOMY AND BIOMECHANICS

The rotator cuff contributes to both stability and movement of the glenohumeral joint (GHJ) and is integral to appropriate functioning of the upper limb.[17] It is a myotendinous complex formed by four muscle-tendon units: the supraspinatus superiorly, the subscapularis anteriorly and the teres minor and infraspinatus posteriorly.[18] The tendons of the rotator cuff are composed primarily of type 1 collagen fibers tightly packed in a parallel configuration with small numbers of long, thin tenocyte cells in between the rows of collagen. The collagen fibers and cells are embedded in a matrix of proteoglycans, glycosaminoglycans, and water.[19] A commonly held view is that the four rotator cuff tendons are separate entities.[20] However, Clark and Harryman[18] showed that these four tendons fuse together approximately half an inch from the point of the insertion of the tendons into the humerus. Prior to their fusion, the triangular space between the supraspinatus and subscapularis, known as the rotator interval, houses the coracohumeral ligament, middle glenohumeral ligament and superior glenohumeral ligament, and the long head of the biceps tendon, which provides stability in the GHJ.[21] The infraspinatus and teres minor join together at their musculotendinus junctions, and then fuse with the supraspinatus approximately 15mm proximal to the insertion site,[11] and then fuse together with the subscapularis over the bicipital groove and into the greater tuberosity of the humerus.[11] When examined microanatomically, both the supraspinatus and infraspinatus tendons are composed of five layers.[18] The most superficial layer is composed of the fibers of coracohumeral ligament; layers two and three are thick tendinous structures, layer four is composed of loose connective tissue and layer five is the joint capsule of the shoulder.[18] Between the fourth and fifth layers, a strip of fibrous tissue extends from the coracohumeral ligament through the supraspinatus tendon on the articular side to the inferior border of the infraspinatus tendon, referred to as the rotator cable.[22] Together with an area of thinner cuff tissue localized lateral to the cable, a biomechanical model has been described, termed the 'cable-crescent' complex.[23] This complex was described in a cadaveric study by Burkhart et al[23] who likened it to a suspension bridge, influencing GHJ mechanics by transferring force from medial tendon fibres through the loaded cable to the humerus, ultimately stress-shielding the crescent tissues.[24]

Classification systems for tears of the rotator cuff tendon have been proposed based upon specific characteristics such as size of the lesion, number of tendons involved, and the reparability of the tear.[25-30] While the definition of a "massive" tear has not yet been clearly standardized, tears greater than 5 cm, or complete tears involving at least two tendons are considered "massive". In addition to these broader-based classifications, specific classification systems focusing on individual tendons have also been proposed. Patte[27] developed a classification for lesions of the supraspinatus, infraspinatus and teres minor, Lafosse et al[26] for tears of the subscapularis, and Ellman et al[28] for partial rotator cuff tears. Most rotator cuff tears occur in the tendinous part of the cuff, where the tendons from the corresponding muscles are not individualized.[31] Location of tears are given in terms of the tendons involved, by differentiating between superior tears (affecting the supraspinatus tendon only), superoposterior tears (affecting the supraspinatus and infraspinatus tendons) and superoanterior tears (affecting the supraspinatus, the rotator interval, the subscapularis and sometimes the long head of the biceps).[27]

Superior tears involving solely supraspinatus tendon have traditionally been considered the most common, and indeed this is the location where many tears initiate and propagate from due to the location of the supraspinatus under the coracoacromial ligament.[32] However, Kim et al[33] analyzed tears in 360 shoulders, and reported that 83% of full-thickness tears and 72% of partial thickness tears were commonly located more posterior than originally thought, approximately 15mm posterior to the biceps tendon. This suggests that most degenerative cuff tears initiate from a region near the junction of the supraspinatus and infraspinatus tendons. Superior rotator cuff tears not involving the cable may be described as biomechanically "intact" and functional. Because the the rotator cable remains intact, it is possible and may explain commonly reported anecdotes whereby an individual with a moderate or large chronic cuff tear is able to preserve normal shoulder function without symptoms. In superoposterior tears larger than medium-sized, the involvement of the subscapularis tendon is three times more likely. These tears interrupt the rotator cable, and alter the normal kinematics of the glenohumeral joint. Complete tears that exceed 50% of the subscapularis tendon increase the risk of pseudoparalysis in patients with massive rotator cuff tears.[34,35]

The 'intrinsic' rotator cuff muscles act in synergy to maintain GHJ stability by compressing and centralizing the humeral head into the glenoid fossa.[36] Their combined GHJ stabilizing role is imperative for shoulder complex stability and function as the larger 'extrinsic' muscles, such as the latissimus dorsi, pectoralis major and deltoid, produce the forces necessary for gross arm and shoulder movements. Electromyography (EMG) studies have demonstrated that rotator cuff muscular activity precedes deltoid and pectoralis major EMG activity during volitional movement,[37] suggesting that the rotator cuff muscles dynamically compress and stiffen the GHJ in preparation for larger destabilizing global muscular contractions. The supraspinatus muscle is the primary superior compressor of the humeral head and resists the superior force exerted by the deltoid muscle.[36] The stabilizing mechanism at the GHJ is largely dependent on the entire rotator cuff, specifically, the transverse force coupling provided by the anterior (subscapularis) and posterior (infraspinatus / teres minor) tendons with their insertion into the proximal humerus[36]. Pre-activation of the rotator cuff muscles has also been demonstrated in a direction specific manner with anterior and posterior rotator cuff muscles working individually to oppose rotational force and maintain a neutral position,[38] effectively "steering" the humeral head within the glenoid. Any disruption to these 'force couples', especially with respect to rotator cuff tears, is likely to contribute to shoulder dysfunction. Tears can cause disruption of normal shoulder kinematics by altering the force balance between the subscapularis and infraspinatus[39]. Clinically, patients with rotator cuff tears can have preserved function if the integrity of the transverse force couple balance is maintained.[11] However, if the tear progresses to involve the posterior cuff musculature, this balance of forces is often disrupted, GHJ stability is lost, and a stable fulcrum for concentric rotation of the humeral head in the glenoid no longer exists.[39]

CLINICAL PRESENTATION

The clinical presentation of an individual with a diagnosed rotator cuff tear varies, dictated by a number of variables including the location and size of the tear. Some patients present without significant pain, symptoms and/or dysfunction, while others report severe pain and demonstrate loss of strength and function. However, the reason why some tears are and may remain asymptomatic is not fully understood. Patients with a symptomatic rotator cuff tear typically present with shoulder pain and cuff weakness. Constant pain and a painful arc (pain during abduction between 70-120 degrees) are strong predictors of tears of the supraspinatus tendon. These patients also typically present with a loss of active shoulder abduction and elevation, weakness and reproduction of pain during resisted abduction or external rotation,[40] and positive impingement signs.[41] In addition, superoposterior tears show a loss of active range of motion and weakness in external rotation with a positive lag sign,[42] while tears of the subscapularis may result in reduced active range of motion, weakness in internal rotation and an abnormal "lift off" sign.[43] A recent clinical study demonstrated that tears exceeding more than half of the subscapularis tendon increased the risk of pseudoparalysis in patients with massive rotator cuff tears.[34] Dysfunction of scapulohumeral rhythm and a compensatory shoulder shrug may be observed during active abduction and elevation. Finally, patients with long-standing rotator cuff tears may present with obvious atrophy, with muscular wasting in the supraspinatus also commonly associated with a concomitant infraspinatus tear.[44]

RELEVANT PATHOPHYSIOLOGY OF ROTATOR CUFF TEARS

The pathogenesis of rotator cuff tears is not fully understood, but is considered to be a combination of 'extrinsic' factors such as impingement from structures surrounding the cuff, and 'intrinsic' factors such as tissue-based degenerative tendon changes that may occur with normal aging and mechanical overuse from repetitive activities. A 'degeneration-microtrauma' theory has been developed, proposing that repetitive stresses lead to small injuries within the tendon that are given an insufficient time to heal before further trauma.[45] The combination of reduced tensile strength and either a single traumatic insult, or progressive microtrauma, can then lead to cuff tearing.[45] Furthermore, after the deep fibers tear, fiber retraction results in an increased load on the remaining fibers that subsequently increases the likelihood of progressive tendon rupture.[46] As a result of repetitive microtrauma in a degenerative rotator cuff tendon, inflammatory mediators alter the local environment and oxidative stress induces tenocyte apoptosis, causing further rotator cuff tendon degeneration.[45,47,48] Yuan and Murrell[47] first described the role of apoptosis in rotator cuff tendon disorders, demonstrating an increase of apoptotic cells in the degenerative supraspinatus tendon (34%) compared with the normal subscapularis tendon (13%). The increased number of apoptotic cells in degenerative tendon could affect the number of functional tendon fibroblasts which may contribute to an impaired rate of collagen synthesis and repair resulting in a weaker tendon thereby promoting tendon degeneration and eventually increasing the risk of rupture.[46] Extrinsic factors involve pathological contributions external to the tendon tissue that may occur as a consequence of anatomical variables such as the shape of the acromion, which may then cause tendon compression during shoulder motion. The chronic impingement syndrome theory described by Neer[49] is a well-known theory, which proposed that the impingement of the rotator cuff tendon against the inferior part of the acromion and coracoacromial ligament was the primary factor in causing tissue damage and tendon tears. Bigliani et al[50] found a higher prevalence of rotator cuff tears in patients with a hooked (type III) acromion morphology compared to individuals with a curved (type II) or a flat (type I) acromion. Wang et al[51] showed that the success of conservative management decreased with changes among these three types of acromion shape: type I responded in 89% of cases, type II in 73% and type III in 58.3%.[51]

ROTATOR CUFF SURGERY

Common surgical interventions include a rotator cuff tendon repair, involving reattachment of the torn cuff tendon to the humeral insertion site, and/or decompression to increase the size of the subacromial space. In support of the extrinsic factor of pathology and the mechanical theory, Bjornsson et al[52] reported that arthroscopic subacromial decompression reduced the prevalence of rotator cuff tears in patients with impingement, with 82% of patients exhibiting intact tendons 15 years after surgery. Subacromial decompression is performed when there is significant impingement of the rotator cuff tendon between the acromion and humerus, and may be performed as either an arthroscopic or open surgery.[53] Tendon repair is performed in order to re-establish an intact tendon-bone interface. Arthroscopic and open repair of the rotator cuff has shown satisfactory outcomes for pain and shoulder function, as well as success rate, defined by avoiding additional surgery, of 94% at five years and 83% at 10 years, with significantly improved post-operative clinical outcomes.[54] Immediate operative repair within three months has been proposed to result in better post-operative patient outcomes, as well as an earlier return to work and decreased costs.[55] Patients undergoing repair within four months of the onset of symptoms can generally expect a good result, whereas repairs of full-thickness tears beyond one year of symptomatic onset have demonstrated poorer results.[56,57] Moosmayer et al[5] demonstrated superior mean functional outcome scores in patients undergoing earlier surgical repair, compared with delayed or late surgery, but did not report the statistical significance of this difference, and both groups did not significantly differ in cuff integrity.

However, despite good clinical results for pain relief and ability to perform activities of daily living, both ultrasound[58,59] and MRI[60,61] findings have demonstrated a high rate of recurrent defects occurring in 20–94% of cases. Assessment of tendon integrity after tendon repair has shown mixed results. Harryman et al[58] reported in a follow-up of 105 tendon repairs five years after open surgery, that a recurrent full-thickness defect was observed in 20% of patients who underwent repair for tears affecting the supraspinatus tendon alone, in 43% of patients who underwent repair for tears affecting the supraspinatus and infraspinatus tendons, and in 68% of patients who underwent repair for three tendon tears. Patients with an intact rotator cuff at post-operative follow-up demonstrated better function and shoulder range of motion than those with a tear recurrence, while the size of the recurrent defect was negatively correlated to the functional outcome. Similar results have been reported for mini-open[62] and arthroscopic repairs.[63,64] Furthermore, the American Academy of Orthopaedic Surgeons (AAOS) clinical practice guidelines on "Optimizing the Management of Rotator Cuff Problems" provided a consensus opinion that surgery should not be performed for asymptomatic rotator cuff tears, and provided a limited recommendation on rotator cuff repair as an option for patients with chronic, symptomatic full thickness tears.[65] Given the aforementioned results, it would appear that conservative, non-surgical treatment should be considered as a viable alternative to surgical intervention.

NATURAL HISTORY OF ROTATOR CUFF TEARS AFTER CONSERVATIVE TREATMENT

Knowledge of the natural history of rotator cuff tears is important when making treatment decisions to achieve best outcomes for patients. Determining the appropriate course of treatment for rotator cuff tears should be based upon symptoms, whether the tear is full-thickness or partial-thickness and whether it is acute (traumatic), chronic (atraumatic) or a combination of both (acute on chronic). As patients with rotator cuff tears present with a wide variety of symptoms, structural characteristics, and physical activity requirements, treatment approaches must be tailored individually. Although conservative treatment can be effective, information regarding who fails conservative treatment and who likely benefits from surgical repair is required to optimize patient outcomes. Characteristics of tears, as well as the individual level of functional deficit and/or patient-reported pain and symptoms that occur after a rotator cuff tear, may serve as a guideline as to what treatment direction to take, whether conservative rehabilitation or surgical repair. A treatment algorithm and indications for directing appropriate treatment for rotator cuff tears has been proposed (Figure 1).[66] This includes three definitive patient groups, stratified via the natural history of partial-thickness and full-thickness tears, whether the tear is acute or chronic, and the prognostic factors for both conservative treatment and surgical treatment.

Group I

Patients over 60 years of age with chronic full-thickness rotator cuff tears, and individuals of any age with large or massive rotator cuff tears with chronic, irreversible rotator cuff changes already present, are thought to benefit from an initial course of conservative treatment. The healing potential in older adults with a rotator cuff tear is compromised and is impaired in this age group even after repair.[63] Only 43% of patients over the age of 65 treated with arthroscopic rotator cuff repair of a full-thickness supraspinatus tear had evidence of healing at 18 months postoperatively compared with 86% of patients under 65.[63] Due to the inconsistent outcomes of surgical repair in the >65 year age group, and the low risk associated with conservative treatment, a trial of non-operative intervention in this patient population is warranted. If non-operative treatment is unsuccessful, surgical treatment may be considered, but because healing is unlikely, the goal of surgery in elderly patients may be to convert a symptomatic tear to an asymptomatic tear.

Group II

Patients with either acute tears, or chronic full-thickness tears greater than 1–1.5cm who are younger

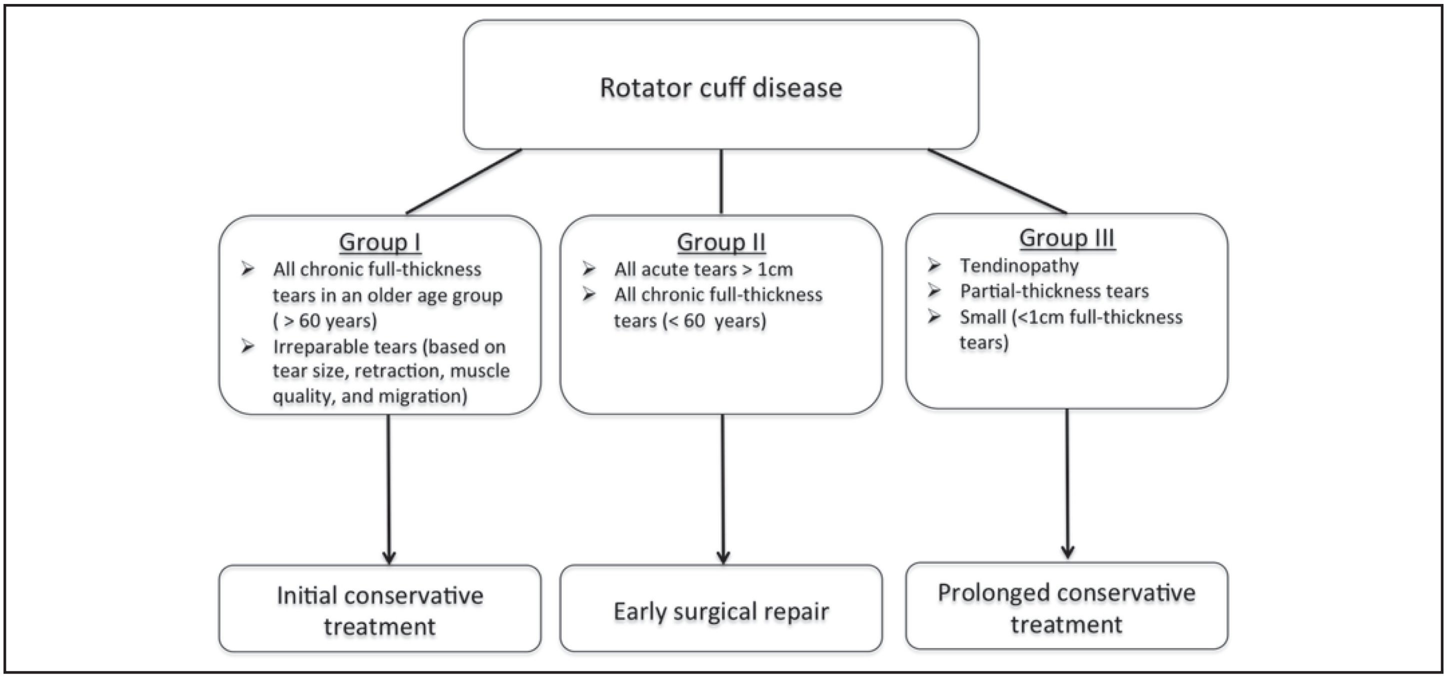

Figure 1. *Treatment algorithm for pathology of the rotator cuff. Information derived from Tashjian et al[66]*

than 60 years old, are thought to benefit from early surgical intervention, due to significant risks for irreversible changes with non-operative treatment and a high likelihood of healing if repair is performed. It is generally recommended that surgical repair be performed instead of initial conservative treatment in active patients with acute tears after trauma.[66,67] Early operative treatment appears to be better for rotator cuff tears with a sudden onset of symptoms and poor function for achievement of maximal return of shoulder function.[68] Rotator cuff repairs are more successful in younger patients with a traumatic etiology as compared to those performed in an older cohort receiving surgery for atraumatic tears.[69] Furthermore in a systematic review, Lazarides et al[70] reported cuff tears in patients younger than age 40 are more commonly full-thickness tears and of traumatic origin, and typically respond well to surgery in terms of pain relief and self-reported outcomes postoperatively, due to good tendon and muscle quality at the time of repair. If left unrepaired, over time the tear may enlarge, and the cuff may lose its elasticity, thus making the possibility of a later surgical repair more difficult. However, Bjornsson and colleagues[71] determined that no differences existed with regard to tendon healing, pain, shoulder elevation, or functional outcomes whether an acute tear was fixed within three months of injury as compared to within three weeks.

It is well accepted that many patients with an atraumatic full-thickness rotator cuff tear will respond well to conservative treatment in the short term. Conservative treatment may be the preferred treatment because of advanced patient age, socioeconomic issues, and medical comorbidities. However, a question remains as to how to appropriately direct a younger (< 60 - 65 years), more active patient with a reparable full-thickness cuff tear, whether symptomatic or not. However, early surgical management in "young patients" with significantly sized, full-thickness tears (>1–1.5 cm) without chronic muscle changes should be considered because of the high risk for tear enlargement and progression over time. Safran et al[72] and Maman et al[73] followed subjects with conservatively treated symptomatic tears and independently noted the risk of tear progression to be between 19% and 49% at a follow-up duration of eighteen to thirty months. Safran et al[72] evaluated 51 patients 60 years of age or younger who were treated non-operatively for a symptomatic full-thickness rotator cuff tear. At an average of 29 months' follow-up, the investigators found an almost identical 49% of tears increased in size (>5 mm). Pain at follow-up was the only factor correlated with tear progression (56% with pain vs 25% without pain). Maman et al[73] evaluated 33 patients with full-thickness symptomatic rotator cuff tears and determined 52% progressed in tear size at an average of 24 months follow-up. Tear progression was more likely after 18 months (50%) compared with before the 18 month time frame (19%). Furthermore, patients older than 60 years and presence of rotator cuff fatty infiltration correlated with tear progression. From these studies, it is evident that there is a significant risk for tear progression in non-operatively treated symptomatic full-thickness tears with approximately 50% progressing at an average of two years.

Group III

Prolonged exercise rehabilitation and non-operative treatment should be considered in patients with rotator cuff tendinopathies, partial-thickness tears, and potentially small full-thickness tears, due to the limited risk for irreversible, chronic rotator cuff changes.[66] Smaller symptomatic full-thickness tears have been shown to have a slower rate of progression, similar to partial-thickness tears, and can be considered for conservative management due to the limited risk for rapid tear progression. Although healing has not been shown to occur with partial tears without repair, significant improvements in functional outcomes have been shown with conservative treatment,[66] as well as a slow, small risk for tear progression.[73,74] Mall et al[74] evaluated 30 asymptomatic partial-thickness rotator cuff tears. At a two-year follow-up, 20 of the patients with asymptomatic tears that remained asymptomatic were compared with 10 patients with tears that became symptomatic. Ultrasound was performed at follow-up to evaluate for tear progression. Of those tears that remained asymptomatic, none progressed to a full-thickness tear. In the 10 patients whose tears became symptomatic, 40% progressed to a full-thickness tear. Pain was highly correlated with tear progression in asymptomatic partial-thickness tears and, therefore, can be used as a warning sign of enlargement and that further evaluation is warranted, such as follow-up imaging.

Maman and colleagues[73] evaluated 30 patients with symptomatic partial-thickness rotator cuff tears at an average of 24 months with an MRI. These investigators found only 10% of symptomatic partial-thickness tears progressed in size (>5 mm), which is significantly less than the 50% progression reported in the same study for symptomatic full-thickness tears. The location of the tear had no effect on tear progression. This data suggests that tear progression of symptomatic partial-thickness tears occurs at a significantly reduced rate compared with symptomatic full-thickness tears; therefore, an initial conservative treatment approach is reasonable due to a decreased risk for tear progression. Furthermore, Fucentese et al[75] reported on the natural history of symptomatic isolated full-thickness supraspinatus tears in 24 patients with a mean age of 54 years. These patients had an average initial tear size of 1.6 cm and were re-evaluated at a mean of 3.5 years after non-operative treatment. Overall, there was no increase in the average tear size at follow-up and only 25% demonstrated tear progression. This is in contrast to the 50% tear progression reported by Maman et al[73] and Safran et al[72] Furthermore, the tear progression that occurred did not affect the reparability of these tears. This suggests that in small, full-thickness tears (<1–1.5 cm), initial observation and conservative management may be reasonable even in young patients, due to a low risk for tear progression (25%) unlike in larger tears, as shown by previous studies, which have a higher risk (approximately 50%) for tear enlargement.[72,73,75]

EVIDENCE FOR CONSERVATIVE MANAGEMENT IN ROTATOR CUFF TEARS

Conservative treatment, including exercise therapy, is often offered as an initial management approach for patients with full thickness rotator cuff tears. Remarkably, it has been observed in patients whose repairs fail after surgical repair, that reported satisfaction levels and clinical outcome scores are similar to those with intact repairs.[3] The authors of this study suggest that the reason for these findings is that because most of the patients in these studies engaged in some form of structured post-operative physical therapy, that it is possible that the post-operative rehabilitation is more responsible for the improvements in outcome.[3] The primary objectives of non-operative management of a rotator cuff tear are to decrease pain, increase function and enhance activities of daily living (while mitigating potential long term adverse outcomes). Until recently, insufficient evidence existed justifying the need and importance for conservative management of rotator cuff tears. While the AAOS 2012 guidelines found inconclusive evidence to provide a recommendation for exercise as a treatment for rotator cuff tears,[65] more recent studies relating to the progression of rotator cuff tendinopathy and tearing, as well as the results of surgical and non-surgical management, have provided sound rationale for exercise therapy in treating rotator cuff tears as an initial alternative to surgery. The Moon Shoulder Group[3] demonstrated significant improvements in patient-reported outcomes and a low rate of surgery after physical therapy in the treatment of atraumatic full thickness rotator cuff tears. The study followed 381 patients (mean age 62 years, range 31-90) with atraumatic full-thickness tears of the rotator cuff, for a minimum of two years. Patients performed 6-12 weeks of non-operative physical therapy focusing on basic rotator cuff strengthening and shoulder mobility. Six weeks into the intervention, patients were assessed and 9% chose to have rotator cuff repair surgery. At 12 weeks, patients were again evaluated resulting in an additional 6% electing surgery. In total, 26% of patients decided to have surgery by the two-year follow-up. Analysis revealed that most patients will elect to undergo surgery in the first 12 weeks; however, if a patient does not choose to have surgery within the first 12-weeks of non-operative rehabilitation, they are unlikely to require surgery for up to two years.

Goldberg et al[76] documented the functional outcome in a consecutive series of 46 patients with full-thickness rotator cuff tears who underwent conservative treatment and follow-up for at least one year. Treatment consisted only of patient education and a home program of gentle stretching and strengthening. Almost 60% of patients experienced improvement in general health and physical function scores, while 30% experienced worsening, and 11% remained unchanged. Two factors of the Simple Shoulder Test (the ability to sleep on the affected side and the ability to place the hand behind the head) improved significantly, whereas other components were not significantly improved. While these results demonstrate encouraging outcomes and suggest the effectiveness of exercise as treatment for cuff tears, it must be noted that there was no comparative cohort who underwent surgery in this study. A recent study by Kukkonen et al[77] compared three different methods of treating symptomatic non-traumatic tears of the supraspinatus tendon in patients greater than 55 years of age. These patients either received physical therapy only, combined acromioplasty and physical therapy, or combined rotator cuff repair, acromioplasty and physical therapy. Of the 167 shoulders evaluated at one year, no differences were reported between any of the groups. Operative treatment was no better than conservative therapy with regard to management of non-traumatic supraspinatus tears, suggesting conservative treatment may be a worthy primary treatment method.

Moosmayer et al[5] compared non-operative treatment to surgical repair of rotator cuff tears less than 3cm in size. In this study, patient-reported clinical outcomes were significantly better at 12 months in the surgery group; however, of the 51 patients randomized to the therapy group, only nine patients (17%) failed treatment and elected to have surgery. At five years, another three patients elected to have surgery, meanwhile the sonographic five-year follow-up of 38 tears treated with physiotherapy alone showed tear size increases of >5 mm in 37% of tears which was associated with an inferior outcome. Moosmayer et al[78] in another study, observed the natural history of 50 patients with asymptomatic rotator cuff tears for three years. Eighteen tears developed symptoms during the period, and comparisons were made between tears that developed symptoms and those that did not. Their results showed a significant increase in the mean tear size, a higher progression rate of muscle atrophy, a significant rate of fatty degeneration, and a higher rate of pathology of the long head of the biceps tendon in the symptomatic group in comparison to patients with no clinical problems. These findings suggest that while non-operative treatment programs and patient education may be a viable initial option and alternative to surgery for many patients, tear size progression and structural deterioration over time may occur, predisposing these patients to symptom recurrence and functional depreciation. This emphasizes the importance of ongoing monitoring and surveillance.

PROGNOSTIC FACTORS

Itoi[41] proposed that those pursuing conservative treatment should consider both the potential responsiveness of the specific patient to conservative treatment as well as the potential for symptom recurrence. Better understanding of who will, or will not, respond well to conservative treatment prior to embarking on a course of conservative rehabilitation is of benefit to both the clinician and the patient. Some authors have described pertinent factors related to a successful outcome following conservative treatment for full-thickness rotator cuff tears. Itoi and Tabata[79] have previously demonstrated that patients who responded well to conservative therapy exhibited good range of motion and abduction strength at initial examination. As mentioned previously, tears spreading into the posterior cuff disrupt the balance of muscular forces, impacting GHJ stability and affecting optimal function.[39] Restricted range of motion in external rotation and tears extending from the supraspinatus to the infraspinatus tendon negatively affect the outcome following conservative treatment.[80] Tanaka et al[80] identified four factors that appeared to correlate well with a successful outcome following conservative treatment: 1) a preserved range of motion in external rotation (>52 degrees); 2) negative impingement signs; 3) little or no atrophy of the supraspinatus muscle, and; 4) a preserved intramuscular tendon of the supraspinatus. Treatment was successful in 87% of cases who presented with at least three of these four factors, suggesting that appropriate identification of these factors and patient stratification may be useful in selecting patients who will best respond to conservative treatment.

Currently, the duration of shoulder symptoms is used as an indication for the surgical treatment of full-thickness rotator cuff tears. Also, an increased duration of a full-thickness rotator cuff tear may contribute to increased tear size, fatty atrophy of the rotator cuff muscle and/or reduced active motion.[57] In a study on atraumatic, chronic rotator cuff tears by the Moon Shoulder Group,[57] no correlations were observed between the duration of symptoms and features of rotator cuff disease, including severity of the rotator cuff tear and muscle atrophy as measured by MRI, patient-reported pain, strength, range of motion and/or general wellbeing. This research would suggest that using duration of symptoms might not be the best clinical feature when deciding an appropriate treatment approach for patients with atraumatic, full-thickness rotator cuff tears. A commonly held view is that patients with chronic rotator cuff tears may develop symptoms when they are more active, or that a higher activity level contributes to the development of rotator cuff lesions. In patients electing initial non-operative treatment, Brophy et al[81] demonstrated that while shoulder activity level is correlated with age and gender in patients with symptomatic, atraumatic rotator cuff tears, it does not correlate with the size or severity of the tear, suggesting it may be possible that increased activity helps patients develop compensatory kinematics and strength, which may prevent or minimize symptoms.

The influence of tear size on the success of conservative management is not known. Bartolozzi et al[82] undertook a study of patients managed conservatively with symptomatic rotator cuff disease, and identified that full-thickness tears greater than $1 cm^2$ combined with symptoms persisting more than one year, and functional impairment and weakness were associated with a worse outcome. Some tears continued to increase in size, whereas many others remained dormant and did not show signs of propagation. Those that did increase in size typically did so gradually, with only a minority (18-49%) enlarging >5 mm in three years of surveillance. Large (3–5 cm) and massive (>5 cm) full-thickness rotator cuff tears generally benefitted from surgical intervention[83]. Nevertheless, some patients with massive tears reported functional and pain improvement with conservative treatment[84].

EXERCISE REHABILITATION PROGRAMS

The primary aim in treating a rotator cuff tear through conservative management is to reduce pain and improve function, and exercise rehabilitation is usually the cornerstone of this conservative management plan. Based on the available literature and the authors' clinical experience, a comprehensive exercise program for the conservative management of rotator cuff tears has been provided (Appendix 1). In a systematic review of conservative treatments for rotator cuff tendinopathy undertaken by Littlewood et al,[7] it was reported that exercise, whether completed at home or in a clinical setting, offered superior outcomes over no treatment or placebo, and did not differ in outcomes compared to surgery or multi-modal physiotherapy. This suggests that the exercise component of physical therapy is fundamental in the treatment of these tears, and most exercise protocols should demonstrate clinically important change in patient-reported outcomes by 12 weeks.[7] Similarly, in a systematic review, Ainsworth & Lewis[20] reported that based on the available literature, exercise therapy when included as part of a treatment program, provided a beneficial effect in patients with symptomatic, full thickness rotator cuff tears. While it is unknown exactly why exercise was beneficial, they postulated that the effect of exercise may be multi-factorial. This may include its potential influence on pain modulation, providing a therapeutic effect on the structurally damaged rotator cuff muscles and tendons, placebo, muscular compensation for deficient movement strategies, and reducing kinesiophobia and the patient's uncertainty if the arm should be moved. In addition, the term "mechanotherapy" has been coined to describe how controlled loading of tendons might stimulate tissue repair and remodeling. It is proposed that cells can respond to mechanical stimuli and convert the stimulus into a cellular response to promote tendon healing.[85]

The goal of exercise as part of the physical therapy regime is to correct modifiable physical impairments thought to contribute to pain and dysfunction, rather than to treat the pathology per se`. While the pathology of shoulder impingement syndrome and rotator cuff tears differ, the clinical presentation of both pathologies remains the same. Symptomatic rotator cuff tears are generally characterized clinically by pain with abduction (painful arc), as well as physical impairments including rotator cuff and scapular muscular weakness and dysfunction, tightness of the posterior capsule and other soft tissues, and postural abnormalities.[86] Thorough patient assessment including inspection and palpation, assessment of range of motion and strength, and provocative shoulder testing for possible impingement syndrome and GHJ instability are all essential to individually tailor an appropriate exercise intervention. The neck and the elbow should also be examined to exclude the possibility that the reported shoulder pain is referred from a pathologic condition in either of these regions. Restoration of full, pain-free range of motion, flexibility, muscle balance, and scapulothoracic and glenohumeral muscular control and stability, are all important goals of the rehabilitation. Initially, patients should be well educated on provocative postures and movements such as reaching overhead,[87] and appropriate advice and re-training be undertaken in avoiding or minimizing the occurrence of any aggravating activities. Exercises to improve shoulder girdle and GHJ range of motion are generally required to facilitate optimal motor patterning. Pendulum exercises (Figure 2) are effective in improving GHJ motion, initiated passively though progressing as tolerated toward active-assisted exercises, which are commonly performed with a bar or wand (3A and 3B) and the assistance of the uninvolved arm (Figure 4A and 4B).

It is well accepted that training and educating patients on improving scapular stability, proper neuromuscular control of shoulder girdle and thoracic posture is essential in a well designed rotator cuff exercise program. Potential contributing mechanisms to abnormal scapular kinematics include pain, soft tissue tightness, altered muscle activation or strength imbalances, muscle fatigue, and thoracic posture.[88] Therefore, before beginning a strengthening program, it is important to identify muscles which appear tight or short, and ensure flexibility is restored. Tightness of the pectoralis minor and posterior glenohumeral capsular stiffness has been described in relation to abnormal scapular position.[89] Increased scapular internal rotation, as well as increased anterior tilting, has been

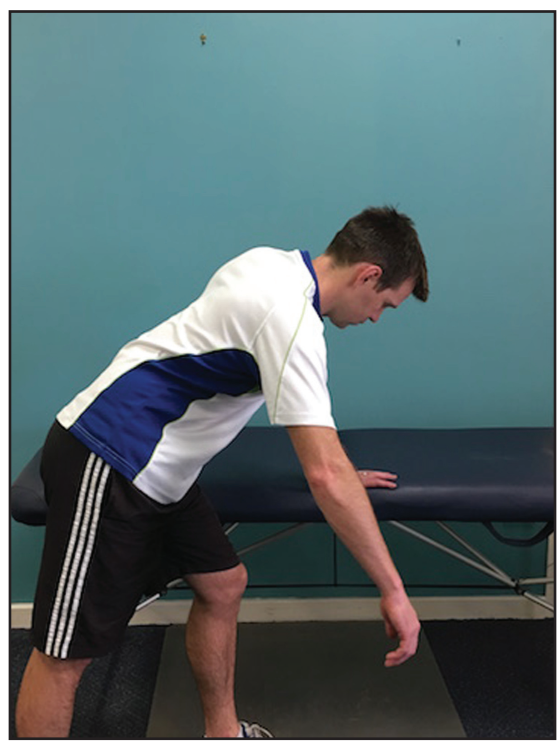

Figure 2. *The pendulum exercise*

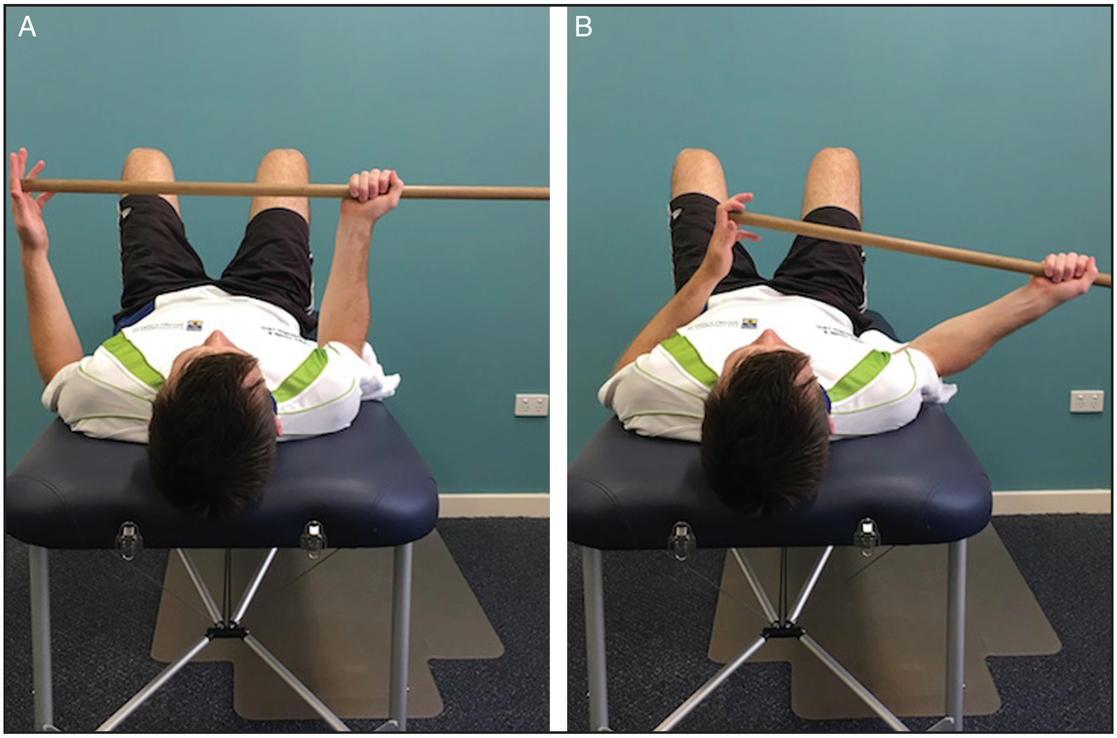

Figure 3A and 3B. *Active-assisted external rotation using a bar powered by the non-affected arm to generate movement*

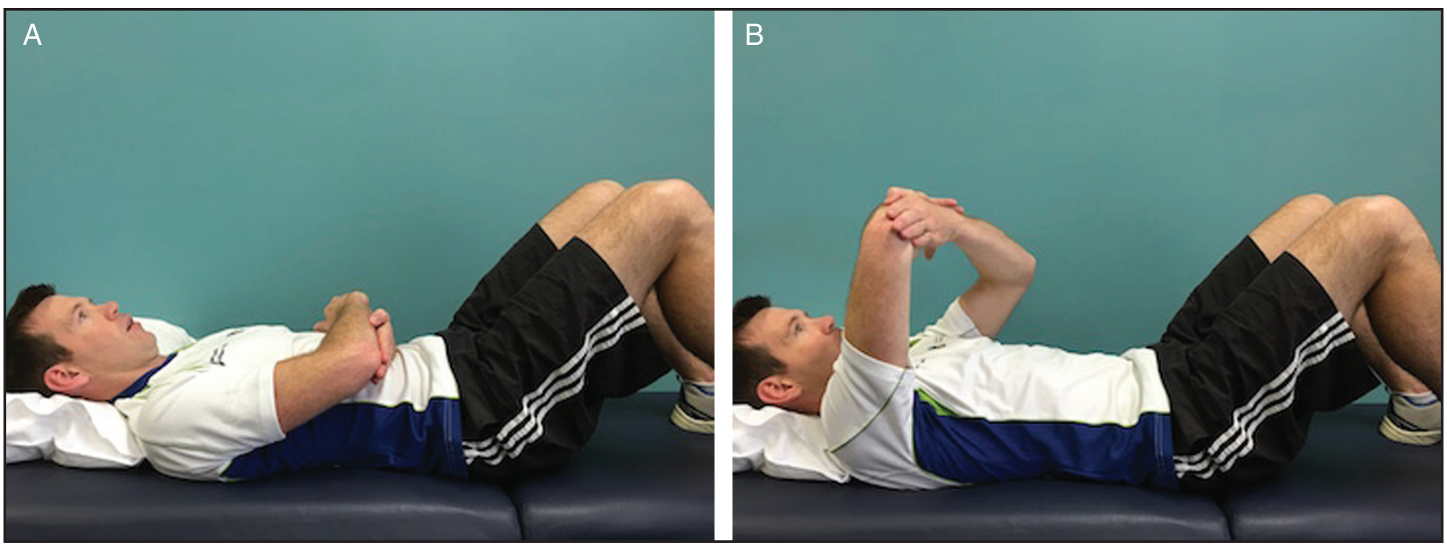

Figure 4A and 4B. *Active-assisted supine elevation, using the the non-affected arm to generate movement*

demonstrated in healthy individuals with a short pectoralis minor, while patients with posterior shoulder stiffness, have been found to have greater scapular anterior tilt compared to subjects with the normal glenohumeral internal rotation range of motion.[89,90] Decreased GHJ internal rotation range of motion and anterior tilting is often observed in shoulder pathologies.[91-93] Exercises that stretch the posterior cuff (Figure 5) and pectoralis minor (Figure 6), and reduce upper trapezius activation, are recommended to improve soft tissue tightness and allow for optimal scapular motion.

Altered scapulohumeral rhythm, due to either fatigue or weakness of the scapular stabilizers, can induce shoulder dysfunction with an associated decrease in

Figure 5. *Cross-body stretch for the posterior capsule*

Figure 6. *Anterior capsule / pectoralis minor stretch using a door-frame*

rotator cuff strength.[2] The muscles acting as scapular stabilizers ensure the scapula remains a stable basis from which the rotator cuff muscles can act, and adjust the glenoid fossa in relation to the humeral head during upper limb movements.[94,95] In patients exhibiting rotator cuff tears and/or subacromial impingement, altered muscular activity or strength, and changes in the timing properties of the serratus anterior the upper, middle and lower portions of the trapezius are frequently observed.[89,96] Specifically, it has been consistently shown that decreased serratus anterior strength, hyperactivity and early activation of upper trapezius, and decreased activity and late activation of middle and lower trapezius are present in patients with shoulder pain and pathology.[89,97] Rehabilitation exercises addressing these altered shoulder complex kinematics to better stabilize and synchronize scapular movements, can increase the capacity of the rotator cuff muscles to stabilize the glenohumeral joint.[98]

Exercise rehabilitation programs aimed at restoring scapulohumeral rhythm have frequently targeted the serratus anterior, middle and lower trapezius, while reducing the muscle activity of upper trapezius to enhance neuromuscular control and synchronised movement during elevation. A moderate level of muscle activation is adequate to retrain neuromuscular control for scapula and glenohumeral musculature, especially in the initial phases of rehabilitation.[99] In the early stages of rehabilitation, conscious neuromuscular control of the scapular muscles may be necessary to improve proprioception and to normalize the scapular resting position, followed by advanced neuromuscular control and scapular co-contraction, in both open and closed-chain settings.[89] Kibler et al[99] identified specific exercises for scapular control in the early to middle phases of shoulder rehabilitation, including the 'low row' (Figure 7), 'lawnmower' and 'robbery' exercises, which activate the key scapular-stabilizing muscles, including the rhomboid, without putting high demands on the GHJ joint. Specific strengthening exercises of the serratus anterior, typically include 'supine protractions' and 'wall push-up' exercises, and are be beneficial in the early stages of rehabilitation[89] while dynamic hugs and push-up varieties are commonly utilized in later stages of rehabilitation.[100,101] Cools et al[102] suggested exercises that promote high middle and lower trapezius activation and minimal upper trapezius participation (i.e a high middle/lower to upper trapezius ratio), are preferable in shoulder complex rehabilitation programs These exercises include side lying external rotation (Figure 8), side lying forward flexion, prone horizontal abduction with external rotation and prone extension (Figure 9), which also show high EMG activity in the rotator cuff muscles, particularly the infraspinatus and teres minor.[103-105]

Understanding the impact that cuff tears have on shoulder complex function and muscle activation patterns can contribute to designing a restorative exercise rehabilitation program. Strengthening of the rotator cuff muscles is important to provide accurate positioning and stabilization of the humeral head in the glenoid fossa, preventing excessive elevation of the humerus, which may cause impingement and compression of the tendon against the coraoacromial arch. Translation of the humeral head relative to the glenoid fossa occurs in healthy shoulders and is maintained within normal limits by the coordinated activity of the rotator cuff muscles.[106] However, when the rotator cuff is torn, this disrupts the glenohumeral fulcrum, leading to abnormal superior translation of the humeral head on the glenoid fossa during arm elevation as the destabilizing force generated by the deltoid muscle is unchallenged.[107,108] Furthermore, the torn supraspinatus can no longer develop an abduction torque at the GHJ; therefore, the deltoid may be required to perform additional work in a compensatory manner during arm elevation.[109] An EMG study by Hawkes et al,[108] demonstrated the reorganization of muscle activation strategies that occur in the upper limb kinetic chain following a rotator cuff tear. Increased activity of the scapula stabilizers and elbow flexor muscles has been reported representing a tactic within proximal and distal segments to reduce demand on the GHJ. They specifically demonstrated increased activation of the latissimus dorsi and teres major muscles, as a partial compensation for the deficient rotator cuff by balancing the destabilizing forces of the deltoid. This has led to the hypothesis that alternative muscle activation strategies can compensate for the deficient rotator cuff to limit the superior migration of the humeral head and establish a stable glenohumeral fulcrum for arm movement.[37,108-110]

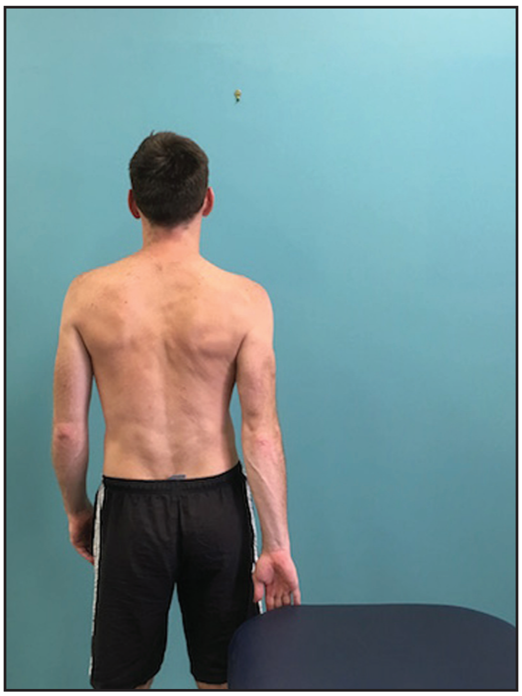

Figure 7. *Low row exercise as described by Kibler et al[99]*

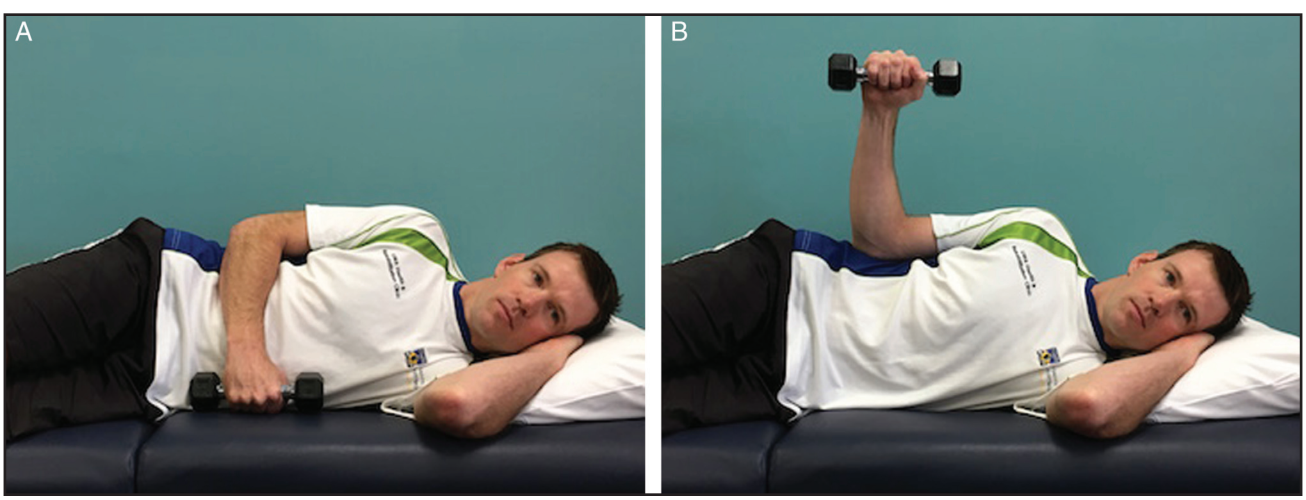

Figure 8A and 8B. *Side-lying external rotation*

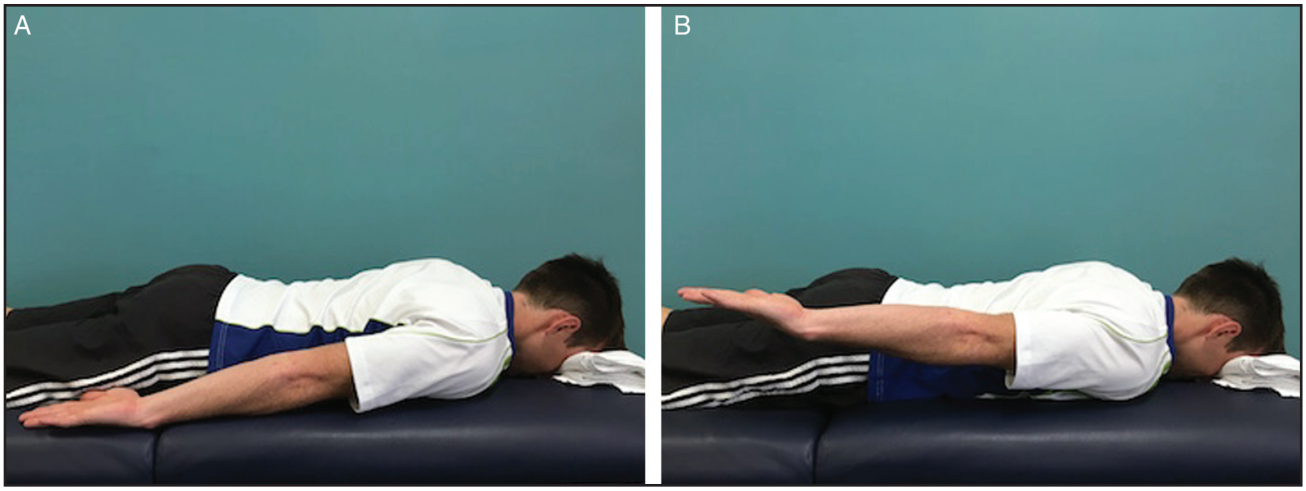

Figure 9A and 9B. *Prone shoulder extension*

Strength-based exercises for rotator cuff tears should appropriately target the remaining intact cuff musculature, initiated with low load activities and progressing as patient comfort permits. In massive rotator cuff tears whereby the supraspinatus and infraspinatus are deficient, the teres minor becomes important in maintaining active external rotation, and should be a focus for the rehabilitation in massive cuff tears. The teres minor muscle provides 20% to 45% of the external rotation power to the glenohumeral joint and retains the power in large and massive tears involving the infraspinatus tendon, as it usually remains intact even in large or massive rotator cuff tears[111]. Exercises that show high EMG activity in the rotator cuff muscles, and in particular the teres minor, include side-lying external rotation (Figure 8), external rotation at 0° and 90° of abduction, and prone external rotation in 90° of abduction.[103-105]

Retraining and strengthening of the anterior deltoid has also been a focus for massive cuff tear patients. In a pilot study, Ainsworth et al[112] proposed a progressive strengthening program for massive rotator cuff tear patients aimed at the anterior deltoid and teres minor muscles, and demonstrated improvements in pain and function after 12 weeks of training. The program was based upon the observation that patients with massive rotator cuff tears utilized the anterior portion of deltoid in order to achieve elevation without upward shearing of the humeral head. Patients progress from supine shoulder flexion (Figure 10), to inclined shoulder flexion (Figure 11) to upright shoulder flexion (Figure 12). Furthermore, the authors observed that patients who had active external rotation, fared better than those who struggled to activate lateral rotation, despite dysfunction of the infraspinatus, and hypothesized teres minor was recruited better in these patients in order to improve their external rotation function enough to enable the greater tuberosity of the humerus to clear the undersurface of the acromion during elevation. Ainsworth et al[113] followed this up with a prospective randomized controlled trial, comparing outcomes between patients with diagnosed massive rotator cuff tears who underwent physiotherapy combined with a comprehensive exercise program, versus physiotherapy without exercise. The exercise program focused on active anterior deltoid strengthening, teres minor strengthening for active external rotation, scapular stability and control exercises, patient education, adaptation, proprioception, and a home exercise program. Both groups demonstrated an overall improvement; however, patients receiving exercise reported a greater and faster improvement compared to those who did not receive exercise. These results were supported by Levy et al,[114] who found that a deltoid muscle rehabilitation regimen was effective in improving function and pain in 17 elderly patients with massive cuff tears, up to at least nine months after starting rehabilitation.

While efficacy of exercise has been demonstrated, optimal dosage remains unknown. Studies reporting favorable outcomes with exercise in people complaining of shoulder pain, generally utilized three

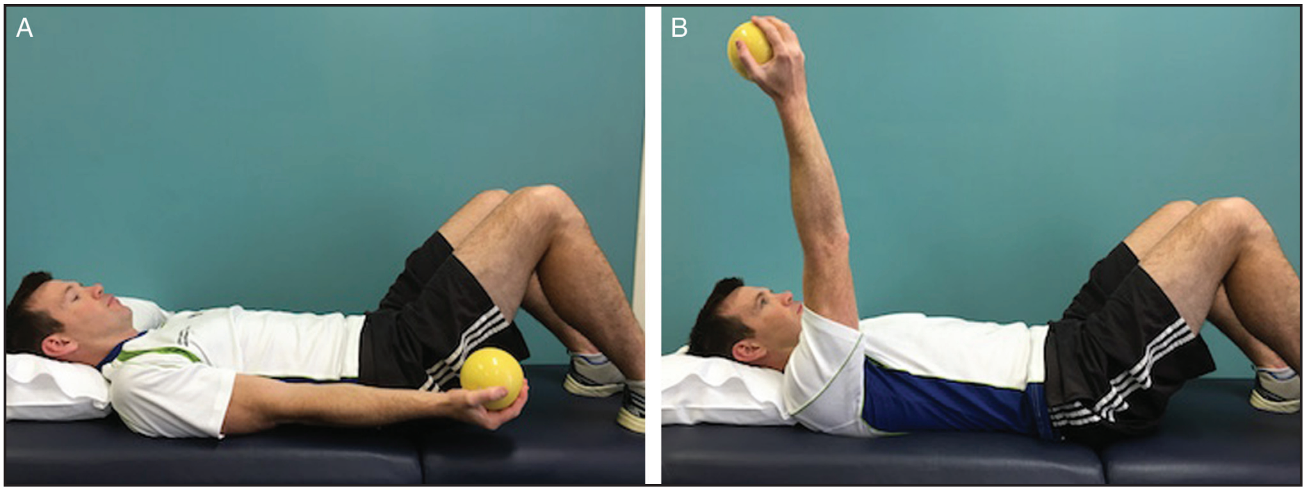

Figure 10A and 10B. *Supine shoulder flexion*

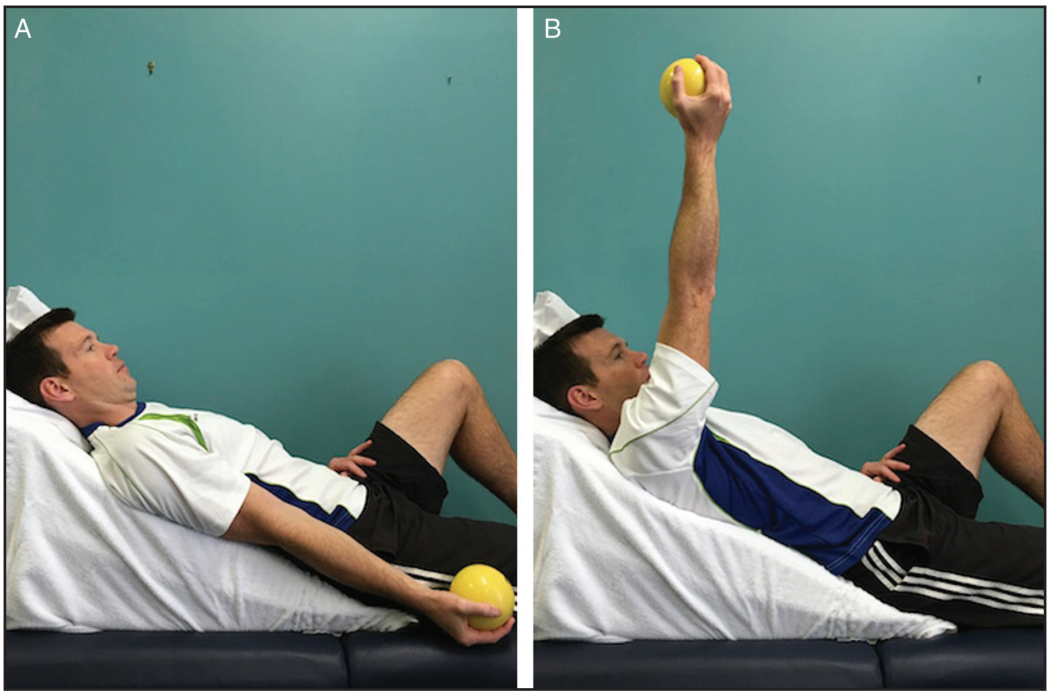

Figure 11A and 11B. *Incline shoulder flexion*

sets of 10-15 repetitions completed twice per day as the recommended dose.[3,95,115,116] It is also recommended that exercise be performed and progressed in the complete absence of pain, as well as during minor discomfort, as recommended by the pain monitoring model,[117] which has been successfully used in earlier studies that included patients with tendinopathy to ensure that the exercise treatment was well tolerated by the patients.[95,117,118] It has been reported that an exercise intervention should be maintained for at least 12 weeks in order to demonstrate clinically significant outcomes,[119] though uncertainty exists over how long to undertake conservative care before seeking a surgical opinion. Recommendations have ranged from 3-18 months.[20,82,120]

SUMMARY

Tendinopathy and tears of the rotator cuff are age-related and commonly degenerative pathologies that can impact an individual's quality of life, and lead to surgical intervention. The economic and social burden associated with symptomatic rotator cuff tears is substantial, and population trends indicate this burden will progressively worsen. The role

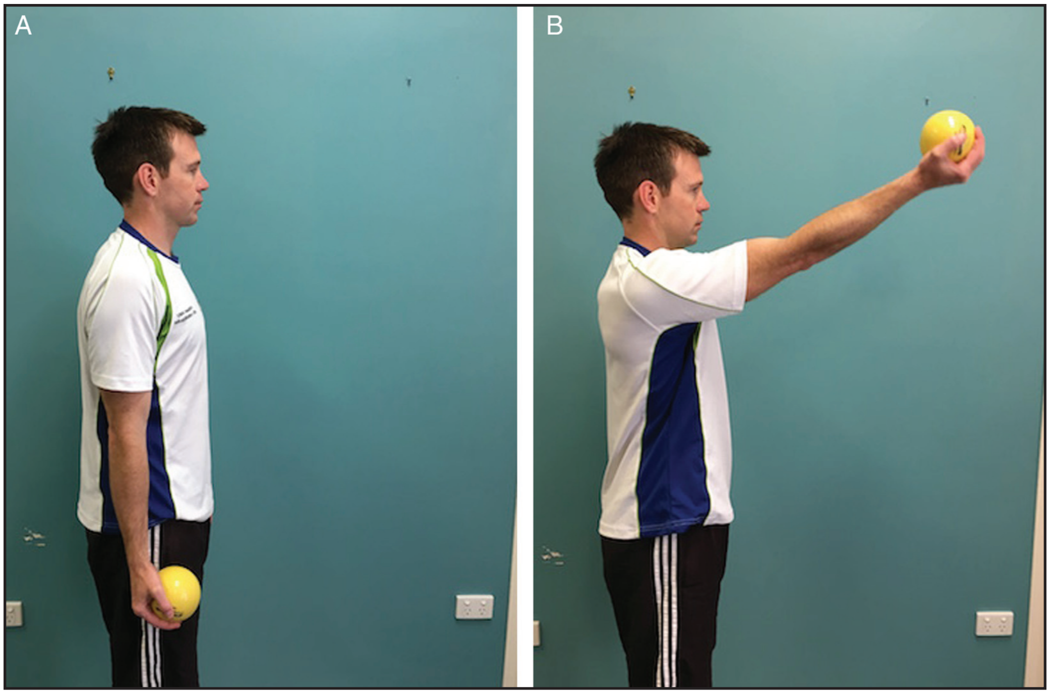

Figure 12A and 12B. *Standing shoulder flexion*

of exercise in treating rotator cuff tears has become increasingly popular as a means to treat and manage partial and full thickness tears of the rotator cuff, by addressing weakness and functional deficits that are commonly present in patients with symptomatic shoulders. Prolonged exercise rehabilitation and non-operative treatment should be considered in patients with rotator cuff tendinopathies, partial-thickness tears and potentially small full-thickness tears. Younger patients with acute tears >1cm will likely respond well to operative intervention, while older patients (> 65 years) with chronic, full-thickness tears and associated muscle atrophy and fatty infiltration will not, and instead respond better to an initial course of exercise rehabilitation. According to reports in the literature, conservative treatment is effective in 73–80% of patients; however, not all patients will respond favorably or quickly. When opting for conservative treatment, it is important to understand that the responsiveness of patients and symptom recurrence will determine the potential for a successful outcome of exercise rehabilitation.

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APPENDIX 1

Evidence-based exercise protocol for the conservative management of rotator cuff tears.

Phase	Goals	Exercises	Dose	Progression

Range of Motion (ROM)	1. Improve glenohumeral motions (forward flexion, abduction & external rotation)
	2. Improve shoulder and thoracic posture
		• Passive ROM (PROM)
		  • Forward flexion, internal / external rotation
		  • Pendulum (Figure 2)
		• Posture
		  • Postural education
		  • Scapula setting exercises
		• Active-assisted ROM (AAROM)
		  • Wand exercises: elevation, abduction, adduction, internal / external rotation (Figure 3)
		  • Pulley-assisted elevation
		• Active ROM (AROM)
		  • Wall slides
			3 x 15 reps, daily	• ROM should begin with PROM and pendulum exercises, progressing to AAROM & AROM as comfort dictates

Flexibility	1. Improve flexibility and reduce tightness of anterior and posterior capsule	• Anterior capsule (pectoralis minor) stretch
		  • Supine bear hugs
		  • Door frame stretch (Figure 6)
		• Posterior capsule stretch
		  • Cross-body stretch (Figure 5)
		  • Towel stretch
		• Upper trapezius stretch
			5 x 30sec stretches,daily	N/A

Strengthening	1. Improve strength of the scapular stabilizing muscles and dynamic scapular control
	2. Improve strength of the anterior deltoid for shoulder elevation
	3. Improve active external rotation strength
		• Isometric low rows (Figure 7)
		• Scapula retraction / rows
		  • Prone scapula retractions (squeezes), prone shoulder extension (Figure 9)
		  • Bent over rows, seated / standing (elastic resistance)
		• Scapula protractions / presses
		  • Supine scapula protractions
		  • Upright wall scapula protractions / retractions, wall push-ups
		  • Quadruped scapula protractions
		  • Standing scapula presses with elastic resistance
		• Anterior deltoid strengthening
		  • Isometric deltoid contractions
		  • Shoulder flexion: supine (Figure 10), inverted (Figure 11) and standing (Figure 12)
		• External Rotation
		  • Standing, 0° abduction with elastic resistance
		  • Side lying with dumbbell (Figure 8)
		• Internal Rotation
		  • Standing, 0° abduction with elastic resistance
		  • Side lying with dumbbell
			3 x 15 reps per exercise, 3 – 4 times per week	• Strengthening is undertaken within limits of pain.
				• Increase volume and load, as comfort, strength and tolerance dictate.
				• Patients exceeding appropriate discomfort level should reduce the level of resistance

Strengthening / proprioception (Advanced)	1. Advance strengthening of the scapular stabilizers
	2. Advance strengthening of the rotator cuff
	3. Introduce work / sport-specific exercises
		• Scapula protractions / presses
		  • Upright Fitball push-ups, push-ups on ground
		  • Standing cable press
		  • Dynamic hug exercise
		• Scapula retractions / rows
		  • Standing cable row
		• External Rotation
		  • Seated & standing 9o° abduction (dumbbell & elastic resistance)
		  • External rotation in 90° prone horizontal abduction
		• Internal Rotation
		  • Standing, 9o° abduction (elastic resistance)
			3 x 15 reps per exercise, 3–4 times per week	• Strengthening is undertaken within limits of pain.
				• Increase volume and load, as comfort, strength and tolerance dictate.
				• Patients exceeding appropriate discomfort level should reduce the level of resistance