Management of full-thickness rotator cuff tears in the elderly: a systematic review

Michael Nganga
Master of Clinical Science
Joanna Briggs Institute
Faculty of Health and Medical Sciences
The University of Adelaide
South Australia, Australia

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Abstract

Introduction: Full-thickness rotator cuff tears are increasingly becoming more prevalent in the elderly community. The management of this condition in this age group may be different from the approach used for the younger population due to differences in aetiology and pathogenesis. The objective of the systematic review described in this thesis was to systematically review the best available evidence on the effectiveness of non-surgical and surgical treatment on the clinical and functional outcomes of elderly patients (60 years of age and over) with full-thickness rotator cuff tears.

Methods: A systematic review using the JBI methodology for quantitative systematic reviews was applied in this study. The review considered randomised controlled trials and cohort studies that investigated the effectiveness of non-surgical and/or surgical treatment in elderly patients (60 and older) with confirmed full-thickness rotator cuff tear. Outcomes considered included pain, range of motion, muscle strength, rotator cuff integrity, shoulder function, patient satisfaction with treatment and health-related quality of life. The search for relevant published studies was conducted in CINAHL, Scopus, MEDLINE, EMBASE, Web of Science and PEDro; for unpublished studies, the following databases were searched: ProQuest Dissertations and Theses, Clinicaltrials.gov, Cochrane Central Register of Controlled Trials, ANZCTR and ICTRP. Eligible studies for inclusion in the review were critically appraised using standardised JBI critical appraisal instruments; studies were included regardless of their methodological quality. Data were extracted from included studies using the JBI standardised data extraction tool. Meta-analysis, where appropriate, was conducted in addition to a narrative synthesis.

Results: A total of 22 articles were included in this review; 14 were single cohort studies, four were comparable cohort studies and four were randomised controlled trials. The overall quality of the randomised controlled trials was poor, however, for the single cohort and comparable cohort studies, methodological quality was considered moderate. The majority of included studies (n=21/22) investigated surgical interventions, with only one study examining the effect of a conservative treatment. Results of this review suggest that, following an initial management with conservative strategies, surgical interventions were effective in improving outcomes associated with full-thickness rotator cuff tear in the elderly. Surgical procedures such as arthroscopic repair with palliative procedure/s, open repair, or mini-open repair of full-thickness rotator cuff tears can lead to positive postoperative clinical and functional outcomes in the elderly, in the short term. When compared to arthroscopic palliative procedures only, arthroscopic repair demonstrated greater improvements postoperatively. There was limited data regarding the effectiveness of conservative interventions.

Conclusion: This systematic review suggests that patients 60 years and above with a full-thickness rotator cuff tear who do not respond adequately to conservative management may be referred for surgery. However, the best approach to surgery remains unknown. Future research should focus on clinical trials that evaluate the effect of conservative interventions and also head to head comparisons of the different types of surgical interventions. Longer follow-up times for outcome measurements should also be considered in future trials to determine the long term effectiveness of surgical interventions.

Declaration

I, Michael Nganga, certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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Chapter 1

This chapter describes the context of the review, specifically, the anatomy of the rotator cuff and how it assists in the functioning of the shoulder, the different types of rotator cuff tears and their mechanism of injury. In addition, the prevalence and outcomes of rotator cuff tears, diagnosis and clinical assessment, the various surgical and non-surgical treatment options, and current practices in the management of rotator cuff tears are discussed. This chapter also provides the rationale for the systematic review, including the objectives of the review.

1.1 Anatomy and function of the Rotator Cuff

The rotator cuff was initially described in the 1900's as consisting of the rotator cable and rotator crescent.[2] The rotator cable is a semilunar arch that originates from the rotator/biceps tendon and ends between the infraspinatus and teres minor insertions.[2] The cable forms a semicircular arch around the adjacent rotator crescent, fibres of which are perpendicular to the axis of the supraspinatus tendon.[2] The rotator cuff is comprised of four muscles (shown in Figure 1) which function as dynamic stabilizers of the shoulder joint. These include the supraspinatus muscle superiorly, subscapularis muscle anteriorly, and the infraspinatus and teres minor muscle posteriorly. These muscles terminate in broad, flat tendons which integrate with the fibrous capsule of the glenohumeral joint forming a musculotendinous mass on all sides the glenohumeral joint except at the inferior quadrant.

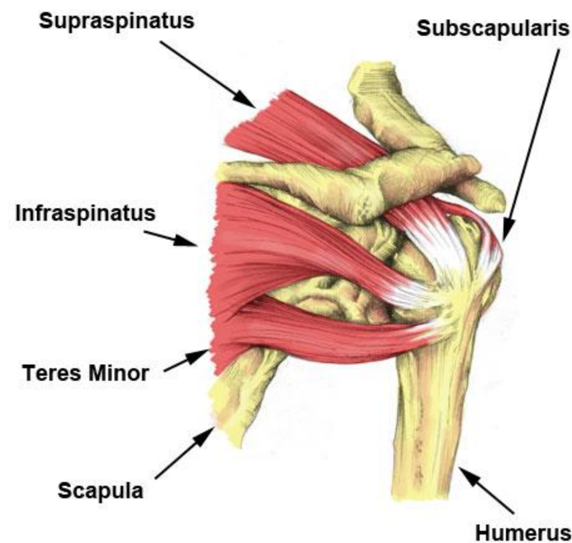

Figure 1: Rotator Cuff Muscles;
Source: sportsinjuryclinic.net[1]

The rotator cuff complex of the shoulder performs several functions. One of the primary functions of the rotator cuff is to work synergistically with the deltoid to maintain a balanced force couple around the glenohumeral joint.[3] A force couple can be defined as a pair of forces that act on an object to produce a coordinated movement.[3] The force couple between the rotator cuff and the deltoid muscle operates in conjunction with other muscles in the shoulder to allow movements such as rotation. The glenohumeral joint is highly mobile and has a shallow joint cavity, which makes the shoulder vulnerable and unstable, requiring anatomical structures to provide stability. The rotator cuff acts as a dynamic stabilizer, and along with the static stabilizers such as the capsule, glenoid labrum and glenohumeral ligaments, they collectively provide stability to the shoulder joint across the glenoid.[4] The rotator cuff force across the glenoid provides concavity compression which creates stability and allows the periscapular muscles to move the humerus around the glenoid.[3, 5]

1.2 Rotator Cuff Tears: Types

The earliest description of a torn rotator cuff appeared in 1788, with Alexander Monro describing a tear in the supraspinatus and infraspinatus in his book "A Description of all the Bursal Mucosae of the Human Body." Rotator cuff tears are often classified into partial-thickness tears and full-thickness tears. Tearing can begin as a partial tear, which can then progress to full-thickness tearing that may eventually lead to a massive tear. Partial-thickness tearing is tearing of only a part of any of the muscles that comprise the rotator cuff. The prevalence of partial thickness rotator cuff tears ranges from 15-32% in the general population[6]. Patients with less than 55% tendon involvement had a 14% chance of tear progression, whilst patients who had 50% or greater tendon involvement progressed 55% of the time towards further tearing.[6] A Grade 1 partial tear is less than 3mm deep, but definite disruption of tendinous fibres can be identified. Grade 2 partial tears are 3-6mm deep and extend into the cuff, but does not exceed one-half of the thickness of the tendon. Grade 3 partial tears are more than 6mm deep and exceed one-half of the thickness of the tendon. When partial-thickness tears tear further, it leads to full-thickness tearing. Increase in size typically happens gradually, with 18-49% enlarging >5mm in three years of observation.[2] Full-thickness tearing is the complete removal of the tendon from the bone.

Full-thickness tears can be classified further as small, medium, large or massive tears. Small tears are tears which are less than 1cm, medium tears are classified as tears between 1cm and 3cm, large tears are tears between 3cm and 5cm and massive tears are tears greater than 5cm. Enlargement of tears can occur as a result of increasing symptoms and advanced age.[2] If not treated or treatment is delayed, full-thickness tearing can cause further damage leading to massive rotator cuff tears. Massive rotator cuff tears have been described as a tear with a

diameter of 5cm or more or as the complete tear of two or more tendons.[3] In massive cuff tears, the long head of the biceps tendon is often displaced.

The most common type of rotator cuff tears are the posterosuperior tears, composed of the supraspinatus and infraspinatus tendons.[7] Posterosuperior tears come in a variety of patterns[8]. These can include crescent tears, accounting for 40% of tears, L- and reverse L-shaped tears, accounting for 30% of tears and U-shaped tears, accounting for 15% of tears.[8] Crescent shaped tears present a medial retraction, beginning near the long head of the biceps tendon and arching medially and posteriorly for 2-3cm. Reverse L-shaped tears show the supraspinatus tear extending medially through rotator cuff interval in line with the long head of biceps tendon. L-shaped tears occur when the supraspinatus tear has extended through junction with infraspinatus, producing an anteromedial displacement. Trapezoidal tears result when both supraspinatus and infraspinatus are torn and the tear extends anteriorly along the rotator interval and posteriorly into the interval between the infraspinatus and teres minor.

1.3 Aetiology and pathophysiology of Rotator Cuff Tears

Rotator cuff tears are a common clinical condition in the older population. The aetiology of rotator cuff tear in an elderly person is often very different from that of someone who is younger.[9] In the elderly, the pathogenesis is multifaceted, including microtrauma and degeneration due to advanced age, and overuse leading to progressive tendionopathy.[9, 10] Most cases have been found to be atraumatic at onset.[9] There is a high percentage of full-thickness tears that progress from asymptomatic to symptomatic tears, even without specific inciting incidents.[9] The trend of progression involves tendinopathy, evolving into partial thickness tears and ending with full-thickness tearing.[11] In older people, the progression of partial-thickness tears to full-thickness tears is common, and typically leads to the development of muscle retraction, fatty infiltration and muscle atrophy.[12] If left untreated,

rotator cuff tear size can increase over time with additional tendon retraction and irreversible muscle atrophy.[13]

1.4 Burden of Disease

Rotator cuff tears have been shown to affect 20-28% of people aged 60-69, 31-40.7% in individuals older than 70, and 51-62% in individuals over 80 years.[12] Patients older than 60 or 65 years of age are more likely to have larger tears and those older than 70 would also have reduced tendon and bone quality.[14] Although many will remain asymptomatic, more than a third of the elderly population with full-thickness rotator cuff tear will develop symptoms over time.[9] Up to 35% of patients will progress to develop pain and be unable to perform activities of daily living.[15] These symptoms can occur at a mean of 2.8 years following initial discovery.[12] Regardless of whether the tear is symptomatic or asymptomatic, patients with full-thickness tears have significantly decreased shoulder function compared to those individuals without rotator cuff tears.[9] Impaired ability to perform activities of daily living is also common.[9] Rotator cuff tears have been associated with higher scores on the Disabilities of the Arm, Shoulder and Hand (DASH), which indicate a greater level of disability and severity of injury.[16]

Patient-reported outcomes scores suggest that shoulder dysfunction is associated with a compromise in an individual's health status similar to that seen in other medical diseases including congestive heart failure, acute myocardial infarction, diabetes mellitus, and clinical depression.[17] Rotator cuff tears can also increase the cost associated with healthcare utilisation and lead to a significant economic burden. For patients over the age of 61 years, societal costs for surgery surpasses those for non-operative treatment, indicating negative societal savings.[18]

1.5 Clinical Assessment and Diagnosis

In the 1990's, diagnosis of rotator cuff tears was made using arthrography, during such time magnetic resonance imaging (MRI) and ultrasound were still not widely available.[19] Years later, physical examinations, such as a positive painful arc and positive external rotation lag test, became important diagnostic considerations.[20] In recent years, imaging technologies including ultrasound, MRI and magnetic resonance arthrogram became available and are considered to provide the most accurate diagnosis of the condition.[20]

Current practice on assessment typically involves a clinical history and physical examination, consisting of pain and irritability assessment, evaluation of range of motion and muscle strength, and functional tests.[11] Clinical assessment begins with the physical examination of the rotator cuff;[21] atrophy of shoulder muscles are a common finding in patients with rotator cuff tears.[22] Patients may feel shoulder discomfort due to subacromial impingement. The scapular motion of the thorax is then examined from the back of the patient.[22] During the physical examination the passive range of motion of the affected shoulder and scores of various scoring assessments are recorded.[21] Scoring systems include the American Shoulder and Elbow Surgeons (ASES) score, Visual Analogue Scale (VAS), or the Constant Shoulder Score (CSS).[21] Torn rotator cuff tears are then confirmed using an MRI.[23]

1.6 Treatment Approaches for Full-Thickness Rotator Cuff Tear

Rotator cuff tear management aims to relieve pain, restore movement and improve function of the shoulder. Management of full-thickness rotator cuff tears can broadly be divided into surgical and non-surgical treatment.

1.6.1 Surgical Techniques

As the average life expectancy increases, the demand for surgical treatment of rotator cuff tears is growing, specifically in elderly patients who want to remain active.[23] Surgical

treatments for full-thickness rotator cuff tears include open repairs, mini-open repair, arthroscopic repairs and reverse shoulder arthroplasty.

Attempts of surgical repair were very rare before the beginning of the nineteenth century.[24] In 1911, a surgical technique to repair supraspinatus tendon was performed in the US and this was considered an important milestone in rotator cuff surgery. Following this, advances in open surgical techniques occurred in order to repair more complex lesions.[24] During this time, many open fixation techniques were used, among these the transosseous repair was considered the gold standard.[24]

Traditionally for an *open rotator cuff repair,* a 3- to 6-cm incision is made over the anterior-superior aspect of the shoulder, parallel to the lateral border of the acromion, in the direction of Langer's lines.[24] The patient is in a beach-chair position and after examination of the deltoid insertion, the muscle is detached from the acromion. Subacromial decompression (also known as acromioplasty/bursectomy), bursal resection and debridement of adhesions from the tendon are then undergone.[24] Resection of the bursa leads to a better visualization of the rotator cuff.[25] After identifying the leading edge of the tendon, debridement of adhesions is undergone to help mobilize the tendon to the greater tuberosity.[25] Following this, bone preparation is performed by using a burr osteoma, forming a trough as long as the exposed bone of the greater tuberosity.[24, 25] A suture is passed through the bony tunnels and through the torn tendon where it is then stitched.[24] The deltoid is then reattached to the acromion. Deltoid reattachment to the acromion is a significant component of open rotator cuff repair, which can have specific implications for postoperative rehabilitation.[25] Despite satisfactory results with open rotator cuff repair, the procedure is also associated with a longer recovery

period.[25] This has led to the introduction of arthroscopic techniques, which is considered one of the most significant milestones in rotator cuff surgery.

In 1990, Levy introduced the arthroscopically-assisted rotator cuff repair known as the 'mini-open' rotator cuff repair.[24, 25] *Mini-open repair*, in its early stages, used arthroscopy to perform a subacromial decompression and avoid deltoid removal.[25] In the mini-open repair, the arthroscopic portal is extended by 1 to 2 cm, and the fibres of the deltoid are split in line to obtain access for secure bone- to-tendon fixation.[25] Due to the procedure being done arthroscopically, both the time requirement and exposure for the deltoid-splitting approach are limited, potentially minimizing any deltoid injury.[25] This type of procedure paved the way for all-arthroscopic techniques.

Arthroscopic rotator cuff repair is another popular treatment option among rotator cuff tears due to its minimally invasive technique. Arthroscopic rotator cuff repair can be performed in either a beach-chair or lateral decubitis position.[24] After identification of the clavicle, acromion, and spine of the scapula, all arthroscopic portals are marked, and a 1 cm longitudinal incision is made.[25] After traction is performed, a standard posterior and antero-superior portals are created.[24] A 5-6mm cannula is placed through the incision of the anterior portal into the glenohumeral joint.[25] Through these portals, a variety of instruments can be introduced into the shoulder to assemble the cuff, implant suture anchors, and tie arthroscopic knots to hold the torn tendon to bone.[25]

In order to repair supraspinatus lesions, the first arthroscopic repair used either a single anchor or a row of anchors positioned from anterior to posterior and implanted a few millimetres lateral to the tendon footprint.[24] This technique became known as the single-row repair. The partial repair is a repair of the subscapularis and infraspinatus tendons, without

supraspinatus repair, which is enough to restore a force couple that stabilizes the humeral head.[24] Both the single-row repair and partial repair remain of interest in the fixation of torn rotator cuffs. In addition, double-row repair has become popular due to the use of a combination of suture anchors placed medially along the anatomic neck and laterally placed bone tunnels to secure a larger surface of tendon to bone.[25] As a result, which fixation method is best for rotator cuff repair is often deliberated.

Studies have reported that bony spurs at the anterior and lateral edges of the acromion have led to 95% of rotator cuff attritions and tears.[26] Because of this, subacromial decompression or acromioplasty, with or without arthroscopic repair, has also become a treatment option for individuals with full-thickness rotator cuff tears. Arthroscopic acromioplasty has increasingly been performed by surgeons due as it allows concomitant visualization of the glenohumeral joint, preservation of the deltoid muscle, improvement of subacromial sight and quick recovery time.[27] The procedure aims to remove the subacromial bursa, as well as any osteophytes on the under surface of the acromion, which can lead to impingement and bursal sided rotator cuffs.[28] Acromioplasty surgeries had an approximate growth of 250% from the mid 90's to mid-2000's, confirming the surgeons certainty in the efficacy of subacromial decompression.[29] However, it is debated now whether functional outcomes are improved with or without acromioplasty.[30, 31]

Although arthroscopic repairs appear to be the most popular technique for full-thickness rotator cuff tears, another surgical technique has also been reported in the literature. The reverse shoulder arthroplasty is becoming another promising strategy to treat irreparable tears in older patients with rotator cuff tears. *Reverse shoulder arthroplasty* began to gain attention in 1985.[32] This procedure involves the use of a prosthesis which utilizes the deltoid

function and establishes improved kinetics when there is considerable rotator cuff dysfunctions or absence of tuberosities healing.[33] The standard surgical approach for the reverse shoulder arthroplasty has been either the deltopectoral approach or the anterosuperior approach.[33] The deltopectoral approach aims to save the deltoid, whereas the anterosuperior approach uses a more limited superior incision by the deltoid split.[33] The deltoid is split between its anterior and middle thirds, starting at the anterolateral corner and extending distally up to 4cm.[33] Using this technique there is exposure of the glenoid, better access to the tuberosity and the ability to preserve the subscapularis tendon in addition to reducing the risk of dislocation.[33] Both approaches however, have disadvantages. The deltopectoral approach with regards to visualization and instrumentation of the posterior glenohumeral structures, can be difficult from an anterior approach making the exposure and reduction of the tuberosity or the implantation of the base plate a difficult procedure.[33] With the anterosuperior approach, on the other hand, the surgeon may face difficulties in placing the glenoid base plate in a neutral or an inferiorly tilted position, and also in terms of the exposure of the humeral shaft due to the limited extensibility of the approach.[33] One concern for the reverse shoulder arthroplasty procedure is the longevity of the repair implant.[32] In many elderly patients, they go back to tasks or exercises they were previously doing before the occurrence of the tear, so the longevity of the repair implant is important to consider when deciding for the treatment option.

1.6.2 Non-surgical Techniques

Non-surgical treatments typically consist of oral medications, physiotherapy and/or injection therapy. Oral medications such as acetaminophen or non-steroidal inflammatory drugs are initially prescribed to control pain and swelling. In addition, individuals with rotator cuff tear receive a range of physiotherapy treatments, which focus on correcting the weakness of

rotator cuff and scapular muscle dysfunction, tightening of the posterior capsule and other soft tissues, and correcting postural abnormalities that contribute to pain and dysfunction.[34]

Physiotherapy interventions commonly consist of stretching and strengthening exercises and can also include electrotherapy and other physical modalities such as ultrasound, moist heat and laser therapy. The typical duration of a physical therapy program is 6-12 weeks and aims to improve range of motion and strengthen the periscapular muscles.[9] Treatment by physical therapy, however, does not always result in the healing of the torn rotator cuff.[35]

Treatment by injections in recent studies often involves corticosteroids, hyaluronic acid and platelet-rich plasma.

Corticosteroids have anti-inflammatory characteristics and can alter the release of noxious chemicals from injured tendons that lead to their analgesic effects. Corticosteroid injection is a popular option for rotator cuff tears, however there is a potential for adverse outcomes such as tendon atrophy and decreased quality of tissue available to repair.[36,37] Conversely, *hyaluronic acid* has biochemical properties that prevent degradation of cartilage and promote its regeneration, and can therefore contribute to the healing process of a soft tissue injury and decrease pain. Hyaluronic acid is a high molecular weight polysaccharide which is present in the extracellular matrix of soft connective tissue and synovial fluid and exerts different physiological roles in different tissues.[38] Honda, H. et al. 2017 in their study found that hyaluronic acid accelerates tendon to bone healing in a rotator cuff, enhanced the biomechanical strength and increased chondroid formation at the repaired site.[38] They further found that hyaluronic acid accelerated the chondrogenic differentiation of mesenchymal cells which are significantly associated with tendon to bone healing after rotator cuff repair.[38] More recently, injections with platelet-rich plasma have also emerged as

a promising intervention for cuff injuries due to its pain-relieving properties and ability to stimulate collagen synthesis and promote healing. The use of biologic therapy such as the *platelet-rich plasma* for the treatment of several musculoskeletal pathologies has increased significantly over the last 10 years.[39] The potential for biologic healing augmentation with association of low risk adverse events make platelet-rich plasma a very viable option for many musculoskeletal pathologies.[39, 40] Platelet-rich plasma contains numerous growth factors and cytokines that have the ability to offer an alternative treatment option to assist in the healing of multiple musculoskeletal disorders.[39] The preparation involves the autologous human plasma with an increased platelet concentration above that contained in normal baseline blood plasma.[39, 41] Platelets contain numerous amounts of growth factors and mediators in their alpha granules, which are concentrated through the centrifugation process to release supraphysiologic amounts of these growth factors and cytokines to an injury site and augment the natural healing process.[41] Platelet-rich plasma can also promote neurovascularization, which can increase the blood supply and nutrients needed for cells to regenerate the injured tissue in addition to bringing new cells and remove debris from damaged tissue.[41] There is variability in the methods used to prepare platelet-rich plasma which can result in differences in blood component concentrations and biomolecular characteristics.[40] Due to this, the varying quality of and preparations of platelet-rich plasma has made comparison among clinical studies challenging.[40]

1.7 Current Treatment Trends

In general, for patients with full-thickness rotator cuff tears the debate remains as to whether surgical or non-surgical treatment is superior for the alleviation of pain and improvement of shoulder function. The literature seems to suggest that majority of patients begin on non-surgical treatment and if pain persists or improvement in function is less than optimal, surgery

is considered.[42] However, the choice of, and response to, rotator cuff tear treatment may vary with age due to differences in aetiology and pathogenesis. Some studies suggest that young patients with traumatic tears may be best managed with surgery while many atraumatic rotator cuff tear which is common in older patients may be amenable to a non-surgical treatment.[43] In addition, compared to younger patients (< 50), rotator cuff tear in older patients (>70) are characterised by greater retraction in the frontal plane and greater fatty infiltration.[44] A previous study reported that rotator cuff repair was much more successful in younger patients compared to an older cohort.[45] Based on the evidence, therefore, treatment options that may be effective for younger patients may not necessarily provide the same results for elderly patients.

1.8 Why a systematic review is needed

The best treatment option for alleviation of pain and restoration of shoulder function in the elderly is still debated, with some health practitioners advocating for conservative intervention and others preferring surgical management.[9] Elderly patients tend to have more severe tears, in terms of tear size, when compared to younger patients, having less capability of healing and higher degrees of muscle atrophy and fatty infiltration.[9] Kim, Y. et al. 2017 concluded full-thickness tears have a higher rate of enlargement than partial thickness tears, indicating a higher risk of enlargement when they occur.[21] Full-thickness rotator cuff tears tend to develop and enlarge with time, with a prevalence of 28% in ≥60 year old individuals, 50% in those ≥70 years old and 80% in those ≥80 years.[10, 13] The research supports that those aged older than 60 to 65 years are likely to have larger tears and patients aged 70 years or older can experience reduced tendon and bone quality.[14] In addition, in a study by Gumina, S. et al. 2013, age older than 60 years was associated with a twofold higher risk of tear occurrence.[46] Due to an aging population and an increasing prevalence of rotator cuff tears

with age, the total number of patients with shoulder dysfunction as a result of full-thickness rotator cuff tears is expected to continue rising.[9]

Few studies have looked at the direct comparison of conservative treatment and surgical management in the older population. A systematic review aimed to identify which treatment, surgical or conservative, provided the best results for elderly patients with full-thickness rotator cuff tears.[17] The reviewers concluded there could be improved outcomes with surgery, however, heterogeneity of the studies and risk of bias made it difficult to make a definitive conclusion on the best treatment approach. Of the eight studies included in the review, seven focused on surgical treatment and only one investigated non-surgical treatment (this study compared the efficacy of sodium hyaluronate against corticosteroid injection). As such, no conclusion on non-surgical treatments was reached. There was also no evidence to support one type of surgery over another. Whilst surgery appears to be promising, recurrent tears and stiffness are commonly reported, especially with degenerative tears which are frequently observed in the older population.[20, 47]

Studies regarding the effectiveness of non-surgical treatment for full-thickness rotator cuff tears are inconclusive. Exercise therapy, for example, may improve joint stability and reduce translation of the glenoid humeral joint, however, there is also evidence that it may not restore the normal kinematics of the shoulder similar to that of an intact rotator cuff.[48] In another study, no statistically significant difference in clinical outcomes was demonstrated when platelet rich plasma (PRP) was compared to no PRP therapy; however, bone-to-tendon healing rates were better in PRP patients who had small and moderately-sized tears.[49] Given the lack of consensus regarding the benefits of surgical and conservative interventions and an ever increasing aging population with a higher incidence of full-thickness rotator cuff tears,

an updated systematic review is now needed. The systematic review presented in this thesis focuses specifically on adults aged 60 years and over and evaluates the effectiveness of surgical and non-surgical treatments for full-thickness rotator cuff tears.

1.9 Review Objective

A systematic review is needed to identify the most effective treatment for full-thickness rotator cuff tear in older individuals. Therefore, the objective of this review was to synthesise the best available evidence on the effectiveness of non-surgical and surgical treatment on the clinical and functional outcomes of older patients with full-thickness rotator cuff tears.

Chapter 2 - Methods

This chapter outlines the methods used to undertake the systematic review including the eligibility criteria (types of studies, population of interest, types of intervention, comparators and the types of outcome measures), search strategy, and procedures used for critical appraisal of included studies, data extraction and data synthesis.

This systematic review was undertaken in accordance with an a priori protocol (Appendix 1). The protocol pre-specified the methods used to identify published and unpublished studies, the critical appraisal process and synthesis of the best available evidence on the effectiveness of surgical and conservative management in the treatment of cull-thickness rotator cuff tears in those aged 60 years and over.

2.1 Systematic Review Methodology

A systematic review identifies, analyses and synthesises the best available evidence from scientific studies in order to investigate a specific clinical question. This methodology includes intensive and critical processes that sets it apart from literature reviews. A systematic review involves specific objectives or review questions, defined parameters for considering studies in the review such as the population of interest, intervention/comparator interventions, and outcomes. In addition, there is a structured method for locating published and unpublished studies using relevant databases (i.e. search strategy), screening scientific articles, critical appraisal for methodological quality, data extraction, data analysis and data synthesis.

With new primary research being made readily available at an ever-increasing rate, clinicians and researchers need a way to maintain knowledge in their field of interest. High-quality up-to-date systematic reviews are needed to help healthcare professionals and researchers keep up with this large and vastly growing body of evidence.[50] Undertaking a systematic review of

effects offers knowledge to both clinicians and patients on the best available evidence regarding the most optimal treatment for a condition.

2.2 Criteria for inclusion of studies in the review

Participants

The systematic review considered studies that included patients aged 60 years and over with full-thickness rotator cuff tears confirmed by MRI, ultrasound, or arthrography. Studies that included patients younger than 60, provided they reported the results separately for patients aged 60 years and over, were also included in the review. If the study reported a mean age of 60 years and the results were not presented separately for those above 60 years of age, the study was excluded. Previous studies have researched and analysed patients with a mean age of 60 years or investigated patients younger than 60 years, leaving a gap in knowledge regarding the best treatment for the elderly population.[51, 52] In order to ensure included studies were representative of an elderly population, only studies which clearly defined results of patients 60 years and over were included.

The review excluded studies which included patients with concomitant shoulder conditions such as osteoarthritis, fractures, osteonecrosis, instability, and additional intra-articular pathology or acromion morphology.

Interventions of Interest

The systematic review considered all studies which examined the effectiveness of non-surgical and/or surgical treatment of full-thickness rotator cuff tears. Non-surgical treatment included physiotherapy such as exercises, electrotherapy, and other physical modalities such as ultrasound, moist heat and laser therapy. Other conservative treatment included injection therapy including corticosteroids, hyaluronic acid and platelet-rich plasma.

Surgical treatment included all arthroscopic procedures, open repair, mini open repair and reverse shoulder arthroplasty.

Comparators

The comparators of interest were conservative interventions against other conservative interventions, conservative interventions against surgical interventions, and surgical interventions against other surgical interventions. Studies which compared two or more of surgical and conservative interventions were also considered for inclusion in the review.

Studies which included age as a comparator were also included if at least one of the groups for comparison had a cohort of patients >60 years old.

Types of Outcomes

This review included studies that measured one or more of the following outcome measures: range of motion, muscle strength and rotator cuff integrity measured by magnetic resonance arthrography or conventional MRI. Pain measured using any of the following scales was considered: visual analogue scale (VAS) or shoulder-specific scales including the American Shoulder and Elbow Surgeons (ASES) instrument and the Constant-Murley score; shoulder function (as measured by shoulder-specific scales including ASES, Simple Shoulder Test, University of California at Los Angeles (UCLA) Shoulder Score) was also included. Studies that reported patient satisfaction with treatment and health-related quality of life measured using any validated instrument were also considered.

Types of Studies

This review considered experimental studies including randomised controlled trials, pseudo-randomised controlled trials, quasi-experimental studies, and observational studies including

case-control and cohort studies. This was done to ensure adequate evidence was sought to better inform the optimal treatment of full-thickness rotator cuff tears.

Only studies published in English were considered for inclusion in this review. A previous systematic review in 2012, which also investigated surgical and non-surgical treatment approaches for rotator cuff tear in the elderly, included studies published until 2009.[17] Due to this length of time and still being an area of uncertainty, this review only included studies published between 2010 and 2017.

2.3 Search Strategy

The search strategy aimed to find both published and unpublished studies. The databases searched for published studies included CINAHL, Scopus, MEDLINE, EMBASE, Web of Science and PEDro. The search for unpublished studies included the databases ProQuest Dissertations and Theses, Clinicaltrials.gov, Cochrane Central Register of Controlled Trials, ANZCTR and ICTRP. The final database search included in this thesis was performed on the 18th December 2019.

An initial limited search of PubMed and CINAHL was undertaken to identify keywords in titles and abstracts. The initial keywords consisted of commonly used terms (for the key concepts of the review questions) to encompass a broader search. These included “rotator cuff tear”, “full-thickness tear”, “elderly”, “conservative treatment” and “surgery.” An analysis of the text words contained in the title and abstract of relevant articles, and the index terms used to describe these articles informed the development of a logic grid and search strategy tailored for each information source. Details of the final search strategies can be found in Appendix 2.

2.4 Study Selection

Following the search, all identified citations were collated and uploaded into a bibliographic citation software (Endnote X8, Thomas Reuters, New York, USA) to assess eligibility for inclusion in the review. Titles and abstracts were screened by one reviewer (MN) against the inclusion criteria for the review. Studies that met the inclusion criteria were retrieved in full and their details imported into the Joanna Briggs Institute (JBI) System for the unified Management Assessment and Review of Information package (SUMARI). If there was insufficient information in the abstract to decide on eligibility, the full text article was also retrieved for further assessment. The full text of selected studies were retrieved and assessed in detail against the inclusion criteria. Full text studies that did not meet the inclusion criteria were excluded and reasons for exclusion are reported in this thesis (Appendix 3).

2.5 Assessment of Methodological Quality

Eligible studies were critically appraised by three independent reviewers (MN, LL, MS) using standardised critical appraisal instruments from JBI SUMARI.[53]

The questions which made up the critical appraisal tool could be answered 'yes', 'no', 'unclear' or 'not applicable'. Answering a 'yes' meant the study met the necessary requirements for the question, a 'no' indicated the study did not meet the necessary requirements, an 'unclear' indicated there was insufficient information provided in the study.

After independent appraisal, any discrepancies between the reviewers were discussed. There were no disagreements between reviewers that could not be resolved through discussion, hence, no additional reviewer was required.

2.6 Data Extraction

Data were extracted from papers included in the review using standardised data extraction tools in JBI SUMARI. The data extracted included specific details about the populations

including age, previous treatment that had occurred and duration of symptoms before current treatment. Characteristics of the injury including tear size and the tendons involved were also extracted. In addition, study methods, the interventions used to treat the rotator cuff tear and the mean follow-up duration, post-intervention rehabilitation, and outcomes of significance to the review question and objectives were extracted. Data extraction was undertaken by the primary author with verification by another reviewer to minimize potential bias and potential errors. Authors did not need to be contacted for any missing data regarding included studies.

2.7 Data Synthesis

Results from individual studies were pooled into a statistical meta-analysis using JBI SUMARI when there was sufficient data comparing different interventions. Heterogeneity was assessed statistically using the standard chi-squared and I-squared tests. Effect sizes were expressed as mean differences and their 95% confidence intervals calculated for analysis. Results of studies with no comparative data were synthesized narratively. Narrative analyses was conducted for each outcome measurement including Constant-Murley score, Simple-Shoulder Test score, American Shoulder and Elbow Surgeons score, University of California Los Angeles (UCLA) score, range of motion and muscle strength.

A 'Summary of Findings' table was created using GRADEPro GDT software. The GRADE approach for grading the quality of evidence was followed. The 'Summary of Findings' table presents the following information: absolute risks for treatment and control, estimates of relative risk, and a ranking of the quality of the evidence based on study limitations including risk of bias, indirectness, inconsistency, imprecision and publication bias.[54, 55]

Chapter 3: Results

This chapter presents the results of the systematic review. These include the search results and characteristics of the included studies, assessment of the methodological quality of included studies and the synthesised evidence on the effectiveness of treatment for various outcomes.

Figure 2 below outlines the study selection process. The search for published and unpublished literature returned 11,842 citations. Of these, 2,323 were duplicates, and a further 8,877 were excluded based on title and abstract screening. A total of 642 were retrieved for full text examination, and of those 620 were excluded for the following reasons: wrong age group, wrong study type, co-morbidities and tear size (Appendix 3). A total of 22 articles were included in the systematic review.

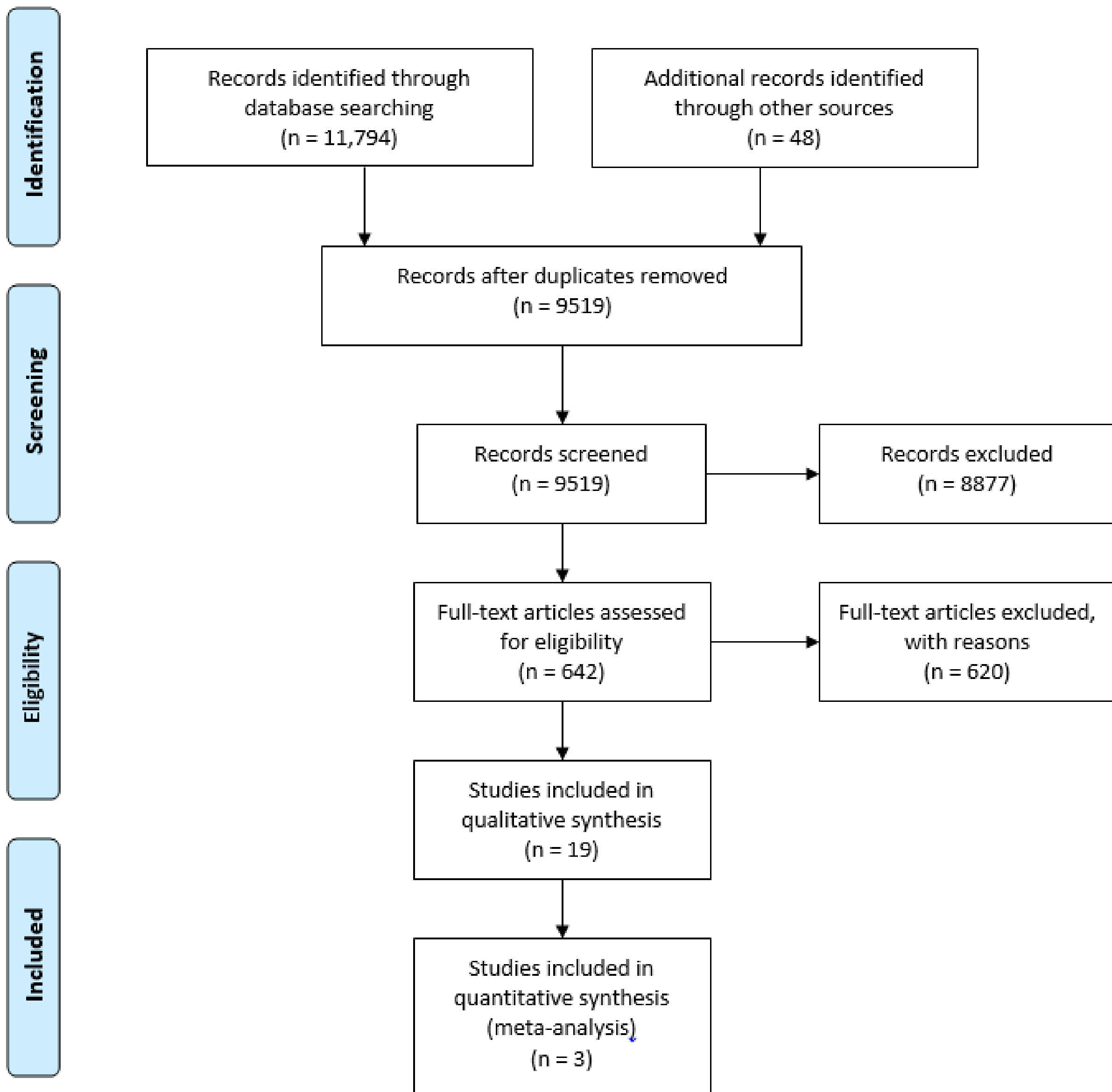

Figure 2: PRISMA flow diagram outlining study selection process[56]

3.1 Methodological Quality

Critical appraisal was conducted for the 22 included studies, which are summarised in Tables 1 and 2. Four were randomised controlled trials, 14 were single group cohort studies, and four were comparable cohort studies.

Critical appraisal of randomised controlled trials

The overall quality of the randomised controlled trials was poor. The randomisation process (Q1) was only described in one study.[57] None of the trials provided information to determine if concealed allocation (Q2) occurred. All trials had comparable treatment groups at baseline (Q3). There was blinding of participants in three trials and uncertain in one[57] (Q4); blinding of those who administered the treatment was not possible in any of the trials (Q5). Information on outcome assessor blinding was unclear in all studies (Q6). Treatment groups were treated identically (except for the intervention of interest) in all trials (Q7). Three of the four trials had complete follow-up (Q8)[57-59] and analysed participants in the groups to which they were randomised (Q9). All trials measured outcomes reliably (Q11), and in the same way for treatment groups (Q10). The statistical analysis in all trials was also appropriate (Q12). The trial design was appropriate (Q13) in only two[57, 58] of the four trials.

Table 1: Appraisal of Randomised Controlled Trials

Citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Dezaly C, Sirveaux F, Philippe R, Wein-Remy F, Sedaghatian J, Roche O, et al. 2011.[58]	U	U	Y	N	N	U	Y	Y	Y	Y	Y	Y	Y
Flurin PH, Hardy P, Abadie P, Desmoineaux P, Essig J, Joudet T, et al. 2013.[60]	U	U	Y	N	N	U	Y	N	N	Y	Y	Y	N
Gialanella B, et al. 2018.[57]	Y	U	Y	U	N	U	Y	Y	Y	Y	Y	Y	N
Jacquot A, Dezaly C,	U	U	Y	N	N	U	Y	Y	Y	Y	Y	Y	Y

Citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Goetzmann T, Roche O, Sirveaux F, Mole D. 2014.[59]													
%	0	0	100	0	0	0	100	67	33	100	100	100	67

Y=yes; N=no; U=unsure; Each yes accrues 1 point

Critical appraisal of cohort studies

The overall quality of the cohort studies included was moderate. Fourteen of the 18 cohort studies had a single cohort; hence criteria (Q1: whether groups were similar and recruited from the same population) and (Q2: whether the exposures were measured similarly to assign people to both exposed and unexposed groups) were not applicable. The remaining four cohort studies had two groups; all met criteria 1 and 2.[61, 62,63, 64] All 18 studies measured the exposure in a valid and reliable way (Q3). Quality appraisal relating to the identification of confounding factors and whether strategies were applied to deal with cofounding factors (Q4, Q5) varied across studies. Nine studies answered yes to both Q4 and Q5[61, 62, 65-71], six studies answered no to both Q4 and Q5[13, 44, 63, 72, 73], one study did not report information related to these criteria[64] and two studies answered yes to Q4 but did not provide sufficient information for assessment of Q5[74, 75]. The criterion related to whether participants were free of the outcome at the start of the study (Q6) was not applicable in the included studies. All studies had outcomes measured in a valid and reliable way (Q7). All studies had sufficient follow-up time (Q8). Majority of studies had complete follow-up or if not, reasons for drop out were discussed (Q9); only four studies did not discuss reasons to loss of follow-up[70, 73-75] and one study did not provide sufficient information to assess this criterion.[44] Nine studies did not apply strategies to address incomplete follow-up (Q10)[62, 65-70, 73, 74] and two studies[44, 75] did

not provide sufficient information to appraise this criterion. All studies applied appropriate statistical analysis (Q11).

Table 2: Appraisal of Cohort Studies

Citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
Charousset C, Bellaiche L, Kalra K, Petrover D. 2010.[65]	N/A	N/A	Y	Y	Y	N/A	Y	Y	Y	N	Y
Cho NS, Lee BG, Rhee YG. 2011.[66]	N/A	N/A	Y	Y	Y	N/A	Y	Y	Y	N	Y
Cho NS, Yi JW, Lee BG, Rhee YG. 2010.[61]	Y	Y	Y	Y	Y	N/A	Y	Y	Y	N/A	Y
Choi S, Kim MK, Kim GM, Roh YH, Hwang IK, Kang H. 2014.[67]	N/A	N/A	Y	Y	Y	N/A	Y	Y	Y	N	Y
Consigliere P, Polyzois I, Sarkhel T, Gupta R, Levy O, Narvani AA. 2017.[72]	N/A	N/A	Y	N	N	N/A	Y	Y	Y	N/A	Y
Djahangiri A, Cozzolino A, Zanetti M, Helmy N, Rufibach K, Jost B, et al. 2013.[68]	N/A	N/A	Y	Y	Y	N/A	Y	Y	Y	N	Y
Fehringer EV, Sun J, Cotton J, Carlson MJ,	Y	Y	Y	Y	Y	N/A	Y	Y	Y	N	Y

Citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
Burns EM. 2010.[62]											
Flurin PH, Hardy P, Abadie P, Boileau P, Collin P, Deranlot J, et al. 2013.[69]	N/A	N/A	Y	Y	Y	N/A	Y	Y	Y	N	Y
Gwark, JY., Sung, CM., Na, JB., Park, H.B. 2018[75]	Y	Y	Y	Y	U	N/A	Y	Y	N	U	Y
Hamie M, Fakih R. 2017.[64]	N/A	N/A	Y	U	U	N/A	Y	Y	Y	N/A	Y
Jung HJ, Sim GB, Bae KH, Kekatpure AL, Chun JM, Jeon IH. 2017.[73]	N/A	N/A	Y	N	N	N/A	Y	Y	N	N	Y
Moraiti C, Valle P, Maqdes A, Boughebri O, Dib C, Giakas G, et al. 2015.[44]	N/A	N/A	Y	N	N	N/A	Y	Y	U	U	Y
Osti L, Papalia R, Del Buono A, Denaro V, Maffulli N. 2010.[63]	N/A	N/A	Y	N	N	N/A	Y	Y	Y	N/A	Y
Park JG, Cho NS, Song JH, Baek JH, Jeong HY, Rhee YG. 2016.[13]	N/A	N/A	Y	N	N	N/A	Y	Y	Y	N/A	Y

Citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
Robinson PM, Wilson J, Dalal S, Parker RA, Norburn P, Roy BR. 2013.[70]	N/A	N/A	Y	Y	Y	N/A	Y	Y	N	N	Y
Saraswat MK, Styles-Tripp F, Beaupre LA, Luciak-Corea C, Otto D, Lalani A, et al. 2015.[71]	N/A	N/A	Y	Y	Y	N/A	Y	Y	Y	N/A	Y
Veado MA, Rodrigues AU. 2010.[74]	N/A	N/A	Y	Y	U	N/A	Y	Y	N	N	Y
Witney-Lagen, C., Mazis, G., Bruguera, J., Atoun, E., Sforza, G., Levy, O. 2019.[76]	Y	Y	Y	N	N	N/A	Y	Y	Y	Y	Y
%	12	18	100	59	53	0	94	94	71	0	94

Y=yes; N=no; U=unsure; NA=not applicable; Each yes accrues 1 point

3.2 Characteristics of included studies

This section describes the population characteristics, the intervention used (e.g. surgical approach) and the rehabilitation interventions received following the surgery.

3.2.1 Study population

The included studies contributed to a total of 1,407 patients. Sixteen studies included patients with a mean age ranging between 60 and 88 years of age. Five studies included patients above and below the age of 60 years.[61, 66, 67, 75, 76] These studies were still included as the results for patients aged 60 and above were discussed separately to those below the age of 60. The

duration of rotator cuff tear symptoms (prior to receiving the intervention of interest, i.e. surgery or injections or physiotherapy) for all studies was at least six months. Ten studies mentioned the shoulder involved and of these, 517 were the dominant shoulder affected; 225 shoulders were right shoulder and 91 were left shoulders. Nine studies described the tear size; there were 52 small tears (<1cm), 229 medium tears (1-3cm), 169 large tears (3-5cm) and 108 massive tears (>5cm). One study reported there were 15 small to medium tears.[13] One study described the tears as distal (60 shoulders), intermediate (21 shoulders) and retracted (7 shoulders).[65] Another study described their tears as small (<10mm in both retraction and base tear size), moderate (11-30mm in either retraction or base tear size), or large/massive (>30mm in either retraction or base tear size).[71]

3.2.2 Interventions and comparators

All included studies, except for one, investigated the effectiveness of a **surgical intervention** for full-thickness rotator cuff tear. Ten of these studies reported the use of conservative strategies or minimally invasive procedures prior to participants receiving surgical interventions. The conservative procedures included physiotherapy[13, 44, 59, 68, 70, 74], rehabilitation exercises[63, 73], non-steroidal inflammatory drugs[13, 44, 63, 73, 74], activity modification[13, 73] and corticosteroid injection[13, 44, 63, 65, 74].

Surgical interventions were grouped into **arthroscopic repair with arthroscopic palliative procedures, mini-open repair and open repair**. **Arthroscopic repair** is a surgical procedure intended to repair the torn rotator cuff tendon, and include approaches such as single- and double-row repair, and suture-bridge technique. **Arthroscopic palliative procedures**, which are intended to minimise the damage to the tendon but not fix the tear, included debridement, acromioplasty (decompression) and biceps tenotomy or tenodesis. Arthroscopic repair procedures are typically accompanied by arthroscopic palliative

procedures. An **open repair** is a surgical procedure that involves an open incision to repair the torn rotator cuff tendon. A **mini-open repair** involves subacromial decompression, followed by a deltoid splitting approach for the repair. Ten included studies investigated arthroscopic rotator cuff repair with arthroscopic palliative procedures.[44, 61, 63-67, 69, 70, 74] One study investigated arthroscopic rotator cuff repair with palliative procedures plus extra-cellular augmentation.[72] This involves patch augmentation of the extracellular matrix (xenograft, allograft, and synthetic).[72] Three studies investigated arthroscopic rotator cuff repair with palliative procedures compared to palliative procedures alone.[58-60] Two studies investigated both arthroscopic and open rotator cuff repair[13, 68], one study investigated open repair technique[73], and two studies investigated mini-open rotator cuff repair[62, 71].

Only one study investigated a **conservative intervention** for full-thickness rotator cuff tear; this study specifically evaluated the effectiveness of supervised arm cycloergometer. The cycloergometer is a mechanical cycling device currently being used in multiple fields of medicine and in the management of some chronic joint diseases to maintain muscle strength.[57] Patients in the intervention group, in addition to standard rehabilitation exercise program (10 sessions of 30-minute exercises), received 15 minutes of training with an arm cycloergometer and were encouraged to use the cycloergometer at home for 20 minutes twice per day. Control patients received the standard rehabilitation exercises and were advised to continue doing the exercises at home.

3.2.3 Timing of surgery and length of follow-up

The timing of surgery was reported in eight papers only, and varied across studies.[13, 44, 61, 63, 65, 68, 73, 74] In some studies, surgery was initiated after a minimum of six months of symptoms whereas others waited for as long as 13 months before surgery was administered. The duration of follow-up post-surgery also varied and ranged between six months and 10 years.

All patients underwent rehabilitation post-surgery (shown in Table 3). Post-surgical rehabilitation commenced with the use of an arm sling from first day of operation to six weeks, and passive exercises. Active exercises were initiated from 4-6 weeks and return to sports and daily activities occurred at six months.

Table 3: Rehabilitation procedure post-intervention

Author	Post-intervention
Charousset, C. (2010)	**After surgery/first day**: Arm sling and physiotherapy **3 months**: Start strengthening exercises and light sporting activities **6 months**: Full return to sports and heavy labour
Cho, N.S. (2010)	**Day of operation:** Passive exercises **Week 6**: Active assisted exercises started and muscle strengthening exercises introduced **6 months**: Return to recreational activities and manual labour
Cho, N.S. (2011)	**Day of operation**: Passive exercises performed **6 weeks**: Active assisted exercises and muscle strengthening exercises introduced **6 months**: Return to recreational activities and manual labour
Choi, S. (2014)	**Day after operation**: Pendulum exercises begun **3 days**: Patients with medium or large tears begin rehab **1 week**: Patients with massive tears begin rehab **4-6 weeks**: Abduction brace worn **6 weeks**: Active exercises and active motion of shoulder slightly increased
Consigliere, P. (2017)	**Day of operation**: Shoulder abduction wedge for 6 weeks; Physiotherapy as per large or massive tear organized before discharge
Dezaly, C. (2011)	Early self-rehabilitation with partial immobilization in a simple sling for 4 weeks
Djahangiri, A. (2013)	**Day of operation:** Abduction brace for 6 weeks **Day 1:** Passive range of motion exercises initiated under patient-controlled interscalene analgesia **6 weeks:** Active range of motion with the elbow fully flexed was allowed **12 weeks**: Elbow extended **3 months**: Strengthening exercises allowed
Gialanella, B. (2018)	**Rehabilitation program:** 10 exercise sessions lasting 30 min, spread over a 2 week period (5 sessions/week)
Gwark, JI. (2018)	**Day of operation:** Abduction brace or shoulder immobilizer

Author	Post-intervention
	6 weeks: Gradual active assistive range of motion exercises allowed **6-12 Weeks:** Shoulder movement allowed **12 weeks:** Internal rotation exercises allowed **12 months:** Full range of labour or sports activity allowed
Fehringer, E.V. (2010)	**Day of surgery**: Passive supine forward elevation to 140 degrees and external rotation with the elbow at the side to 40 degrees **6 weeks**: Active-assisted and active elevation begun; external rotation was limited to 20 degrees in those with subscapularis repairs; Progressive active use allowed with one-tendon tears **12 weeks**: Full activity progression allowed
Flurin, P.H. (2013)	Elbow brace immobilization for 6 weeks and early self-rehabilitation
Flurin, P.H. (2013)	Standardized post-operative protocol implemented with early self-rehabilitation and splint immobilization for 8-10 days after pain had disappeared in patients who had received decompression or for 6 weeks in patients who underwent rotator cuff repair
Jacquot, A. (2014)	**Day of operation:** Partial immobilisation was achieved by wearing a simple sling for 4 weeks **Day 1:** A passive self-rehabilitation programme taught to all patients and started immediately, with simple oral analgesics **4 weeks:** Physiotherapy sessions prescribed if needed
Jung, H.J. (2017)	**Day of operation**: A shoulder abduction brace applied for 7-8 weeks **Day 1**: Patients started passive forward elevation **Day 3:** Stretching exercises including pendulum exercises and passive external rotation started **4 weeks**: Pulley exercises to gain full forward elevation **8 weeks**: Strengthening of the rotator cuff and periscapular muscle using TheraBand and wall push ups were started after removal of the shoulder abduction brace **3 months**: Posterior capsular stretching exercises and internal rotation stretching initiated after 3 months of strengthening exercises
Moraiti, C. (2015)	**Day 1:** Physiotherapy started immediately with daily pendular and passive range of motion exercises **4 weeks:** Active assisted range of motion **6 weeks:** Active range of motion with terminal stretching and rotator cuff strengthening exercises
Osti, L. (2010)	Post-intervention not described
Park, J.G. (2016)	**Day of operation:** Passive exercises including pendulum exercises, passive forward flexion and external rotation exercises performed **6 weeks:** Active assisted exercises started and muscle strengthening exercises introduced gradually

Author	Post-intervention
Robinson, P.M. (2013)	Rehabilitation began 10-14 days post-op. During this phase, passive movements and closed kinetic chain exercises were performed **4 weeks:** Polyslings removed and active assisted exercises started **6 weeks:** Progression to active exercises **8 weeks:** Full active movements throughout all ranges with rotator cuff strengthening and proprioceptive exercises, specific functional activities also introduced
Saraswat, M.K. (2015)	Patients placed in a Velpeau sling for 6 weeks and were referred to physical therapy, commencing 2 weeks after surgery, using a standardized protocol. **1-6 weeks**: self-assisted range of motion and pendular exercises of the shoulder were permitted. Active range of motion exercises of the elbow, wrist and hand were also performed. **6-10 weeks:** Active shoulder range of motion and self-assisted stretching toward end range were added. Scapular stabilization exercises were progressed. **10-26 weeks:** Progressive strengthening exercises were commenced, starting with isometric exercises and progressing to isotonic exercises in both closed and open kinetic chain positions. Range of motion exercises were continued with therapist-assisted joint mobilization and stretching was added to the program to maximise the return of range of motion.
Veado, M.A. (2010)	During the immediate postoperative period, the patients' affected arm was kept in a Velpeau sling. Self-administered passive exercises for the shoulder and elbow were started 24 hours after the surgery and the stitches removed 7 days after surgery **2 weeks:** Muscle strengthening, and physiotherapeutic guidance started
Witney-Lagen, C. (2018)	Patients placed in mild abduction sling for 6 weeks; Gentle pendular exercises started immediately for small tears **3 weeks:** For medium tears gentle pendular exercises began and passive exercises started for small and medium tears **6 weeks:** For large and massive tears gentle pendular exercises and passive exercises started; Active movement and strengthening exercises performed from 6 weeks onward
Hamie, M. (2017)	**1-6 weeks:** Shoulder sling with passive and limited active range of motion allowed **6 weeks:** Sling removed, and patients allowed to commence unrestricted active range of motion and light resistance exercises **12 weeks:** Resistance and weight exercises **6 months**: Return to full activity

3.3 Findings of the review

Results of the 22 studies were grouped according to outcomes including **Constant score**, **Simple Shoulder Test score**, **ASES score**, **University of California-Los Angeles Shoulder score**, **range of motion** and **muscle strength**. Where there were sufficient data comparing different interventions, a meta-analysis was performed. Results from studies with no comparative data were synthesized narratively.

3.3.1 Effect on Constant-Murley Score

The Constant-Murley scoring tool was the most commonly used outcome instrument in the included studies. This scoring tool is a 100-point scale that assesses pain (15 points), activities of daily living (20 points), range of motion (40 points) and strength (25 points).[77] The higher the score, the higher the quality of the shoulder function.

Three randomised controlled trials compared **arthroscopic repair plus arthroscopic palliative procedures with arthroscopic palliative procedures only** [58-60] and presented Constant score data as mean change from baseline to final follow-up. Two studies had a follow-up of one year and the other study had a four-year follow-up. The results of these trials involving a total of 373 participants were pooled in a meta-analysis (Figure 3) A statistically significant benefit favouring arthroscopic repair over arthroscopic palliative procedures alone was demonstrated (WMD 6.54, 95% CI 4.62 – 8.47); results of Chi^2 and I^2 analysis showed no statistical heterogeneity. However, arthroscopic repair did not provide clinically important benefits over arthroscopic palliative procedures alone (the minimal clinically important difference for Constant score is 10.4 points[78]). The standard deviations used for one study were based on a generalised estimation by the authors of the systematic review, due to the standard deviations not being included in the study and being unable to contact the author.[60]

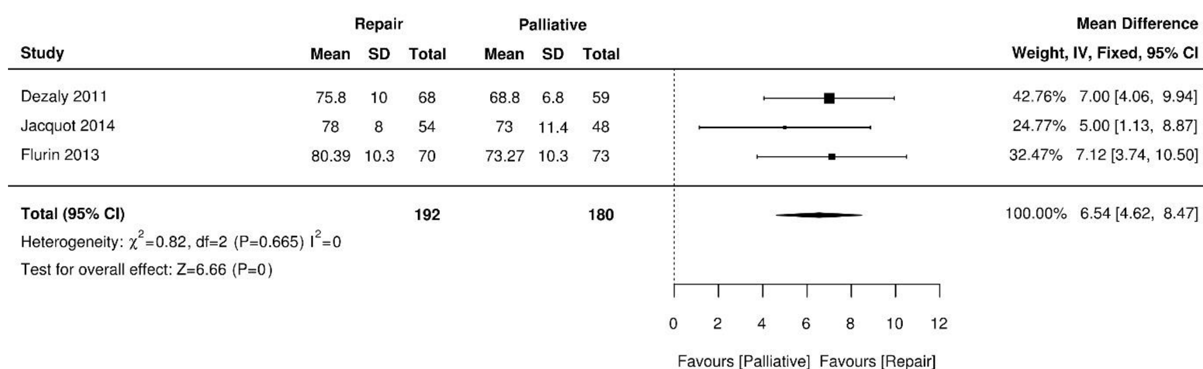

Figure 3: Meta-analysis of Constant scores (Dezaly 2011; Jacquot 2014; Flurin 2013)

Twelve studies evaluating **surgical interventions** that assessed Constant score did not provide comparative data and therefore results were synthesised narratively and summarised in Table 4. Improvements in Constant-Murley scores were reported in all twelve studies, regardless of the surgical intervention received by patients. Two studies reported results at six months follow-up.[64, 72] One study reported a final follow up at four years, one study had a follow up period of just over three years and one study followed up for close to five years.[59, 65, 68] All other studies reported a follow-up score at one year.

Table 4: Mean Pre-operative and Post-operative Constant-Murley Scores

	Intervention	*Pre-op (mean ± SD)*	*Post-op (mean ± SD)*	*Follow-up*	*p-value*
Arthroscopic repair with arthroscopic palliative procedures					
Charousset, C. et al. 2010 n = 88	Single-row rotator cuff repair with tenotomy of the long head of the biceps tendon, bursectomy and resection of the coracoaromial ligament	45.1±10	76.9±7.8	41 months (24-77 months)	<0.01

	Intervention	*Pre-op (mean ± SD)*	*Post-op (mean ± SD)*	*Follow-up*	*p-value*
Robinson, P.M. et al. 2013 n = 68	Single-row rotator cuff repair with debridement of the long head of the biceps tendon (n=6), tenodesis (n=11) and tenotomy (n=6)	22.6±14	58.6±19.9	1 year	<0.001
Hamie, M. et al. 2017 n = 25	Single or Double-row rotator cuff repair* with subacromial decompression and biceps tenodesis	34.80±7.89	80.44±4.21	6 months	<0.0001
Flurin, P.H. et al. 2013b n = 145	Single or double-row rotator cuff repair with acromioplasty; majority (95% cases) also had tenotomy or tenodesis of the long head of the biceps	44.4±12	76±31.5	1 year	<0.05
Gwark, JY. et al. 2018	Single-row or Double-row or Suture bridge technique with biceps tenotomy or tenodesis	33±16	NR	1 year	<0.01
Moraiti, C. et al. 2015 n = 40	Single-row (n=22) and Double-row (n=18) repair with Acromioplasty (n=33)/ Resection of coracoacromial ligament (n=28)/	48.8	74.6	1 year	<0.05

	Intervention	*Pre-op (mean ± SD)*	*Post-op (mean ± SD)*	*Follow-up*	*p-value*
	Resection of acromioclavicular joint (n=6)/ Tenotomy of long head of the biceps tendon (n=30)/ Tenodesis of long head of the biceps tendon (n=4)				
Witney-Lagen, C. et al. 2019	Single-row (n=32) and Double-row (n=28) repair with concomitant long head of the biceps tenotomy or tenodesis (n=30)	38.3	63.4±17.0	26 months	NR
Arthroscopic repair with arthroscopic palliative procedures and Augmentation					
Consigliere, P. et al. 2017 n = 10	Double-row rotator cuff repair and extracellular matrix augment with acromioclavicular joint excision (n=5) and long head biceps tenotomy (n=3)	53±4	75±11	6 months	<0.05
Mini-open repair					
Fehringer, E.V. et al. 2010 n = 39	Mini-open rotator cuff repair with Biceps tenodesis (n=11)	NR (healed)	85 (range 66-98) (median score) (healed)	1 year	NR
		NR (not healed)	58 (range 38-87) (median score) (not healed)	1 year	NR
Arthroscopic repair with arthroscopic palliative procedures or Open Repair					
Djahangiri, A. et al. 2013	Open technique with biceps tenodesis (1st	49	78	57 months (24-112 months)	<0.05

	Intervention	*Pre-op (mean ± SD)*	*Post-op (mean ± SD)*	*Follow-up*	*p-value*
	phase of the study)/ Single-row arthroscopic repair with biceps tenotomy and acromioplasty (2nd phase of the study)				
Park, J.G. et al. 2016 n = 25	Double-row repair with suture-bridge technique (n=6)/ Single-row repair (n=13)/ Open repair (n=6)	39.5 (re-tear group)	63.6 (re-tear)	1 year	<0.001
		49.3 (healed group)	71.9 (healed)	1 year	0.008
Open Repair					
Jung, H.J. et al. 2017 n = 64	Open rotator cuff repair with open acromioplasty	44±18	76±7	1 year	<0.001

NR – not reported
*- Single or double technique not specified
n= number of patients who had the main intervention and the arthroscopic palliative procedure in that cohort of patients

Seven studies investigated **arthroscopic repair with arthroscopic palliative procedures** and demonstrated significant improvements in Constant score. Two studies investigated the single-row approach,[65, 70] four examined either a single row or a double row approach,[44, 64, 69, 75, 76] and one assessed single row, double row or suture bridge technique for arthroscopic repair.[72] Various arthroscopic palliative procedures were used including subacromial decompression (also known as acromioplasty)[44, 64, 68, 69, 73], tenotomy of the biceps tendon[44, 65, 68-70, 72, 75, 76], debridement of the biceps tendon[70], bursectomy and resection of the coracoacromial ligament[44, 65], biceps tenodesis[44, 62, 64, 68-70, 75, 76], and resection of the acromioclavicular joint.[44, 72] Pre-operative mean Constant scores across studies ranged from 22.6 to 53, which increased to scores ranging from 58.6 to 80.44 following the intervention.

One study found increasing age (i.e. > 70 years) increased the occurrence of sustaining a re-tear 1.12 times higher (95% CI 1.02 to 1.23) than the risk of re-tear in patients aged one year younger after arthroscopic rotator cuff repair,[70] whereas another study demonstrated that patient age did not influence the clinical result (p=0.24).[69] One study compared patients younger than 60 years and older than 60 years.[64] The mean Constant score in <60 years increased from 39.67 (± 6.71) preoperatively to 85.57 (± 9.328) at the final follow-up ($p < .0001$), and for those >60 years, score improved from 34.80 (± 7.89) preoperatively to 80.44 (± 4.21) at the final follow-up ($p < .0001$); no significant differences in improvements were found between groups (p=0.25).[64] These results suggest that arthroscopic repair can yield comparable outcomes in patients older than and younger than 60 years.[64] Another study also compared different age groups, i.e. patients who were less than 50 years (group 1) and those older than 70 years (group 2).[44] The Constant score significantly improved in both groups. However, partial re-tear occurred in two patients in group 1 and five patients in group 2. Complete re-tear was observed in two patients in group 2 and none for group 1.

One study investigated the addition of **extracellular matrix augmentation with arthroscopic repair** (plus acromioclavicular joint excision in 5 patients; plus long head biceps tenotomy in 3 patients; concomitant subscapularis repair in 2 patients) in 10 patients with large or massive tears.[72] The mean Constant score improved from 53 (SD=4) preoperatively to 65 (SD=12) at three-month follow-up. At six-month follow-up there was still a significant improvement, 75 (SD= 11) (p<0.005).[72] Two patients had a follow-up of 12 months. One improved from a preoperative score of 50 to 59, the other patient also had an improvement of 51 to 80.[72]

One study assessed whether rotator cuff heals in older patients who received **mini-open rotator cuff repair** with biceps tenodesis and whether their function was comparable to older

patients with untreated tears and older people with intact rotator cuff.[62] No difference in Constant score was found between patients with healed repairs and older people with intact rotator cuff. Shoulders with healed repairs had higher Constant score than those with unhealed repairs ($p<0.0001$). In addition, shoulders with healed repairs demonstrated higher Constant score than those with untreated tears ($p<0.0001$).[62]

Two studies reported combined post-operative results for patients who were treated with **arthroscopic repair** and those who received **open repair**.[13, 68] Both studies demonstrated significant improvement in Constant score post-intervention. One study also compared Constant scores between patients who had a re-tear and those with healed tears following repair.[13] Constant scores improved significantly in both cohorts, with no significant differences between groups at the final follow-up (mean follow-up was 36.3 months; range of 18 to 114 months).[13]

One study investigated the outcomes of **open repair** with acromioplasty in 64 patients and found significant improvements in Constant score post-operatively. Follow-up was performed in 46 patients one year after the surgery; of these, 12 patients had re-tears (11 with massive tears and 1 with a large tear). Constant scores showed significant improvements not only in the intact group but also in the re-tear group, with no significant differences between groups.[73]

One study evaluated the effectiveness of a **conservative intervention, i.e. arm cycloergometer**. The cycloergometer allowed for passive and active exercises of shoulder in forward elevation, extension, abduction and internal rotation.[57] These exercises lubricate articular surfaces, nourish the joint, elasticize the connective tissue band and reduce muscular tension.[57] Furthermore, the increased oxygenation of muscles can lead to a reduction in acute

pain.[57] Improvements in Constant score in the arm cycloergometer group were significantly better than the control group (38.16±18.0 vs. 25.16±11.56).[57]

3.3.2 Effect on Simple Shoulder Test (SST) Score

The SST is a self-reported questionnaire that measures the functional disability of the shoulder. The test consists of 12 items with dichotomous response options of “1 = yes” or “0 = no”; scores range from 0 (worst) to 12 (best). The questions are about function, related to pain (2 items), function/strength (7 items) and range of motion (3 items).[79] Only four studies reported on SST scores; all evaluated a surgical intervention. Table 5 below outlines the significance between pre-op and post-op SST scores.

Table 5: SST Scores from Cohort Studies

	Intervention	*Pre-op (mean ± SD)*	*Post-op (mean ± SD)*	*Follow-up*	*p-value*
Arthroscopic repair with arthroscopic palliative procedure					
Charousset, C. et al. 2010 n = 88	Single-row rotator cuff repair with tenotomy of the long head of the biceps tendon, bursectomy and resection of the coracoaromial ligament	2.4±0.9	10.03±1.9	41 months (24-77 months)	<0.01
Flurin, P.H. et al. 2013b n = 145	Single or double-row rotator cuff repair with acromioplasty; majority (95% cases) also had tenotomy or tenodesis of the long head of the biceps	3.52±2.4	10	1 year	<0.05
Mini-open repair					
	Mini-open rotator cuff	NR (healed)	12 (7-12) (median score)	2.7 years (1-5 years)	

	Intervention	*Pre-op (mean ± SD)*	*Post-op (mean ± SD)*	*Follow-up*	*p-value*
Fehringer, E.V. et al. 2010 n = 39	repair with Biceps tenodesis (n = 11)		(healed)		
		NR (untreated)	6 (1-12) (median score) (untreated)	2.7 years (1-5 years)	

NR – not reported

Four studies used SST as an outcome measure; of these, only one study (randomised trial) provided comparative data[60]. This randomised trial compared the outcomes of patients who received **arthroscopic repair plus decompression** to those who were treated with **decompression only**[60]. One year following treatment, patients in the repair group demonstrated significantly better improvement in SST score than the decompression group (p=0.02). The trial also compared outcomes by age, 70-74 year group and a 75 or older group; the superiority of repair over decompression remained evident.

The three cohort studies that used SST as an outcome measure also showed significant improvement or a trend towards improvement between preoperative and postoperative SST scores following **either arthroscopic repair with arthroscopic palliative procedures[65, 69] or mini open repair[62].** In one study, which investigated single-row rotator cuff repair with tenotomy of the long head of the biceps tendon, bursectomy and resection of the coracoaromial ligament, repair integrity was classified into stage 1 (healed), stage 2 (partially healed) and stage 3 (re-tear).[65] When SST scores were compared, patients with stage 3 classification showed significantly inferior outcome compared to patients with stage 1 and stage 2 classification (p<0.01); patients with stage 2 healing did not show any functional inferiority compared to those with stage 1 healing.[65] Of the 88 patients, 27 patients had stage 1 repair, 20 had stage 2 repair and 34 had stage 3 repair.[65] Another study used either single or double-row rotator cuff repair with patients and acromioplasty, with 95% of cases also

having tenotomy or tenodesis of the long head of the biceps tendon.[69] They examined the influence of age on outcomes after the intervention; statistical analysis of the SST score showed significant improvement post-intervention (p<0.05) and that age did not influence the clinical result.[69] One other study compared outcomes for people with healed rotator cuffs following **mini-open repair** and those with untreated cuff tear.[62] Postoperatively, the median SST score for the healed group was 12 (7,12) and patients with untreated cuff tear had an SST score of 9.5 (0,12), which was significantly lower than the SST score of the healed group.[62]

3.3.3 Effect on American Shoulder and Elbow Surgeons (ASES) Score

The ASES score contains practitioner-rated and patient-rated sections, and only the pain visual analogues scale and 10 functional questions are typically used to report ASES score.[80] The total score is weighted, 50% for pain and 50% for function. The maximum score for ASES is 100, with higher scores indicating better outcomes. Table 6 below outlines the pre-operative and post-operative ASES scores for individual studies.

Table 6: Mean ASES Score from cohort studies

	Intervention	***Pre-op (mean±SD)***	***Post-op (mean±SD)***	***Follow-up***	***p-value***
Arthroscopic repair with arthroscopic palliative procedure					
Flurin, P.H. et al. 2013b n = 145	Single or double-row rotator cuff repair with acromioplasty; majority (95% cases) also had tenotomy or tenodesis of the long head of the biceps	35.44±14.6	90	1 year	<0.05
Hamie, M. et al. 2017 n = 25	Single or Double-row rotator cuff repair* with subacromial decompression	29.89±6.47	81.53±4.21	6 months	<0.0001

	Intervention	*Pre-op (mean±SD)*	*Post-op (mean±SD)*	*Follow-up*	*p-value*
	and biceps tenodesis				
Open repair					
Jung, H.J. et al. 2017 n = 64	Open rotator cuff repair with open acromioplasty	42±16 (healed)	84±8	1 year	<0.001
		47±19 (re-tear)	78±11	1 year	<0.001
Mini-open repair					
Saraswat, M.K. et al. 2015 n = 59	Mini-open rotator cuff repair with subacromial decompression and labral debridement, biceps tenodesis and/or biceps debridement	59.6±21.1 (60-69 years)	86.8±27.6 (60-69 years)	10 year	<0.001
		50.6±21.5 (>70 years)	96.2±4.4 (>70 years)		

*-Single or double-row arthroscopic repair not specified for which patients

Five studies utilised ASES score to measure outcomes; of these, one trial provided comparative data.[60] This trial compared outcomes between older patients who received **arthroscopic repair plus decompression to those who were managed with decompression only**.[60] A significantly better improvement in ASES score was observed in the repair group compared to the decompression group (p=0.010). The superiority of arthroscopic repair over decompression also remained apparent when a subgroup analysis by age (70-74 years versus 75 and older) was performed.

All other studies that used ASES score demonstrated a favourable outcome following **arthroscopic repair with arthroscopic palliative procedure**[64, 69], **open repair** [73] **or mini-open repair** [71]. In addition to investigating the effect of single- and double-row repair, one study explored the effect of age on shoulder outcomes, and found that not only re-rupture was more common in older patients (aged 76 and above), but also had worse ASES score (those

aged 74 and above) compared to younger patients.[69] Another study compared outcomes between patients aged 60-69 and those who were 70 and older.[71] Both cohorts showed positive improvement at one year follow-up. At the 10 year follow-up, similar results were found, with mean ASES score improving from 59.6±21.1 to 86.8±27.6 for patients 60-69 years of age, and for 70 and older the mean ASES score increased from 86.1±16.2 to 96.2±4.4.[71] A study investigating treatment using open rotator cuff repair with acromioplasty, found significant improvement with ASES scores.[73] Preoperative score went from 42±16 to 84±8 postoperatively.[73] 45 out of 64 patients presented with functional scores >80.[73] Those who sustained a re-tear also experienced significant improvement, with preoperative score of 47±19 improving to 78±11 ($p<0.001$).[73] The study investigating mini-open technique demonstrated improved ASES score following treatment, which was maintained even at 10 years.[71]

3.3.4 Effect on University of California Los Angeles UCLA Score

The UCLA scoring tool was initially used in the assessment of the outcome of shoulder arthroplasty, since then the UCLA has been used for a variety of scoring conditions.[80] The UCLA score is a combination of physical examination findings (active forward flexion and muscle strength) and patient-reported measures (pain, satisfaction and function). The maximum score is 35 points; higher score indicates better function. Table 7 below outlines the pre-operative and post-operative UCLA scores found in individual studies.

Table 7: UCLA Score

	Intervention	***Pre-op (mean±SD)***	***Post-op (mean±SD)***	***Follow-up***	***p-value***
Arthroscopic repair with arthroscopic palliative procedure					
Osti, L. et al. 2010 n = 28	Single-row rotator cuff	9 (3-21) (median score)	31 (14-35) (median score)	2 years	<0.001

	Intervention	*Pre-op (mean±SD)*	*Post-op (mean±SD)*	*Follow-up*	*p-value*
	repair with biceps tenotomy				
Hamie, M. et al. 2017 n = 25	Double-row rotator cuff repair	10.52±2.00	30.48±2.04	6 months	<0.0001
Arthroscopic palliative procedure					
Veado, M.A. et al. 2010 n = 22	Arthroscopic debridement/ with biceps tenotomy (n=12)	15	31	2 years	NR
Arthroscopic repair with arthroscopic palliative procedures or Open Repair					
Park, J.G. et al. 2016 n = 25	Double-row repair with suture-bridge technique (n=6)/ Single-row repair (n=13)/ Open repair (n=6)	14.4±4.6 (re-tear group)	28.3±4.3	1 year	0.008
		15.8±3.8 (healed group)	31.1±2.3	1 year	0.008

All studies demonstrated significant improvements in UCLA score regardless of the surgical procedure received. The shortest follow-up was six months and the longest follow-up was two years.

Two studies investigated **arthroscopic repair with arthroscopic palliative procedure**. One study investigated repair by single-row rotator cuff repair and biceps tenotomy; based on median score, the study found a significant improvement in UCLA score (p<0.001).[63] The other study used the double-row rotator cuff repair technique and found a significant improvement within six months follow up (p<0.0001). **Arthroscopic palliative procedure** alone was used for one study, with the intervention being arthroscopic debridement with biceps tenotomy**.**[74] Improvement was observed with a preoperative score of 15 to a postoperative score of 31.[74] Of the 22 patients, 18 were over the age of 60 years and had just as much improvement as those below 60 years of age.[74] One study investigated the outcomes of rotator cuff repair

either through arthroscopic techniques or open procedure and compared scores between the re-tear group and the healed group. Nine patients had re-tears and a pre-operative mean UCLA score of 14.4±4.6 and postoperative score of 28.3±4.3.[13] Sixteen patients had healed rotator cuffs from either arthroscopic or open repair; pre-operative mean UCLA score was 15.8±3.8 and postoperative score was 31.1±2.3.[13] Significant improvements were found for both re-tear and healed groups, with no significant difference (p=0.388) between groups.[13]

3.3.5 Effect on Range of Motion

Included studies assessed flexion, abduction, external rotation and internal rotation. Range of motion was evaluated in nine studies; interventions included **surgical approaches** such as **arthroscopic repair with arthroscopic palliative procedure, arthroscopic palliative procedure alone, open repair and mini-open repair, and a conservative treatment, i.e. arm cycloergometer.**

Range of motion outcomes for studies investigating surgical approaches are shown in Table 8.

Table 8: Range of Motion

	Intervention	Flexion (⁰)		Abduction (⁰)		External Rotation (⁰)		Internal Rotation (⁰)	
		Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op	Pre-op	Post-op
Arthroscopic repair with arthroscopic palliative procedure									
Gwark, JI. et al. 2018 n =	Single-row or Double-row or Suture bridge technique with biceps tenotomy or tenodesis	120⁰	158⁰	101⁰	140⁰	47⁰	53⁰	10.4⁰	8.2⁰

Hamie, M. et al. 2017 n = 25	Single or Double-row rotator cuff repair* with subacromial decompression and biceps tenodesis	61-90°	121-150°	31-60°	121-150°	Narrative – see text below	Narrative – see text below	Narrative – see text below	Narrative – see text below
Moraiti, C. et al. 2015 n = 40	Single or Double-row rotator cuff repair*/ Acromioplasty (n=33)/ Resection of coracoacromial ligament (n=28)/ Resection of acromioclavicular joint (n=6)/ Tenotomy of long head of the biceps tendon (n=30)/ Tenodesis of long head of the biceps tendon (n=4)	145±34.6	164±25.5**	134±34.3	150±31.3**	6.4±2.6	9±1.6**	8±2.3	9±1.7**
Osti, L. et al. 2010 n = 28	Single-row rotator cuff repair with biceps tenotomy	134(8)	159(8)**	NR	NR	42(7)	53(6)**	26(3)	36(6)**
Arthroscopic palliative procedure									
Veado, M.A. et al. 2010 n = 22	Arthroscopic debridement / with biceps tenotomy (n=12)		164°				47°		
Open repair									

Jung, H.J. et al. 2017 n = 64	Open repair with open acromioplasty	124° ± 18° (intact group)	143° ± 13° **	NR	NR	30±10	38±11**	NR	NR
		107° ± 19° (re-tear group)	137° ± 19° **	NR	NR	20±13	36±4**	NR	NR
Mini-open repair									
Saraswat, M.K. et al. 2015 n = 59	Mini-open rotator cuff repair with subacromial decompression and labral debridement, biceps tenodesis and/or biceps debridement	131.6±26.7 (standing)	146.2 ±27.7 **	NR	NR	50.5±16.0 (0° abduction)	54.8±17.5	NR	NR
		144.2±28.7 (supine)	152.8 ±28.9 *			60.4±28.1 (90° abduction)	81.7±16.4*		
Arthroscopic repair with arthroscopic palliative procedures or Open Repair									
Djahangiri, A. et al. 2013	Open repair with biceps tenodesis (1st phase)/Single-row Arthroscopic repair with biceps tenotomy and acromioplasty (2nd phase)	128 (40-180)	160 (90-180)*	117 (30-180)	159 (90-180)*	49 (0-90)	49 (0-90)	L3 (T-D7)	D12 (S-D7)
Park, J.G. et al. 2016	Double-row repair with suture-bridge technique (n=6) or Single-row repair (n=13) or Open repair (n=6)	117±37 (re-tear group)	141±26*	136±27	123±29	58±18	51±15	T12±2.0	T11±2.7
		137±33 (healed group)	149±12*	124±28	138±24	52±13	44±14	T12±4.0	T11±3.9

*= $p<0.05$ **=$p<0.001$; T= thigh S= sacrum

Four studies investigated **arthroscopic repair with arthroscopic palliative procedure.** One study investigated single-row or double-row or suture bridge technique with biceps tenotomy or tenodesis.[75] They found range of motion increase for flexion, abduction and external rotation.[75] One study investigated single or double row intervention with subacromial decompression and biceps tenodesis.[64] Range of motion was assessed including flexion, abduction, internal rotation and external rotation and found positive improvement in all four postoperatively. Flexion and abduction measurements are reported in Table 8. External rotation improved from maximum reach of hand behind hand, elbow back to hand on top of head, elbow back ($p<0.0001$).[64] Internal rotation also had improvement from hand reaching buttock to T12 at final follow-up ($p<0.0001$).[64] Another study evaluated single or double-row repair with palliative procedures such as acromioplasty, resection of the acromioclavicular joint, resection of the coracoacromial ligament, tenotomy of the long head of biceps or tenodesis of the long head of biceps.[44] The study found significant improvement with flexion, extension, external rotation and internal rotation ($p<0.001$).[44] A study which investigated single-row arthroscopic repair with biceps tenotomy as the intervention evaluated flexion, internal rotation and external rotation and found significant improvement ($p<0.001$) in all motions.[63]

Two studies evaluated flexion and external rotation only. One study investigated **open repair** with open acromioplasty and the study found significant improvement between preoperative and postoperative range of motion for flexion and external rotation ($p<0.001$).[73] Participants were followed up at one year to compare outcomes between those patients who had a re-tear and those with intact rotator cuff. The study reported no significant difference in range of motion (both flexion and external rotation) between groups.[73] The other study investigated

mini-open repair with arthroscopic palliative procedure.[71] Range of motion evaluations were made at baseline, one year and ten years. At one year follow-up, scores for forward flexion (standing) had increased to 145.2±14.8 and forward flexion (supine) to 156.6±14.8, both of which were found to be significant ($p<0.001$ and $p<0.002$ respectively).[71] At the 10-year follow-up, forward flexion (standing) increased to 146.2±27.7, however, this was not significant ($p=0.773$).[71] Forward flexion (supine) decreased to 152.8±28.9 ($p=0.305$).[71] Scores for external rotation (0°abduction) at one year decreased to 49.7±13.4, but increased to 54.8±17.5 at the 10-year follow-up ($p<0.01$).[71] External rotation (90° abduction) showed improvement at one year, 69.9±14.5, which was not found to be significant ($p=0.023$). At the 10-year follow-up, however, a significant difference was found, 81.7±16.4 ($p<0.001$).[71]

Two studies which investigated **arthroscopic repair with arthroscopic palliative procedure or open repair** evaluated range of motion.[13, 68] One study evaluated range of motion after intervention by open repair with biceps tenodesis and single-row arthroscopic technique with biceps tenotomy and acromioplasty.[68] A significant difference was found between preoperative and postoperative scores of flexion and abduction ($p<0.05$), but there was no significant difference for internal and external rotation ($p>0.05$).[68] The second study investigated double-row repair with suture-bridge technique for medium to large tears in six patients, single-row repair for small and massive tears in 13 patients, and open repair six patients.[13] Analysis of all patients showed postoperative improvements in flexion, abduction, external and internal rotation, however, only flexion was statistically significant.[13] Range of motion outcomes for patients who had a re-tear was compared to those with healed rotator cuff. No significant differences were found for flexion, external rotation, internal rotation and abduction between groups.[13]

A randomised trial investigated the range of motion outcomes in patients who were treated with arm cycloergometer.[57] Compared to the control group, participants who received the **arm cycloergometer** demonstrated significant improvement in forward elevation (p<0.001), abduction (p=0.001) and external rotation (p=0.006).[57]

3.3.6 Muscle Strength

Only four studies evaluated muscle strength as an outcome.[13, 68, 73, 76] Three studies used **arthroscopic repair with arthroscopic palliative procedures or open repair.**[13, 68, 76] One of these assessed strength in 90° of abduction (kg) and found significant improvement from 2.5kg to 5.0kg.[68] Another study compared the muscle strength of patients who had a re-tear to those with a healed rotator cuff. Significant improvement in the strength of forward flexors, external rotators, internal rotators and abductors was demonstrated in the healed group; patients in the re-tear group experienced improvement, however, this was not significant (Table 9).[13] However, one study found mean postoperative muscle strength did not differ when the elderly cohort of patients aged 75 years and over were compared to the young cohort of patients (p=0.504).[76]

The remaining study investigated **open repair** with palliative procedure[73]. This study demonstrated significant improvements in mean supraspinatus muscle strength from 51% ± 19% (range 21% - 92%) to 78% ± 14% (range 44%-113%) and external rotator strength improving from a score of 59% ± 14% (range 22%-85%) to 81% ± 13% (range 40%-105%) (p<0.001).[73] This measurement was done using the Nottingham Mecmesin Myometer, with values being recorded as percentages.

Table 9: Muscle Strength (Park, J.G. et al.)[13]

	Re-tear Group			Healed Group		
	Pre-op (mean±SD)	Post-op (mean±SD)	p-value	Pre-op (mean±SD)	Post-op (mean±SD)	p-value
Forward Flexion (kg)	3.1±1.7	4.3±2.9	0.206	4.9±2.3	7.3±3.5	0.049
External Rotation (kg)	4.4±2.3	5.4±2.5	0.214	5.4±1.8	7.7±2.9	0.044
Internal Rotation (kg)	5.4±1.7	6.7±3.7	0.314	6.3±2.2	8.9±3.2	0.015
Abduction (kg)	3.4±1.6	4.9±2.2	0.139	4.5±2.1	6.4±2.3	0.002

3.4 Summary of Findings

The Summary of Findings table aims to summarise key results and evaluate confidence in the estimate of effects. This review found very little confidence in the effect estimate. Although the intervention proved to be slightly more beneficial than the comparison, the true effect is likely to be substantially different from the estimate of effect. This is due to poor randomization, data from studies at a high risk of bias, large statistical heterogeneity, wide confidence intervals and small sample sizes. Arthroscopic repair in addition to palliative procedures results in improved Constant-Murley Score, compared to palliative procedures alone (Table 10). However, arthroscopic repair did not provide clinically important benefits over arthroscopic palliative procedures alone (the minimal clinically important difference for Constant score is 10.4 points[78]).

Table 10: Summary of Findings

Arthroscopic Repair + Palliative Procedures compared to Palliative Procedures Only for Treatment of Full-thickness Rotator Cuff Tears

Patient or population: Treatment of Full-thickness Rotator Cuff Tears

Setting:

Intervention: Arthroscopic Repair + Palliative Procedures

Comparison: Palliative Procedures Only

Outcome № of participants (studies)	Relative effect (95% CI)	Anticipated absolute effects (95% CI)			Certainty	What happens
		Intervention	Comparison	**Difference**		
Constant-Murley Score follow up: range 1 to 4 years № of participants: 372 (3 RCTs)	-	The mean Constant-Murley Score was **78.06**	The mean Constant-Murley Score was 71.69	MD **6.54** (CI: 4.62 to 8.47)	⊕◯◯◯ VERY LOW [a]	Arthroscopic repair with palliative procedures was more effective than palliative procedures only.

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval; **MD:** Mean difference

0 = Poor score ; 100 = Optimal score

GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

a. Poor randomization
b. Individual studies at high risk of bias
c. Large statistical heterogeneity
d. Wide confidence intervals
e. Small sample size

Chapter 4: Discussion and Conclusion

This chapter explains the findings of the systematic review and presents these findings in the light of the existing knowledge around management strategies for full-thickness rotator cuff tears in the older population. Also considered in this chapter are the limitations and issues within individual studies and the systematic review process that could have cofounded the review results. Implications for practice and future research are then presented.

The aim of this systematic review was to synthesise the best available evidence on the effectiveness of non-surgical and surgical treatment on the clinical and functional outcomes of elderly patients (60 and older) with full-thickness rotator cuff tear. The majority of included studies investigated surgical interventions and only one study evaluated the effect of conservative treatment. Results of this review suggest that following an initial management with conservative strategies, surgical interventions are effective in improving outcomes associated with full-thickness rotator cuff tear in the elderly. Surgical procedures such as arthroscopic repair with palliative procedure/s, open repair, or mini-open repair of full-thickness rotator cuff tears can lead to positive postoperative clinical and functional outcomes in the elderly, in the short term. When compared to arthroscopic palliative procedures only, arthroscopic repair demonstrated greater improvements postoperatively. There was limited data regarding the effectiveness of conservative interventions.

4.1 General Discussion

In 2012, Downie et al. investigated in a systematic review the evidence regarding treatment of rotator cuff tears in older patients (mean age ranging between 59.3 and 64 years).[17] The review, which included three randomised controlled trials and five cohort studies, concluded that although outcomes following a surgical intervention were promising, there was

insufficient evidence to demonstrate the effectiveness of either surgical or non-surgical interventions.[17] Since this review was undertaken, several studies investigating treatment for full-thickness rotator cuff have been published, which made it apparent that a systematic review update is needed.

The current systematic review updated the previous review[1] and determined the effectiveness of non-surgical and surgical treatment on the clinical and functional outcomes of patients aged 60 years and older with full-thickness rotator cuff tears. In the geriatric population, rotator cuff tears are a prominent clinical problem, with age older than 60 years being associated with a twofold higher overall risk of tear occurrence (OR = 2.12, 95% CI 1.44 – 3.01) compared to the younger population.[46] The rate of rotator cuff tear in advanced age has been reported to be as high as 54% in those over 60 years old in contrast to only 4% in individuals less than 40 years old.[81, 82] Furthermore, patients older than 60 years are twice as likely to experience a large tear (OR = 2.29, 95% CI 1.51 – 3.27) and three times more likely to experience a massive tear (OR = 3.09. 95% CI 2.07 – 5.38) compared to younger individuals.[46] Even in the older population, rotator cuff tears are a substantial cause of disability, loss of income and missed work days (with increasing age for retirement) and are also associated with chronic pain, weakness and dysfunction of the upper extremity.[17, 83] Focusing the review in this age group is important as the treatment of rotator cuff tears in the older population can be considerably different from that of the younger population. This may be due to various factors associated with aging including differences in healing potential, aetiology of the tear, levels of activity and physical demands, and different long-term expectations.[43] The majority of rotator cuff tears in the elderly are the result of age-related degeneration.[82] Older patients are more likely to experience tears that are atraumatic, stemming from over-use and long-term degradation,[43] whereas younger patients tend to have acute traumatic tears and tears

associated with overuse in overhead athletes.[43, 84]Muscle atrophy and fatty degradation at the time of diagnosis also tend to be higher in older patients compared to younger patients.[43] In addition, younger patients tended to be impacted more by extrinsic factors such as subacromial and internal impingement, tensile overload and repetitive stress, which are not necessarily observed in the older population.[82] As such, there are reasons to believe that the approach to treatment for full-thickness rotator cuff tears in the elderly may not be similar to that of the younger patient cohort.

Twenty two studies were included in this systematic review, all except for one investigated the impact of surgical approaches. The focus on the use of surgery, instead of conservative strategies, as a treatment for rotator cuff tears in the existing studies may be due to a number of reasons. One reason for this may be due to the increase in the number of surgeons trained in arthroscopic techniques and is likely to become more commonly performed as shoulder arthroscopic skills and instrumentation improves.[85, 86] The arthroscopic technique appears to be the most common surgical approach due to the improved cosmetic results and treatment of concomitant pathological conditions, the lower levels of postoperative pain and the potentially lower risk of shoulder stiffness.[86, 87] In addition, new instrumentations, including new suture-passing devices, suture anchors and knot-less repair techniques have been introduced in the recent years.[85] Second, there is also a growing number of older but physically active patients who may potentially benefit from rotator cuff repair rather than conservative means, leading to the increased demand for surgical repair.[85] With the popularity of these surgical techniques, the challenge then becomes identifying patients with the greatest chance for a successful repair and optimizing the timing of the surgical intervention, such that the tear does not progress to a point of irreparability.[42]

In the reviewed studies, the length of symptom duration prior to surgical treatment was six months to one year, during which time patients received a trial of conservative treatment. Conservative treatments prior to surgery included subacromial cortisone injection, physiotherapy, nonsteroidal anti-inflammatory medication, exercises, activity modification, and/or corticosteroid injections.[13, 44, 59, 63, 65, 68, 70, 73, 74] These treatments were aimed at improving pain, supporting the affected shoulder and/or strengthening the shoulder muscles. Patients who were treated by conservative treatment and experienced no benefit or significant improvement within six months to one year, were referred for a surgical intervention. The decision to cease the conservative treatment and be referred for surgical repair was also informed by individual patient circumstances, taking into account patients' level of activity, long-term goals, work requirements (if they are still working), medical comorbidities, characteristics of the tear and individual level of functional defecit.[12, 88, 89] Operative repair within three months of the onset of a full-thickness tear has been proposed to result in better outcomes, as well as earlier return to work and decreased costs.[89] A patient undergoing repair for full-thickness tear within four months can generally expect a good result, whereas repairs of full-thickness tears beyond one year of symptomatic onset have poorer outcomes.[89] There is evidence that the risk for tear progression in conservative treated symptomatic full-thickness tears is high with approximately 50% progressing at an average of two years.[89] The results of this review suggest that a trial of conservative treatment for full-thickness tears may be worthwhile in older patients and failure to respond to such approach could then trigger referral to surgery, which is essentially similar to the treatment approach for younger patients.[10]

The introduction of arthroscopy-assisted surgery has driven a new wave of developments in rotator cuff repair.[90] This systematic review demonstrated that arthroscopic repair showed a

statistically significant benefit compared to palliative procedures only (e.g. acromioplasty, tenotomy) although no clinically important differences were observed. This result should be interpreted with caution due to the limited number of studies (three studies only, with high risk of bias) being involved in the meta-analysis. The use of palliative procedures, for example acromioplasty, can be readily performed; in this procedure the deltoid is preserved and the muscle-tendon unit released, and strong attachment to the greater tuberosity is still achieved.[90] Patients who undergo palliative procedures alone can have worse shoulder function and insufficient pain relief, compared to those who undergo repair plus palliative procedures.[91] The addition of arthroscopic palliative procedures such as debridement, tenotomy or tenodesis of the biceps and acromioplasty to rotator cuff repair aids in complete tendon healing and improves shoulder function in patients with rotator cuff tear. Surgeons who advocate acromioplasty, for example, suggest it prevents further compression over the cuff, improves visualization for cuff repair, and provides better healing.[92] Arthroscopic repairs are therefore always accompanied by palliative procedures.

In terms of the different arthroscopic repair procedures, none of the included studies compared the different techniques and hence, the most optimal method remains unclear. Studies investigating the single-row repair for rotator cuff tears have reported re-tears and incomplete tendon healing following this technique.[93] This could be a result of the single-row technique not completely recreating the native footprint insertion of the tendon onto the greater tuberosity, resulting in incomplete tendon healing.[93] Another article suggested that the single-row technique is simpler, quicker, inflicts less trauma to tendon margins, cheaper and easier to repair compared to other arthroscopic approaches.[92] Surgeons have been suggesting the use of the double-row arthroscopic repair technique as a means of increasing the contact area between the repaired rotator cuff and the native bone bed, which may

contribute to creating a better environment for tendon healing.[93] The aim of the double-row technique is to re-establish the anatomical mediolateral footprint restoration. However, a systematic review comparing the single row and double row techniques found no difference in their clinical outcomes and structural integrity of the shoulder.[93] The results from this review suggest that double-row arthroscopic repair and single-row arthroscopic repair with arthroscopic palliative procedure is beneficial for improvement in functional outcome scores.

A number of studies in this review also investigated open repair or mini-open repair, however, none of them compared outcomes between the different types of surgical approach.[62, 71, 73] What has been demonstrated in this review was that surgical repair, of any approach, was beneficial in the short term for elderly patients aged 60 years or above. While arthroscopic techniques seem to be the trend in recent years, findings of the current review do not favour one approach over another, which is similar to the results of a prospective comparative trial (involving individuals with mean age ranging between 56 and 61 years old) which showed no significant differences in clinical outcomes, and rate of healing and re-tears between open and arthroscopic rotator cuff repair.[94] A study undertaken by Dewan et al determined medical professionals' preferences for the type of surgery they undertake.[95] The majority preferred arthroscopic, followed by mini-open and only a few indicated they would choose open repair.[95] Most respondents had no opinion in terms of cost-effectiveness or which technique provided the best outcome, although more respondents thought arthroscopic and mini-open promoted quick healing and good cosmetic outcomes and led to better patient satisfaction compared to open repair.[95] However, they also perceived these procedures as harder to learn and more challenging than open repair.[95] It would seem therefore that the decision for the use of a particular surgical approach for full-thickness rotator cuff repair is dependent on the surgeon's preference.

One included study in the systematic review investigated the effect of extracellular biological augmentation in addition to arthroscopic repair. The study of cellular and molecular biology of tendon is increasing, yet still lacking.[96] Re-tear rates are still a defining problem for rotator cuff tears. As shown by ultrasonography, re-tears commonly occur at the suture-tendon junction and can be recognized by the tension at the repair site.[97] Extracellular matrix was introduced in the hope of augmenting the initial repair to reduce the possibility of failure. Despite advances in surgical approach, repairs of large (3-5cm) to massive (>5cm) rotator cuff tears have a high risk of retears.[97] Augmentation has become a topic of interest to improve the healing process after surgical repair of rotator cuff tears, including full-thickness tears, thereby improving surgical outcomes.[83] The aim of the augmentation is to decrease re-tear rates by evenly spreading the mechanical load across the repair site and strengthening the repair construct as well as enhancing the biological environment required for healing by providing different growth factors and structural protein.[72] This techniques appears to be promising, however, previous investigation into the extracellular matrix have reported a high rate of postoperative inflammatory reaction.[2] Until more good quality studies are undertaken to investigate the effectiveness of this technique, no definitive implications for practice relating to the use of biological augmentation can be reported.

4.2 Limitations

4.2.1 Limitations of included studies

There are a number of limitations within the included studies that need to be considered. First, there was a lot of methodological and clinical heterogeneity in the included studies which precludes comparison of findings across studies. Clinical heterogeneity included differences in the surgical techniques, outcomes measures and follow-up times. Methodological heterogeneity included differences in study design and risk of bias. Second,

only two studies assessed clinical outcomes past one year, which made it impossible to gain meaningful data on long-term outcomes of patients. Third, no studies on conservative treatments were found, hence, investigation of treatment effectiveness was only made possible for surgical approaches. Fourth, the lack of head to head comparisons for the different surgical interventions made the techniques difficult to compare. Finally, the quality of included studies, specifically the randomised controlled trials, was poor, and the majority of studies were observational cohort in design. As such, no definitive recommendations for practice can be made based on the available research evidence.

4.2.2 Limitations of the review process

There are a number of limitations to the systematic review process which should also be considered when interpreting the results of this review. First, only studies published in English were included which could have potentially introduced a language bias. Second, as in all systematic review studies, it is possible that some articles were missed in the search process which could have consequently excluded some important studies that would have been useful in drawing conclusions about the effectiveness of treatment. Finally, the screening of papers for inclusion in the review was done by the primary reviewer only (i.e. student author), increasing the potential for missing relevant studies.

4.3 Conclusion

The results of this systematic review suggest that following a trial of conservative treatment, a surgical repair for a full-thickness rotator cuff tear is beneficial for improving clinical and functional outcomes in elderly patients. However, whether or not these positive outcomes are sustained in the long term remains unknown, as is the best approach for surgical repair. No specific conclusions can be made regarding the effectiveness of conservative interventions as only one small study investigating such approach was found in the systematic review.

4.3.1 Implications for clinical practice

Based on the results of this review, patients 60 years and above with a full-thickness rotator cuff tear who do not respond adequately to conservative management may be referred for surgery. Rotator cuff repair combined with palliative procedures may result in better outcomes than palliative procedures alone. Based on current research, no specific recommendations can be made regarding the best approach to surgery and therefore the choice of surgical technique may be based on the training, skills and individual preference of the surgeon and ideally with input from a well-informed patient.

4.3.2 Implications for research

Given the variability and lack of standardised approach to surgical repair of full-thickness rotator cuff tears in the elderly, future research should focus on clinical trials that assess head to head comparisons of the different types of surgical interventions. Longer follow-up times for outcome measurements should also be considered in future trials to determine the long term effectiveness of surgical interventions. These trials should also aim to explore whether techniques such as extracellular matrix augmentation can address re-tears in surgically repaired rotator cuff tears. Research into the use of conservative treatment and its effectiveness in this population group should also be conducted. This might determine which patients have the potential to benefit from conservative intervention as well as those who are not likely to respond positively, and perhaps the duration for which nonsurgical techniques need to be trialled prior to referral for surgery to avoid the point of irreparability. Further studies on the treatment of full-thickness rotator cuff tear in the elderly should aim for clinical and methodological homogeneity to allow meta-analysis in the future, which could possibly lead to definitive conclusions and recommendations about rotator cuff tear treatment.

Appendices

Appendix 1: Joanna Briggs Institute Critical Appraisal Tool for use in JBI Systematic Reviews

JBI Critical Appraisal Checklist for Cohort Studies

Reviewer____Date______________________________

Author ____Year_________Record Number______

	Yes	No	Unclear	Not applicable
1. Were the two groups similar and recruited from the same population?	□	□	□	□
2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?	□	□	□	□
3. Was the exposure measured in a valid and reliable way?	□	□	□	□
4. Were confounding factors identified?	□	□	□	□
5. Were strategies to deal with confounding factors stated?	□	□	□	□
6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	□	□	□	□
7. Were the outcomes measured in a valid and reliable way?	□	□	□	□
8. Was the follow up time reported and sufficient to be long enough for outcomes to occur?	□	□	□	□
9. Was follow up complete, and if not, were the reasons to loss to follow up described and explored?	□	□	□	□
10. Were strategies to address incomplete follow up utilized?	□	□	□	□

11. Was appropriate statistical analysis used? ☐ ☐ ☐ ☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

Comments (Including reason for exclusion)

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JBI Critical Appraisal Checklist for Randomised Controlled Trials

Reviewer___________________________________Date___________________________

Author ____________________________________Year_________Record Number______

	Yes	No	Unclear	Not applicable
1. Was true randomization used for assignment of participants to treatment groups?	☐	☐	☐	☐
2. Was allocation to treatment groups concealed?	☐	☐	☐	☐
3. Were treatment groups similar at the baseline?	☐	☐	☐	☐
4. Were participants blind to treatment assignment?	☐	☐	☐	☐
5. Were those delivering treatment blind to treatment assignment?	☐	☐	☐	☐
6. Were outcome assessors blind to treatment assignment?	☐	☐	☐	☐
7. Were treatment groups treated identically other than the intervention of interest?	☐	☐	☐	☐
8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	☐	☐	☐	☐
9. Were participants analysed in the groups to which they were randomized?	☐	☐	☐	☐
10. Were outcomes measured in the same way for treatment groups?	☐	☐	☐	☐
11. Were outcomes measured in a reliable way?	☐	☐	☐	☐
12. Was appropriate statistical analysis used?	☐	☐	☐	☐

13. Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial? ☐ ☐ ☐ ☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

Comments (Including reason for exclusion)

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Appendix 2: Search Strategy

MEDLINE

1	rotator cuff[mh] OR rotator cuff[tw] OR rotator cuff injuries[mh] OR rotator cuff tear arthropathy[mh]
2	aged[mh] OR aged[tw] OR ageing[tw] OR aging[tw] OR elder*[tw] OR geriatric*[tw] OR old*[tw]
3	1 AND 2 (Limit to English and from 2012)

EMBASE

1	‘rotator cuff rupture’/exp OR ‘rotator cuff injury’/exp OR ‘rotator cuff arthropathy’/exp OR ‘rotator cuff’/exp OR ‘rotator cuff’
2	‘aged'/exp OR ‘aged’ OR ‘ageing’ OR ‘aging’/exp OR ‘aging’ OR ‘very elderly’/exp OR ‘elder*’ OR ‘geriatric patient’/exp OR ‘geriatric*’ OR ‘old*’
3	1 AND 2 (Limit to English and from 2012)

CINHAL

1	MH rotator cuff+ OR TX rotator cuff OR MH rotator cuff injuries
2	MH aged+ OR TX aged OR TX ageing OR TX aging OR TX elder* OR TX geriatric* OR TX older
3	1 AND 2 (Limit to English and from 2012)

Web of Science

1	rotator cuff* OR rotator cuff injur* OR rotator cuff arthropathy
2	aged OR ageing OR ageing OR aging OR very elderly OR geriatric patient OR geriatric OR old
3	1 AND 2 (Limit to English and from 2012)

Scopus

1	TITLE-ABS-KEY(“rotator cuff” OR “rotator cuff injur*” OR rotator cuff tear OR “rotator cuff tear” OR “rotator cuff arthropathy”)
2	TITLE-ABS-KEY(aged OR aging OR aging OR “very elderly” OR elderly OR “geriatric patient” OR geriatric OR old)
3	1 AND 2 (Limit to English and from 2012)

Appendix 3: Excluded Articles

Abate, M. Schiavone, C. Salini, V. Sonographic evaluation of the shoulder in asymptomatic elderly subjects with diabetes. BMC Musculoskeletal Disorders. 2010; 11:278

Reason for exclusion: Outcome of interest

Abate, M. Schiavone, C. Salini, V. The use of Hyaluronic Acid after tendon surgery and in tendinopathies. BioMed Research International. 2014.

Reason for exclusion: Concomitant shoulder condition (osteoarthritis)

Abboud, J.A. and Kim, J.S. The effect of hypercholesterolemia on rotator cuff disease. Clinical Orthopaedics and related research. 2010; 468(6): 1493-1497

Reason for exclusion: Inclusion criteria

Abrams, G.D., Gupta, A.K., Hussey, K.E., Tetteh, E.S., Karas, V., Bach, B.R., Cole, B.J., Romeo, A.A., Verma. N.N. Arthroscopic repair of full-thickness rotator cuff tears with and without acromioplasty: Randomized prospective trial with 2-year follow-up. American Journal of Sports Medicine. 2014; 42(6):1296-1303

Reason for exclusion: Age group

Abtahi, A.M., Granger, E.K., Tashjian, R.Z. Factors affecting healing after arthroscopic rotator cuff repair. World Journal of Orthopaedics. 2015; 6(2):211-220

Reason for exclusion: Study type (literature review)

Akpinar, S. Uysal, M., Pourbagher, M.A., Ozalay, M., Cesur, N., Hersekli, M.A. Prospective evaluation of the functional and anatomical results of arthroscopic repair in small and medium-sized full-thickness tears of the supraspinatus tendon. Acta Orthopaedica et Traumatologica Turcica. 2011; 45(4):248-253

Reason for exclusion: Age group

Alcobia-Diaz, B., Lopiz, Y., Garcia-Fernandez, C., Rizo de Alvaro, B., Marco, F. Patient reported activities after reverse total shoulder arthroplasty in rotator cuff arthropathy patients. Rev Esp Cir Ortop Traumatol. 2017; 61(4): 273-280

Reason for exclusion: Concomitant shoulder condition

Aleem, A.W. and Brophy, R.H. Outcomes of rotator cuff surgery: What does the evidence tell us?. Clinical Journal of Sport Medicine. 2012; 31(4): 665-674

Reason for exclusion: Study type

Aleem, A.W., Syed, U.A., Wascher, J., Zoga, A.C., Close, K., Abboud, J.A., Cohen, S.B. Functional outcomes after bilateral arthroscopic rotator cuff repair. Journal of Elbow and Shoulder Surgery. 2016; 25(10): 1668-1673

Reason for exclusion: Age group

Alenabi, T., Dal Maso, F., Tetreault, P., Begon, M. The effects of plane and arc elevation on electromyography of shoulder musculature in patients with rotator cuff tears. Clinical Biomechanics. 2016; 32; 194-200

Reason for exclusion: Outcomes of interest

Alentorn-Geli, E., Clark, N.J., Assenmacher, A.T., Samuelsen, B.T., Sanchez-Sotelo, J., Cofield, R.H., Sperling, J.W. What are the complications, survival and outcomes after revision to reverse shoulder arthroplasty in patients older than 80 years?. Clinical Orthopaedics and Related Research. 2017

Reason for exclusion: Concomitant shoulder condition

Alexander, L.D., Gilman, D.R.D., Brown, D.R., Brown, J.L., Houghton, P.E. Exposure to low amounts of ultrasound energy does not improve soft tissue shoulder pathology: A Systematic Review. Physical Therapy. 2010; 90(1):14-25

Reason for exclusion: Outcomes of interest

Ames, J.B., Horan, M.P., Van der Meijden, O.A., Leake, M.J., Millett, P.J. Association between acromial index and outcomes following arthroscopic repair of full-thickness rotator cuff tears. Journal of Bone and Joint Surgery. 2012; 94(20):1862-1869

Reason for exclusion: Concomitant shoulder condition (osteoarthritis)

Anakwenze, O.A., Baldwin, K., Milby, A.H., Warrender, W., Shulman, B., Abboud, J.A. Arthroscopic repair of large rotator cuff tears using the double-row technique: An analysis of surgeon experience on efficacy and outcomes. Journal of Shoulder and Elbow Surgery. 2013; 22(1): 26-31

Reason for exclusion: Age group

Antoni, M. Klouche, S., Mas, V., Ferrand, M., Bauer, T., Hardy, P. Return to recreational sport and clinical outcomes with at least 2 years follow-up after arthroscopic repair of rotator cuff tears. Orthopaedics and Traumatology: Surgery and Research. 2016; 102(5): 563-567

Reason for exclusion: Age group

Antuna, S., Barco, R., Martinez Diez, J.M. Platelet-rich fibrin in arthroscopic repair of massive rotator cuff tears: A prospective randomized pilot clinical trial. Acta Orthopaedica Belgica. 2013; 79(1): 25-30

Reason for exclusion: Age group

Aspey, B., Park, H.Y., Ostrander, R. Extensive heterotopic ossification after arthroscopic rotator cuff repair. JBJS Case Connector. 2015; 5(3)

Reason for exclusion: Concomitant shoulder condition (degenerative arthritis)

Aydin, N., Kocaoglu, B., Guven, O. Single-row versus double-row arthroscopic rotator cuff repair in small to medium-sized tears. Journal of Shoulder and Elbow Surgery. 2010; 19(5):722-725

Reason for exclusion: Age group

Bae, K.H., Kim, J.W., Kim, T.K., Kweon, S.H., Kang, H.J., Kim, J.Y., Joo, M.S., Kim, D.M. Is the arthroscopic modified suture band technique suitable for all full-thickness rotator cuff tears?. Journal of Shoulder and Elbow Surgery. 2016; 25(9): 1457-1463

Reason for exclusion: Age group

Baker, D.K., Perez, J.L., Watson, S.L., McGwin, G., Brabston, E.W., Hudson, P.W., Ponce, B.A. Arthroscopic Versus Open Rotator Cuff Repair: Which has a better complication and 30-day readmission profile?. Arthroscopy – Journal of Arthroscopic and Related Surgery. 2017; 33(10): 1764-1769

Reason for exclusion: Outcomes of interest

Barber, F.A. Triple-loaded Single-row Versus Suture-bridge Double-row Rotator Cuff Tendon Repair with Platelet-rich Plasma Fibrin Membrane: A randomized controlled trial. Arthroscopy – Journal of Arthroscopic and Related Surgery. 2016; 32(5): 753-761

Reason for exclusion: Age group

Barber, F.A., Hrnack, S.A., Snyder, S.J., Hapa, O. Rotator cuff repair healing influenced by platelet-rich plasma construct augmentation. Arthroscopy. 2011; 27(8): 1029-1035

Reason for exclusion: Age group

Barth, J., Fotiadis, E., Barthelemy, R., Saffarini, M. Critical postoperative time for rotator cuff healing and re-tear predisposing risk factors. Retrogression curve type of diagram on cuff integrity over time. Arthroscopy – Journal of Arthroscopic and Related Surgery; 31(6)

Reason for exclusion: Unable to access paper

Baumer, T.G., Chan, D., Mende, V., Dischler, J., Zauel, R., Holsbeeck van, M., Siegal, D.S., Divine, G., Moutzouros, V., Bey, M.J. Effects of rotator cuff pathology and physical therapy on in vivo shoulder motion and clinical outcomes in patients with a symptomatic full-thickness rotator cuff tear. Orthopaedic Journal of Sports Medicine. 2016; 4(9)

Reason for exclusion: Age group

Bell, S., Lim, Y.J., Coghlan, J. Long-term longitudinal follow-up of mini-open rotator cuff repair. Journal of Bone and Joint Surgery. 2013; 95(2): 151-157

Reason for exclusion: Age group

Bennell, K., Wee, E., Coburn, S., Green, S., Harris, A., Staples, M., Forbes, A., Buchbinder, R. Efficacy of standardised manual therapy and home exercise programme for chronic rotator cuff disease: Randomised placebo controlled trial. BMJ. 2010; 341(7763): 82

Reason for exclusion: Age group

Berdusco, R., Trantalis, J.N., Nelson, A.A., Sohmer, S., More, K.D., Wong, B., Boorman, R.S., Lo, I.K. Arthroscopic repair of massive, contracted, immobile tears using interval slides: Clinical and MRI structural follow-up. Knee Surgery, Sports Traumatology, Arthroscopy. 2015; 23(2): 502-507

Reason for exclusion: Age group

Bergeson, A.G., Tashjian, R.Z., Greis, P.E., Crim, J., Stoddard, G.J., Burks, R.T. Effects of platelet-rich fibrin matrix on repair integrity of at-risk rotator cuff tears. American Journal of Sports Medicine. 2012; 40(2): 286-293

Reason for exclusion: Age group

Berth, A., Neumann, W., Awiszus, F., Pap, G. Massive rotator cuff tears: Functional outcome after debridement or arthroscopic partial repair. Journal of Orthopaedics and Traumatology. 2010; 11(1): 13-20

Reason for exclusion: Age group

Bhatia, S., Greenspoon, J.A., Horan, M.P., Warth, R.J., Millet, P.J. Two-year outcomes after arthroscopic rotator cuff repair in recreational athletes older than 70 years. American Journal of Sports Medicine. 2015; 43(7): 1737-1742

Reason for exclusion: Concomitant shoulder condition (osteoarthritis)

Bhatia, S., Piasecki, D.P., Nho, S.J., Romeo, A.A., Cole, B.J., Nicholson, G.P., Boniquit, N., Verma, N.N. Early return to work in workers' compensation patients after arthroscopic full-thickness rotator cuff repair. Arthroscopy. 2010; 26(8): 1027-1034

Reason for exclusion: Age group

Bialoszewski, D. and Zaborowski, G. Usefulness of manual therapy in the rehabilitation of patients with chronic rotator cuff injuries. Preliminary report. Ortopedia, traumatologia, rehabilitacja. 2011; 13(1): 9-20

Reason for exclusion: Unable to access paper

Bjornsson, H., Norlin, R., Knutsson, A., Adolfsson, L. Fewer rotator cuff tears fifteen years after arthroscopic subacromial decompression. Journal of Shoulder and Elbow Surgery. 2010; 19(1): 111-115

Reason for exclusion: Age group

Black, E.M., Lin, A., Srikumaran, U., Jain, N., Freehill, M.T. Arthroscopic transosseous rotator cuff repair: Technical note, outcomes, and complications. Orthopaedics. 2015; 38(5): 352-358

Reason for exclusion: Age group

Boileau, P., McClelland Jr, W.B., Rumian, A.P. Massive irreparable rotator cuff tears: how to rebalance the cuff-deficient shoulder. Instructional course lectures. 2014; 63: 71-83

Reason for exclusion: Study type

Bond, E.C., Maher, A., Hunt, L., Leigh, W., Brick, M., Young, S.W., Caughey, M. The role of acromioplasty when repairing rotator cuff tears – no difference in pain or functional outcome at 24 months in a cohort of 2,441 patients. The New Zealand Medical Journal. 2017; 130(1458): 13-20

Reason for exclusion: Age group

Boorman, R.S., More, K.D., Hollinshead, R.M., Wiley, J.P., Brett, K., Mohtadi, N.G., Nelson, A.A., Lo, I.K., Bryant, D. The rotator cuff quality-of-life index predicts the outcome of nonoperative treatment of patients with a chronic rotator cuff tear. Journal of Bone and Joint Surgery. 2014; 96(22): 1883-1888

Reason for exclusion: Age group

Boyer, P., Bouthors, C., Delcourt, T., Stewart, O., Hamida, F., Mylle, G., Massin, P. Arthroscopic double-row cuff repair with suture-bridging technique: A structural and functional comparison of two techniques. Knee Surgery, Sports Traumatology, Arthroscopy. 2015; 23(2): 478-486

Reason for exclusion: Age group

Boykin, R.E., Heuer, H.J.D., Vaishnav, S., Millett, P.J. Rotator cuff disease? Basics of diagnosis and treatment. Rheumatology Reports. 2010; 2(1): 1-12

Reason for exclusion: Study type

Boyland, D.A. and Lowe, J. The influence of balance and postural control on shoulder function in a patient with chronic rotator cuff pathology. Orthopaedic Physical Therapy Practice. 2011; 23(1): 14-19

Reason for exclusion: Study type

Braunstein, V., Ockert, B., Windolf, M., Sprecher, C.M., Mutschler, W., Imhoff, A., Postl, L.K., Biberthaler, P., Kirchhoff, C. Increasing pullout strength of suture anchors in osteoporotic bone using augmentation—a cadaver study. Clinical Biomechanics. 2015; 30(3): 243-247

Reason for exclusion: Patients involved

Brophy, R.H., Dunn, W.R., Kuhn, J.E. Shoulder activity level is not associated with the severity of symptomatic, atraumatic rotator cuff tears in patients electing nonoperative treatment. American Journal of Sports Medicine. 2014; 42(5): 1150-1154

Reason for exclusion: Concomitant shoulder condition (osteoarthritis)

Brumitt, J., Meira, E.P., En Gilpin, H., Brunette, M. Comprehensive strength training program for a recreational senior golfer 11-months after rotator cuff repair. International Journal of Sports Physical Therapy. 2011; 6(4): 343-356

Reason for exclusion: Study type

Bryant D., Holtby, R., Willits, K., Litchfield, R., Drosdwech, D., Spouge, A., White, D., Guyatt, G. A randomized clinical trial to compare the effectiveness of rotator cuff repair with or without augmentation using porcine small intestine submucosa for patients with moderate to large rotator cuff tears: A pilot study. Journal of Shoulder and Elbow Surgery. 2016; 25(10): 1623-1633

Reason for exclusion: Age group

Buess, E., Waibl, B., Seidner, R., Werlen, S. Outcome of arthroscopic rotator cuff repair in large tears: The exposed footprint. Acta Orthop Belg. 2011; 77(6): 743-750

Reason for exclusion: Age group

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Reason for exclusion: Study type

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Reason for exclusion: Study type

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Reason for exclusion: Study type

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Reason for exclusion: Age group

Can, B., Kara, M., Ulger, Z., Frontera, W.R., Ozcakar, L. The value of musculoskeletal ultrasound in geriatric care and rehabilitation. International Journal of Rehabilitation Research. 2017

Reason for exclusion: Study type

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Reason for exclusion: Age group

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Reason for exclusion: Age group

Carr, A.J., Cooper, C., Campbell, M.K., Rees, J., Moser, J., Beard, D.J., Fitzpatrick, R., Gray, A., Dawson, J., Murphy, J., Bruhn, H., Cooper, D., Ramsay, C. Clinical effectiveness and cost-effectiveness of open and arthroscopic rotator cuff repair [the UK rotator cuff surgery (UKUFF) randomised trial. Health Technology Assessment. 2015; 19(80): 1-218

Reason for exclusion: Age group

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Reason for exclusion: Study type

Castricini, R., De Benedetto, M., De Nardo, P., Orlando, N., Gasparini, G., Galasso, O. Functional status and failed rotator cuff repair predict outcomes after arthroscopic assisted latissimus dorsi transfer for irreparable massive rotator cuff tears. Journal of Shoulder and Elbow Surgery. 2016; 25(4): 658-665

Reason for exclusion: Age group

Castricini, R., Gasparini, G., Di Luggo, F., De Bendetto, M., De Gori, M., Galasso, O. Health-related quality of life and functionality after reverse shoulder arthroplasty. Journal of Shoulder and Elbow Surgery. 2013; 22(12): 1639-1649

Reason for exclusion: Concomitant shoulder condition (osteoarthritis)

Castricini, R., Longo, U.G., De Benedetto, M., Loppini, M., Zini, R., Maffulli, N., Denaro, V. Arthroscopic- assisted latissimus dorsi transfer for the management of irreparable rotator cuff tears: Short-term results. Journal of Bone and Joint Surgery. 2014; 96(14): 119

Reason for exclusion: Concomitant shoulder condition (osteoarthritis)

Castricini, R., Longo, U.G., De Benedetto, M., Panfoli, N., Zini, R., Maffulli, N., Denaro, V. Platelet-rich plasma augmentation for arthroscopic rotator cuff repair: A randomized controlled trial. American Journal of Sports Medicine. 2011; 39(2): 258-265

Reason for exclusion: Age group

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Reason for exclusion: Study Type

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Reason for exclusion: Study type

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Reason for exclusion: Age group

Chen, H.T. Simultaneous rupture of bilateral quadriceps tendon and rotator cuff tear: A case report. West Indian Medical Journal. 2012; 61(2): 204-206

Reason for exclusion: Study type

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Reason for exclusion: Age group

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Reason for exclusion: Partial tears included, age group

Cho, C.H., Jang, H.K., Bae, K.C., Lee, S.W., Lee, Y.K., Shin, H.K. Clinical outcomes of rotator cuff repair with arthroscopic capsular release and manipulation for rotator cuff tear with stiffness: A matched-pair comparative study between patients with and without stiffness. Arthroscopy. 2015; 31(3): 482-487

Reason for exclusion: Age group

Cho, C.H., Song, K.S., Min, B.W., Jung, G.H., Lee, Y.K., Sin, H.K. Anterolateral approach for mini-open rotator cuff repair. International Orthopaedics. 2012; 36(1): 95-100

Reason for exclusion: Age group

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Reason for exclusion: Partial tears included, age range

Choi, S.W., Nam, K.W., Kim, M.K., Kim, S.R., Kang, H.S., Teong, C.T. Correlation of clinical and structural outcomes after arthroscopic rotator cuff repair with a suture bridge technique. Arthroscopy – Journal of Arthroscopic and Related Surgery. 2013; 29(10): 96

Reason for exclusion: Unable to access

Choo, H.J., Lee, S.J., Kim, J.H., Kim, D.W., Park, Y.M., Kim, O.H., Kim, S.J. Delaminated tears of the rotator cuff: Prevalence, characteristics, and diagnostic accuracy using indirect MR arthrography. American Journal of Roentgenology. 2015; 204(2): 360-366

Reason for exclusion: Objective of the study

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Reason for exclusion: Objective of the study

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Reason for exclusion: Age group

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Reason for exclusion: Age group, concomitant shoulder condition

Christoforetti, J.J., Krupp, R.J., Singleton, S.B., Kissenberth, M.J., Cook, C., Hawkins, R.J. Arthroscopic suture bridge transosseus equivalent fixation of rotator cuff tendon preserves intratendinous blood flow at the time of initial fixation. Journal of Shoulder and Elbow Surgery. 2012; 21(4): 523-530

Reason for exclusion: Objective of the study

Chuang, M.J., Jancosko, J., Notage, W.M. Clinical outcomes of single-row arthroscopic revision rotator cuff-repair. Orthopaedics. 2014; 37(8): e692-698

Reason for exclusion: Concomitant shoulder condition (rheumatoid arthritis)

Chung, S.W., Kim, J.Y., Kim, M.H., Kim, S.H., Oh, J.H. Arthroscopic repair of massive rotator cuff tears: Outcome and analysis of factors associated with healing failure or poor postoperative function. American Journal of Sports Medicine. 2013; 41(7): 1674-1683

Reason for exclusion: Age group

Chung, S.W., Kim, J.Y., Yoon, J.P., Lyu, S.H., Rhee, S.M., Oh, S.B. Arthroscopic repair of partial-thickness and small full-thickness rotator cuff tears: Tendon quality as a prognostic factor for repair integrity. American Journal of Sports Medicine. 2015; 43(3): 588-596

Reason for exclusion: Age group

Chung, S.W., Park, J.S., Kim, S.H., Shin, S.H., Oh, J.H. Quality of life after arthroscopic rotator cuff repair: Evaluation using SF-36 and an analysis of affecting clinical factors. American Journal of Sports Medicine. 2012; 40(3): 631-639

Reason for exclusion: Concomitant shoulder condition (arthritis)

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Reason for exclusion: Age group

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Reason for exclusion: Study type

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Reason for exclusion: Objective of the study

Cole, B.J., Cotter, E.J., Wang, K.C., Davey, A. Patient understanding, expectations, and satisfaction regarding rotator cuff injuries and surgical management. Arthroscopy. 2017; 33(8): 1603-1606

Reason for exclusion: Study type

Collin, P., Abdullah, A., Kherad, O., Gain, S., Denard, P.J., Ladermann, A. Prospective evaluation of clinical and radiologic factors predicting return to activity within 6 months after arthroscopic rotator cuff repair. Journal of Shoulder and Elbow Surgery. 2015; 24(3): 439-445

Reason for exclusion: Age group

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Reason for exclusion: Age group

Collin, P.G., Gain, S., Nguyen Huu, F., Ladermann, A. Is rehabilitation effective in massive rotator cuff tears?. Orthopaedics & Traumatology: Surgery and Research. 2015; 101(4): S203-205

Reason for exclusion: Age group

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Reason for exclusion: Objective of the study

Connelly, T.M., Shaw, A., O'Grady, P. Outcome of open massive rotator cuff repairs with double-row suture knotless anchors: Case Series. International Orthopaedics. 2015; 39(6): 1109-1114

Reason for exclusion: Age group

Conti, M., Garofalo, R., Castagna, A. Does a brace influence clinical outcomes after arthroscopic rotator cuff repair?. Musculoskeletal Surgery. 2015; 99(1): S31-35

Reason for exclusion: Age group

Cooper, H.J., Mililo, R., Klein, D.A., DiFelice, G.S. The MRI geyser sign: Acromioclavicular joint cysts in the setting of a chronic rotator cuff tear. American Journal of Orthopaedics (Belle Mead NJ). 2011; 40(6): E118-121

Reason for exclusion: Study type

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Reason for exclusion: Objective of the study

Cuff, D., Clark, R., Pupello, D., Frankle, M. Reverse shoulder arthroplasty for the treatment of rotator cuff deficiency: A concise follow-up at a minimum of five years, of a previous report. American Journal of Bone and Joint Surgery. 94(21): 1996-2000

Reason for exclusion: Concurrent shoulder condition (arthritis)

Cuff, D.J. and Pupello, D.R. Prospective randomized study of arthroscopic rotator cuff repair using an early versus delayed postoperative physical therapy protocol. Journal of Shoulder and Elbow Surgery. 2012; 21(11): 1450-1455

Reason for exclusion: Age group

Cuff, D.J., Pupello, D.R., Santoni, B.G. Partial rotator cuff repair and biceps tenotomy for the treatment of patients with massive cuff tears and retained overhead elevation: Midterm outcomes with a minimum 5 years of follow-up. Journal of Shoulder and Elbow Surgery. 2016; 25(11): 1803-1809

Reason for exclusion: Age group

Davidson, J. and Burkhart, S.S. The geometric classification of rotator cuff tears: A system linking tear pattern to treatment and prognosis. Arthroscopy. 2010; 26(3): 417-424

Reason for exclusion: Study type

Day, J.S., MacDonald, D.W., Olsen, M. Getz, C., Williams, G.R., Kurtz, S.M. Polyethylene wear in retrieved reverse total shoulder components. Journal of Shoulder and Elbow Surgery. 2012; 21(5): 667-674

Reason for exclusion: Objective of the study

De Biase, C.F., Decogliano, M., Borroni, M., Castagna, A., Reverse total shoulder arthroplasty: Radiological and clinical result using an eccentric glenosphere. Musculoskeletal Surgery. 2012; 96: S27-34

Reason for exclusion: Objective of the study

De Carvalho, B.R., Puri, A., Calder, J.A. Open rotator cuff repairs in patients 70 years and older. ANZ Journal of Surgery. 2012; 82(6): 461-465

Reason for exclusion: Partial-thickness tear included

De Casas, R., Lois, M., Cidoncha, M., Valadron, M. Clinic and electromyographic results of latissimus dorsi transfer for irreparable posterosuperior rotator cuff tears. Journal of Orthopaedic Surgery and Research. 2014; 9:83

Reason for exclusion: Age group

De Castro Veado, M.A., Prata, E.F., Gomes, D.C. Rotator cuff injury in patients over the age of 65 years: Evaluation of function, integrity and strength. Rev Bras Ortop. 2015; 50(3): 318-323

Reason for exclusion: Thickness of tear not specified

De Oliveira, F.C.L., De Fontenay, B.P., Bouyer, L.J., Desmeules, F., Roy, J.S. Effects of Kinesiotaping added to a rehabilitation programme for patients with rotator cuff tendinopathy: Protocol for a single-blind, randomised controlled trial addressing symptoms, functional limitations, and underlying deficits. BMJ Open. 2017; 7(9)

Reason for exclusion: Age group

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Reason for exclusion: Age group

De Witte, P.B., Van der Zwaal, P., Van Arkel, E.R.A., Nelissen, R.G.H.H., De Groot, J.H. Pathologic deltoid activation in rotator cuff patients: Normalization after cuff repair?. Medical and Biological Engineering and Computing. 2014; 52(3): 241-249

Reason for exclusion: Age group

Defroda, S.F., Feller, R., Klinge, S.A. Surgical management of the aging athlete. Current Sports Medicine Reports. 2016; 15(6): 426-432

Reason for exclusion: Study type

DeHaan, Alexander M., Axelrad, Thomas W., Kaye, E., Silvestri, L., Puskas, B., Foster, Timothy, E. Does double-row rotator cuff repair improve functional outcome of patients compared with single-row technique? A systematic review. American Journal of Sports Medicine. 2012; 40(5): 1176-1185

Reason for exclusion: Study type

Demirors, H., Circi, E., Akgun, R.C., Tarhan, N.C., Cetin, N., Akpinar, S., Tuncay, I.C. Correlations of isokinetic measurements with tendon healing following open repair of rotator cuff tears. International Orthopaedics. 2010; 34(4): 531-536

Reason for exclusion: Age group

Demos, T.C., Lomasney, L.M., Familiari, F., Huri, G., Gonzalez-Zapata, A., McFarland, E.G. Scapula fracture and os acromiale after reverse total shoulder arthroplasty. Orthopaedics. 2014; 37(7): 434-495

Reason for exclusion: Study type

Denard, P.J. and Burkhart, S.S. Medialization of the subscapularis footprint does not affect functional outcome of arthroscopic repair. Arthroscopy – Journal of Arthroscopic and Related Surgery. 2012; 28(11): 1608-1614

Reason for exclusion: Age group

Denard, P.J., Jiwani, A.Z., Ladermann, A., Burkhart, S.S. Long-term outcome of a consecutive series of subscapularis tendon tears repaired arthroscopically. Arthroscopy; 28(11): 1587-1591

Reason for exclusion: Age group

Denard, P.J., Jiwani, A.Z., Ladermann, A., Burkhart, S.S. Long-term outcome of arthroscopic massive rotator cuff repair: The importance of double-row fixation. Arthroscopy. 2012; 28(7): 909-915

Reason for exclusion: Age group

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Reason for exclusion: Age group

Deranlot, J., Herisson, O., Nourissat, G., Zbili, D., Werthel, J.D., Vigan, M., Bruchou, F. Arthroscopic subacromial spacer implantation in patients with massive irreparable rotator cuff tears: Clinical and radiographic results of 39 retrospective cases. Arthroscopy – Journal of Arthroscopic and Related Surgery. 33(9): 1639-1644

Reason for exclusion: Age group

Diebold, G., Lam, P., Walton, J., Murrell, G.A.C. Relationship between age and rotator cuff re-tear: A study of 1,600 consecutive rotator cuff repairs. American Journal of Bone and Joint Surgery. 2017; 99(14): 1198-1205

Reason for exclusion: Partial thickness tears included

Dodson, C.C., Kitay, A., Verma, N.N., Adler, R.S., Nguyen, J., Cordasco, F.A., Altchek, D.W. The long-term outcome of recurrent defects after rotator cuff repair. Amrican Journal of Sports Medicine. 38(1): 35-39

Reason for exclusion: Age group

Doppelt, J.D., Neviaser, R.J. Mini-open rotator cuff repair does not result in intractable stiffness. American Journal of Orthopaedics (Belle Mead NJ). 2011; 40(12): E253-256

Reason for exclusion: Age group

Doss, A. Neotendon infilling of a full-thickness rotator cuff foot print tear following ultrasound guided liquid platelet rich plasma injection and percutaneous tenotomy: Favourable outcome up to one year. F1000 Research; 2

Reason for exclusion: Study design

Downie, B.K. and Miller, B.S. Treatment of rotator cuff tears in older individuals: A systematic review. Journal of Shoulder and Elbow Surgery. 2012; 21(9): 1255-1261

Reason for exclusion: Study type

Du Plessis, M., Eksteen, E., Jenneker, A., Kriel, E., Mentoor, C., Stucky, T., Van Staden D., Morris, L.D. The effectiveness of continuous passive motion on range of motion, pain, and muscle strength following rotator cuff repair: A systematic review. Clinical Rehabilitation. 2011; 25(4): 291-302

Reason for exclusion: Study type

Duquin, T.R., Buyea, C., Bisson, L.J. Which method of rotator cuff repair leads to the highest rate of structural healing? A systematic review. 2010; 38(4): 835-841

Reason for exclusion: Study type

Duzgan, I., Baltaci, G., Ahmet, Atay, O. Comparison of slow and accelerated rehabilitation protocol after arthroscopic rotator cuff repair: Pain and Functional activity. Acta Orthopaedica et Traumatogica Turica. 2011; 45(1): 23-33

Reason for exclusion: Age group

Duzgan, I., Baltaci, G., Turgut, E., Atay, O. A. Effects of slow and accelerated rehabilitation protocols on range of motion after arthroscopic rotator cuff repair: Acta Orthopaedica et Traumatologica Turcica. 2014; 48(6): 642-648

Reason for exclusion: Age group

Dwyer, T., Razmjou, H., Henry, P., Gosselin-Fournier, S., Holtby, R. Association between pre-operative magnetic resonance imaging and reparability of large and massive rotator cuff tears: Knee Surgery, Sports Traumatology, Arthroscopy. 2015; 23(2): 415-422

Reason for exclusion: Age group

Edwards, P., Ebert, J., Joss, B., Bhabra, G., Ackland, T., Wang, A. Exercise rehabilitation in the non-operative management of rotator cuff tears: A review of the literature: International Journal of Sports Physical Therapy. 2016; 11(2): 279-301

Reason for exclusion: Study Type

El Hyaoui, H., El Koumiti, N., Toua, T., Chahrane, Y., Hamit Moukhtar, C., Messoudi, A., Hassoun, J., Arssi, M., Garch, A., Kassimi, E.H., Lmidmani, F., Elfatimi, A. Dislocation of the shoulder in elderly patients over 50 years: About 23 cases. Annals of Physical and Rehabilitation Medicine. 2014; 57

Reason for exclusion: Study type

El-Azab, H., Buchmann, S., Beitzel, K., Waldt, S., Imhoff, A.B. Clinical and structural evaluation of arthroscopic double-row suture-bridge rotator cuff repair: Early results of a novel technique. Knee Surgery, Sports Traumatology, Arthroscopy. 2010; 18(12): 1730-1737

Reason for exclusion: Age group

El-Azab, H.M., Rott, O., Irlenbusch, U. Long-term follow-up after latissimus dorsi transfer for irreparable posterosuperior rotator cuff tears. American Journal of Bone and Joint Surgery. 2015; 97(6): 462-469

Reason for exclusion: Age group

Elhassan, B.T., Wagner, E.R., Werthel, J.D. Outcome of lower trapezius transfer to reconstruct massive irreparable posterior-superior rotator cuff tear. Journal of Shoulder and Elbow Surgery. 2016; 25(8): 1346-1353

Reason for exclusion: Age group

Ellera Gomes, J.L., Da Silva, R.C., Silla, L.M., Abreu, M.R., Pellanda, R. Conventional rotator cuff repair complemented by the aid of mononuclear autologous stem cells. Knee Surgery, Sports Traumatology, Arthroscopy. 2012; 20(2): 373-377

Reason for exclusion: Age group

Encalada-Diaz, I., Cole, B.J., Macgillivray, J.D., Ruiz-Suarez, M., Kercher, J.S., Friel, N.A., Valero-Gonzalez, F. Rotator cuff repair augmentation using a novel polycarbonate polyurethane patch: Preliminary results at 12 months' follow-up. Journal of Shoulder and Elbow Surgery. 2011; 20(5): 788-794

Reason for exclusion: Age group

Fabbri, M., Ciompi, A., Lanzetti, R.M., Vadala, A., Lupariello, D., Iorio, C., Serlorenzi, P., Argento, G., Ferretti, A., De Carli, A. Muscle atrophy and fatty infiltration in rotator cuff tears: Can surgery stop muscular degenerative changes? Journal of Orthopaedic Science. 2016; 21(5): 614-618

Reason for exclusion: Age group

Fabbro, E., Ferrero, G., Orlandi, D., Sconfienza, L.M., Silvestri, E., Serafini, G. Ultrasound-guided subacromial injection of hyaluronic acid in the treatment of elderly patients affected by massive rupture of the rotator cuff. CardioVascular and Interventional Radiology. 2011; 34

Reason for exclusion: Unable to access paper

Farhan-Alanie, O.M. and Brooksbank, A. Rotator cuff injury following shoulder dislocation: Investigation and management. International Journal of Surgery; 12: S65-66

Reason for exclusion: Age group, Objective of study

Favard, L., Levigne, C., Nerot, C., Gerber, C., De Wilde, L., Mole, D. Reverse prostheses in arthropathies with cuff tear: Are survivorship and function maintained over time?. Clinical Orthopaedics and Related Research. 2011; 469(9): 2469-2475

Reason for exclusion: Age group

Fermont, A.J., Wolterbeek, N., Wessel, R.N., Baeyens, J.P., De Bie, R.A. Prognostic factors for successful recovery after arthroscopic rotator cuff repair: A systematic literature review. Journal of Orthopaedic and Sports Physical Therapy. 2014; 44(3): 153-163

Reason for exclusion: Study type

Fermont, A.J., Wolterbeek, N., Wessel, R.N., Baeyens, J.P., De Bie, R.A. Prognostic factors for recovery after arthroscopic rotator cuff repair: A prognostic study. Journal of Shoulder and Elbow Surgery. 2015; 24(8): 1249-1256

Reason for exclusion: Age group

Fink Barnes, L.A., Kim, H.M., Caldwell, J.M., Buza, J., Ahmad, C.S., Bigliani, L.U., Levine, W.N. Satisfaction, function, and repair integrity after arthroscopic versus mini-open rotator cuff repair. Bone and Joint Journal. 2017; 99(2): 245-249

Reason for exclusion: Age group

Fischer, C.A., Weber, M.A., Neubecker, C., Bruckner, T., Tanner, M., Zeifang, F. Ultrasound vs. MRI in the assessment of rotator cuff structure prior to shoulder arthroplasty. Journal of Orthopaedics. 2015; 12(1): 23-30

Reason for exclusion: Study objective

Fishman, L.M., Wilkins, A.N., Ovadia, T., Konnoth, C., Rosner, B., Schmidhofer, S. Yoga-based maneuver effectively treats rotator cuff syndrome. Topics in Rehabilitation. 2011; 27(2): 151-161

Reason for exclusion: Age group

Flury, M., Rickenbacher, D., Jung, C., Schneider, M.M., Endell, D., Audige, L. Porcine dermis patch augmentation of supraspinatus tendon repairs: A pilot study assessing tendon integrity and shoulder function 2 years after arthroscopic repair in patients aged 60 years or older. Arthroscopy. 2017

Reason for exclusion: Not clear on patients with osteoarthritis

Flury, M., Rickenbacher, D., Schwyzer, H.K., Jung, C., Schneider, M.M., Stahnke, K., Goldhahn, J., Audige, L. Does pure platelet-rich plasma affect postoperative clinical outcomes after arthroscopic rotator cuff repair? A randomized clinical trial. American Journal of Sports Medicine. 2016; 44(8): 2136-2146

Reason for exclusion: Age group

Franceschi, F., Papalia, R., Franceschetti, E., Palumbo, A., Del Buono, A., Paciotti, M., Maffulli, N., Denaro, V. Double-row repair lowers the re-tear risk after accelerated rehabilitation. 2016; 44(4): 948-956

Reason for exclusion: Age group

Franceschi, F., Papalia, R., Vasta, S., Leonardi, F., Maffulli, N., Denaro, V. Surgical management of irreparable rotator cuff tears. Knee Surgery, Sports Traumatology, Arthroscopy. 2015; 23(2): 494-501

Reason for exclusion: Age group

Friedman, R.J., Flurin, P.H., Wright, T.W., Zuckerman, J.D., Roche, C.P. Comparison of reverse total shoulder arthroplasty outcomes with and without subscapularis repair. Journal of Shoulder and Elbow Surgery. 2017; 26(4): 662-668

Reason for exclusion: Concomitant shoulder condition (osteoarthritis, rheumatoid arthritis)

Frostick, S.P. Rotator cuff tears: Assessment, treatment and outcome. Malaysian Orthopaedic Journal. 2012; 6:45

Reason for exclusion: Study design

Fucentese, S.F., Von Roll, A.L., Pfirrmann, C.W., Gerber, C., Jost, B. Evolution of nonoperatively treated symptomatic isolated full-thickness supraspinatus tears. American Journal of Bone and Joint Surgery. 2012; 94(9): 801-808

Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Concomitant shoulder condition (arthritis)

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Concomitant shoulder condition (osteoarthritis), age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Study design

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Reason for exclusion: Age group

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Reason for exclusion: Unable to access article

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Reason for exclusion: Age group

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Reason for exclusion: Study objective, age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Partial tears included, age group

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Reason for exclusion: Study design

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Study design

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Reason for exclusion: Study objective

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Study objective

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

Kim, S.J., Choi, Y.R., Jung, M., Lee, W., Chun, Y.M. Arthroscopic repair of anterosuperior massive rotator cuff tears: Does repair integrity affect outcomes?. American Journal of Sports Medicine. 2017; 45(8): 1762-1768

Reason for exclusion: Concomitant shoulder condition (arthritis)

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Study design

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Reason for exclusion: Study design

Kraemer, N.P. Management of patients following a rotator cuff repair: A case report. Orthopaedic Physical Therapy Practice. 2010; 22(4): 220-230

Reason for exclusion: Study design

Kuhn, J. E., Dunn, W. R., Sanders, R., An, Q., Baumgarten, K. M., Bishop, J. Y., Brophy, R. H., Carey, J. L., Holloway, B. G., Jones, G. L., Ma, C. B., Marx, R. G., McCarty, E. C., Poddar, S. K., Smith, M. V., Spencer, E. E., Vidal, A. F., Wolf, B. R., Wright, R. W. Effectiveness of physical therapy in treating atraumatic full-thickness rotator cuff tears: A multicenter prospective cohort study. The Journal of Shoulder and Elbow Surgery. 2013; 22(10): 1371-1379

Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Study design

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Reason for exclusion: Age group

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Reason for exclusion: Study objective

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Partial tears included

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Reason for exclusion: Study design

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Reason for exclusion: Age group

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Reason for exclusion: Concomitant shoulder condition (osteolysis)

Lee, W. H., Do, H. K., Lee, J. H., Kim, B. R., Noh, J. H., Choi, S. H., Chung, S. G., Lee, S. U., Choi, J. E., Kim, S., Kim, M. J., Lim, J. Y. Clinical Outcomes of Conservative Treatment and Arthroscopic Repair of Rotator Cuff Tears: A Retrospective Observational Study. Annals of Rehabilitation Medicine. 2016; 40(2): 252-262

Reason for exclusion: Partial tears included

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Reason for exclusion: Partial tears included

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Reason for exclusion: Unable to access

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Reason for exclusion: Study design

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Concomitant shoulder condition (osteoarthritis, osteonecrosis)

Meyer, M., Klouche, S., Rousselin, B., Boru, B., Bauer, T., Hardy, P. Does arthroscopic rotator cuff repair actually heal? Anatomic evaluation with magnetic resonance arthrography at minimum 2 years follow-up. Journal of Shoulder and Elbow Surgery. 2012; 21(4): 531-536

Reason for exclusion: Age group

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Reason for exclusion: Study objective

Mihata, T., Lee, T. Q., Watanabe, C., Fukunishi, K., Ohue, M., Tsujimura, T., Kinoshita, M. Clinical results of arthroscopic superior capsule reconstruction for irreparable rotator cuff tears. Arthroscopy. 2013; 29(3): 459-470

Reason for exclusion: Partial tears included, concomitant shoulder condition (osteoarthritis)

Mihata, T., Watanabe, C., Fukunishi, K., Ohue, M., Tsujimura, T., Fujiwara, K., Kinoshita, M. Functional and structural outcomes of single-row versus double-row versus combined double-row and suture-bridge repair for rotator cuff tears. American Journal of Sports Medicine. 2011; 39(10): 2091-2098

Reason for exclusion: Age group

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Reason for exclusion: Age group

Miller, R. and Carpenter, B. A comparison of rehabilitation strategies in the non-operative management of symptomatic rotator cuff tears. Journal of Orthopaedic Research. 2016; 34

Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

Minagawa, H., Yamamoto, N., Abe, H., Fukuda, M., Seki, N., Kikuchi, K., Kijima, H., Itoi, E. Prevalence of symptomatic and asymptomatic rotator cuff tears in the general population: From mass-screening in one village. Journal of Orthopaedics. 2013; 10(1): 8-12

Reason for exclusion: Study design

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Reason for exclusion: Age group

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Reason for exclusion: Concomitant shoulder condition (arthrosis)

Miyoshi, N., Suenaga, N., Oizumi, N., Taniguchi, N., Itou, H. Anatomic reconstruction using small head humeral prosthesis in patients under 70 years old with irreparable rotator cuff tear. Journal of Shoulder and Elbow Surgery. 2012; 21(12): e28-29

Reason for exclusion: Age group

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Reason for exclusion: Concomitant shoulder condition in some participants (avulsion fracture)

Moosmayer, S., Gartner, A. V., Tariq, R. The natural course of nonoperatively treated rotator cuff tears: an 8.8-year follow-up of tear anatomy and clinical outcome in 49 patients. Journal of Shoulder and Elbow Surgery. 2017; 26(4): 627-634

Reason for exclusion: Age group

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Reason for exclusion: Partial thickness tears included

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Reason for exclusion: Study design

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Reason for exclusion: Age group

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Reason for exclusion: Age group

Murthi, A. M. and Ramirez, M. A. Shoulder dislocation in the older patient. Journal of the American Academy of Orthopaedic Surgeons. 2012; 20(10): 615-622

Reason for exclusion: Study design

Naggar, L. The balloon, a new revolutionary technique for massive irreparable rotator cuff tears: Preliminary results at 1 year follow-up, after balloon degradation. Swiss Medical Weekly. 2013; 143: 9s

Reason for exclusion: Age group

Namdari, S., Donegan, R. P., Dahiya, N., Galatz, L. M., Yamaguchi, K., Keener, J. D. Characteristics of small to medium-sized rotator cuff tears with and without disruption of the anterior supraspinatus tendon. Journal of Shoulder and Elbow Surgery. 2014; 23(1): 20-27

Reason for exclusion: Age group

Nicholas, S. J., Lee, S. J., Mullaney, M. J., Tyler, T. F., Johnson, C. D., Fukunaga, T., McHugh, M. P. Functional outcomes after double row versus single row rotator cuff repair: A prospective randomized trial. Orthopaedic Journal of Sports Medicine. 2015; 3(7)

Reason for exclusion: Concomitant shoulder condition (degenerative joint disease), age group

Nove-Josserand, L., Hardy, M. B., Leandro Nunes Ogassawara, R., Carrillon, Y., Godeneche, A. Clinical and structural results of arthroscopic repair of isolated subscapularis tear. American Journal of Bone and Joint Surgery. 2012; 94(17): e125

Reason for exclusion: Age group

Noyes, M. P., Ladermann, A., Denard, P. J. Functional outcome and healing of large and massive rotator cuff tears repaired with a load-sharing rip-stop construct. Arthroscopy. 2017; 33(9): 1654-1658

Reason for exclusion: Age group

Oh, J. H., Kim, S. H., Kang, J. Y., Oh, C. H., Gong, H. S. Effect of age on functional and structural outcome after rotator cuff repair. American Journal of Sports Medicine. 2010; 38(4): 672-678

Reason for exclusion: Concomitant shoulder condition (arthritis)

Ortmaier, R., Plachel, F., Lederer, S., Hitzl, W. Auffarth, A., Matis, N., Resch, H. Reverse shoulder arthroplasty after failed pectoralis major tendon transfer with a minimum follow-up of 5 years. A case series. Journal of Orthopaedic Science. 2016; 21(5): 591-595

Reason for exclusion: Age group

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Reason for exclusion: Age group

Pak, C. H., Moon, Y. L., Sim, S. W., Elsayed, M. I. Bilateral arthroscopic rotator cuff repair using a single-stage procedure. Orthopaedics. 2015; 38(5): e423-427

Reason for exclusion: Age group

Pandey, V., Bandi, A., Madi, S., Agarwal, L., Acharya, K. K., Maddukuri, S., Sambhaji, C., Willems, W. J. Does application of moderately concentrated platelet-rich plasma improve clinical and structural outcome after arthroscopic repair of medium-sized to large rotator cuff tear? A randomized controlled trial. Journal of Shoulder and Elbow Surgery. 2016; 25(8): 1312-1322

Reason for exclusion: Age group

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Reason for exclusion: Age group

Papadopoulos, P., Karataglis, D., Boutsiadis, A., Fotiadou, A., Christoforidis, J., Christodoulou, A. Functional outcome and structural integrity following mini-open repair of large and massive rotator cuff tears: a 3-5 year follow-up study. Journal of Shoulder and Elbow Surgery. 2011; 20(1): 131-137

Reason for exclusion: Age group

Pappou, I. P., Schmidt, C. C., Jarrett, C. D., Steen, B. M., Frankle, M. A. AAOS appropriate use criteria: optimizing the management of full-thickness rotator cuff tears. Journal of the American Academy of Orthopaedic Surgeons. 2013; 21(12): 772-775

Reason for exclusion: Study design

Paribelli, G., Boschi, S., Randelli, P., Compagnoni, R., Leonardi, F., Cassarino, A. M. Clinical outcome of latissimus dorsi tendon transfer and partial cuff repair in irreparable postero-superior rotator cuff tear. Musculoskeletal Surgery. 2015; 99(2): 127-132

Reason for exclusion: Age group

Park, J. G., Cho, N. S., Song, J. H., Baek, J. H., Rhee, Y. G. Long-term outcome of tuberoplasty for irreparable massive rotator cuff tears: Is tuberoplasty really applicable?. Journal of Shoulder and Elbow Surgery. 2016; 25(2): 224-231

Reason for exclusion: Age group

Park, J. Y., Lhee, S. H., Oh, K. S., Moon, S. G., Hwang, J. T. Clinical and ultrasonographic outcomes of arthroscopic suture bridge repair for massive rotator cuff tear. Arthroscopy. 29(2): 280-289

Reason for exclusion: Study design

Park, J. Y., Siti, H. T., Keum, J. S., Moon, S. G., Oh, K. S. Does an arthroscopic suture bridge technique maintain repair integrity?: A serial evaluation by ultrasonography. Clinical Orthopaedics and Related Research. 2010; 468(6): 1578-1587

Reason for exclusion: Age group

Parsons, B. O., Gruson, K. I., Chen, D. D., Harrison, A. K., Gladstone, J., Flatow, E. L. Does slower rehabilitation after arthroscopic rotator cuff repair lead to long-term stiffness? Journal of Shoulder and Elbow Surgery. 2010; 19(7): 1034-1039

Reason for exclusion: Age group

Pauly, S., Stahnke, K., Klatte-Schulz, F., Wildemann, B., Scheibel, M., Greiner, S. Do patient age and sex influence tendon cell biology and clinical/radiographic outcomes after rotator cuff repair? American Journal of Sports Medicine. 2015; 43(3): 549-556

Reason for exclusion: Concomitant intra-articular pathology

Pauzenberger, L., Grieb, A., Hexel, M., Laky, B., Anderl, W., Heuberer, P. Infections following arthroscopic rotator cuff repair: incidence, risk factors, and prophylaxis. Knee Surgery, Sports Traumatology, Arthroscopy. 2017; 25(2): 595-601

Reason for exclusion: Study objective

Payne, C., Jaggi, A., Le Leu, A., Garofalo, R., Conti, M. (v) Rehabilitation for shoulder arthroplasty. Orthopaedics and Trauma. 2015; 313-323

Reason for exclusion: Study design

Pecora, J. O., Malavolta, E. A., Assuncao, J. H., Gracitelli, M. E., Martins, J. P., Ferreira, A. A., Jr. Prognostic factors for clinical outcomes after rotator cuff repair. Acta Ortop Bras. 2015; 23(3): 146-149

Reason for exclusion: Age group, partial tears included

Penning, L. I., De Bie, R. A., Leffers, P., Weijers, R. E., Walenkamp, G. H. Empty can and drop arm tests for cuff rupture: Improved specificity after subacromial injection. Acta Orthop Belg. 2016; 82(2): 166-173

Reason for exclusion: Age group

Pennington, W. T., Gibbons, D. J., Bartz, B. A., Dodd, M., Daun, J., Klinger, J., Popovich, M., Butler, B. Comparative analysis of single-row versus double-row repair of rotator cuff tears. Arthroscopy. 2010; 26(11): 1419-1426

Reason for exclusion: Age group

Peters, K. S., McCallum, S., Briggs, L., Murrell, G. A. A comparison of outcomes after arthroscopic repair of partial versus small or medium-sized full-thickness rotator cuff tears. American Journal of Bone and Joint Surgery. 2012; 94(12): 1078-1085

Reason for exclusion: Age group

Petri, M., Ettinger, M., Brand, S., Stuebig, T., Krettek, C., Omar, M. Non-operative management of rotator cuff tears. Journal of Open Orthopaedics. 2016; 10: 349-356

Reason for exclusion: Study design

Petrie, M. J. and Ismaiel, A. H. Treatment of massive rotator-cuff tears with a polyester ligament (LARS) patch. Acta Orthop Belg. 2013; 79(6): 620-625

Reason for exclusion: Age group, concomitant shoulder condition

Proctor, C.S. Long-term successful arthroscopic repair of large and massive rotator cuff tears with a functional and degradable reinforcement device. Journal of Shoulder and Elbow Surgery. 2014; 23(10): 1508-1513

Reason for exclusion: Concomitant shoulder condition

Ramírez, J., Pomés, I., Cabrera, S., Gómez, M. E., Inciarte, J., Rosario, V., Pomés, J., Sanmartí, R., Cañete, J. Subacromial steroid injection do not increase the rate of full-thickness rotator cuff tear. Annals of the Rheumatic Disease. 2013; 71

Reason for exclusion: Age group

Ramirez, J., Pomes, I., Cabrera, S., Pomes, J., Sanmarti, R., Canete, J. D. Incidence of full-thickness rotator cuff tear after subacromial corticosteroid injection: a 12-week prospective study. Modern Rheumatology. 2014; 24(4): 667-670

Reason for exclusion: Age group

Randelli, P., Arrigoni, P., Ragone, V., Aliprandi, A., Cabitza, P. Platelet rich plasma in arthroscopic rotator cuff repair: a prospective RCT study, 2-year follow-up. Journal of Shoulder and Elbow Surgery. 2011; 20(4): 518-528

Reason for exclusion: Age group

Randelli, P., Cabitza, P., Stoppani, C. A., Zaolino, C., Menon, A., Randelli, F. Advantages of arthroscopic rotator cuff repair with a transosseous suture technique: A prospective randomized controlled trial. American Journal of Sports Medicine. 2017; 45(9): 2000-2009

Reason for exclusion: Age group

Razmjou, H., Henry, P., Costa, G., Dwyer, T., Holtby, R. Effect of arthroscopic rotator cuff surgery in patients with preoperative restricted range of motion. BMC Musculoskeletal Disorders. 2016; 17(1): 99

Reason for exclusion: Age group

Rhee, Y. G., Cho, N. S., Parke, C. S. Arthroscopic rotator cuff repair using modified Mason-Allen medial row stitch: knotless versus knot-tying suture bridge technique. American Journal of Sports Medicine. 2012; 40(11): 2440-2447

Reason for exclusion: Age group

Rhee, Y. G., Cho, N. S., Yoo, J. H. Clinical outcome and repair integrity after rotator cuff repair in patients older than 70 years versus patients younger than 70 years. Arthroscopy. 2014; 30(5): 546-554

Reason for exclusion: Concomitant shoulder condition (osteoarthritis)

Rimmke, N., Maerz, T., Cooper, R., Yadavalli, S., Anderson, K. Arthroscopic suture bridge rotator cuff repair: functional outcome, repair integrity, and preoperative factors related to postoperative outcome. The Physician and Sportsmedicine. 2016; 44(2): 126-132

Reason for exclusion: Age group

Rodeo, S. A., Delos, D., Williams, R. J., Adler, R. S., Pearle, A., Warren, R. F. The effect of platelet-rich fibrin matrix on rotator cuff tendon healing: a prospective, randomized clinical study. American Journal of Sports Medicine. 2012; 40(6): 1234-1241

Reason for exclusion: Age group

Rogers, B. A., Little, N. J., Ricketts, D. M. The management of rotator cuff tears in the elderly. Journal of Perioperative Practice. 2012; 22(1): 30-34

Reason for exclusion: Study design

Rousseau, T., Roussignol, X., Bertiaux, S., Duparc, F., Dujardin, F., Courage, O. Arthroscopic repair of large and massive rotator cuff tears using the side-to-side suture technique. Mid-term clinical and anatomic evaluation. Orthopaedics & Traumatology: Surgery & Research. 2012; 98(4): S1-8

Reason for exclusion: Age group

Roy, S., Driggs, J., Elgharably, H., Biswas, S., Findley, M., Khanna, S., Gnyawali, U., Bergdall, V. K., Sen, C. K. Platelet-rich fibrin matrix improves wound angiogenesis via inducing endothelial cell proliferation. Wound Repair and Regeneration. 2011; 19(6): 753-766

Reason or exclusion: Study objective

Rubenis, I., Lam, P. H., Murrell, G. A. C. Arthroscopic Rotator Cuff Repair Using the Undersurface Technique: A 2-Year Comparative Study in 257 Patients. Orthopaedic Journal of Sports Medicine. 2015; 3(10)

Reason for exclusion: Concomitant shoulder condition

Ruiz-Moneo, P., Molano-Munoz, J., Prieto, E., Algorta, J. Plasma rich in growth factors in arthroscopic rotator cuff repair: a randomized, double-blind, controlled clinical trial. Arthroscopy. 2013; 29(1): 2-9

Reason for exclusion: Age group

Russo, R., Cautiero, F., Giudice, G., Ciccarelli, M., Visconti, V. Arthroscopic repair of rotator cuff tears using absorbable anchors with a single-row technique. Journal of Orthopaedic Surgery (Hong Kong). 2010; 18(3): 332-337

Reason for exclusion: Age group

Sánchez, M., Filardo, G., Yoshioka, T. Platelet Rich Plasma and Orthopedics: Why, When, and How. BioMed Research International. 2015

Reason for exclusion: Study design

Senekovic, V., Poberaj, B., Kovacic, L., Mikek, M., Adar, E., Dekel, A. Prospective clinical study of a novel biodegradable sub-acromial spacer in treatment of massive irreparable rotator cuff tears. European Journal of Orthopaedic Surgery & Traumatology. 2013; 23(3): 311-316

Reason for exclusion: Age group

Senekovic, V., Poberaj, B., Kovacic, L., Mikek, M., Adar, E., Markovitz, E., Maman, E., Dekel, A. The biodegradable spacer as a novel treatment modality for massive rotator cuff tears: a prospective study with 5-year follow-up. Biomed Research International. 2017; 137(1): 95-103

Reason for exclusion: Study objective

Sethi, P. M., Noonan, B. C., Cunningham, J., Shreck, E., Miller, S. Repair results of 2-tendon rotator cuff tears utilizing the transosseous equivalent technique. Journal of Shoulder and Elbow Surgery. 2010; 19(8): 1210-1217

Reason for exclusion: Age group

Sheps, D. M., Bouliane, M., Styles-Tripp, F., Beaupre, L. A., Saraswat, M. K., Luciak-Corea, C., Silveira, A., Glasgow, R. Balyk, R. Early mobilisation following mini-open rotator cuff repair: a randomised control trial. The Bone and Joint Journal. 2015; 97-b(9): 1257-1263

Reason for exclusion: Age group

Shimo, S., Sakamoto, Y., Tokiyoshi, A., Yamamoto, Y. Early rehabilitation affects functional outcomes and activities of daily living after arthroscopic rotator cuff repair: a case report. The Journal of Physical Therapy Science. 2016; 28(2): 714-717

Reason for exclusion: Study design

Shin, S. J., Chung, J., Lee, J., Ko, Y. W. Recovery of Muscle Strength After Intact Arthroscopic Rotator Cuff Repair According to Preoperative Rotator Cuff Tear Size. American Journal of Sports Medicine. 2016; 44(4): 972-980

Reason for exclusion: Age group

Shin, S. J., Yun, Y. H., Kim, D. J., Yoo, J. D. Treatment of traumatic anterior shoulder dislocation in patients older than 60 years. American Journal of Sports Medicine. 2012; 40(4): 822-827

Reason for exclusion: Partial tears included, concomitant shoulder condition (

Shon, M. S., Koh, K. H., Lim, T. K., Kim, W. J., Kim, K. C., Yoo, J. C. Arthroscopic Partial Repair of Irreparable Rotator Cuff Tears: Preoperative Factors Associated With Outcome Deterioration Over 2 Years. American Journal of Sports Medicine. 2015; 43(8): 1965-1975

Reason for exclusion: Age group

Tagliafico, A., Serafini, G., Sconfienza, L. M., Lacelli, F., Perrone, N.Succio, G. Martinoli, C. Ultrasound-guided viscosupplementation of subacromial space in elderly patients with cuff tear arthropathy using a high weight hyaluronic acid: Prospective open-label non-randomized trial. European Radiology. 2011; 21(1): 182-187

Reason for exclusion: Concomitant shoulder condition (

Tahal, D. S., Katthagen, J. C., Millett, P. J. Rotator cuff repair in the elderly: Is it worthwhile? Current Orthopaedic Practice. 2016; 27(3): 281-290

Reason for exclusion: Study design

Tanaka, M., Itoi, E., Sato, K., Hamada, J., Hitachi, S., Tojo, Y., Honda, M., Tabata, S. Factors related to successful outcome of conservative treatment for rotator cuff tears. Upsala Journal of Medical Sciences. 2010; 115(3): 193-200

Reason for exclusion: Age group

Taniguchi, N., Suenaga, N., Oizumi, N., Miyoshi, N., Araki, N., Chosa, E. Surface-holding repair: an original arthroscopic rotator cuff repair technique. Journal of Shoulder and Elbow Surgery. 2014; 620-627

Reason for exclusion: Concomitant shoulder condition (osteoporotic bones)

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Reason for exclusion: Age group

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Reason for exclusion: Unable to access paper

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Concomitant shoulder condition (osteoarthritis)

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Reason for exclusion: Age group

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Reason for exclusion: Concomitant shoulder injury

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Reason for exclusion: Concomitant shoulder condition (rheumatoid arthritis)

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Concomitant shoulder condition (osteoarthritis)

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Concomitant shoulder condition

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Reason for exclusion: Age group

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Reason for exclusion: Inclusion criteria

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Concomitant shoulder condition (arthritis)

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Partial rotator cuff tears

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Co-morbidity

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Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group not specified

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Reason for exclusion: Age group

Gialanella, B. and Prometti, P. Effects of Corticosteroids Injection in Rotator Cuff Tears. Pain Medicine. 2011; 12(10): 1559-1565

Reason for exclusion: Concomitant shoulder condition (osteoarthritis)

Gilot, G. J., Alvarez-Pinzon, A. M., Barcksdale, L., Westerdahl, D., Krill, M., Peck, E. Outcome of large to massive rotator cuff tears repaired with and without extracellular matrix augmentation: A prospective comparative study. Arthroscopy: Arthroscopic & Related Surgery. 2015; 31(8): 1459-1465

Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

Gotoh, M., Mitsui, Y., Yoshimitsu, K., Nakama, K., Okawa, T., Higuchi, F., Nagata, K. The modified massive cuff stitch: Functional and structural outcome in massive cuff tears. Journal of Orthopaedic Surgery and Research. 2013; 8(1)

Reason for exclusion: Age group

Greiner, S., Schmidt, C., Herrmann, S., Pauly, S., Perka, C. Clinical performance of lateralized versus non-lateralized reverse shoulder arthroplasty: A prospective randomized study. Journal of Shoulder and Elbow Surgery. 2015; 24(9): 1397-1404

Reason for exclusion: Concomitant shoulder condition (arthritis)

Gulotta, L. V., Nho, S. J., Dodson, C. C., Adler, R. S., Altchek, D. W., MacGillivray, J. D. Prospective evaluation of arthroscopic rotator cuff repairs at 5 years: Part II-prognostic factors for clinical and radiographic outcomes. Journal of Shoulder and Elbow Surgery. 2011; 20(6): 941-946

Reason for exclusion: Age not specified

Gumina, S. and Carbone, S. The impact of aging on rotator cuff tear size. Rotator Cuff Tear: Pathogenesis, Evaluation and Treatment. 2016; 69-70

Reason for exclusion: Study criteria

Gumina, S., Castricini, R., De Benedetto, M., Orlando, N. Latissimus dorsi transfer for primary treatment of irreparable rotator cuff tears. Rotator Cuff Tear: Pathogenesis, Evaluation and Treatment. 2016; 323-333

Reason for exclusion: Study design

Gupta, A. K., Hug, K., Berkoff, D. J., Boggess, B. R., Gavigan, M., Malley, P. C., Toth, A. P. Dermal tissue allograft for the repair of massive irreparable rotator cuff tears. America Journal of Sports Medicine. 2012; 40(1): 141-147

Reason for exclusion: Age group

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Reason for exclusion: Age group

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Reason for exclusion: Age group

Henseler, J. F., Nagels, J., Nelissen, R. G. H. H., De Groot, J. H. Does the latissimus dorsi tendon transfer for massive rotator cuff tears remain active postoperatively and restore active external rotation? Journal of Shoulder and Elbow Surgery. 2014; 23(4): 553-560

Reason for exclusion: Age group

Henseler, J. F., Nagels, J., Van Der Zwaal, P., Nelissen, R. G. H. H. Teres major tendon transfer for patients with massive irreparable posterosuperior rotator cuff tears: Short-term clinical results. Bone and Joint Journal. 2013; 95B(4): 523-529

Reason for exclusion: Age group

Holtby, R. and Razmjou, H. Relationship between clinical and surgical findings and reparability of large and massive rotator cuff tears: A longitudinal study. BMC Musculoskeletal Disorders. 2014; 15(1)

Reason for exclusion: Age group

Iagulli, N. D., Field, L. D., Hobgood, E. R., Ramsey, J. R., Savoie, F. H. Comparison of partial versus complete arthroscopic repair of massive rotator cuff tears. American Journal of Sports Medicine. 2012; 40(5): 1022-1026

Reason for exclusion: Age group

Ji, J. H., Shafi, M., Jeong, J. J., Park, S. E. Arthroscopic repair of large and massive rotator cuff tears using the biceps-incorporating technique: mid-term clinical and anatomical results. European Journal of Orthopaedic Surgery and Traumatology. 2014; 24(8): 1367-1374

Reason for exclusion: Age group

Jo, C. H., Kim, J. E., Yoon, K. S., Lee, J. H., Kang, S. B., Lee, J. H., Han, H. S., Rhee, S. H., Shin, S. Does platelet-rich plasma accelerate recovery after rotator cuff repair? A prospective cohort study. American Journal of Sports Medicine. 2011; 39(10):2082-2090

Reason for exclusion: Age group

Jo, C. H., Shin, J. S., Lee, Y. G., Shin, W. H., Kim, H., Lee, S. Y., Yoon, K. S., Shin, S. Platelet-rich plasma for arthroscopic repair of large to massive rotator cuff tears: A randomized, single-blind, parallel-group trial. American Journal of Sports Medicine. 2013; 41(10): 2240-2248

Reason for exclusion: Age group

Jo, C. H., Shin, J. S., Park, I. W., Kim, H., Lee, S. Y. Multiple channeling improves the structural integrity of rotator cuff repair. American Journal of Sports Medicine. 2013; 41(11): 2650-2657

Reason for exclusion: Age group

Jo, C. H., Shin, J. S., Shin, W. H., Lee, S. Y., Yoon, K. S., Shin, S. Platelet-Rich Plasma for Arthroscopic Repair of Medium to Large Rotator Cuff Tears: A Randomized Controlled Trial. American Journal of Sports Medicine. 2015; 43(9): 2102-2110

Reason for exclusion: Age group

Jo, S. H., Kim, J. Y., Cho, N. S., Rhee, Y. G. Reverse total shoulder arthroplasty: Salvage procedure for failed prior arthroplasty. Clinics in Orthopaedic Surgery. 2017; 9(2): 200-206

Reason for exclusion: Co-morbidity

Jobin, C. M., Brown, G. D., Bahu, M. J., Gardner, T. R., Bigliani, L. U., Levine, W. N., Ahmad, C. S. Reverse total shoulder arthroplasty for cuff tear arthropathy: The clinical effect of deltoid lengthening and center of rotation medialization. Journal of Shoulder and Elbow Surgery. 2012; 21(10): 1269-1277

Reason for exclusion: Co-morbidity/Arthritis

Kany, J., Guinand, R., Croutzet, P., Valenti, P., Werthel, J. D., Grimberg, J. Arthroscopic-assisted latissimus dorsi transfer for subscapularis deficiency. European Journal of Orthopaedic Surgery and Traumatology. 2016; 26(3): 329-334

Reason for exclusion: Co-morbidity/Arthritis

Keener, J. D., Wei, A. S., Kim, H. M., Paxton, E. S., Teefey, S. A., Galatz, L. M., Yamaguchi, K. Revision arthroscopic rotator cuff repair: Repair integrity and clinical outcome. Journal of Bone and Joint Surgery. 2010; 92(3): 590-598

Reason for exclusion: Age group

Kerr, J., Borbas, P., Meyer, D. C., Gerber, C., Buitrago Téllez, C., Wieser, K. Arthroscopic rotator cuff repair in the weight-bearing shoulder. Journal of Shoulder and Elbow Surgery. 2015; 24(12): 1894-1899

Reason for exclusion: Age group

Kijima, H., Minagawa, H., Nishi, T., Kikuchi, K., Shimada, Y. Long-term follow-up of cases of rotator cuff tear treated conservatively. Journal of Shoulder and Elbow Surgery. 2012; 21(4): 491-494

Reason for exclusion: Age group

Kim, H. M., Caldwell, J. M. E., Buza, J. A., Fink, L. A., Ahmad, C. S., Bigliani, L. U., Levine, W. N. Factors affecting satisfaction and shoulder function in patients with a recurrent rotator cuff tear. Journal of Bone and Joint Surgery. 2014; 96(2): 106-112

Reason for exclusion: Co-morbidity

Kim, K. C., Shin, H. D., Cha, S. M., Lee, W. Y. Comparison of repair integrity and functional outcomes for 3 arthroscopic suture bridge rotator cuff repair techniques. American Journal of Sports Medicine. 2013; 41(2): 271-277

Reason for exclusion: Age group

Kim, K. C., Shin, H. D., Cha, S. M., Park, J. Y. Comparisons of retear patterns for 3 arthroscopic rotator cuff repair methods. American Journal of Sports Medicine. 2014; 42(3): 558-565

Reason for exclusion: Age group/ Partial thickness tears

Kim, K. C., Shin, H. D., Lee, W. Y. Repair integrity and functional outcomes after arthroscopic suture-bridge rotator cuff repair. Journal of Bone and Joint Surgery. 2012; 94(8): e48.1-48.6

Reason for exclusion: Age group

Kim, K. C., Shin, H. D., Lee, W. Y., Han, S. C. Repair integrity and functional outcome after arthroscopic rotator cuff repair: Double-row versus suture-bridge technique. American Journal of Sports Medicine. 2012; 40(2): 294-299

Reason for exclusion: Age group

Kim, S. J., Choi, Y. R., Jung, M., Lee, W., Chun, Y. M. Arthroscopic repair of anterosuperior massive rotator cuff tears: Does repair integrity affect outcomes? American Journal of Sports Medicine. 2017; 45(8): 1762-1768

Reason for exclusion: Age group

Kim, S. J., Choi, Y. R., Jung, M., Lee, W. Y., Chun, Y. M. Isolated Subscapularis Repair in Irreparable Posterosuperior Massive Rotator Cuff Tears Involving the Subscapularis Tendon. American Journal of Sports Medicine. 2017; 45(6): 1269-1275

Reason for exclusion: Age group

Kim, S. J., Jung, M., Lee, J. H., Kim, C., Chun, Y. M. Arthroscopic repair of anterosuperior rotator cuff tears: InContinuity technique Vs. disruption of subscapularis supraspinatus tear margin comparison of clinical outcomes and structural integrity between the two techniques. Journal of Bone and Joint Surgery. 2014; 96(24): 2056-2061

Reason for exclusion: Age group

Kim, S. J., Kim, S. H., Lee, S. K., Seo, J. W., Chun, Y. M. Arthroscopic repair of massive contracted rotator cuff tears: Aggressive release with anterior and posterior interval slides do not improve cuff healing and integrity. Journal of Bone and Joint Surgery. 2013; 95(16): 1482-1488

Reason for exclusion: Age group

Kim, S. J., Lee, I. S., Kim, S. H., Lee, W. Y., Chun, Y. M. Arthroscopic partial repair of irreparable large to massive rotator cuff tears. Arthroscopy - Journal of Arthroscopic and Related Surgery. 2012; 28(6): 761-768

Reason for exclusion: Age group

Kim, Y. K., Jung, K. H., Won, J. S., Cho, S. H. Medialized repair for retracted rotator cuff tears. Journal of Shoulder and Elbow Surgery. 2017; 26(8): 1432-1440

Reason for exclusion: Age group

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Reason for exclusion: Age group

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