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Comparison of Functional Capacity and Outcomes of Patients with Rotator Cuff Injury: Surgery Versus Non-Invasive Methods

Brian Schiller
University of North Dakota

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by

Brian Schiller, PA-S

Bachelor of Science, University of South Dakota, 2018

Contributing Author: Daryl Sieg,
MSPAed

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Abstract

Rotator cuff tears are acute or chronic tears of one or more of four specific muscles that encompass the glenohumeral joint. These tears can cause pain, decrease range of motion, and affect an individual for many years if not treated appropriately. The purpose of this literature review is to assess the most appropriate means of treatment between surgery, physical therapy, and injection therapies. The literature review was performed using electronic search databases CINAHL, PubMed, Clinical Key, Cochrane Library, Embase, SPORTDiscus and Research Gate. Studies were included if they directly evaluated the efficacy of surgical rotator cuff methods, physical therapy, corticosteroid injections, mesenchymal stem cell injections, or platelet rich plasma injections. Studies were excluded if the sole purpose was to compare different variations of repairs (single row versus double row, etc.). Other non-operative methods of treatment including acupuncture, alternative therapies, or experimental solutions were also not considered. No anecdotal reports or single case studies were included. Studies were narrowed down by currency, only taking literature from 2015 to current date. The review showed that there are specific variables to consider that will aid in which management route will be most effective. Age, tear size, and patient activity level are three factors which influence outcomes. Conservative measures in chronic rotator cuff tear cases are first line, these include physical therapy and corticosteroid injections. If these therapies fail, then surgery is warranted and is an effective treatment for this injury.

Keywords: rotator cuff disease, rotator cuff tear, management, surgery, physical therapy, injections, and outcomes

Introduction

A rotator cuff tear involves partial or total tear of one or more muscles surrounding the glenohumeral joint. These muscles include the supraspinatus, infraspinatus, subscapularis, and teres minor. DynaMed (2018) states that the overall prevalence of rotator cuff tears (RCT) are in up to 40% of asymptomatic patients and 64% of symptomatic patients. Partial thickness tears in the general population are thought to be around 15% to 32% with the extent of tears varying with other factors including increased age of patients (DynaMed, 2018). Tashjian (2020) states "full-thickness rotator cuff tears are present in approximately 25% of individuals in their 60s and 50% of individuals in their 80s" (p. 589). The risk increases with smoking, repetitive physical activity involving the shoulder, age, hypercholesterolemia, and a genetic predisposition (Tashjian, 2020).

Statement of the Problem

With rotator cuff disease having such a high prevalence in the general population, as discussed in the introduction, there is a need to know how to properly evaluate the injury, educate the patient, and refer these patients to the proper treatment option for their given circumstances. The variability in injury severity, patient preferences of treatment, and amount of treatment options makes navigating decision making more challenging for these cases. With more information and consolidation of recommendations, medical providers will be able to make more accurate and concise management decisions.

Research Question

In patients with rotator cuff tears, what is the effect of physical therapy on function preservation and overall outcomes when compared to surgery?

In patients with rotator cuff tears, what is the effect of joint injections on function preservation and overall outcomes when compared to surgery?

Methods

A literature review was performed using electronic search databases; CINAHL, PubMed, Clinical Key, Cochrane Library, Embase, SPORTDiscus and Research Gate. Both keyword and mesh terms were used to define a set of the literature discussing clinical outcomes for rotator cuff tear at varying stages of severity when utilizing surgery, physical therapy (PT), and/or joint injections. Keywords used of the search included “rotator cuff disease”, “rotator cuff tear”, “management”, “surgery”, “physical therapy”, “injections”, and “outcomes”. Studies were included if they directly evaluated the efficacy of surgical rotator cuff methods, physical therapy, corticosteroid injections, mesenchymal stem cell injections, or platelet rich plasma injections. Studies were excluded if the sole purpose was to compare different variations of repairs (single row versus double row, etc.). Other non-operative methods of treatment including acupuncture, alternative therapies, or experimental solutions were also not considered. No anecdotal reports or single case studies were included. Studies were narrowed down by currency, only taking literature from 2015 to current date.

Literature Review

Efficacy of Surgery

Altintas, Anderson, Pitta, Buckley, Bhatia, Provencher, and Millett (2020) is a systematic review that was posted in *The American Journal of Sports Medicine.* They initially set out to find what kind of impact age had on rotator cuff repair (RCR) and reverse total shoulder arthroplasty (RTSA). Secondly, the systematic review was meant to compare the results of the two surgical

methods when it comes to cost, pain relief, longevity, and activity preservation. When assessing the overall quality and strength of information, there were a few factors that stand out. The main weaknesses are inclusion criteria allowed for heterogeneous patients, surgeries, and variations of tear size and onset. Also, there were many studies that had lower levels of evidence (level 3 or 4) which suggest fair quality, but not high quality. The Altintas et al. did not disclose what parameters they used to deem certain statistics as "significant" which opens the information to be potentially biased. One of the strengths of the review come from the higher number of total patients at 680. The review also was transparent in study criteria, limitations, and the goals of the review which all lend strength to the information.

The main methods used were searching PubMed and Cochrane databases for articles and reviews with the key terms "rotator cuff", "repair", "over", "older", and "70 years". Altintas et al. (2020) used only English articles with level 1-4 evidence strength were used. They excluded simple case studies and level 5 evidence studies. Of the 11 studies they used, there were 680 patients total that were evaluated at a mean age of 74.9 years old. The studies reported on evaluated patient satisfaction scores post-op on a scale of 1 to 10. The lowest satisfaction rate out of the studies was 80% and the highest was 97.5% (Altintas et al., 2020). Pain reduction was also significant from pre and peri-op to post-op, with 5 studies reporting an improvement from a mean of 5.5 (range, 4.6-6.4) down to 1.3 (range, 0.5-2.3). Lastly, function was measured pre- and post-op with many of the studies varying in the specific method of evaluation. Overall, the studies in Altintas et al. showed significant functional improvement with studies using the American Shoulder and Elbow Surgeons (ASES) criteria scoring 44.2 (range, 35.4- 56) pre-op to 87.9 (range, 84-90.3) post-op, except for one which did not report on function. Also, of note is that patients with novel tears improved more significantly comparatively to individuals with re-

torn cuff injuries. Another component of the research was how these individuals returned to sports and activities of daily living. The Constant score was used to evaluate a group for returning to daily life and showed a functional score increase from 7 to 15 on a scale of 20 (Altintas et al., 2020). ROM was measured pre- and post-op by all but two of the studies in the report. Flexion, extension, internal rotation and external rotation were all quantified and it was consistently shown that the operation improved every one of the motions.

Complication are always a consideration when talking about procedures and all studies reported on them. In Altintas et al. (2020), five studies reported on complications not related to the shoulder including one patient with pneumonia. Out of the 680 patients, seven required surgery again. Majority were due to varying infections or manual manipulation for frozen shoulder, but three required total replacement at an average of 3.3 years later. Tendon integrity and re-tear rate were also tracked very well with studies following up with ultrasound, magnetic resonance imaging (MRI), or contrast arthrograms. The re-tear rates were statistically similar between open procedures and arthroscopic procedures at 27.8% and 26.8% ($p = .831$) respectively (Altintas et al., 2020). 513 total shoulders were imaged at an average of 21.5 months and found 139 re-tears. Of the information gathered, there was an association between the size of original tear and rate of re-tears with massive tears being 68.3% and the large tears being 18.3% (Altintas et al., 2020).

The main focus of Altintas et al. (2020) was on the aging population as their rates of more significant tears is higher and often the efficacy of repair is called into question due to their decreased tendon to bone healing and potential comorbidities. The systematic review found that when compared to RTSA, RCR is a valid option for patients wanting a less invasive, cost effective option to improve function and decrease pain. The re-tear rates between the RTSA and

RCR have no significant difference either. The total replacement has been considered gold standard for aging individuals, but more recently the RCR has gain favor due to less damage to the deltoid and more preservation to the surrounding joint anatomy.

Chen, Jiang, Li, Chen, Qiao, Li, and Ge (2020) is a level three cohort study which will provide fair quality information. The strengths of the study include a clear statistical bar set to provide significance, very clear inclusion and exclusion criteria where given, and it was a single-blinded study. The inherent weaknesses include subjective reporting from the patients as to their level of activity, a small number of re-tears which may take away its significance, a lower follow-up rate (78%) of patients who met the criteria versus those who participated in the study, and the potential variability of when a re-tear happened as it could have been before any activity. In Chen et al., the main question being evaluated was whether there is a relationship between the amount of activity of the individual post-op and the frequency of re-tear or decreased quality of the joint. The method behind this evaluation was taking everyone that had a small to large rotator cuff tear identified during surgery and tracking the amount of activity and exercise each patient engaged in within 6 months post-op. Stratifying patients between sedentary, light, moderate, and strenuous activity across four different categories including exercise, daily living, job, and amount of average weight being lifted. Exclusion was based off the amount of degeneration of the joint, previous surgeries on either of the shoulders, and massive tears.

A total of 186 patients qualified for the study and 145 patients remained through the 2 years for final assessment. The Chen et al. (2020) did not elaborate on what happened to the patients lost in follow-up. 48 of these were included in the active category and 97 patients were a part of the sedentary group. During the comparison performed by Chen et al., it was found that there was a difference between the two groups when it came to range of motion with forward

flexion (active 161 vs sedentary 157, p = .005) and abduction (158 vs 152, p = .004), but no significant difference when assessing pain (1.6 vs 1.2, p = .067), function (ASES, 87.1 vs 88.2, p = .550), or strength (p = .044). MRI evaluation was done and 24 totally re-tears were found. 13 of the 24 were found in the active group, and 11 were found in the sedentary group. Statistically this is a significant difference, (27.1% vs 11.3%, respectively; p = .016; risk ratio, 2.39 [95% CI, 1.16-4.93]) (Chen et al., 2020). Of the factors analyzed including fatty infiltration, muscle atrophy, and preoperative stiffness, only tear size and shoulder activity level where influencing factors on outcomes.

The main conclusion of Chen et al. (2020) is that shoulder intensive activities have a negative effect on the potential for re-tear in an individual. Speculated factors that contribute to this outcome may be the inability of tendon to bone regrowth to ever be complete or back to baseline before the tear and surgery, or the post-op tendon tension is much higher than pre-op therefore never truly allowing the biomechanics of the shoulder to be the same as pre-op. There is another significant conclusion drawn from this study, which is the general Visual Analog Scale (VAS) pain scale scores were higher in the re-tear group that was active versus those with re-tears of the sedentary group (2.6 vs 1.2, respectively; P = .002) (Chen et al., 2020).

Karjalainen, Jain, Heikkinen, Johnston, and Page (2019) is a systematic review that was focused on rotator cuff tears that were managed with surgery. There are several reasons why this systematic review has a stronger level of evidence. One is the number of participants, between all studies there were a total of 1007 patients. They also increase their strength by detailing out all known biases of each study involved and the authors' own potential biases. The review gives a detailed inclusion and exclusion criteria list and provides an in-depth look at the characteristics of each study included. There are several weaknesses including the biases of each study, which

vary on severity. There are also differences in the completeness of data sets among the studies which result in missing information or heterogeneous results in the systematic review. There was no study available that compared surgery to placebo, and it was recommended that future studies need to be done to address this issue. Lastly, Karjalainen et al. (2019) did not include reliable p values or many ranges of stats which make analyzing the data for strength more difficult and could lead to falsely represented outcomes.

The objective of Karjalainen et al. (2019) is to synthesis all the relevant existing data on rotator cuff surgeries and consolidate outcomes. They incorporated randomized control trials that involved adults with rotator cuff tears. Moving forward, they excluded studies which involved individuals with preserved tendons, surgeries for joint instability or frozen shoulder. Studies were not excluded based on the type of surgery performed including arthroscopic versus open repair, or by any varying surgical technique. The values of interest in the studies evaluated include pain, functional preservation, quality of life measures, and complications. From previous reviews, all but one of the studies used were invalid based on their new inclusion criteria. For this current review they used eight new randomized control trials and the one remaining valid study from the previous review.

Breaking up the studies based on the direct comparisons they made, there were several focuses of the systematic review. First was a comparison between surgery and non-surgical methods. Karjalainen et al. (2019) found that the mean pain rating (out of 10, lower being better) the non-surgical patients were 2.1 and the surgical patient mean was 1.13 points better than that (95% CI 0.22 better to 2.04 better; 207 participants). Function was comparable between the two groups at the different time intervals of recheck (6 months, 12 months, and 2 years), however, at 5 years the absolute improvement was 8% higher in surgical patients (95% CI 1.30 worse to

12.50 better) (Karjalainen et al., 2019). When comparing health-related quality of life measures, surgery was found to be no different or slightly worse than non-surgical means at every time interval. When assessing patient reported success, surgery had a slight but non-significant improvement on scores over non-surgical. Karjalainen et al. (2019) states, "at 12 months, 57.5 points with non- operative treatment and 1.3 points worse (95% CI 4.49 worse to 1.89 better; 103 participants)" (p. 18). Many of the findings were excluded due to Karjalainen et al. having a CI of 95%, in which case many of the comparisons did not meet this requirement. This concludes that there is little statistical significance between surgical and conservative methods in patients with rotator cuff tears.

The other two comparisons in Karjalainen et al. (2019) were based on comparing different types of surgeries to one another including repair with subacromial decompression versus decompression only and repair with acromioplasty versus repair only. For the basis of this scholarly project, this information does not yield itself to clarifying the overall objectives and therefore, were left out of the summary.

Rashid, Cooper, Cook, Cooper, Dankin, Snelling, and Carr (2017) was a randomized control trial that reported data from 2007 to 2014. This study had a large patient sample from multiple different hospitals which lends strength to the outcomes as well as the disclosure of what patients made it to follow-up and what the inclusion and exclusion criteria were. They also highlighted the statistical goals the data had to reach to be deemed significant. However, a weakness of the study was that the surgeons' decisions to operate were not standardize, which could lead to variability based on what imaging they each used to evaluate patients pre-operatively.

The purpose of Rashid et al. (2017) was to address why the rates of failing to heal after rotator cuff surgery was high and was variables influence the outcomes. Their method included 447 patients that were originally referred to surgery to evaluate for rotator cuff tears and of those 255 patients underwent either arthroscopic or open repair. Some patients were not candidates for surgery due to no presence of tear, some patients had resolution of symptoms, and others were too damaged to qualify for surgery. During the time of surgery, the tears were categorized into four different groups including small (less than 1 cm), medium (greater than 1cm, less than 3 cm), large (full thickness tears in two cuffs, greater than 3 cm, less than 5 cm) and massive (3 cuff tears greater than 5 cm) tear sizes. They are then followed up by 8, 12, and 24-month post-operative assessments and an MRI at 12 months and well as questioned using several different indexes and methods including the Oxford Shoulder Score and the Shoulder Pain and Disability Index. To be deemed as a successful heal on imaging the tendon needed to lack a full thickness tear. If there was a small partial tear it was still deemed heal, and if it was a large partial tear, then it was considered inconclusive.

Of the 255 that made it through original assessment to have surgery, 220 of them made it to the final analysis. Rashid et al. (2017) found that the overall failure rate at 12 months was 43%. The higher the grade of tear was, the greater the percentage of failure was. Of the small tears, 34% failed while massive tears had a failure rate of 73%. Another correlation found the younger the patient, the higher chance of having a successful repair at 12-months (OR 0.94, CI 0.91–0.98, $p < 0.01$). Using a logistic regressive model, it was calculated that of all variables including age, hand dominance, number of joint injections, and sex, only tear size was a completely independent predictor of healing rates (OR 0.18, CI 0.05–0.61, $p < 0.01$) (Rashid et al., 2017).

Rashid et al. (2017) reported the overall healing rate of the 220 patients was 57%. In a systematic review, 49 total studies were considered. 28 of these studies were Level 1 evidence but could still be influenced by unknown bias. These results averaged the overall healing rate to be 68% and the average age of healing to be 60 years old. With age and tear size being the two predominant risk factors for healing failure, clinical decision making must take these into account when selecting treatment options.

Efficacy of Physical Therapy

Boorman, More, Hollinshead, Wiley, Mohtadi, Lo, and Brett (2018) conducted a 5-year follow-up on patients that underwent conservative treatments for rotator cuff tears and assessed quality-of-life of these patients. Boorman et al. (2018) addressed several limitations this study had which included the fact that there was no physical evaluation of the patient's shoulder, only subjective outcomes. Also, that there was a follow-up rate of 84% from the first portion of the study. Although that percentage it acceptable, they compared several characteristics of the original study to the 5-year follow-up group and found that the two groups did not vary in the baseline characteristics which means the loss of patients to follow-up was deemed acceptable. They also could not tell with any certainty if the patients had sought any other type of treatment since the first study including any therapies or injections. The strengths of the study include the clear, concise inclusion and exclusion criteria of patients, clearly delineated terms of success and evaluation, disclosure of events that led to each individual non-follow-up patient, and available demographic information.

Boorman et al. (2018) looked at the efficacy of nonoperative approaches to full-thickness rotator cuff tears with symptoms of at least 3 months or greater. A cohort study had been

performed following patients on a comprehensive nonoperative regimen, and 75% of patients had successful treatment of their complete tear 2 years post-op. The goal of this study is to look at the outcomes of nonoperative care 5 years post-op of the same patients, as to analyze the efficacy of conservative treatment on a more long-term scale.

The methods of exclusion where mainly based on only following patients with full tears of either the supraspinatus or infraspinatus, chronic symptoms of 3 or more months, and between 40 to 85 years old. Boorman et al. (2018) excluded elite athletes, other rotator cuff muscle tears, concomitant shoulder disease or pathology, acute injury, and several other smaller exclusion criteria. The patients that qualified were put on a comprehensive regimen tailored by a physiotherapist and sports medicine physician that comprised of stretching and strengthening as well as pain management with either non-steroid anti-inflammatory drugs (NSAIDs) or corticosteroid injections (CIs) for pain control. They were then re-evaluated by a surgeon 3 months out to see if they still qualified for surgery or not. If not, the treatment was deemed a "success" by the standards of the study. The successful patients were then followed up 1- and 2-years post treatment as previously reported on by the researchers.

Of the original 104 patients enrolled in the first portion of the study, 63 remained to report on a 5-year follow-up rotator cuff quality of life index (RC-QOL). Some were lost due to surgery within that time, some did not answer when contacted for the 5-year re-evaluation, and several died. 46 patients of the 63 remained in the nonoperative, successfully treated group and of those individuals, the mean RC-QOL score was 83 out of 100 (SD, 16). The patients that were not successful in the nonoperative methods and underwent surgery, the mean RC-QOL score was 89 out of 100 (SD, 11) at 5-years (Borman et al., 2018).

The study conclusion was that there was little statistical difference in overall quality of life between those that managed non-surgically versus those that underwent surgery (P = .11) (Boorman et al., 2018). Nonoperative management also has longevity and should be considered in the discussion for treatment of chronic, full tear injuries in individuals. There was no imaging to determine tear size, however, regardless of tear size increase, the patients that reported felt like their quality of life was improved.

Page, Green, McBain, Surace, Deitch, Lyttle, and Mrocki (2016) is a systematic review focusing on manual therapy and exercise for the treatment of rotator cuff tears. The systematic review performed by Page et al. (2016) did a comprehensive job at evaluating and grading the level of bias of each included study and broke down each of their respective weaknesses. It also had a large total of patients (3620) involved and was upfront about their limitations. There was a lack of highly processed data to include p values and a set limitation of what is deemed significant for the review. There were also limitations based on the heterogenicity of each given study, resulting in many comparisons lacking data.

Page et al. (2016) focused on the efficacy of physical therapy as it relates to outcomes of pain reduction, function, range of motion (ROM) and overall patient satisfaction. The systematic review mainly compared PT with surgery, acupuncture, placebo (inactive ultrasound therapy), and corticosteroid injection. 60 total trials achieved their inclusion criteria but of those 60, only 10 addressed their main goal of comparison of PT to other therapies directly, and only one was PT compared to placebo. The average age of participants from all trials was 51 years and the average duration of symptoms was 11 months with 52% of the patients being women. When totaled between the 60 studies, there were 3620 participants. All but one on the trials was a randomized control trial. Page et al. found a study with high-level of evidence showing there was

a slight increase in function with patients undergoing physical therapy (PT) compared to placebo but no significant improvement in patient function outcomes (MD 7.1, 95% CI 0.30 - 13.90) and overall pain (MD 6.8, 95% CI 0.70 - 14.30). When comparing PT to corticosteroid joint injections, the overall reduction in pain (control group score 1.7 vs injection group 1.6) and functional preservation (23.3 vs 22.3 out of 100, range -8.77 to 6.77) were statistically insignificant (Page et al., 2016). The quality of life reporting was higher in the injection group at 11 weeks versus at 12 months which is not surprising given the short-acting nature of injections. The systematic review calls for more randomized control trials where manual therapy and exercise are directly compared to placebo and the need for more high-quality evidence studies.

Petri, Ettinger, Brand, Stuebig, Krettek, & Omar (2016) included a limited literature search and direct surgeon experiences and is an entry in *The Open Orthopedics Journal*. A drawback to this type of evaluation is from its lack of large data sets and deeper analytical evaluation, not including elements such as p values and confidence intervals. What lends this entry credibility is the respected lead author M. Petri, who has published 45 peer-reviewed articles and co-authored two books. Also, this format of assessment lends itself to offering promising clinically valuable information and guidance to Primary Care Providers (PCPs) managing patients with this condition. The articles researched are heterogeneous and offer, at times, dissenting information. The goal of this literature review was to synthesize the available data on non-operative management of rotator cuff tears to help better guide future medical providers on what factors help predict favorable outcomes versus those patients that surgery would benefit more. The main management styles assessed where conservative, non-PT management, physical therapy, hyaluronic acid injection, platelet rich plasma (PRP) injections, and corticosteroid injections.

With at-home stretching and exercise that was not guided by physical therapy, around 59% of patients had some improvement with a 2.5-year follow-up, however, 30% got worse and 11% had no change. This information was rendered after following 46 patients, with the goal to assess the normal process of a tear without much intervention. PT guided regimens are far more popular in RCT management. Petri et al. (2016) found after following 452 patients, there was a 75% patient satisfactory score at 2-year follow up. This satisfaction is based on function, pain, and ROM; not on tear size or joint condition. Of note, 25% of the 452 had crossed over to surgical management, with majority switching 6 to 12 weeks after starting PT.

Corticosteroid injections are helpful in controlling pain for individuals not undergoing surgery. Petri et al. (2016) analyzed data from 60 participants which showed pain relief for a mean of 3 months after a triamcinolone injection, with little difference if the patient receives another injection within 3 weeks. This suggests there is no need for multiple injection within a short time duration. Petri et al. also showed a symptom relief in 83% of patients at 6-month follow-up, however, more study specifics were not available. Hyaluronic acid injection when compared to corticosteroid injections had little statistical difference (the author did not include specific values) in symptom improvement, and overall had a low success rate. PRP injections have mainly only been studied as an accelerant to healing post-op and not as a stand-alone treatment or in conjunction with PT. Further studies are needed to access this field.

Overall, the average success rate of non-surgical, conservative management of RCTs is around 75% (Petri et al., 2016). The drawback from these methods are they generally do not influence the progression of the tear or of fatty infiltration of the surrounding joint tissue, they only improve patient symptoms. The suggested ideal patient for these methods would be those

with decreased functional demand, those with moderate symptoms, or of course those that either refuse or do not qualify for surgery.

Micallef, Pandya, and Low (2019) conducted a literature review that totaled 32 articles including six randomized control trials. The strengths of this review include a clear list of inclusion and exclusion criteria, a more comprehensive layout of the basics of the issue (RCT), the deeper evaluation at every level of care to include history, physical examination, and imaging. It also includes specifics on the referenced studies with details such as single- or double-blinded studies. It lacks in specific values of data such as p values and confidence intervals.

Micallef et al. (2019) starts with an explanation of rotator cuff anatomy, the pathophysiology of tears, and the mechanics of tendon healing as well as the mechanical disruption that happen with cuff tears. It then describes the history, physical exam, and imaging that can all evaluate severity and scope of disruption for the patient. When considering imaging for RCTs, x-ray is a good starting point to assess for osteoarthritis, glenohumeral displacement, and any avascular necrosis. After initial assessment, ultrasound or MRI are both great imaging modalities, ultrasound due to its cost effectiveness, ease, and relatively good sensitivity and specificity at 84% and 89% respectively (Micallef et al., 2019). MRI is the good standard however due to its ability to assess the entire apparatus as well as any atrophy, fatty infiltration, and more sensitive assessment of partial tears which is something ultrasound lacks in.

When moving on to selecting a treatment plan, Micallef et al. (2019) suggested that the current literature available supports trying conservative measures in symptomatic RCT patients and after failing the typical steps, only then should they be evaluated for surgical consultation.

75% of symptomatic patients have success in reduction of pain and stabilize function from non-surgical means. Micallef et al. stated that of 452 patients in randomized control trials undergoing PT, it was found that after a 2-year follow-up 74% of the patients did not required surgical evaluation. Micallef et al. found that when comparing PT, PT and acromioplasty, and RCR with incremental follow-up at 3, 6, and 12-monthts, showed no statistical difference (authors did not include specific values) between the 3 methods when considering pain, function, and patient satisfaction.

Corticosteroid injection was assessed against placebo injections at was found to only provide limited duration relief of pain compared to placebo, however, it does not influence disease progression in any way. These injections used as monotherapy may not be recommended due to the lack of benefit versus the risk of infection or complication from the procedure. When paired with physical therapy it can prove useful in decreasing pain to enhance movement during the therapy. PRP is another form of injection that is thought to have benefit for those with RCTs. The thought is PRP has several concentrated growth factors and cytokines that all facilitate the healing process (Micallef et al., 2019). Micallef et al. concluded that there is no difference between control groups and those using PRP when evaluating functional outcomes and pain reduction.

Micallef et al. (2019) showed that surgical intervention remains a cost-effective means of managing patients with RCTs. There are several different surgical methods used depending on the type of tear, the patient goals, and patient qualification. An open or arthroscopic cuff repair is a very common surgery on the shoulder as it aims to repair the tendon footprint on the humoral head, retrieving the proper force coupling of cuff musculature. This type of surgical procedure can be successful in the aging population as well, with one prospective study claiming that there

was a 94% satisfied rate among patients undergoing RCR (Micallef et al., 2019). When RCR is compared to other surgical procedures including RCR plus acromioplasty or biceps tenotomy, the stand-alone repair had statistically similar results. Superior capsule reconstruction is a newer procedure that is aimed at those with massive tears that may not be candidates for typical RCR. Reconstructing the superior capsule may allow restored translation of the humoral head to that of a tear-free joint. There still needs to be more research in this area to delineate long-term effects but seems to be a new, viable options for those who qualify. Lastly, subacromial decompression can be utilized when pain and function loss are attributed to impingement from that anatomical region. Micallef et al. found that overall satisfaction was at 78.8% of those undergoing the procedure for partial thickness tears. However, there are minimal long-term positive effects from the procedure and that the efficacy was found to only remain short-term (Micallef et al., 2019).

In summary, non-surgical management techniques should be first line for patients with RCTs. If the patient fails the preliminary methods, surgical intervention may be appropriate. Selection of the type of procedure depends on the type of tear, tear size, and probable cause of pain.

Yoon, T., Kim, Choi, Yoon, S., and Chun (2019) conducted a study that evaluated 108 patients with unrepairable rotator cuff tears that underwent physical therapy. The concept of this study was to assess the outcomes of patients with massive cuff tears and the relationship of preserved subscapularis and teres minor muscles in non-surgical outcomes. The hypothesis is that if both the subscapularis and teres minor remain intact, the force coupling would result in less pain, greater mobility, and better conservative management success. The key strengths of this study include the cohort size, specific and pertinent inclusion and exclusion criteria, clear outlines of what determines failure of treatment, and direct comparisons of the two groups to

evaluate differences in pain and functional outcomes. The limitations as outlined by the authors included a relatively short follow-up time from original assessment, no knowledge of the indications or outcomes of patients that went to other facilities to have surgeries performed, and no follow-up MRI.

Yoon et al. (2019) separated patients into group A which had preservation of both the subscapularis and teres minor muscles but tears in the supraspinatus and infraspinatus, and group B which had either a three muscle tear involving either the subscapularis or teres minor, or a tear of both subscapularis and teres minor with preserved supraspinatus and infraspinatus muscles. In total there were 108 patients in the study. The patients underwent conservative therapies including stretching and strengthening along with pain management using anti-inflammatories.

Before the start of the study, both groups had statistically similar ASES functional scores (group A 65.9, range 52-78 vs group B 64.3, range 48-75), ROM (forward flexion 134º, range 120º-145º vs 133º, range 120º-140º external rotation 24º, 15º-55º vs 21º, range 10º-52º, internal rotation 12º, range 9º-15º vs 15º, range 12º-18º) and pain (3.2, range 0–4 vs 3.3, range 0–4) values (Yoon et al., 2019). The patients then were scheduled and evaluated at 3- and 6-month intervals. At final assessment, it was found that there was again little difference between the two groups in ASES functional scores (68.8, range 48-82 vs 68, range 50-77), ROM (forward flexion 136º, range 120º-160º vs 135º, range 120º-160º, external rotation 25º, range 10º-60º vs 22º, range 10º-50º, internal rotation 12º, range 9º-15º vs 15º, range 11º-17º), and pain values (2.6, range 0-4 vs 2.7, range 0-4). However, the group with preserved subscapularis and teres minor muscles had significant lower failure rates and conversion to surgical management (56.7% vs 31.7%) (Yoon et al., 2019).

Efficacy of Joint Injections

Cimino et al. (2020) was a systematic review focused on the efficacy of corticosteroid injections in relation to clinical outcomes and re-tear rates post-RCR. The systematic review was thorough, it addressed the limitations including the variability of cohort size between the studies, decreased level of evidence studies, variability of many factors including tear size, chronicity of symptoms, additional surgeries along with the RCR, and biases based on non-blinded studies. Strengths of this review include overall large patient cohort size, methodical inclusion criteria, and clear goals of the outcomes to be considered significant. The focus of this article is to bring information together concerning the efficacy of CIs pre-operatively and post-operatively. There are dissenting opinions concerning the long-term outcomes of CIs pre-operatively and if post-operatively they increased risk of poor healing and re-tears. To conduct the systematic review, studies were included that assessed for tears with either ultrasound or MRI. These studies needed to include CIs before or after RCR. Case reports, reviews, and studies that were not in English were excluded.

First, starting with pre-operative CIs, there was a study found that sampled 4,959 patients that received CIs 0-3 (OR=1.38 [1.03-1.84]) months and 0-6 (OR=1.822 [1.290-2.537]) months prior to surgery. The study concluded that the group receiving CIs had a significantly higher rate of re-tear and potential need for revision versus those that did not (Cimino et al., 2020). There were multiple other studies reported that looked at patients receiving CIs anywhere from 0 months to over 12 months before surgery, and all but one concluded statistically significant increased risk for re-tear in the group receiving the injections (1.6% vs 1.1%; OR=1.3 [1.1-1.8]). One study found that two or more injections increased the risk even further (OR=2.12 [1.82-2.47]) over just one CI (OR=1.25 [1.10-1.43]) (Cimino et al., 2020).

Functional stores were assessed using multiple different methods including VAS pain score, Constant-Murley score, and UCLA shoulder score. It was found that both the group that received any amount of CIs pre-op and those that never received one scored significantly higher post RCR (author does not provide specific values). Although the greatest difference was in the CI group, these patients also started out with generally lower scores pre-op. It also does not matter when the CI given within one year of surgery. There were increases in revision rates, but two months was found to have the highest rates of re-tears (Cimino et al., 2020).

Post-op CI outcomes were also evaluated and there were five studies that specifically compared patients receiving post-op CIs and the control group. Follow-up was performed to check for re-tears and was mainly done with MRI, although one study used ultrasound. The average time for the MRI scans was 7.5 months post-op and the ultrasound study was 3.1 years post RCR. Four of the studies found no statistical difference between the groups (author does not provide specific values) and one study showed a statistically significant increase in re-tears in the CI group (OR=2.19 [1.23-3.92]) (Cimino et al., 2020).

There were five studies reviewed by Cimino et al. (2020) that evaluated functional scores post-op, and compared patients receiving CIs to patients that did not. It was found that when CIs preceded the functional evaluation, such as one study that injected at week 8 post-op and evaluated at week 12 post-op, the functional scores were much better in the CI group. However, when a 6-month follow-up was performed, there was no statistical difference between groups. This pattern was reproduced in every study.

There were several conclusions that were reached in Cimino et al. (2020). The re-tear rates and following surgical revision rates were higher in the groups receiving pre-operative CIs.

It stated, “patients receiving a CI within one year prior to RCR were 25% more likely to require revision surgery while those who received a CI within two months prior to RCR were 50-70% more likely to require revision surgery” (Cimino et al., 2020). The increased rates were consistent until around 6 months or more out from surgery, where re-tear rates become similar to control. Cimino et al. (2020) found that the more injections a patient receives, the higher the rates of re-tear and revision. Post-op CIs do not share the same relationship, however. A CI given after a period of healing immediately after surgery does not increase rates of re-tear. CIs improve functional stores post-op, but efficacy is only short-term as functional scores return to baseline for the long-term recovery.

Kim, Sung, Chung, Kwak, and Koh (2017) is a cohort study that reported on efficacy of mesenchymal stem cell (MSC) injections on repair outcomes. The limitations of this study include a decreased number of participants, the use of clinical and MRI imaging to assess for structural healing rather than biopsy to look for physical signs of proper healing, and it not being a blinded study. The strengths include two groups narrowed down in an attempt at homogeneity, clear inclusion and exclusion criteria, an explanation of how the injections are gathered and prepared, and open about limitations and potential biases. The hypothesis is that the use of MSC would improve functional outcomes as well as decrease the re-tear rates. The study was performed by taking 182 patients that were having rotator cuff repair performed, some patients did not meet criteria or were lost to follow-up, and some refused the subsequent MRI. Of the remaining patients, 85 underwent RCR without MSC and 76 had RCR with MSC. Taking 35 patients from the first group, they matched 35 patients from the other group based on tear size, sex, age, and other criteria. The 70 total patients were then to be assessed by several functional standards, VAS pain scale, ROM, and an MRI 12 months post-surgery to assess for re-tears.

Patients were stratified into groups by tear size, chronicity of dysfunction, failure of conservative management, and finally accepted as a candidate for RCR by a surgeon. Patients that had previous tears, surgeries, or severe arthritis in the joint were excluded.

Kim et al. (2017) found that when evaluating the groups pre- and post-op for pain (conventional 2.1 decreased to 0.3, MSC 1.9 decreased to 0.4; $p = <.001$ for both) and Constant functional scores (63.3 to 80.1 and 65.2 to 78.3; $p = <.001$ for both) there were significant improvements post-op. Comparison between the two groups post-op, there was little difference in pain ($p = .256$) or Constant functional scores ($p = .634$). However, the re-tear rates between the groups was significant with 28.6% of the conventional group having re-tears of some degree while the MSC group had a re-tear rate of 14.3% ($p = <.001$) (Kim et al., 2017). With these results, the hypothesis is correct in saying that MSC has a positive influence on structural outcomes and produce more substantial healing. However, there is little to no difference in pain, ROM, or functional standards with MSC administration.

Lin, Wang, and Dines (2018) is a literature review and entry in the *Orthopedic Clinics of North America* journal. The purpose of this article is to approach the main forms of injectable treatments indicated for rotator cuff disease and systematically review each and its efficacy. The treatments reviewed include CIs, PRP, stem cells, and prolotherapy. Reviewing the history of injectable therapies for the shoulder help understand the progress that has been made and realize the amount of progress that still needs to be made. There are several limitations to this entry, however. The authors do not go into any type of detail to suggest what is considered statistically significant in any included article, nor do they show any inclusion or exclusion criteria. Strengths include comprehensive background on each method of treatment, utilization of several functional methods of assessment, and stating the strengths of included studies.

Lin et al. (2018) stated that CIs have been the mainstay of treatment for many years, providing individuals pain relief after a conservative trial of NSAIDs have failed. The review found mixed results from the studies that were included. There was a randomized control trial that showed statistically insignificant differences in VAS pain scale results and ROM functional methods when comparing CI with concurrent NSAID treatment versus NSAIDs alone (author does not provide specific values). The efficacy of CI treatment remained consistently short-term, with most reevaluations at 3 months or greater to have no difference between CI and control groups. The accuracy of injection was also brought to question as one study using arthrographic methods found that only 70% of CI were being delivered into the subacromial space while 21% were in the deltoid and 4% into the glenohumeral joint (Lin et al., 2018).

Lin et al. (2018) discussed how prolotherapy is another type of injection used to promote increased function and decreased pain. The injection is a hypertonic dextrose solution and it is thought to increased healing and strengthening at tendon and ligament insertions by stimulating scar tissue proliferation, however, the exact mechanism of action is unknown. There are several retrospective studies done on this treatment showing some improvements to patient ROM, VAS pain scale, and the Shoulder Pain and Disability index (author does not provide specific values). The drawback to this therapy is the lack of randomized control trials or comparative studies that ultimately does not allow full evaluation of this type of injection. Future studies are needed to see the true value of prolotherapy.

PRPs are meant to increase the rate of healing by providing a higher concentration of the necessary growth factors, cytokines, and other biological items. PRP injections are used along with RCR to decrease re-tear rates and promote healing. Drawbacks from the current studies available include variability in commercial manufacturing, intrapersonal and interpersonal

variation in compound composition, as well as methods of administration and repair techniques. When a level 1 evidence study compared RCR with PRP versus control, there was no statistically significant difference between the two (Lin et al., 2018). Lin et al. (2018) also showed decreased functional results when the solution was injected over the surface of the tendon but more promising results when it was focused at the tendon-bone insertion.

MSC derived from a patient's marrow can be injected into a surgical repair site to promote healing. Stem cells have multiple characteristics such as controlling inflammation and stimulation cell proliferation that make them effective as modulators in the healing process. A level 3 study showed that there was little difference in function and pain when comparing those undergoing RCR and receiving MSC injection and control, however, when reassessing for re-tears at least 1 year later using MRI the MSC group had a significant decrease in re-tear rates at 14.3% compared to 28.5% (Lin et al., 2018). Lin et al. (2018) also provides information about ultrasound-guided needle therapies, however, for the purposes of this review are not to be included based on relevancy.

Discussion

Efficacy of Surgery

When evaluating the efficacy of surgery, all variables must be considered including type of surgery, risk factors and variations of patients, and the severity of injury. Of the studies included in this review, Altintas et al. (2020), Chen et al. (2020), and Rashid et al. (2017) identified age as playing a pivotal role in predicting outcomes post-op. The review also showed that the type, size, and severity of the tear had a considerable bearing on efficacy of the surgery. Altintas et al. found that there was an association between the size of original tear and rate of re-

tears with massive tears being 68.3% and the large tears being 18.3%. Chen et al. similarly concluded that of all the main factors influencing outcomes, the tear size was more substantially influencing results. However, the focus of this review is to establish direct efficacy of surgery and its outcomes when evaluating pain reduction, functional capabilities, and risk of re-tear.

Altintas et al. (2020) and Karjalainen et al. (2019) both show increased functional capacity post-surgery in individuals, regardless of type of shoulder surgery technique used. Chen et al. (2020) showed no difference in function after surgery between the active and sedentary groups compared in the study but did note an overall improvement when compared to pre-surgery. Pain was also assessed in multiple studies, 2 of which found surgery decreasing follow-up pain scores (Altintas et al. 2020, Karjalainen et al. 2019). Altintas et al. and Rashid et al. demonstrated a correlation between size of tear and risk of re-tear. The greater the size of tear, the greater the chance of re-tear. Chen et al. found that the more activity an individual uses their shoulder post-surgery, the higher the change of re-tear as well. This does not include physical therapy regimens but rather more athletic uses of daily living.

Efficacy of Physical Therapy

Physical therapy for the management of rotator cuff injury has been a mainstay technique for many years. This analysis attempts to delineate when PT can be used to the greatest effect with options including non-surgical maintenance, treatment to push off surgery as long as possible, or post-op rehabilitation. The points of analysis will include functional capacity, ROM, pain reduction, and patient satisfaction. Each point was not covered in every article, but comparisons and conclusions can still be yielded from the results.

Both Petri et al. (2016) and Micallef et al. (2019) found that the use of PT for non-surgical management resulted in approximately a 75% patient satisfaction rate with symptom stability and not eventually needing surgery. Boorman et al. (2018) compared patients who underwent surgery after failing conservative methods versus those that remained successful with conservative methods and found little difference in quality of life measures between the two groups (mean RC-QOL of 89 vs 83 out of 100 respectively). Yoon et al. (2019) evaluated the outcomes of PT in relation to when muscles where involved in the tear. The results found that if the subscapularis and teres minor remained intact, these patients stood a much lower chance of failure and need for surgery (56.7% vs 31.7%). However, when comparing the groups, there was little difference in functional capacity, pain reduction, or ROM (Yoon et al., 2019).

Efficacy of Joint Injections

The realm of joint injections is quite considering there are several different types including CI, MSC, PRP, and prolotherapy. This review focused on CI and MSC but also evaluated PRP and prolotherapy to a smaller degree. CI therapy is by far the most popular and well-studied of the injections. The current guidelines highlighted in Lin et al. (2018) suggest a trial of NSAID usage to control pain as long as possible before the initiation of CIs. Cimino et al. (2020) found that there is an elevated risk of re-tear following surgery if CIs were used in pre-op management within 6 months of surgery. Both Cimino et al. and Lin et al. concluded that while CIs are used for pain relief, the duration of efficacy is short, with Lin et al. no difference in CI and control group at 3 months, and Cimino et al. at 6 months.

MSC injections are used for a different purpose than CIs. In theory, the use of MSC injections will increase healing post-op and decrease the re-tear rates. Kim et al. (2017) and Lin

et al. (2018) found a direct relationship between the use of MSC injections and decreased re-tear rates. Kim et al. showed the numbers of re-tear rates to be 28.6% without and 14.3% with. Prolotherapy and PRP are both newer therapies that may eventually results in benefits for individuals with RCTs but at this time there is just too little information to make a sound conclusion for either. Both types need more randomized control trials to gain any confidence for mainstay medical management of these patients.

Applicability to Clinical Practice

From the information provided in this literature review, any medical care provider should be able to have a better understanding on how to assess patients with rotator cuff injury and provide them current information on the best treatment strategies for the given injury. The main variables to consider when deciding on a type of therapy include patient age, size and type of tear, and amount of disruption to the patient's quality of life and daily living. The patient preference, co-morbidities, and other situational variables also play into the decision-making. This review did not cover the younger patient group or rotator cuff tears caused by acute injury. The information gathered can be used to evaluate generally older individuals with chronic injury.

NSAID usage for pain control is first line when considering either conservative or surgical approaches. If there is break-through pain, then CI therapy is a short-term option providing relief for most individuals for varying lengths, around 3 to 6 months of coverage. However, if the patient is a surgical candidate, be careful not to use CIs within 6 months of surgery due to the increased risk of re-tear post-op. If the patient wishes to attempt conservative management, PT has similar outcomes of quality of life for up to 75% of all patients given that they do not fail conservative treatment and need surgery. Patients with preserved subscapularis and teres minor muscles are more successful staying with conservative treatments. Most in-depth evaluation for surgical candidacy is performed

by the orthopedic surgeon, however, knowing the factors at play for successful outcomes as a primary care provider is important. Patient age and tear size are two major factors in surgery success. The older the patient, the greater chance there is of re-tear post-op. It was also found that the more extensive of a tear (size and amount of muscles involved), the greater the risk of re-tear. Given this information, it will be easier to make evidence-based decisions when managing a patient with chronic RCT and have knowledge of the important variables to assess when working up these individuals.

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