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RESEARCH ARTICLE

Non-Operative Management of Rotator Cuff Tears

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Abstract:

Background:

The role of nonoperative management for rotator cuff tears remains a matter of debate. Clinical results reported in the literature mainly consist of level IV studies, oftentimes combining a mixed bag of tear sizes and configurations, and are contradictory to some extent.

Methods:

A selective literature search was performed and personal surgical experiences are reported.

Results:

Most studies show an overall success rate of around 75% for nonoperative treatment. However, the majority of studies also present a progression of tear size and fatty muscle infiltration over time, with however debatable clinical relevance for the patient. Suggested factors associated with progression of a rotator cuff tear are an age of 60 years or older, full-thickness tears, and fatty infiltration of the rotator cuff muscles at the time of initial diagnosis.

Conclusion:

Non-operative management is indicated for patients with lower functional demands and moderate symptoms, and/or of course for those refusing to have surgery. Close routinely monitoring regarding development of tear size should be performed, especially in patients that remain symptomatic during nonoperative treatment. To ensure judicious patient counseling, it has to be taken into account that 1) tears that are initially graded as reparable may become irreparable over time, and 2) results after secondary surgical therapy after failed nonoperative treatment are usually reported to be inferior to those who underwent primary tendon repair.

Keywords: Conservative treatment, clinical outcomes, injections, non-operative treatment, physical therapy, rotator cuff, rotator cuff tear.

INTRODUCTION

Even though rotator cuff tears are the most frequent tendon injury in adults, the natural history of conservatively treated full-thickness tears still remains a matter of debate.

A review of cadaver and radiologic studies revealed a prevalence of rotator cuff tears of at least 10% in people over the age of 60 in the United States [1]. Numbers of rotator cuff surgeries performed per year in the United States are estimated between 75,000 to 250,000 patients [2]. These numbers indicate that actually less than 5% of patients in the United States with rotator cuff tears are treated surgically.

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Depending on the patient cohort, failure rates of surgical repair of rotator cuff tears have been reported between 25 and 90% [3 - 11]. However, clinical results of those with intact repairs and those with failed repairs in terms of imaging are often comparable [12].

Furthermore, as the economic value provided by surgical procedures is becoming increasingly important due to aging population and rising health-care costs, the decision about surgical *vs.* non-surgical treatment has also become one about cost-effectiveness [13].

Sound knowledge of the expected evolution in tear size is of great relevance for counseling patients towards either surgical or nonoperative management [14]. According to the force couple concept introduced by Burkhart *et al*. [15], the rotator cuff muscles act as force couples with each other and the deltoid, containing the inherently unstable glenohumeral joint. The coronal force couple is built up by the deltoid and supraspinatus and compresses the humeral head to the glenoid in abduction. The axial force couple consists of the subscapularis and infraspinatus, providing a compressive joint reaction force in the transverse plane increasing joint stability [16]. As torn tendons cannot participate in load sharing, the tensile load on the remaining fibers is increasing [16]. As an example, a shoulder with a massive posterosuperior tear requires greater forces by both the deltoid and the intact muscle tendon units of the rotator cuff, mainly the subscapularis, to achieve stable abduction [17]. This can contribute to the extension of a tear, particularly if the remaining tendon is of poor quality.

On the other hand, rotator cuff tendon healing is a complex, cell-mediated process following the stepwise progression of inflammatory, proliferative and remodeling phases [18]. Of interest, Hernigou *et al*. recently revealed that the level of mesenchymal stem cells (MSCs), which are of great relevance for the structural healing at the tendon-bone-interface, in the greater tuberosity was siginificantly reduced in patients with rotator cuff tear, emphasizing the potential for biologic augmentation for these patients [19].

Treatment options providing pain relief and improvement of symptoms are not necessarily equivalent with healing of the damaged tissues. Symptoms may get better over time, with still little or no healing response within the tendon. Discussions and evidence regarding non-operative treatment options that both provide relief of symptoms and promote healing at the cellular level is lacking in the literature.

Activity modification, stretching and strengthening exercises of the deltoid and periscapular musculature, anti-inflammatory use, and corticosteroid injections have been suggested [20 - 22].

A systematic review from 2010 analyzing 137 studies concluded that all studies had a high risk of bias and that evidence of various operative and non-operative treatments for rotator cuff tears was limited and inconclusive [23].

Appropriate patient counseling and selection is of particular importance for non-operative management. The patient has to be aware that non-operative treatment does commonly not cure or repair the tear, but may improve symptoms. Ideally, the patients should have largely intact rotator cuff force couples and pain as the primary symptom. For those who decide to live with their functional limitations imposed by the rotator cuff tear and wish to avoid perioperative risks, non-operative management is indicated.

Study Background and Reported Clinical Outcomes

Goldberg *et al*. reported the functional outcome of 46 consecutive patients with full-thickness rotator cuff tears who elected nonoperative management. The tear patterns of this patient cohort were heterogeneous, ranging from single-tendon tears to three-tendon tears and one third of unspecified tear pattern. Treatment consisted only of patient education and a home program of gentle stretching and strengthening without any formal physical therapy (PT). At an average follow-up of 2.5 years, 59% of the patients experienced improvement with non-operative treatment, while 30% patients experienced worsening, and 11% patients remained unchanged [24]. This study is of particular interest as it did not include any formal PT or other non-operative intervention, therefore being close to representing the natural history of rotator cuff tears.

A study on 19 patients with an average age of 64 years and massive rotator cuff tears (among these 68% of 3-tendon-tears) and non-operative management revealed a mean relative Constant score of 83% and a mean subjective shoulder value (SSV) of 68% after a mean 4-year follow-up. However, it also showed an increasing size of the tendon tear, progress of fatty infiltration according to the Goutallier classification by one stage on average, and progression of glenohumeral osteoarthritis. Half of the tears that were initially graded as reparable were considered as irreparable at final follow-up. The results of patients with 3-tendon tears were significantly worse than those of patients with 2-tendon

tears. The authors concluded that satisfactory shoulder function can be maintained despite progression of the rotator cuff tears and adverse joint changes [25].

Maman *et al*. retrospectively analyzed 54 patients (mean age of 59 years) with nonoperatively managed rotator cuff tears. Their patient cohort was rather heterogeneous, with 56% of full-thickness tears, 44% of partial-thickness tears, and 10% combined. Size of the tear was also variable, with 83% single-tendon tears and 17% of large or massive tears. Follow-up was also variable and showed more often progression in tear size in patients who were followed for more than 18 months compared to those with a follow-up of less than 18 months. Fifty-two percent of the full-thickness tears increased in size compared to only 8% of the partial-thickness tears. Of interest, 8.5% of tears decreased in size. They found remarkably better results for patients younger than 60 years (17% patients deteriorating over time) compared to patients older than 60 years (54% deteriorating). Twenty-four percent of patients with full-thickness tears developed supraspinatus muscle atrophy, compared to none who had partial-thickness tears. Patients with fatty muscular infiltration were more likely to increase in tear size [26].

Among 195 patients that were prospectively followed as a cohort for 2 years, Mall and coworkers found that 40% of patients with partial-thickness tears progressed to full-thickness tears over the 2-year study period [27].

Safran and coworkers prospectively followed 51 patients younger than 60 years with full-thickness rotator cuff tears who underwent non-operative management. At a mean follow-up of 29 months, ultrasound examination revealed that 49% of the tears had increased in size, 43% had not changed, and 8% had decreased in size. On the initially intact contralateral shoulders, 25% developed a new full-thickness rotator cuff tear. The authors did not find any correlation between behaviour of tear size and age, sex, prior trauma, and initial tear size. The only relevant correlation was found between an increase in tear size and considerable pain at follow-up, which matches clinical expectations [14]. The authors concluded that surgery should be initially considered in these younger patients to prevent an increase in size of the rotator cuff tear.

Of interest, these findings by Safran *et al*. [14] highlighting the rather poor outcomes in younger patients are somewhat contradictory to those of Maman *et al*. [26] who found worse results in older patients.

On the other hand, Fucentese and coworkers reported surprisingly good clinical and magnetic resonance imaging (MRI) results on 24 consecutive patients with a mean age of 52 years and isolated full-thickness supraspinatus tears who were offered surgical management, but elected nonoperative treatment. At a mean follow-up of 3.5 years, the mean Constant score was 75 points with a relative Constant score of 86%; the subjective shoulder score was 74%. Contradictory to the findings of Zingg [25] Mall [27], and Safran [14], the mean rotator cuff tear size did not significantly change over time in their cohort. Of interest, the tear size got smaller on MRI in 37.5% shoulders and was even no longer detectable on MRI in 8.3% of the patients. Another 37.5% of tears have kept their original size, and only 25% had increased in size. Fatty muscle infiltration of the supraspinatus slightly increased over time, but did not exceed Goutallier stage 2 in any patient at the latest follow-up [28]. However, this study only dealt with small rotator cuff tears (supraspinatus tendon only), not allowing to extrapolate these results for larger tears as well.

Boorman *et al*. recently presented their results of a prospective cohort of 93 patients with chronic full-thickness rotator cuff tears undergoing a three-month supervised program of non-operative treatment. 75% of the patients were successfully treated without surgery. The baseline Rotator Cuff Quality-of-Life Index (RC-QOL) score was a significant predictor of outcome. Of particular interest, 89% of the patients maintained their three-month outcome at two years of follow-up [29].

Adding to this information, Yamaguchi *et al*. followed the natural history of 45 patients with initially asymptomatic rotator cuff tears over a 5-year period. They demonstrated that 51% of these patients became symptomatic after a mean of 2.8 years, with a high risk for tear size progression over time [30]. This raises the question whether the commonly used 2-year follow-up is sufficient to estimate the true success of therapeutic regimens.

Moosmayer *et al*. randomized 103 patients with rotator cuff tears up to 3 cm diameter to either primary tendon repair or physical therapy. They had a remarkably high five-year follow-up rate of 98%. 23.5% of the patients in the physiotherapy group failed non-operative management and finally underwent secondary tendon repair. The results of these patients were significantly inferior to those who underwent primary tendon repair in terms of pain, satisfaction, and clinical scores. In the physiotherapy group, 37% of rotator cuff tears increased by more than 5 mm in tear size over five years, which was associated with an inferior outcome. The authors concluded that primary repair of small and medium-sized rotator cuff tears yielded better outcomes than non-operative management with physiotherapy, with

however small differences that may be below clinical importance [31].

The MOON shoulder group investigated 434 patients with a mean age of 62.7 years and symptomatic atraumatic rotator cuff tears treated nonoperatively regarding predictors of shoulder activity level. They found that shoulder activity was not associated with severity of the rotator cuff tear, but negatively associated with age and female sex [32].

Physical Therapy

As the vast majority of patients obtain physical therapy (PT) after their surgical repair, it is hard to differentiate the pure effect of surgery alone from the potential benefit by PT postoperatively regarding outcomes [33].

In 1993, Bokor and coworkers presented the results of non-operative management of 53 patients with a mean age of 62 years and full-thickness rotator cuff tears with a remarkable average follow-up of 7.6 years. The treatment program consisted of non-steriodal anti-inflammatory drugs (NSAIDs), stretching, strengthening, and occasional steroid injections. Even though 94% of the patients had evidence of muscular weakness and 56% had demonstrable muscle atrophy at follow-up, 74% of the patients reported only slight or no shoulder discomfort. Among those patients who had presented within three months of injury, even 86% rated their result as satisfactory. On the other hand, those patients who initially presented with shoulder pain for more than 6 months, only 56% were satisfied with their result [34]. The size of tears was not reported in this study though, therefore requiring some precaution with the interpretation of the results.

A physiotherapy regimen focused on anterior deltoid strengthening and functional rehabilitation was applied to 10 elderly patients with massive rotator cuff tears. After a 3-month follow-up, the Oxford Shoulder Disability Questionnaire showed a mean improvement of 9, while pain scores on the SF 36 increased on average by 22 points and the perceived health subsection declined by 9 points [35].

The MOON shoulder group followed a multicentric cohort of 452 patients with atraumatic full-thickness rotator cuff tears over 2 years of non-operative management. Patients pursued a standardized physical therapy program including daily postural exercises, active and active assisted range of motion, active training of scapula muscles; daily anterior and posterior shoulder stretching; and three times per week strengthening of the rotator cuff and periscapular muscles exercises. Physical therapists provided manual mobilization as needed, and progressed the patient to a home therapy program when ready. Patients had to complete a compliance diary regarding their PT visits and the frequency of home therapy.

Patients then returned for evaluation at 6 and 12 weeks. Clinical outcomes including Short Form 12 score, American Shoulder and Elbow Surgeons score, Western Ontario Rotator Cuff score, Single Assessment Numeric Evaluation score, and Shoulder Activity Scale, all improved significantly at 6 and 12 weeks. Less than 25% of the patients crossed over to surgical management, the majority of these between 6 and 12 weeks after initiation of the physical therapy program. This left 75% of the patients who were satisfied with non-operative treatment after 2 years of follow-up [33]. The strength of this study consists in its large patient cohort and standardized physical therapy protocol. As a limitation, no MRI follow-up was performed, which would have added to the value of the study.

Corticosteroid Injections

For partial thickness rotator cuff tendon tears, corticosteroid injections can provide pain relief and improve associated limited range of motion [36 - 39].

In a 6 month follow-up after fluroscopically guided subacromial steroid injection, symptom relief was demonstrated in 83% of patients [39]. However, no longer follow-up data is available until today.

Alvarez and coworkers conducted a randomized clinical trial comparing subacromial injection of xylocaine plus betamethasone to xylocaine alone in patients with chronic rotator cuff tendinosis or partial rotator cuff tears. Fifty-eight patients with failure of 6 weeks of PT and 2 weeks of NSAIDs were included and re-evaluated at 2, 6, 12, and 24 weeks after injection.

Both groups showed significant improvement in all outcomes compared to the initial baseline. No statistically significant difference was found between the two treatment groups for all outcomes and time intervals [40].

Wei *et al*. investigated the influence of subacromial corticosteroid injections on rotator cuff tendons in rats by examining the type-III to type-I collagen expression ratio as a tendon injury marker. They found that a single dose of corticosteroid did not alter the acute phase response in rats with injured tendons, with however the same steroid dose

initiating a short-term response equivalent to that of structural injury in rats with uninjured tendons [41]. Even though a rat trial, these results indicate that the effects of corticosteroid injections on human tendons require further clarification and that such injections should be used carefully.

Contreras *et al*. found a 40% failure rate after subacromial corticosteroid injection in a cohort of 49 patients with a mean follow-up of 22 months. The success rate was significantly higher in men (76%) than in women (45%). Neither age, hand dominance, duration of symptoms, or any clinical score was predictive for failure of non-operative management [42].

Gialanella *et al*. performed a randomized controlled clinical trial including 60 patients on the effect of intraarticular triamcinolone injections in patients with symptomatic rotator cuff tears. They found that a single injection of triamcinolone provided significant pain relief for an average of 3 months compared to the control group, without any benefit by another injection after 3 weeks. The Constant-Murley scores of all groups, including the control group, were similar at 3 months of follow-up [43]. This study, in synopsis with Wei´s study [41], indicates that corticosteroid injections should better not be repeated within short time intervals.

Hyaluronic Acid

Shibata *et al*. performed a randomized study on 78 patients with rotator cuff tears, comparing injections of 25 mg of sodium hyaluronate (SH group) to 2 mg of dexamethasone (steroid group). Injections were repeated once a week for 5 consecutive weeks. At an average 6-month follow-up, they found comparable rates of therapeutic success of 39.5% in the SH group and and 35% in the steroid group [44]. Compared to other studies investigating non-operative treatment options, this is a rather low succes rate.

A study on 22 elderly patients with a mean age of 78 years evaluated the efficacy of hyaluronic acid injections, followed by PT consisting of passive and active assisted kinesitherapy. The authors found significant improvements for pain, range of motion, and autonomy in daily life activities [45].

PRP

Platelet rich plasma (PRP) has been suggested as a method to enhance rotator cuff healing by accelerating the natural healing cascade [46, 47]. However, all studies until today have only investigated the influence of PRP as an adjunct to rotator cuff repair. This topic is dealt with in detail in another review paper of this special thematic issue. Studies investigating the effects of PRP only in non-operative treatment of rotator cuff tears are lacking.

CONCLUSION

Data from clinical outcomes studies investigating non-operative management of rotator cuff tears are contradictory. Most studies show an overall success rate of around 75% for conservative treatment. However, the majority of studies also shows a progression of tear size and fatty muscle infiltration over time, with however debatable clinical relevance for the patient. Suggested factors associated with progression of a rotator cuff tear are an age of 60 years or older, full-thickness tears, and fatty infiltration of the rotator cuff muscles at the time of initial diagnosis.

Non-operative management is a reasonable treatment option for patients with low functional demands and moderate symptoms, and/or of course for those refusing to have surgery.

For patients undergoing non-operative management, close routinely monitoring regarding development of tear size by magnetic resonance imaging should be performed, especially if these patients remain symptomatic. For patient counseling, it has to be taken into account that 1) tears that are initially graded as reparable may become irreparable over time, and 2) results after secondary surgical therapy after failed non-operative treatment are usually reported to be inferior to those who underwent primary tendon repair.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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REFERENCES

[1] Reilly P, Macleod I, Macfarlane R, Windley J, Emery RJ. Dead men and radiologists don't lie: a review of cadaveric and radiological studies of rotator cuff tear prevalence. Ann R Coll Surg Engl 2006; 88(2): 116-21. [Pubmed Central PMCID: 1964063.] [http://dx.doi.org/10.1308/003588406X94968] [PMID: 16551396]

[2] Vitale MA, Vitale MG, Zivin JG, Braman JP, Bigliani LU, Flatow EL. Rotator cuff repair: an analysis of utility scores and cost-effectiveness. J Shoulder Elbow Surg 2007; 16(2): 181-7. [PMID: 17399623.] [http://dx.doi.org/10.1016/j.jse.2006.06.013]

[3] Bishop J, Klepps S, Lo IK, Bird J, Gladstone JN, Flatow EL. Cuff integrity after arthroscopic versus open rotator cuff repair: a prospective study. J Shoulder Elbow Surg 2006; 15(3): 290-9. [PMID: 16679227]

[4] Feng S, Guo S, Nobuhara K, Hashimoto J, Mimori K. Prognostic indicators for outcome following rotator cuff tear repair. J Orthop Surg (Hong Kong) 2003; 11(2): 110-6. [PMID: 14676334]

[5] Galatz LM, Ball CM, Teefey SA, Middleton WD, Yamaguchi K. The outcome and repair integrity of completely arthroscopically repaired large and massive rotator cuff tears. J Bone Joint Surg Am 2004; 86-A(2): 219-24. [PMID: 14960664]

[6] Gerber C, Fuchs B, Hodler J. The results of repair of massive tears of the rotator cuff. J Bone Joint Surg Am 2000; 82(4): 505-15. [PMID: 10761941]

[7] Harryman DT II, Mack LA, Wang KY, Jackins SE, Richardson ML, Matsen FA III. Repairs of the rotator cuff. Correlation of functional results with integrity of the cuff. J Bone Joint Surg Am 1991; 73(7): 982-9. [PMID: 1874784]

[8] Klepps S, Bishop J, Lin J, *et al.* Prospective evaluation of the effect of rotator cuff integrity on the outcome of open rotator cuff repairs. Am J Sports Med 2004; 32(7): 1716-22. [http://dx.doi.org/10.1177/0363546504265262] [PMID: 15494338]

[9] Mellado JM, Calmet J, Olona M, *et al.* Surgically repaired massive rotator cuff tears: MRI of tendon integrity, muscle fatty degeneration, and muscle atrophy correlated with intraoperative and clinical findings. AJR Am J Roentgenol 2005; 184(5): 1456-63. [http://dx.doi.org/10.2214/ajr.184.5.01841456] [PMID: 15855096]

[10] Thomazeau H, Boukobza E, Morcet N, Chaperon J, Langlais F. Prediction of rotator cuff repair results by magnetic resonance imaging. Clin Orthop Relat Res 1997; (344): 275-83. [PMID: 9372778]

[11] Zanetti M, Jost B, Hodler J, Gerber C. MR imaging after rotator cuff repair: full-thickness defects and bursitis-like subacromial abnormalities in asymptomatic subjects. Skeletal Radiol 2000; 29(6): 314-9. [http://dx.doi.org/10.1007/s002560000203] [PMID: 10929412]

[12] Slabaugh MA, Nho SJ, Grumet RC, Wilson JB, Seroyer ST, Frank RM, *et al.* Does the literature confirm superior clinical results in radiographically healed rotator cuffs after rotator cuff repair? Arthroscopy 2010; 26(3): 393-403. [PMID: 20206051] [http://dx.doi.org/10.1016/j.arthro.2009.07.023]

[13] Bell JE. Repair of symptomatic rotator cuff tears after failed nonoperative treatment is cost-effective: commentary on an article by Richard C. Mather III, MD, *et al.*: "The societal and economic value of rotator cuff repair". J Bone Joint Surg Am 2013; 95(22): e178. [http://dx.doi.org/10.2106/JBJS.M.01223] [PMID: 24257678]

[14] Safran O, Schroeder J, Bloom R, Weil Y, Milgrom C. Natural history of nonoperatively treated symptomatic rotator cuff tears in patients 60 years old or younger. Am J Sports Med 2011; 39(4): 710-4. [http://dx.doi.org/10.1177/0363546510393944] [PMID: 21310940]

[15] Burkhart SS, Nottage WM, Ogilvie-Harris DJ, Kohn HS, Pachelli A. Partial repair of irreparable rotator cuff tears. Arthroscopy 1994; 10(4): 363-70. [PMID: 7945631] [http://dx.doi.org/10.1016/S0749-8063(05)80186-0]

[16] Parsons IM, Apreleva M, Fu FH, Woo SL. The effect of rotator cuff tears on reaction forces at the glenohumeral joint. J Orthop Res 2002; 20(3): 439-6. May [PMID: 12038616] [http://dx.doi.org/10.1016/S0736-0266(01)00137-1]

[17] Hansen ML, Otis JC, Johnson JS, Cordasco FA, Craig EV, Warren RF. Biomechanics of massive rotator cuff tears: implications for treatment. J Bone Joint Surg Am 2008; 90(2): 316-25. [http://dx.doi.org/10.2106/JBJS.F.00880] [PMID: 18245591]

[18] Wurgler-Hauri CC, Dourte LM, Baradet TC, Williams GR, Soslowsky LJ. Temporal expression of 8 growth factors in tendon-to-bone healing in a rat supraspinatus model. J Shoulder Elbow Surg 2007; 16(5): S198-203. [PMID: 4001791] [http://dx.doi.org/10.1016/j.jse.2007.04.003]

[19] Hernigou P, Merouse G, Duffiet P, Chevalier N, Rouard H. Reduced levels of mesenchymal stem cells at the tendon-bone interface tuberosity in patients with symptomatic rotator cuff tear. Int Orthop 2015; 39(6): 1219-25. [PMID: 25757411] [http://dx.doi.org/10.1007/s00264-015-2724-8]

[20] Millett PJ, Wilcox RB III, O'Holleran JD, Warner JJ. Rehabilitation of the rotator cuff: an evaluation-based approach. J Am Acad Orthop Surg 2006; 14(11): 599-609.
[http://dx.doi.org/10.5435/00124635-200610000-00002] [PMID: 17030593]

[21] van der Meijden OA, Westgard P, Chandler Z, Gaskill TR, Kokmeyer D, Millett PJ. Rehabilitation after arthroscopic rotator cuff repair: current concepts review and evidence-based guidelines. Int J Sports Phys Ther 2012; 7(2): 197-218.
[PMID: 22530194]

[22] Lin JC, Weintraub N, Aragaki DR. Nonsurgical treatment for rotator cuff injury in the elderly. J Am Med Dir Assoc 2008; 9(9): 626-32.
[http://dx.doi.org/10.1016/j.jamda.2008.05.003] [PMID: 18992694]

[23] Seida JC, LeBlanc C, Schouten JR, *et al.* Systematic review: nonoperative and operative treatments for rotator cuff tears. Ann Intern Med 2010; 153(4): 246-55.
[http://dx.doi.org/10.7326/0003-4819-153-4-201008170-00263] [PMID: 20621893]

[24] Goldberg BA, Nowinski RJ, Matsen FA III. Outcome of nonoperative management of full-thickness rotator cuff tears. Clin Orthop Relat Res 2001; (382): 99-107.
[http://dx.doi.org/10.1097/00003086-200101000-00015] [PMID: 11154011]

[25] Zingg PO, Jost B, Sukthankar A, Buhler M, Pfirrmann CW, Gerber C. Clinical and structural outcomes of nonoperative management of massive rotator cuff tears. J Bone Joint Surg Am 2007; 89(9): 1928-34.
[http://dx.doi.org/10.2106/JBJS.F.01073] [PMID: 17768188]

[26] Maman E, Harris C, White L, Tomlinson G, Shashank M, Boynton E. Outcome of nonoperative treatment of symptomatic rotator cuff tears monitored by magnetic resonance imaging. J Bone Joint Surg Am 2009; 91(8): 1898-906.
[http://dx.doi.org/10.2106/JBJS.G.01335] [PMID: 19651947]

[27] Mall NA, Kim HM, Keener JD, *et al.* Symptomatic progression of asymptomatic rotator cuff tears: a prospective study of clinical and sonographic variables. J Bone Joint Surg Am 2010; 92(16): 2623-33.
[http://dx.doi.org/10.2106/JBJS.I.00506] [PMID: 21084574]

[28] Fucentese SF, von Roll AL, Pfirrmann CW, Gerber C, Jost B. Evolution of nonoperatively treated symptomatic isolated full-thickness supraspinatus tears. J Bone Joint Surg Am 2012; 94(9): 801-8.
[http://dx.doi.org/10.2106/JBJS.I.01286] [PMID: 22552669]

[29] Boorman RS, More KD, Hollinshead RM, *et al.* The rotator cuff quality-of-life index predicts the outcome of nonoperative treatment of patients with a chronic rotator cuff tear. J Bone Joint Surg Am 2014; 96(22): 1883-8.
[http://dx.doi.org/10.2106/JBJS.M.01457] [PMID: 25410506]

[30] Yamaguchi K, Tetro AM, Blam O, Evanoff BA, Teefey SA, Middleton WD. Natural history of asymptomatic rotator cuff tears: a longitudinal analysis of asymptomatic tears detected sonographically. J Shoulder Elbow Surg 2001; 10(3): 199-203.
[PMID: 11408898] [http://dx.doi.org/10.1067/mse.2001.113086]

[31] Moosmayer S, Lund G, Seljom US, *et al.* Tendon repair compared with physiotherapy in the treatment of rotator cuff tears: a randomized controlled study in 103 cases with a five-year follow-up. J Bone Joint Surg Am 2014; 96(18): 1504-14.
[http://dx.doi.org/10.2106/JBJS.M.01393] [PMID: 25232074]

[32] Brophy RH, Dunn WR, Kuhn JE, Group MS. Shoulder activity level is not associated with the severity of symptomatic, atraumatic rotator cuff tears in patients electing nonoperative treatment. Am J Sports Med 2014; 42(5): 1150-4.
[http://dx.doi.org/10.1177/0363546514526854] [PMID: 24658346]

[33] Kuhn JE, Dunn WR, Sanders R, An Q, Baumgarten KM, Bishop JY, *et al.* Effectiveness of physical therapy in treating atraumatic full-thickness rotator cuff tears: a multicenter prospective cohort study. J Shoulder Elbow Surg 2013; 10(5): 1150-4.: 1371-154.
[PMID: 23540577] [http://dx.doi.org/10.1016/j.jse.2013.01.026]

[34] Bokor DJ, Hawkins RJ, Huckell GH, Angelo RL, Schickendantz MS. Results of nonoperative management of full-thickness tears of the rotator cuff. Clin Orthop Relat Res 1993; (294): 103-10.
[PMID: 8358901]

[35] Ainsworth R. Physiotherapy rehabilitation in patients with massive, irreparable rotator cuff tears. Musculoskelet Care 2006; 4(3): 140-51.
[http://dx.doi.org/10.1002/msc.85] [PMID: 17042025]

[36] Koester MC, Dunn WR, Kuhn JE, Spindler KP. The efficacy of subacromial corticosteroid injection in the treatment of rotator cuff disease: A systematic review. J Am Acad Orthop Surg 2007; 15(1): 3-11.
[http://dx.doi.org/10.5435/00124635-200701000-00002] [PMID: 17213378]

[37] Buchbinder R, Green S, Youd JM. Corticosteroid injections for shoulder pain. Cochrane Database Syst Rev 2003; (1): CD004016.
[PMID: 12535501]

[38] Yu CM, Chen CH, Liu HT, Dai MH, Wang IC, Wang KC. Subacromial injections of corticosteroids and xylocaine for painful subacromial impingement syndrome. Chang Gung Med J 2006; 29(5): 474-9.
[PMID: 17214391]

[39] Hambly N, Fitzpatrick P, MacMahon P, Eustace S. Rotator cuff impingement: correlation between findings on MRI and outcome after fluoroscopically guided subacromial bursography and steroid injection. AJR Am J Roentgenol 2007; 189(5): 1179-84.
[http://dx.doi.org/10.2214/AJR.07.2421] [PMID: 17954658]

[40] Alvarez CM, Litchfield R, Jackowski D, Griffin S, Kirkley A. A prospective, double-blind, randomized clinical trial comparing subacromial injection of betamethasone and xylocaine to xylocaine alone in chronic rotator cuff tendinosis. Am J Sports Med 2005; 33(2): 255-62. [http://dx.doi.org/10.1177/0363546504267345] [PMID: 15701612]

[41] Wei AS, Callaci JJ, Juknelis D, *et al.* The effect of corticosteroid on collagen expression in injured rotator cuff tendon. J Bone Joint Surg Am 2006; 88(6): 1331-8. [http://dx.doi.org/10.2106/JBJS.E.00806] [PMID: 16757768]

[42] Contreras F, Brown HC, Marx RG. Predictors of success of corticosteroid injection for the management of rotator cuff disease. HSS J 2013; 9(1): 2-5. Pubmed Central PMCID: 3640713. [PMID: 24426836] [http://dx.doi.org/10.1007/s11420-012-9316-6]

[43] Gialanella B, Prometti P. Effects of corticosteroids injection in rotator cuff tears. Pain Med 2011; 12(10): 1559-65. [http://dx.doi.org/10.1111/j.1526-4637.2011.01238.x] [PMID: 21951654]

[44] Shibata Y, Midorikawa K, Emoto G, Naito M. Clinical evaluation of sodium hyaluronate for the treatment of patients with rotator cuff tear. J Shoulder Elbow Surg 2001; 10(3): 209-16. [PMID: 11408900.] [http://dx.doi.org/10.1067/mse.2001.113501]

[45] Costantino C, Olvirri S. Rehabilitative and infiltrative treatment with hyaluronic acid in elderly patients with rotator cuff tears. Acta biomedica 2009; 80(3): 225-9.

[46] Barber FA, Hrnack SA, Snyder SJ, Hapa O. Rotator cuff repair healing influenced by platelet-rich plasma construct augmentation. Arthroscopy 2011; 27(8): 1029-35. [PMID: 21802625] [http://dx.doi.org/10.1016/j.arthro.2011.06.010]

[47] Randelli PS, Arrigoni P, Cabitza P, Volpi P, Maffulli N. Autologous platelet rich plasma for arthroscopic rotator cuff repair. A pilot study. Disabil Rehabil 2008; 30(20-22): 1584-9. [http://dx.doi.org/10.1080/09638280801906081] [PMID: 18608363]