Journal of Orthopaedic Surgery and Research

SYSTEMATIC REVIEW

Open Access

Arthroscopic procedures for degenerative rotator cuff disease: a systematic review and network meta-analysis

Zhennan Feng[1], Song Wu[1], Hai Hu[1], Hong Long[1], Luozhifei Zhou[2] and Minren Shen[1*]

Abstract

Background Treatment of rotator cuff diseases often involves various arthroscopic procedures but their combined effectiveness remains contentious, especially in complex cases.

Methods We focused on patients with degenerative shoulder cuff diseases requiring arthroscopic rotator cuff repair. Searches covered multiple databases (Medline, Embase, Web of Science, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, and Cochrane Clinical Answers) up to April 1, 2024. Bias risk was assessed using RevMan (v 5.4), and a network meta-analysis was conducted with netmeta (v 2.8).

Result From 16 studies, 1232 patients (average age, 56.2 years; balanced sex ratio) were included. Arthroscopic rotator cuff repair ranked highest in functional score networks, surpassing other interventions. Physiotherapy was superior for pain relief compared to arthroscopic procedures combined with platelet-rich plasma (mean, 2.5; 95% confidence interval, 4.48–0.52). Arthroscopic rotator cuff repair and subacromial decompression were significantly superior to arthroscopic rotator cuff repair and subacromial decompression combined with platelet-rich plasma (MD, 1.80; 95% CI, 3.39–0.21).

Discussion Moderate bias risks were noted in both networks due to blinding issues and methodological quality reporting. Arthroscopic rotator cuff repair is favored for improving shoulder function, while other procedures or intra-articular treatments offer no significant benefits. Regarding pain management, physiotherapy is preferred; however, more evidence is needed to support this recommendation and caution is advised.

Other Systematic review registration PROSPERO CRD42023450150.

Keywords Rotator cuff disease, Network meta-analysis, Arthroscopic procedures, Physiotherapy

*Correspondence:
Minren Shen
shenminren@163.com
[1]Department of Orthopaedics, The Third Xiangya Hospital of Central South University, 410013 Changsha, Hunan, China
[2]Department of Rehabilitation, The Third Xiangya Hospital of Central South University, 410013 Changsha, Hunan, China

Introduction

The shoulder joint has been reported as the third most common site of musculoskeletal pain [1], with an estimated global community prevalence of approximately 16% [2]. Chronic shoulder pain imposes a significant economic burden in various regions of the world, and this trend is on the rise [3]. Most cases of chronic shoulder pain are age-related and result from degenerative changes in the shoulder without traumatic injury [4, 5].

Among the different cases of chronic shoulder pain, rotator cuff disease accounts for the vast majority and often coexists with the long head of the biceps tendinopathy [6]. Though the pathogenesis remains unclear, shoulder impingement syndrome [7] not only elucidates the underlying causes of rotator cuff diseases, but also results in lesions of the long head of the biceps tendon [8] and reveals the interplay of deep structures. Beyond the macro-level impingement mechanisms, inflammatory infiltration of the intra-articular bursa and synovial proliferation occur in degenerative shoulder conditions [9].

Such findings collectively indicate similar widespread effects caused by complex alterations within degenerative rotator cuff disease [10]. It just likes osteoarthritis, similar to Jo et al.'s perspective [11], involves pathologies affecting extensive intra-articular structures and encompasses various corresponding surgical procedures. The various potential scenarios within degenerative rotator cuff disease are challenging to predict [12], where imaging findings often do not correlate with clinical presentations [13], still need to be confirmed by arthroscopy [14], which is the diagnostic gold standard, this also puts surgeons in a passive position to plan operations based on the results of the diagnostic arthroscopy [15]. Further, due to the weak correlation between pathological lesions and symptoms, the superposition of multiple surgical procedures can make the effectiveness uncertain [16].

While the effectiveness and risks of certain procedures within arthroscopic surgery have been thoroughly validated [17], previous evidence, as well as registered future studies, have compared only a limited number of surgical technique combinations, which may not adequately address patients with degenerative rotator cuff disease. To address these issues and simulate intraoperative decision-making, we conducted a network meta-analysis (NMA) of arthroscopic procedures for rotator cuff disease to determine the optimal procedures.

Methods

Protocol

During the conduct and reporting of this prospective registered systematic review, we adhered to the PRISMA extension statement for reporting of systematic reviews [18] incorporating NMAs and combined it with the PERSiST guidelines specific to the field of sports science [19].

Search strategy and eligibility criteria two researchers independently conducted searches of electronic databases (Medline, Embase, Web of Science, Cochrane Database of Systematic Review, Cochrane Central Register of Controlled Trials, and Cochrane Clinical Answers) from inception until April 1, 2024, based on the inclusion criteria, screened records, and extracted study characteristics and data according to the PICO principles. Any discrepancies were resolved by another independent researcher when finalizing study inclusion. The inclusion criteria were patients who needed arthroscopic rotator cuff repair in randomized controlled clinical trial. The exclusion criteria were (1) secondary shoulder pain (e.g., suprascapular nerve entrapment, thoracic outlet syndrome, and axillary nerve injury), (2) specific shoulder joint lesions (e.g., septic arthritis, and pigmented villonodular synovitis), and (3) isolated long head of biceps tendinitis, isolated acromioclavicular joint arthritis, and isolated rotator cuff tears other than supraspinatus muscle (e.g., isolated subscapular muscle injuries, most commonly post-traumatic, rotator cuff tearing arthropathy, shoulder cartilage disease, or shoulder instability [i.e., complete upper lip or complete anterior or posterior lip cleft, known as Bankart disease]), (4) revision surgery and prior procedures on the affected shoulder, (5) inclusion of specific, customized rehabilitation methods that could potentially affect prognosis and outcome indicator measurements (i.e., short-term intra-articular injections), and (6) all shoulder function related scores will be included in the data extraction, but if the data is limited, the scoring network will abandon the data analysis.

Data extraction and transformation

Data extraction and transformation were for the primary outcomes conducted independently by two researchers according to the PICO principles [20]. To ensure the interpretability and robustness of the study results, we extracted and will further explore potential covariates, such as rehabilitation plans [21], follow-up duration, surgeon, surgical indications, and specific procedural details, as necessary. Therefore, the research and reasons for the need for preliminary screening are evaluated. The data represented by mean and standard deviation, 95% confidence interval and range were converted according to the manual for subsequent analysis. The data used for statistical analysis underwent verification and were cross-checked to ensure consistency between the original and transformed datasets. Any discrepancies were reviewed by a third-party for verification, and if necessary, resolved through discussion.

Statistical analysis

We employed NMA based on weighted least squares regression, utilizing the netmeta package for all statistical

analyses (version 2.8) [22]. The software version used was 4.1.3 (R Project for Statistical Computing). Statistical significance was determined using Egger's test and Cochran's Q test [23], with a significance threshold set at $P<0.05$. Raw data were presented as the differences between baseline and last follow-up continuous outcomes, with means and standard deviations indicating data distribution [24]. The different effect sizes were aggregated using a frequentist random-effects NMA model, and 95% confidence intervals (CIs) were provided [25]. Pooled weights for each intervention were computed based on pairwise comparisons. The findings were summarized in a forest plot and league table. Statistical heterogeneity within our model was evaluated using I^2 [26] and τ^2 [27]. We defined heterogeneity by combining different ranges of I^2 with the confidence intervals of τ^2, with $I^2 > 75\%$ indicating high heterogeneity [28]. The sources of moderate to high heterogeneity will be explored in additional analyses. Additionally, Cochran's Q test was conducted to assess overall heterogeneity and inconsistency [29]. The test results were used to distinguish the heterogeneity within the study and the inconsistency between the studies. The node-splitting analysis and the proportion of direct comparison would be presented to further explore potential inconsistency [30]. Treatment rankings were represented using P-scores based on the random-effects model [31]. The surface under the cumulative ranking curve was calculated to construct the rankogram [31, 32]. Additionally, the league graph simultaneously presents rankings depicting pairwise mixed and direct comparisons.

Additional analysis

To satisfy the transitivity assumption, we used identical definitions for common comparators [33]. Furthermore, an evaluation was conducted by comparing the distribution of trial characteristics across study groups (publication year, male/female ratio, mean age, baseline pain, and functional scores) [34]. In order to assess the robustness of the results obtained from the primary model, we performed sensitivity analyses on the main outcomes of pain and function to explore potential sources of heterogeneity. Comparison-adjusted funnel plots and Egger's test were used to evaluate the publication bias in NMAs [35]. We assessed the methodological quality of the included randomized controlled trials using the Cochrane Collaboration's Risk of Bias assessment method [36].

Results

Study identification and selection

The retrieval strategy outlined in Appendix 1 was utilized to search the databases, resulting in 2603 articles. After automated and manual removal of duplicate articles using Endnote software, the titles and abstracts of the remaining 1577 articles were reviewed and classified. The specific procedures and classifications are summarized in Fig. 1. The remaining articles underwent full-text review, and basic characteristics were extracted based on the PICO principle. After excluding some studies, data extraction continued to assess eligibility for analysis, resulting in the inclusion of 16 studies. The study characteristics are summarized in Appendix 2.

Characteristics of the included studies

We included a total of 1232 patients from 16 studies, with an average age of 56.2 years and roughly balanced sex ratios. Demographic and clinical information potentially influencing the outcomes of these studies, such as sex, age, basic characteristics of the population, postoperative rehabilitation programs, and preparation of injectable products, were all fully extracted (Appendix 3) to determine their potential impact (Appendix 4). The functional score network formed by the 16 studies [37–52] is illustrated in Fig. 2A, while the pain score network formed by 9 studies [37, 39, 42–44, 46–48, 52] is shown in Fig. 2B.

Network meta-analysis

In the functional score network, arthroscopic rotator cuff repair ranked as the highest intervention (Appendix 6.1) and was significantly superior to arthroscopic rotator cuff repair and autologous microfragmented lipoaspirate tissue (MD, 9.76; 95% CI, 19.47– 0.05). Only one randomized control trial contributed to this comparison, and there were no significant differences observed among the other comparisons. The network exhibited significant heterogeneity and inconsistency (Appendix 5.1), primarily stemming from within-designs heterogeneity. Isolated long head of the biceps tendon tenotomy was less effective than physiotherapy, and neither combined with rotator cuff repair nor combined with subacromial decompression and rotator cuff repair showed improvement; the same applied to tenodesis surgery. Platelet-rich plasma did not aid with rotator cuff repair or combined subacromial decompression and rotator cuff repair (Appendix 6.1.1).

In the pain score network consisting of 9 studies, physiotherapy served as the best intervention, as observed in the control group (Appendix 6.2), and was significantly superior to arthroscopic rotator cuff repair and subacromial decompression and platelet-rich plasma (MD, 2.5; 95% CI, 4.48–0.52). Arthroscopic rotator cuff repair and subacromial decompression were significantly superior to arthroscopic rotator cuff repair and subacromial decompression and platelet-rich plasma (MD, 1.80; 95% CI, 3.39–0.21). There were no significant differences observed among the comparisons of other interventions. The network exhibited significant heterogeneity and inconsistency primarily originating from

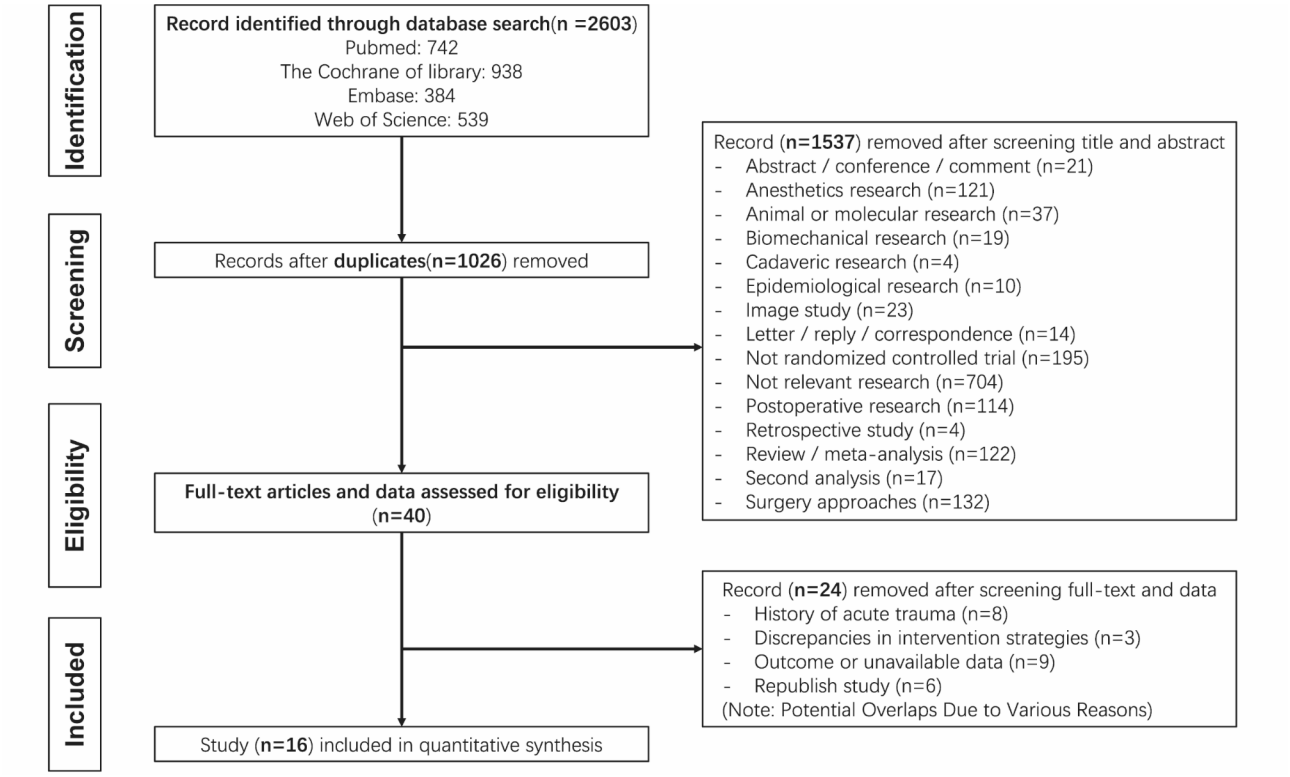

Fig. 1 Summary of studies identification and selection flow diagram

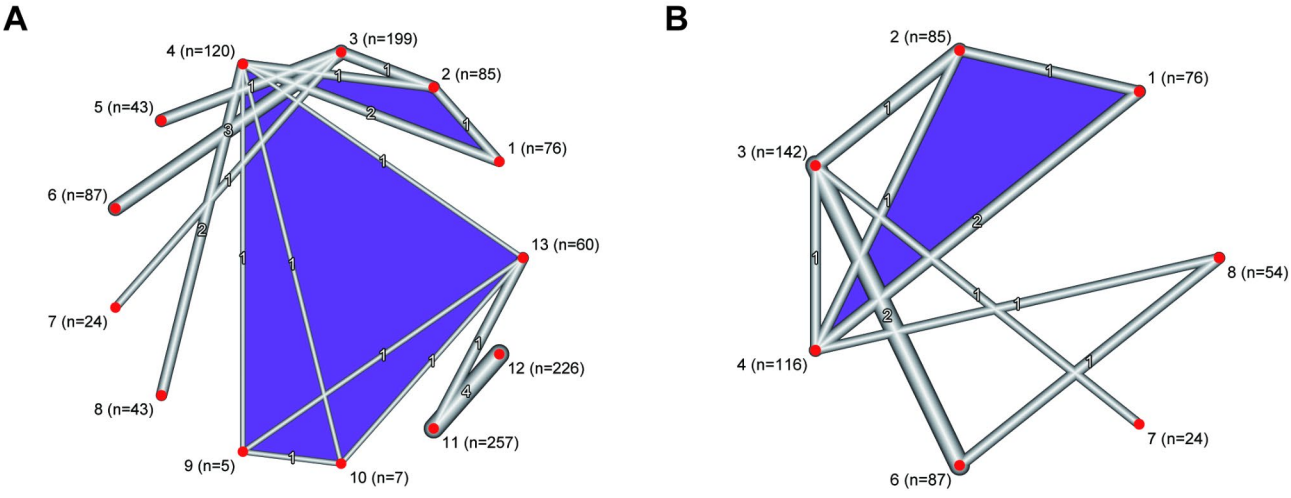

Fig. 2 Structure of network formed by interventions (A) Network with functional scores as outcome measures; (B) Network with pain scores as outcome measures. (1) Physiotherapy; (2) Subacromial decompression; (3) Arthroscopic rotator cuff repair; (4) Arthroscopic rotator cuff repair and subacromial decompression; (5) Arthroscopic rotator cuff repair and platelet-rich fibrin (matrix); (6) Arthroscopic rotator cuff repair and platelet-rich plasma; (7) Arthroscopic rotator cuff repair and autologous microfragmented lipoaspirate tissue; (8) Arthroscopic rotator cuff repair and subacromial decompression and platelet-rich plasma; (9) Long head of biceps (LHB) tenotomy; (10) Subacromial decompression and LHB Tenotomy; 11. Arthroscopic rotator cuff repair and LHBT Tenotomy; 12. Arthroscopic rotator cuff repair and LHBT Tenodesis; 13. Arthroscopic rotator cuff repair and subacromial decompression and LHBT Tenotomy

between-designs inconsistency (Appendix 5.2). The effectiveness of subacromial decompression combined with rotator cuff repair was superior to the standalone procedure. The combination surgical treatment of platelet-rich plasma and autologous microfragmented lipoaspirate tissue showed no improvement (Appendix 6.2.1).

Additional analysis

All details of the exploratory analysis of the transitivity assumption are summarized in Appendix 5.1 and Appendix 5.2. Apart from some outliers, the transitivity assumption was generally satisfied. Absence of heterogeneity and robustness of results were maintained even after excluding potential sources, such as the study by Carli et al. [53], as confirmed by the sensitivity analysis (Appendix 6.3). Furthermore, the corrected funnel plot, supported by Egger's test (not significant, $p=0.402$), suggested the absence of small-study effects and publication bias. Similarly, excluding the study by Randelli et al. [54] regarding platelet-rich plasma in the pain score network yielded stable results. However, the corrected funnel plot in Appendix 6.2.2 and Egger's test suggested potential superior interventions. The methodological quality was evaluated for all included trials. In both networks, some studies (5/16 in the functional score network and 4/9 in the pain score network) had a high risk of bias due to imperfect blinding, including two studies that compared surgical and physiotherapy interventions without blinding. Additionally, some studies (5/16 in the functional score network and 2/9 in the pain score network) did not report methodological quality, while the remaining studies (6/16 in the functional score network and 3/9 in the pain score network) had complete methodological quality.

Discussion

Principal findings

This NMA, based on 16 studies, compared the effects of various arthroscopic procedures with physiotherapy on functional improvement and pain relief in degenerative rotator cuff disease. The results indicated that physiotherapy is indeed a clinically effective treatment with pain relief comparable to that of surgical intervention, and shoulder repair is necessary for functional improvement, while other procedures or intra-articular injection therapies are not helpful.

Comparisons with previous studies

To date, studies comparing various arthroscopic combined procedures have been extremely limited. A recent study integrated an of arthroscopic rotator cuff repair techniques with intra-articular injection therapy [55]. However, in that study, the interventions included overlooked the concurrent arthroscopic procedures, affecting the accuracy of results, while also neglecting the complex intra-articular pathologies of chronic rotator cuff disease [56]. There are also studies that solely analyze the effectiveness of rotator cuff repair for degenerative rotator cuff injuries [57], but they too overlook the complex intra-articular pathologies of chronic rotator cuff disease. We adopted strict criteria for the inclusion and exclusion of patients with chronic rotator cuff disease to clarify the degenerative process, excluding only a small subset of patients with trauma history that could affect symptoms. Assuming patients have varying degrees of degeneration such as inflammation, wear, and osteophyte formation in the subacromial bursa, long head of the biceps tendon [58], and subacromial surface in addition to the rotator cuff injury requiring repair, different combined procedures can be considered for these different pathological changes [59]. Conducting NMAs on such complex cases involving multiple pathologies and combined treatment modalities synthesizes the most comprehensive evidence from randomized controlled trials, enabling a more robust and precise identification of the optimal treatment choice among various treatment options for patients [60].

Limitations

Firstly, we were unable to fully explore the reasons for heterogeneity due to the large number of covariates and limited number of studies with available data. Secondly, most studies lacked complete follow-up records, resulting in a wide range of follow-up durations ranging from 1 to 120 months, which blurred the accuracy of analysis and introduced too many potential variables [61]. Moreover, some studies had missing allocation concealment and blinding, and since the most commonly used outcome measure, the Constant score, inherently includes subjective results [62], this compromised the objectivity of the study conclusions to some extent. Thirdly, half of the studies involved arthroscopic procedures beyond clinical trial reporting, with varying standards (Appendix 3) [63]. Although the minority maintaining a certain proportion did not affect the outcome analysis, it indirectly confirms the unpredictability of lesions in chronic rotator cuff disease, often requiring intraoperative exploration to determine the specific procedure, which aligns with the original intent of this study. Despite this, indirect evidence is consistent with existing direct evidence, and the detected inconsistency or heterogeneity does not affect the conclusions; thus, the current study appears reliable.

Clinical and research implications

The body of evidence that reflects varying surgical indications and treatment protocols still suggests that rotator cuff repair is the best option among arthroscopic surgeries. However, prudence is advised when considering additional combined surgical procedures. Simultaneous

biological treatments, such as platelet-rich plasma in conjunction with rotator cuff repair, have not significantly improved the inflammatory degenerative environment [64]. Nevertheless, this finding contradicts the conclusions in some studies [65]. We found that many of the sources that combined direct evidence in the data extraction process did not standardize several key factors, such as pathological changes and surgical indications, the wide range of follow-up durations, platelet-rich plasma preparation methods [66], or rehabilitation protocols [21]. These variables are likely to have nonnegligible effects in some cases. Additionally, to include as many studies as possible and provide indirect evidence for a broader population, we had to include physiotherapy as a control group. All of these factors warrant further exploration. Recent studies have introduced diagnostic arthroscopy as an ideal intervention for future research, as it allows for precise intra-articular diagnoses and a more detailed classification of lesions while providing a valid control group [67, 68]. Furthermore, the limited available evidence stems not only from the design of clinical research protocols [69] but also from the multifaceted interactions within the shoulder joint [5]. For example, both the anterior impingement caused by the long head of the biceps tendon [70–72] and the inflammatory mediators in subacromial bursitis contribute to the progression of acromioclavicular joint disease [73]. Additionally, patient characteristics such as obesity [74] and other metabolic syndrome-related conditions (e.g., diabetes, hypertension, and hyperlipidemia) serve as risk factors by affecting the supraspinatus artery and promoting the release of proinflammatory factors, which leads to oxidative stress and tendon pathology [58]. An elucidation of these various mechanisms would reveal the complexity of rotator cuff disease and provide insights into its features [5].

Conclusion

The systematic review and NMA conducted in this study revealed that arthroscopic rotator cuff repair provides the greatest improvement in overall shoulder joint function, supported by substantial direct evidence. For pain relief, if surgery is necessary, concurrent subacromial decompression should be considered; however, physiotherapy remains the preferred option. Further evidence is needed to yield more conclusive results.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13018-024-05129-5.

Supplementary Material 1

Acknowledgements
We extend our gratitude to Dr. Wen-Zhe Gao and Dr. Jun-Ru Wu for providing additional statistical analysis methods.

Author contributions
F.Z.N. provided the search strategy and conducted literature screening in collaboration with H.H. L.H. and W.S. extracted and transformed the data for analysis. The inclusion of studies and review of data were determined through discussions led by S.M.R. and Z.L.Z.F., followed by statistical analysis.

Funding
Changsha City Natural Science Foundation, kq2202434.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 28 July 2024 / Accepted: 28 September 2024
Published online: 14 October 2024

References

1. Parot-Schinkel E, Descatha A, Ha C, Petit A, Leclerc A, Roquelaure Y. Prevalence of multisite musculoskeletal symptoms: a French cross-sectional working population-based study. BMC Musculoskelet Disord. 2012;13:122.
2. Lucas J, van Doorn P, Hegedus E, Lewis J, van der Windt D. A systematic review of the global prevalence and incidence of shoulder pain. BMC Musculoskelet Disord. 2022;23(1):1073.
3. Monrad N, Ganestam A, Kallemose T, Barfod KW. Alarming increase in the registration of degenerative rotator cuff-related lesions a nationwide epidemiological study investigating 244,519 patients. Knee Surg Sports Traumatol Arthrosc. 2018;26(1):188–94.
4. Warren RF. Lesions of the long head of the biceps tendon. Instr Course Lect. 1985;34:204–9.
5. Bedi A, Bishop J, Keener J, Lansdown DA, Levy O, MacDonald P, Maffulli N, Oh JH, Sabesan VJ, Sanchez-Sotelo J et al. Rotator cuff tears. Nat Rev Dis Primers, 10(1):8.
6. Harwood MI, Smith CT. Superior labrum, anterior-posterior lesions and biceps injuries: diagnostic and treatment considerations. Prim Care. 2004;31(4):831–55.
7. Neer n CS. Impingement lesions. Clin Orthop Relat Res 1983(183):70–7.
8. Chen CH, Hsu KY, Chen WJ, Shih CH. Incidence and severity of biceps long head tendon lesion in patients with complete rotator cuff tears. J Trauma. 2005;58(6):1189–93.
9. Voloshin I, Gelinas J, Maloney MD, O'Keefe RJ, Bigliani LU, Blaine TA. Proinflammatory cytokines and metalloproteases are expressed in the subacromial bursa in patients with rotator cuff disease. Arthroscopy. 2005;21(9):1076. e1071-1076 e1079.
10. Keener JD, Patterson BM, Orvets N, Chamberlain AM. Degenerative rotator cuff tears: Refining Surgical indications based o n natural History Data. J Am Acad Orthop Surg, 27(5):156–65.
11. Jo YH, Lee KH, Kim SJ, Kim J, Lee BG. National trends in surgery for Rotator Cuff Disease in Korea. J Korean Med Sci. 2017;32(2):357–64.
12. van Wijnen AJ, Abdel MP: Toward a Genetic Crystal Ball for Patients with Rotator Cuff Disease: Commentary on an article by Elizabeth L., Yanik SM et al. Ide ntification of a Novel Genetic Marker for Risk of Degenerative Rotator Cuff Disease Surgery in the UK Biobank. *J Bone Joint Surg Am*, 103(14):e55.
13. Maffulli N, Nilsson Helander K, Migliorini F. Tendon appearance at imaging may be altered, but it may not indicate p athology. Knee Surg Sports Traumatol Arthrosc, 31(5):1625–8.
14. Osti L, Del Buono A, Maffulli N. Rotator cuff repair: imaging success and clinical results may not corr espond. Orthopedics, 37(1):17–8.
15. Groarke P, Jagernauth S, Peters SE, Manzanero S, O'Connell P, Cowderoy G, Gilpin D, Hope B, Marchant D, Cutbush K, et al. Correlation of magnetic

resonance and arthroscopy in the diagnosis of shoulder injury. ANZ J Surg. 2021;91(10):2145–52.
16. Diercks R, Bron C, Dorrestijn O, Meskers C, Naber R, de Ruiter T, Willems J, Winters J, van der Woude HJ. Dutch Orthopaedic A: Guideline for diagnosis and treatment of subacromial pain syndrome: a multidisciplinary review by the Dutch Orthopaedic Association. Acta Orthop. 2014;85(3):314–22.
17. TV K, NB J, CM P, RV TAL, L JPS, CL K, PO V. Subacromial decompression surgery for rotator cuff disease. Cochrane Database Syst Rev. 2019;1(1):CD005619.
18. Page MJ, Moher D, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE et al. PRISMA 2020 explanation and elaboration: updated guidance and exemplar s for reporting systematic reviews. BMJ, 372:n160.
19. Ardern CL, Büttner F, Andrade R, Weir A, Ashe MC, Holden S, Impellizzeri FM, Delahunt E, Dijkstra HP, Mathieson S et al. Implementing the 27 PRISMA 2020 Statement items for systematic reviews in the sport and exercise medicine, musculoskeletal rehabilitation an d sports science fields: the PERSiST (implementing Prisma in Exercise, Rehabilitation, Sport medicine and SporTs science) guidance. Br J Sports Med, 56(4):175–95.
20. Cumpston M, Li T, Page MJ, Chandler J, Welch VA, Higgins JP, Thomas J. Updated guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for Systematic Reviews of Interventions. Cochrane Database Syst Rev, 10(10):ED000142.
21. Paolucci T, Agostini F, Conti M, Cazzolla S, Mussomeli E, Santilli G, Poso F, Bernetti A, Paoloni M, Mangone M. Comparison of early versus traditional Rehabilitation Protocol after R otator Cuff Repair: an umbrella-review. J Clin Med, 12(21):6743.
22. Rücker G, Petropoulou M, Schwarzer G. Network meta-analysis of multicomponent interventions. Biom J, 62(3):808–21.
23. Hoaglin DC. Misunderstandings about Q and 'Cochran's Q test' in meta-analysis. Stat Med, 35(4):485–95.
24. Effect Sizes Based on Means. In: Introduction to Meta-Analysis. edn. 2009: 21–32.
25. Schwarzer G, Chemaitelly H, Abu-Raddad LJ, Rücker G. Seriously misleading results using inverse of Freeman-Tukey double arc sine transformation in meta-analysis of single proportions. Res Synth Methods, 10(3):476–83.
26. Higgins JPT, Thompson SG. Quantifying heterogeneity in a meta-analysis. Stat Med, 21(11):1539–58.
27. Jackson D, White IR, Riley RD. A matrix-based method of moments for fitting the multivariate random e ffects model for meta-analysis and meta-regression. Biom J, 55(2):231–45.
28. Nunes A, Trappenberg T, Alda M. The definition and measurement of heterogeneity. Translational Psychiatry. 2020;10(1):299.
29. Higgins JPT, Jackson D, Barrett JK, Lu G, Ades AE, White IR. Consistency and inconsistency in network meta-analysis: concepts and m odels for multi-arm studies. Res Synth Methods, 3(2):98–110.
30. Yu-Kang T. Node-splitting generalized Linear mixed models for evaluation of Incon sistency in Network Meta-Analysis. Value Health, 19(8):957–63.
31. Mbuagbaw L, Rochwerg B, Jaeschke R, Heels-Andsell D, Alhazzani W, Thabane L, Guyatt GH. Approaches to interpreting and choosing the best treatments in network meta-analyses. Syst Rev, 6(1):79.
32. Rücker G, Schwarzer G. Ranking treatments in frequentist network meta-analysis works without resampling methods. BMC Med Res Methodol, 15:58.
33. Efthimiou O, Debray TPA, van Valkenhoef G, Trelle S, Panayidou K, Moons KGM, Reitsma JB, Shang A, Salanti G. GetReal methods Review G: GetReal in network meta-analysis: a review of the methodology. Res Synth Methods, 7(3):236–63.
34. Dias S, Sutton AJ, Ades AE, Welton NJ. Evidence synthesis for decision making 2: a generalized linear modelin g framework for pairwise and network meta-analysis of randomized contr olled trials. Med Decis Mak, 33(5):607–17.
35. Salanti G, Del Giovane C, Chaimani A, Caldwell DM, Higgins JPT. Evaluating the quality of evidence from a network meta-analysis. PLoS ONE, 9(7):e99682.
36. Thombs BD, Arthurs E, El-Baalbaki G, Meijer A, Ziegelstein RC, Steele RJ. Risk of bias from inclusion of patients who already have diagnosis of or are undergoing treatment for depression in diagnostic accuracy stud ies of screening tools for depression: systematic review. BMJ, 343:d4825.
37. Ahmet Nadir Aydemir SE, Levent Berkem. Oğuz Şükrü Poyanlı, İrfan Esenkaya, Hüsnü Kaya Akan: results of biceps Tenotomy in the treatment of shoulder impingement and rotator cuff tears. Med J Bakırköy. 2015;11:74–81.
38. Castricini R, Longo UG, De Benedetto M, Panfoli N, Pirani P, Zini R, Maffulli N, Denaro V. Platelet-rich plasma augmentation for arthroscopic rotator cuff repair: a randomized controlled trial. Am J Sports Med. 2011;39(2):258–65.
39. D'Ambrosi R, Palumbo F, Paronzini A, Ragone V, Facchini RM. Platelet-rich plasma supplementation in arthroscopic repair of full-thickness rotator cuff tears: a randomized clinical trial. Musculoskelet Surg. 2016;100(Suppl 1):25–32.
40. De Carli A, Vadalà A, Zanzotto E, Zampar G, Vetrano M, Iorio R, Ferretti A. Reparable rotator cuff tears with concomitant long-head biceps lesions: tenotomy or tenotomy/tenodesis? Knee Surg Sports Traumatol Arthrosc. 2012;20(12):2553–8.
41. Jacquot A, Dezaly C, Goetzmann T, Roche O, Sirveaux F, Molé D. Is rotator cuff repair appropriate in patients older than 60 years of age? Prospective, randomised trial in 103 patients with a mean four-year follow-up. Orthop Traumatol Surg Res. 2014;100(6 Suppl):S333–338.
42. Jo CH, Shin JS, Shin WH, Lee SY, Yoon KS, Shin S. Platelet-rich plasma for arthroscopic repair of medium to large rotator cuff tears: a randomized controlled trial. Am J Sports Med. 2015;43(9):2102–10.
43. Kukkonen J, Ryösä A, Joukainen A, Lehtinen J, Kauko T, Mattila K, Äärimaa V. Operative versus conservative treatment of small, nontraumatic supraspinatus tears in patients older than 55 years: over 5-year follow-up of a randomized controlled trial. J Shoulder Elb Surg. 2021;30(11):2455–64.
44. Lambers Heerspink FO, van Raay JJ, Koorevaar RC, van Eerden PJ, Westerbeek RE, van 't Riet E, van den Akker-Scheek I, Diercks RL. Comparing surgical repair with conservative treatment for degenerative rotator cuff tears: a randomized controlled trial. J Shoulder Elb Surg. 2015;24(8):1274–81.
45. Lee HJ, Jeong JY, Kim CK, Kim YS. Surgical treatment of lesions of the long head of the biceps brachii tendon with rotator cuff tear: a prospective randomized clinical trial comparing the clinical results of tenotomy and tenodesis. J Shoulder Elb Surg. 2016;25(7):1107–14.
46. Malavolta EA, Gracitelli MEC, Assunção JH, Ferreira Neto AA, Bordalo-Rodrigues M, de Camargo OP. Clinical and structural evaluations of Rotator Cuff Repair with and without added platelet-rich plasma at 5-Year Follow-up: a prospective Randomized Study. Am J Sports Med. 2018;46(13):3134–41.
47. Randelli PS, Cucchi D, Fossati C, Boerci L, Nocerino E, Ambrogi F, Menon A. Arthroscopic rotator Cuff Repair Augmentation with Autologous Microfragmented Lipoaspirate tissue is safe and effectively improves short-term clinical and functional results: a prospective Randomized Controlled Trial with 24-Month follow-up. Am J Sports Med. 2022;50(5):1344–57.
48. Randelli PS, Stoppani CA, Santarsiero G, Nocerino E, Menon A. Platelet-Rich plasma in arthroscopic rotator cuff repair: clinical and radiological results of a prospective Randomized Controlled Trial Study at 10-Year Follow-Up. Arthroscopy. 2022;38(1):51–61.
49. van Deurzen DFP, Auw Yang KG, Onstenk R, Raven EEJ, van den Borne MPJ, Hoelen MA, Wessel RN, Willigenburg NW, Klaassen AD, van den Bekerom MPJ. Long head of biceps Tenotomy is not inferior to Suprapectoral Tenodesis in Arthroscopic repair of nontraumatic rotator cuff tears: a Multicenter, non-inferiority, Randomized, Controlled Clinical Trial. Arthroscopy. 2021;37(6):1767–e17761761.
50. Wang T, Ren Z, Zhang Y, Zhao X, Liu X, Yu T, Zhang Y. Comparison of arthroscopic debridement and repair in the treatment of Ellman Grade II Bursal-side partial-thickness rotator cuff tears: a prospective Randomized Controlled Trial. Orthop Surg. 2021;13(7):2070–80.
51. Zhang Q, Zhou J, Ge H, Cheng B. Tenotomy or tenodesis for long head biceps lesions in shoulders with reparable rotator cuff tears: a prospective randomised trial. Knee Surg Sports Traumatol Arthrosc. 2015;23(2):464–9.
52. Zhang Z, Wang Y, Sun J. The effect of platelet-rich plasma on arthroscopic double-row rotator cuff repair: a clinical study with 12-month follow-up. Acta Orthop Traumatol Turc. 2016;50(2):191–7.
53. De Carli A, Vadalà A, Zanzotto E, Zampar G, Vetrano M, Iorio R, Ferretti A. Reparable rotator cuff tears with concomitant long-head biceps lesions: tenotomy or tenotomy/tenodesis? Knee Surg Sports Traumatol Arthrosc, 20(12):2553–8.
54. Randelli PS, Stoppani CA, Santarsiero G, Nocerino E, Menon A. Platelet-Rich plasma in arthroscopic rotator cuff repair: clinical and radiological results of a prospective Randomized Controlled Trial Stu Dy at 10-Year Follow-Up. Arthroscopy, 38(1):51–61.
55. You T, Wu S, Ou X, Liu Y, Wang X. A network meta-analysis of arthroscopic rotator cuff repair. BMC Surg, 23(1):201.
56. Hebert-Davies J, Teefey SA, Steger-May K, Chamberlain AM, Middleton W, Robinson K, Yamaguchi K, Keener JD. Progression of fatty muscle degeneration in Atraumatic Rotator Cuff Te ars. J Bone Joint Surg Am, 99(10):832–9.
57. Jain NB, Ayers GD, Koudelková H, Archer KR, Dickinson R, Richardson B, Derryberry M, Kuhn JE, Group ARCT. Operative vs nonoperative treatment for atraumatic rotator cuff tears: a Trial Protocol for the arthroscopic rotator cuff pragmatic randomiz ed clinical trial. JAMA Netw Open, 2(8):e199050.

58. Giri A, O'Hanlon D, Jain NB. Risk factors for rotator cuff disease: a systematic review and meta-an alysis of diabetes, hypertension, and hyperlipidemia. Ann Phys Rehabil Med, 66(1):101631.
59. Zadro JR, O'Keeffe M, Ferreira GE, Haas R, Harris IA, Buchbinder R, Maher CG. Diagnostic Labels for Rotator Cuff Disease Can Increase People's Perce ived Need for Shoulder Surgery: An Online Randomized Controlled Trial. J Orthop Sports Phys Ther, 51(8):401–11.
60. Shim S, Yoon B-H, Shin I-S, Bae J-M. Network meta-analysis: application and practice using Stata. Epidemiol Health, 39:e2017047.
61. Donegan S, Dias S, Tudur-Smith C, Marinho V, Welton NJ. Graphs of study contributions and covariate distributions for network meta-regression. Res Synth Methods, 9(2):243–60.
62. Ziegler P, Kühle L, Stöckle U, Wintermeyer E, Stollhof LE, Ihle C, Bahrs C. Evaluation of the constant score: which is the method to assess the ob jective strength? BMC Musculoskelet Disord, 20(1):403.
63. Mokkink LB, Terwee CB, Patrick DL, Alonso J, Stratford PW, Knol DL, Bouter LM, de Vet HCW. The COSMIN checklist for assessing the methodological quality of studi es on measurement properties of health status measurement instruments: an international Delphi study. Qual Life Res, 19(4):539–49.
64. Lähdeoja T, Karjalainen T, Jokihaara J, Salamh P, Kavaja L, Agarwal A, Winters M, Buchbinder R, Guyatt G, Vandvik PO et al. Subacromial decompression surgery for adults with shoulder pain: a sys tematic review with meta-analysis. Br J Sports Med, 54(11):665–73.
65. Lu J, Li H, Zhang Z, Xu R, Wang J, Jin H. Platelet-rich plasma in the pathologic processes of tendinopathy: a re view of basic science studies. Front Bioeng Biotechnol, 11:1187974.
66. Collins T, Alexander D, Barkatali B. Platelet-rich plasma: a narrative review. EFORT Open Rev, 6(4):225–35.
67. Beard DJ, Rees JL, Cook JA, Rombach I, Cooper C, Merritt N, Shirkey BA, Donovan JL, Gwilym S, Savulescu J et al. Arthroscopic subacromial decompression for subacromial shoulder pain (CSAW): a multicentre, pragmatic, parallel group, placebo-controlled, t hree-group, randomised surgical trial. Lancet, 391(10118):329–38.
68. Paavola M, Malmivaara A, Taimela S, Kanto K, Inkinen J, Kalske J, Sinisaari I, Savolainen V, Ranstam J, Järvinen TLN et al. Subacromial decompression versus diagnostic arthroscopy for shoulder i mpingement: randomised, placebo surgery controlled clinical trial. BMJ, 362:k2860.
69. Migliorini F, Maffulli N, Eschweiler J, Schenker H, Tingart M, Betsch M. Arthroscopic versus mini-open rotator cuff repair: a meta-analysis. Surgeon, 21(1):e1–12.
70. Witten A, Mikkelsen K, Wagenblast Mayntzhusen T, Clausen MB, Thorborg K, Hölmich P, Barfod KW. Terminology and diagnostic criteria used in studies investigating pati ents with subacromial pain syndrome from 1972 to 2019: a scoping revie w. Br J Sports Med, 57(13):864–71.
71. Veen EJD, Koorevaar CT, Verdonschot KHM, Sluijter TE, de Groot T, van der Hoeven JH, Diercks RL, Stevens M. Compensatory Movement patterns are based on abnormal activity of the B iceps Brachii and posterior deltoid muscles in patients with Symptomat Ic Rotator Cuff tears. Clin Orthop Relat Res, 479(2):378–88.
72. Diplock B, Hing W, Marks D. The long head of biceps at the shoulder: a scoping review. BMC Musculoskelet Disord, 24(1):232.
73. Mall NA, Foley E, Chalmers PN, Cole BJ, Romeo AA, Bach BR Jr. Degenerative joint disease of the acromioclavicular joint: a review. Am J Sports Med, 41(11):2684–92.
74. Giri A, Freeman TH, Kim P, Kuhn JE, Garriga GA, Khazzam M, Higgins LD, Matzkin E, Baumgarten KM, Bishop JY et al. Obesity and sex influence fatty infiltration of the rotator cuff: the Rotator Cuff outcomes Workgroup (ROW) and Multicenter Orthopaedic Outc Omes Network (MOON) cohorts. J Shoulder Elb Surg, 31(4):726–35.

Publisher's note