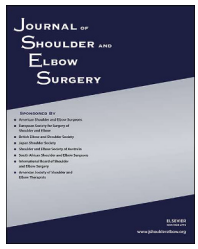
Journal of Shoulder and Elbow Surgery xxx (2026) 1–13

Available online at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/ymse



Leukocyte-poor platelet-rich plasma reduces retear risk after arthroscopic rotator cuff repair: a meta-analysis with mechanistic and economic evaluation

Quinn Dunivan, BSE[a,*], *Michael Allen, BS*[a], *Brian E. Caplan, BA*[b], *and Brian J. Cole, MD, MBA*[b]

[a]*University of Illinois College of Medicine, Chicago, IL, USA*
[b]*Rush University Medical Center, Chicago, IL, USA*

ABSTRACT

Background: Rotator cuff repair (RCR) is one of the most common orthopedic procedures, yet 20%-40% of repairs fail structurally within two years, leading to pain, functional decline, and costly revision surgery. Platelet-rich plasma (PRP) has been proposed to enhance tendon–bone healing, but prior reviews frequently pooled heterogeneous formulations as a homogeneous intervention, producing conflicting conclusions. This review aimed to clarify formulation-specific effects within the PRP literature and, where benefit is observed, examine the biological rationale and practical economic implications for surgical adoption.

Methods: A systematic review and meta-analysis were conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 guidelines. PubMed and Embase were searched through July 2025 for comparative clinical studies of intraoperative PRP augmentation during arthroscopic RCR with imaging-confirmed retear outcomes. Risk of bias was assessed using Risk of Bias 2 tool (randomized controlled trials) and Risk Of Bias In Nonrandomized Studies–I (nonrandomized studies). Random-effects models (restricted maximum likelihood; Hartung–Knapp) pooled risk ratios (RRs) for structural failure and, secondarily, mean differences in patient-reported outcome measures (PROMs). Prespecified subgroups included PRP formulation, tear size, and follow-up duration; sensitivity analyses excluded high-risk and atypical studies. Publication bias was evaluated with Egger's regression and trim-and-fill. A pragmatic U.S. payer–perspective cost-consequence model estimated revision-related economic impact using pooled absolute risk reduction, number needed to treat, amortized per-case PRP setup costs, and reported reoperation rates after RCR.

Results: Twenty-one studies (1,279 patients) were synthesized. PRP reduced retear risk with moderate heterogeneity (RR: 0.74, 95% confidence interval [CI]: 0.55-0.99; $I^2 \approx 29\%$). Across formulations, LP-PRP demonstrated the clearest reduction. Inclusion of one critically biased trial increased heterogeneity ($I^2 = 53.3\%$), whereas its exclusion yielded a precise, homogeneous estimate (RR: 0.37, 95% CI: 0.19-0.73; $I^2 = 0\%$). Benefit was most evident in medium-sized tears (RR: 0.68, 95% CI: 0.48-0.96). PROMs did not improve consistently. Publication-bias diagnostics suggested small-study effects (Egger $P = .017$); trim-and-fill ($k_0 = 8$) yielded an exploratory adjusted RR of 0.91 (95% CI: 0.69-1.19). Using an absolute risk reduction of 11.8% (number needed to treat 9) for LP-PRP, economic modeling projected substantial reductions in structural failures, with cost neutrality or net savings achievable under low-cost preparation strategies when scaled by reported revision probabilities.

*Reprint requests: Quinn Dunivan, BSE, University of Illinois College of Medicine, Chicago, IL USA.
E-mail address: qduni@uic.edu (Q. Dunivan).

https://doi.org/10.1016/j.jse.2026.02.018

Conclusion: Leukocyte-poor PRP augmentation during arthroscopic RCR is associated with reduced structural retear rates, with the most consistent benefit observed in medium-sized tears and no reliable improvement in PROMs. The economic value of LP-PRP is conditional rather than uniform and depends on revision probability and preparation cost. When applied using low-cost preparation methods, LP-PRP may achieve cost neutrality or modest savings, supporting selective adoption as a structural safeguard rather than a symptomatic modifier.

Level of evidence: Level III; Systematic Review/Meta-Analysis; Treatment Study

Keywords: Platelet-rich plasma; rotator cuff repair; tendon healing; meta-analysis; orthobiologics; health economics

Rotator cuff repair (RCR) is one of the most commonly performed orthopedic procedures, yet structural failure remains a persistent challenge. Despite technical advances, 20%-40% of repairs exhibit radiologic retears within two years, often resulting in pain, functional decline, and costly revision surgery.[1] National utilization data show that more than 300,000 RCRs are performed annually in the United States, with a rising comorbidity burden among patients.[18,47] Given these clinical and economic stakes, strategies to improve tendon–bone healing have garnered substantial interest.

Platelet-rich plasma (PRP) has emerged as a promising biologic adjunct due to its autologous nature, ease of preparation, and capacity to deliver supraphysiologic concentrations of growth factors to the repair site. However, PRP is not a single entity. Formulations differ widely in leukocyte content, fibrin structure, and processing protocols, resulting in distinct biological effects.[12,36] This variability reflects both a lack of standardized preparation methods and the absence of definitive evidence favoring one protocol over another.[5] Leukocyte-poor PRP (LP-PRP) is enriched in regenerative cytokines while minimizing proinflammatory mediators, whereas leukocyte-rich PRP (LR-PRP) contains higher leukocyte levels that may promote inflammation, fibrosis, and scar-dominated healing.[22,28,46] These distinctions may directly influence tendon–bone integration and long-term repair durability.

Prior systematic reviews and meta-analyses have generally treated PRP as a uniform intervention, leading to conflicting conclusions.[2,11] While some reported modest reductions in retear rates, others found only transient or inconsistent improvements in pain and function, leaving uncertainty around recommendations pertaining to clinical adoption. Notably, prior publications have not integrated mechanistic rationale with formulation-specific clinical outcomes or downstream economic considerations. This disconnect limits pragmatic decision-making for both surgeons and payers.

To address this gap, we conducted a systematic review and meta-analysis examining whether intraoperative PRP reduces retear risk after arthroscopic RCR when stratified by formulation. We further explored the consistency of these effects through prespecified subgroup and sensitivity analyses and estimated the potential cost implications of adoption using a conservative economic model. By integrating formulation-specific analysis with clinical outcomes and pragmatic economic considerations, this study aims to inform real-world surgical decision-making. We hypothesized that LP-PRP would be associated with lower structural retear rates after arthroscopic RCR compared with LR-PRP or no PRP.

Methods

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 guidelines.[29]

Search strategy and study selection

A systematic search of PubMed and Embase was conducted through July 2025 using combinations of terms including PRP, rotator cuff, and repair. Eligible studies were comparative clinical investigations of PRP use during arthroscopic RCR that reported imaging-confirmed retear outcomes.

Exclusion criteria were: (1) animal studies; (2) non-PRP biologics; (3) stand-alone PRP injection studies; (4) absence of a control group; (5) no imaging follow-up; and (6) incompatible retear definitions. Specifically, studies were required to define retear as Sugaya grade IV or V,[40] or an equivalent full-thickness failure. Trials that grouped Sugaya grades III-V together without stratified reporting were excluded to minimize misclassification risk.

Data extraction and risk of bias

Study characteristics, patient demographics, PRP formulation (LP, LR, platelet-rich fibrin matrix [PRFM], PRP gel, leukocyte PRF), tear size, follow-up duration, and outcomes were extracted into a standardized spreadsheet. Risk of bias was assessed using the Risk of Bias 2 tool for randomized controlled trials (RCTs) and Risk Of Bias In Nonrandomized Studies–I for nonrandomized studies.[38,39]

Outcomes

The primary outcome was radiologic retear defined as structural failure on post-operative imaging. Where Sugaya grading was reported, retear was defined as Sugaya grade IV or V. In studies reporting dichotomous outcomes, retear was defined as a full-thickness defect, consistent with criteria equivalent to Sugaya grade IV. Studies defining retear as partial-thickness failure (eg, Sugaya grade III) without reporting grade-specific event counts were excluded to maintain consistency in outcome definition. Secondary outcomes included patient-reported function (American Shoulder and Elbow Surgeons [ASES], Constant, University of California Los Angeles [UCLA]) and pain (visual analog scale [VAS]). An exploratory economic analysis estimated the cost implications of PRP adoption.

Statistical analysis

Dichotomous outcomes were summarized as risk ratios (RRs) with 95% confidence intervals (CIs) and pooled using a Mantel–Haenszel random-effects model with between-study variance (τ^2) estimated by restricted maximum likelihood. Hartung–Knapp adjustment was applied for the overall model; for small-k subgroups (eg, formulation and tear-size strata), Hartung–Knapp was not applied by design. A continuity correction of 0.5 was used only when any study arm contained zero events. In multiarm trials with a shared control (eg, Yao et al), the control group was proportionally split to avoid double-counting in subgroup analyses. Heterogeneity was assessed using τ^2, Cochran's Q, and I^2 statistics, with prediction intervals reported when available.

Prespecified subgroup analyses examined:

1. PRP formulation (LP, LR, PRFM, gel, leukocyte- and platelet-rich fibrin).
2. Tear size (medium, large, massive).
3. Follow-up duration, categorized as short term (≤6 months), midterm (>6-12 months), and long term (>12 months).

Sensitivity analyses included: (1) exclusion of high-risk-of-bias studies; (2) randomized trials only; and (3) exclusion of Auregan et al, the only study rated at critical overall risk of bias, and the three-arm Yao et al trial. Publication bias was assessed using Egger's regression and trim-and-fill methods.[13,14] Influence diagnostics included leave-one-out analyses to assess the impact of individual studies on pooled estimates. Analyses were performed in R using the meta and metafor packages.[32]

Economic analysis

A cost-consequence model was developed from a U.S. payer perspective using a perioperative, episode-of-care time horizon. The model incorporated 2 primary cost inputs: (1) the cost of revision RCR (base case: $5,101 per revision) and (2) the consumable cost of intraoperative PRP preparation (base case: $52.27 per case).

Revision costs were derived from average Medicare facility reimbursement rates across ambulatory surgery centers and hospital outpatient departments using the Centers for Medicare & Medicaid Services Physician Fee Schedule Look-Up Tool (accessed 2025).[9] Per-case PRP setup costs were derived from a published manual PRP preparation protocol.[8] All supplies required for PRP preparation (including needles, syringes, tubes, gloves, forceps, centrifuge, and laminar flow hood) were itemized and priced using contemporary U.S. vendor data (Fisher Scientific, Thomas Scientific, Amazon Medical). Capital equipment was amortized over a 5-year expected lifespan, while consumables were costed per use, yielding an average per-case preparation cost of $52.27 (range $19.93-$79.84 based on vendor pricing). This costing approach used universally available consumables and amortized equipment, allowing evaluation across both hospital and ambulatory surgery center settings.

Retear risks for LP-PRP and LR-PRP were derived from pooled meta-analytic estimates. Absolute risk reduction (ARR) and number needed to treat (NNT) were calculated, and national projections were generated by applying pooled estimates to approximately 300,000 annual RCRs in the United States.[18,47] As not all structural failures proceed to revision surgery, revision-cost avoidance estimates were conservatively scaled using a base-case revision probability of 6%, consistent with prospective series summarized in a contemporary narrative review and with large administrative cohorts reporting low rates of subsequent ipsilateral shoulder surgery after arthroscopic RCR.[16,24,27] Exploratory sensitivity analyses evaluated higher revision probabilities (up to 12%) to reflect variability across clinical settings and follow-up durations. Indirect costs, quality-adjusted life-years, and nonrevision health care utilization were excluded from the primary model to avoid introducing additional assumptions and maintain a conservative analytic framework.

Results

Study characteristics

Twenty-one studies involving 1,279 patients (660 receiving PRP, 619 control) were included, comprising 14 RCTs and 7 comparative nonrandomized studies[3,4,6,7,10,19-21,23,25,26,30,33-35,37,42,43,48-50] (Fig. 1, Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram). All trials reported imaging-confirmed retears defined as Sugaya grade IV-V or an equivalent full-thickness failure. Most studies involved medium-to-large tears repaired arthroscopically. Risk of bias was generally low to moderate among RCTs and moderate to serious among nonrandomized studies. Auregan et al (2019) was the only study rated at critical overall risk of bias.

Primary outcome—retear rate

Across all formulations, intraoperative PRP reduced structural retear risk compared with control (RR: 0.74, 95% CI: 0.55-0.99) with moderate heterogeneity ($I^2 \approx 29\%$) (Fig. 2).

When stratified by formulation, LP-PRP showed the strongest directional benefit when Auregan et al. (2019) was included (RR: 0.53, 95% CI: 0.21–1.31; $I^2 = 53.3\%$; Supplementary Fig. S1). As Auregan et al. was the only study at critical overall risk of bias, Figure 3 presents the sensitivity analysis excluding this study, which yielded a homogeneous, precise effect (RR: 0.37, 95% CI: 0.19–0.73; $I^2 = 0\%$). LR-PRP trended protective but remained nonsignificant (RR: 0.76, 95% CI: 0.52–1.12; $I^2 = 0\%$). Other constructs (eg, PRFM, gel) showed no consistent advantage (Supplementary Fig. S1).

Sensitivity analyses

Sensitivity analyses confirmed the direction and stability of the overall effect. Restricting to RCTs strengthened the signal (RR: 0.64, 95% CI: 0.42-0.97; $I^2 = 0.4\%$), while excluding high-risk-of-bias studies yielded a similar trend (RR: 0.74, 95% CI: 0.49-1.12; $I^2 = 0.4\%$). Removal of the three-arm Yao et al (2024) trial produced comparable results (RR: 0.75, 95% CI: 0.57-0.99; $I^2 = 30.7\%$).

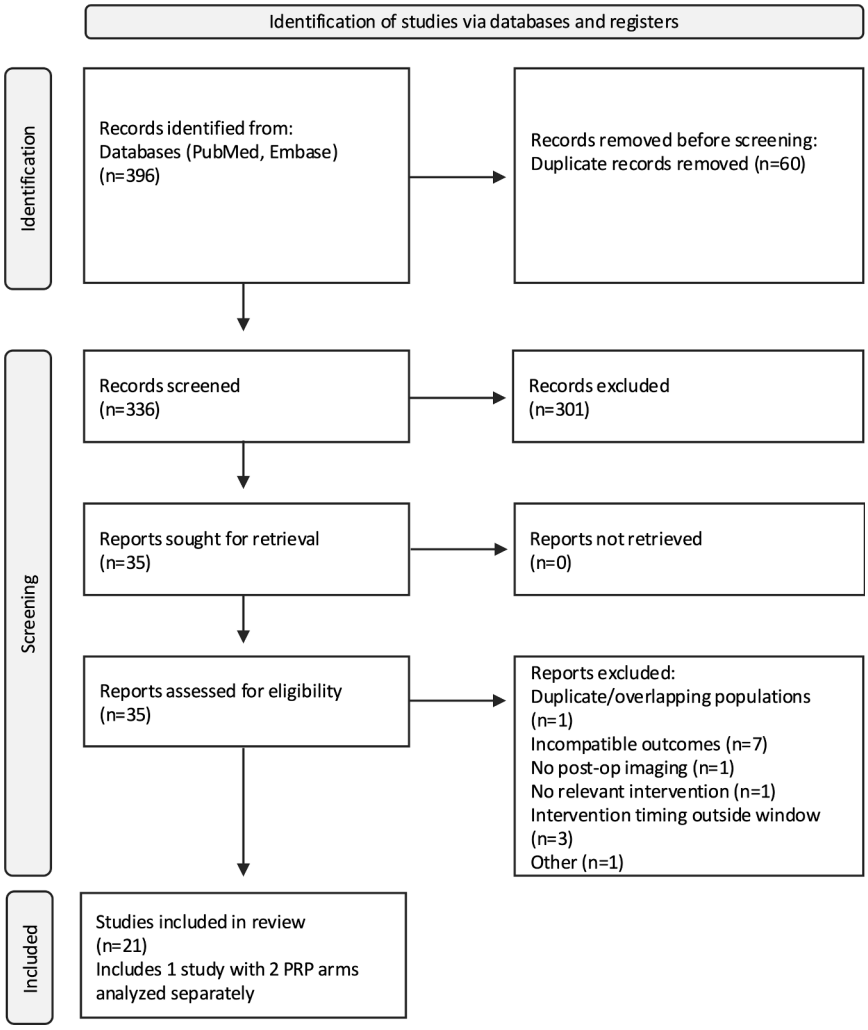


Figure 1 – PRISMA flow diagram of study selection. PRISMA 2020 diagram showing study identification, screening, eligibility, and inclusion. Of 396 records, 336 were screened after duplicates; 35 full texts were assessed, and 21 studies were included (one with 2 PRP arms analyzed separately). Reasons for exclusion at full text: overlapping population (n = 1), incompatible outcomes (n = 7), no post-operative imaging (n = 1), irrelevant intervention (n = 1), intervention timing outside the prespecified window (n = 3), and Other (n = 1). *PRP*, platelet-rich plasma; *PRISMA*, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Auregan et al (2019) was the only study at critical overall risk of bias. With Auregan included, the LP-PRP subgroup I^2 was 53.3%. Excluding Auregan reduced I^2 to 0% and narrowed the CI around a stable, stronger effect (RR: 0.37, 95% CI: 0.19-0.73). Using the observed control event rate of 18.7%, this corresponds to ARR 11.8% and NNT 9 to prevent one retear.

Tear size and follow-up duration

The clearest and most consistent benefit was observed in medium-sized tears (RR: 0.68, 95% CI: 0.48-0.96; I^2 = 12.1%; Fig. 4), which represented the largest subgroup across 16 studies (n = 895; 466 PRP, 429 control). Protective effects were also seen in large tears (RR: 0.80, 95% CI: 0.41-1.57; Fig. 4), although with wider CIs given the smaller sample size across 5 studies (n = 323; 163 PRP, 160 control). No measurable benefit was found in massive tears, which were assessed in a single study (n = 61; 31 PRP, 30 control). Benefit was observed across short-, mid-, and long-term follow-up periods, with no significant time-by-treatment interaction (Supplementary Fig. S2).

Patient-reported outcome measures

No clinically meaningful improvements were observed in patient-reported outcome measures. Pooled analyses of ASES, Constant, and UCLA scores revealed no significant between-group differences, and although VAS pain showed a statistically detectable reduction favoring PRP (mean difference = −0.1, P = .028), the magnitude was well below the

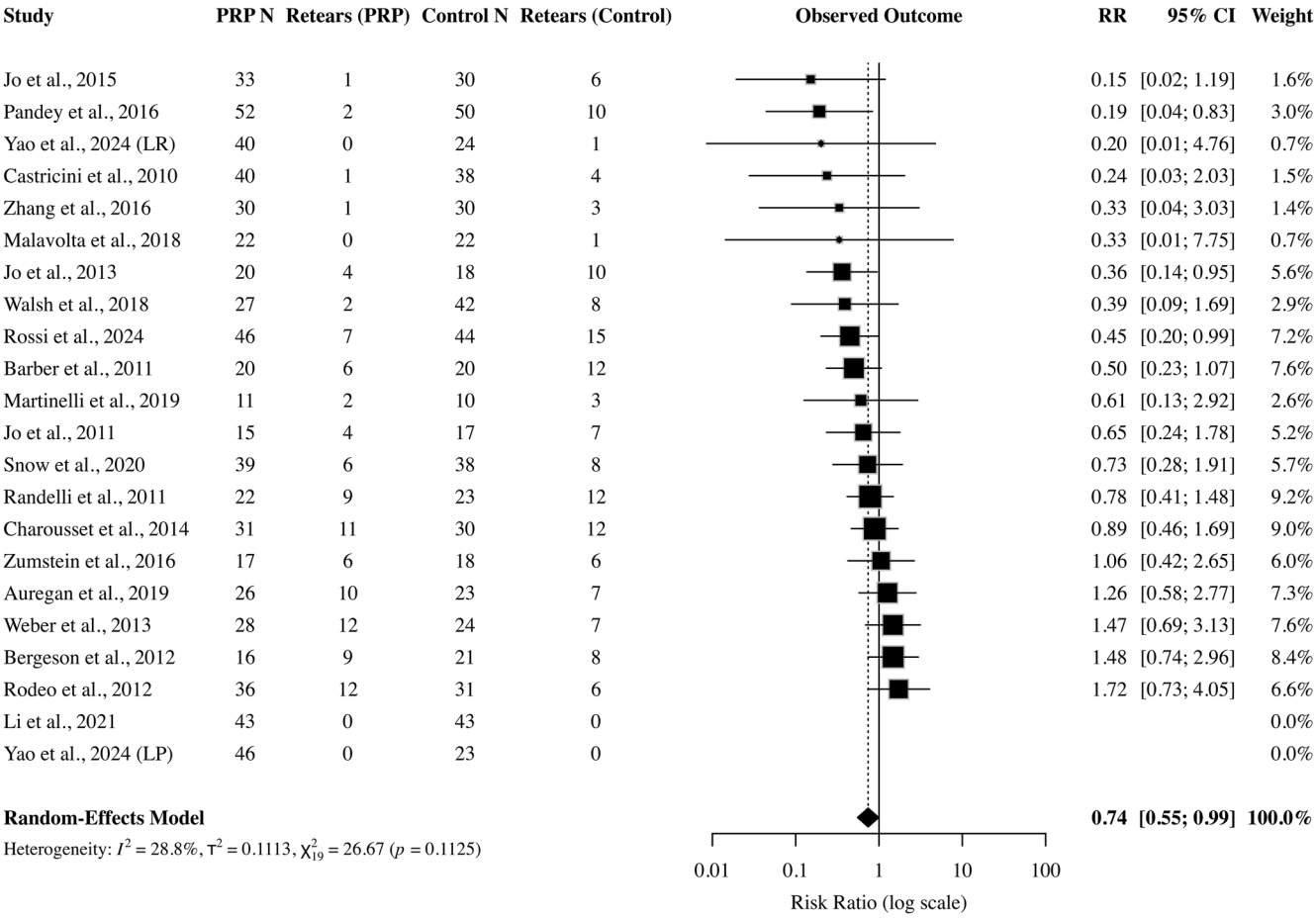


Figure 2 – Overall retear after arthroscopic rotator cuff repair: PRP vs. control. Forest plot of imaging-confirmed retears comparing PRP with control. Effects are RRs (log scale) pooled with a random-effects model (REML; Hartung–Knapp). Squares show study estimates (size ∝ weight), horizontal lines indicate 95% CIs, and the diamond is the pooled effect. PRP reduced retear risk (RR: 0.74, 95% CI: 0.55-0.99) with low–moderate heterogeneity ($I^2 = 28.8\%$). *PRP*, platelet-rich plasma; *RR*, risk ratio; *CI*, confidence interval; *REML*, restricted maximum likelihood; *L-PRF*, leukocyte- and platelet-rich fibrin.

Minimal Clinically Important Difference, indicating no true clinical benefit (Fig. 5 A–*D*).[41]

Small-study effects and publication bias

Egger's regression indicated funnel plot asymmetry ($P = .017$), consistent with small-study effects. Trim-and-fill imputed $k_0 = 8$ studies; the bias-adjusted estimate attenuated to RR: 0.91 (95% CI: 0.69-1.19), interpreted cautiously as a sensitivity analysis rather than a corrected effect size (Supplementary Figs. S3 and S4).

Economic implications

Using pooled LP-PRP estimates (Fig. 6), application across approximately 300,000 annual U.S. RCRs was projected to prevent an estimated 35,343 structural retears. When scaled using the base-case revision probability of 6%, this corresponded to approximately 2,120 avoided revision procedures annually. Under exploratory sensitivity scenarios extending revision probability to 12%, up to 4,241 avoided revisions were projected.

Under these assumptions, the modeled break-even total PRP cost per case ranged from approximately $36 at a 6% revision probability to approximately $72 under the exploratory 12% scenario. At the base-case PRP consumable cost ($52.27 per case), the implied break-even revision probability was approximately 9%. When applied nationally, the modeled net cost impact ranged from an estimated $4.9 million deficit under conservative assumptions to an estimated $6.0 million surplus under higher revision-rate scenarios. These projections reflect short-term, episode-of-care economic effects only; long-term societal costs and quality-of-life outcomes were not incorporated into the base model.

Discussion

This meta-analysis demonstrates that intraoperative PRP reduces structural failure after arthroscopic RCR, with the

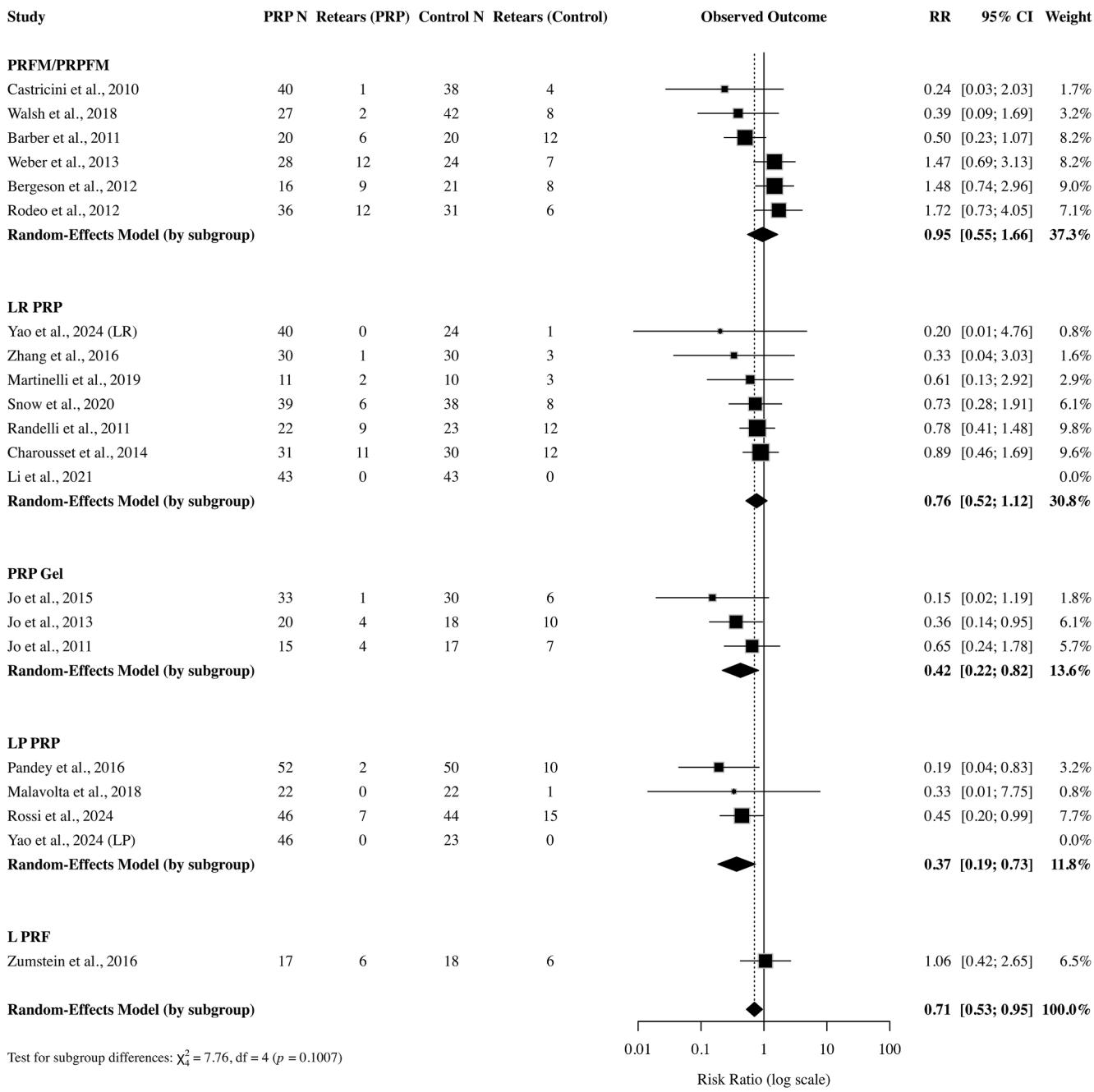


Figure 3 – Retear risk by PRP formulation. Forest plot of subgroup analyses by PRP formulation. LP-PRP showed the clearest and most precise reduction (RR: 0.37, 95% CI: 0.19-0.73); excluding the single critically biased study (*Auregan* 2019) reduced LP-PRP heterogeneity from 53.3% to 0.0%, clarifying the formulation-specific signal. LR-PRP trended protective but was not significant (RR: 0.76, 95% CI: 0.52-1.12); PRFM/PRP matrix showed no consistent advantage, while PRP gel favored PRP (RR: 0.42, 95% CI: 0.22-0.82). Diamonds indicate random-effects pooled estimates for each subgroup; the test for subgroup differences was not significant ($\chi^2 = 7.76$, df = 4, $P = .100$). *LP*, leukocyte-poor; *LR*, leukocyte-rich; *PRFM*, platelet-rich fibrin matrix; *RR*, risk ratio; *CI*, confidence interval; *PRP*, platelet-rich plasma.

most consistent and durable effect observed in LP-PRP. In contrast to prior reviews that pooled heterogeneous PRP formulations and yielded conflicting conclusions, our stratified approach shows that the clinical signal depends on formulation. Including the single study at critical overall risk of bias (Auregan et al) inflated heterogeneity in the LP-PRP subgroup ($I^2 = 53.3\%$), whereas excluding it eliminated heterogeneity ($I^2 = 0\%$) and clarified a precise effect (RR: 0.37, 95% CI: 0.19-0.73), supporting a formulation-specific effect under lower-bias conditions. LP-PRP demonstrated the most

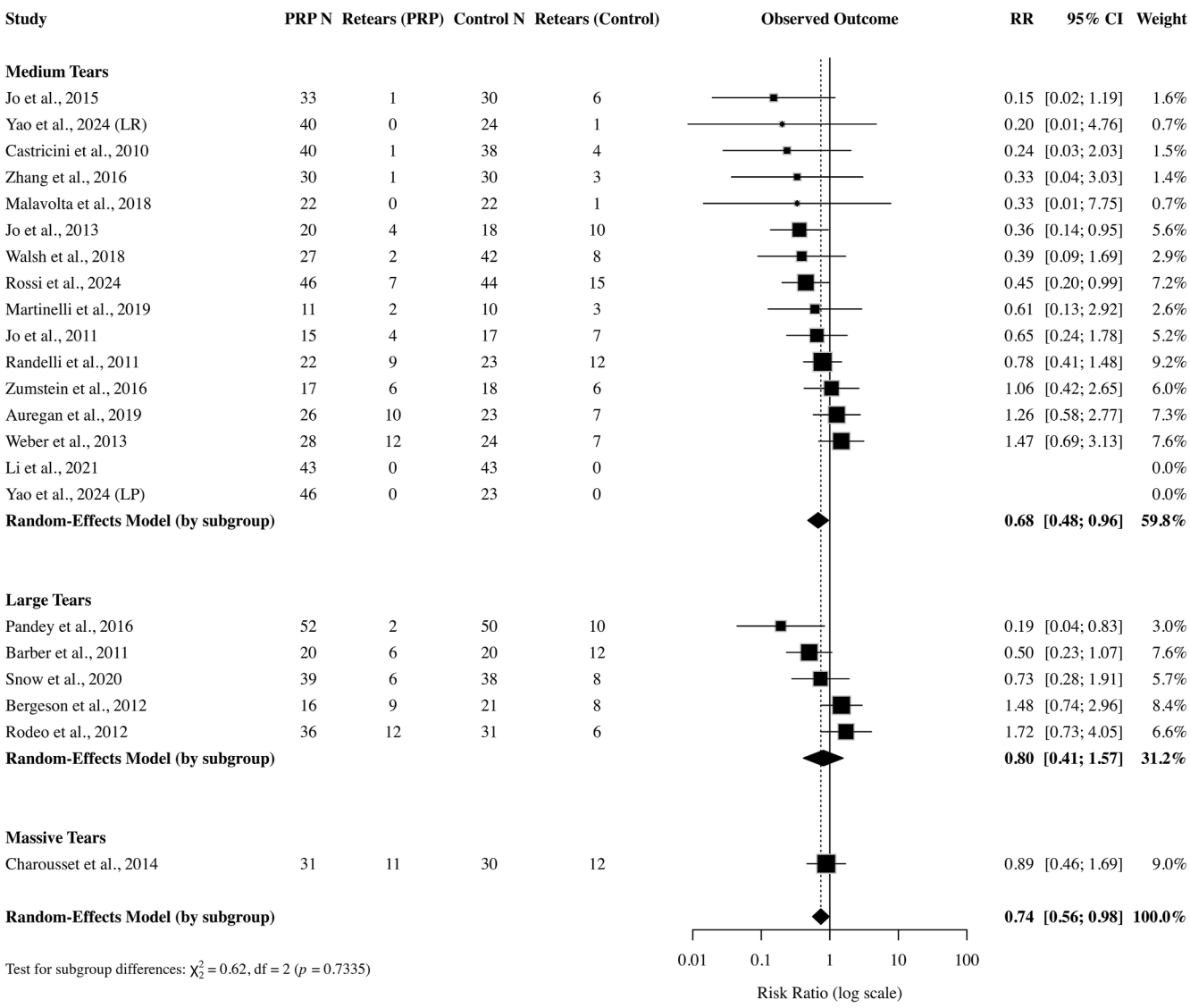


Figure 4 – Retear risk stratified by tear size. Forest plot of imaging-confirmed retears after arthroscopic rotator cuff repair grouped by baseline tear size. Medium tears showed a significant reduction with PRP (RR: 0.68, 95% CI: 0.48-0.96), whereas large (RR: 0.80, 95% CI: 0.41-1.57) and massive tears (RR: 0.89, 95% CI: 0.46-1.69) were not significant. Diamonds indicate random-effects pooled estimates within each subgroup; the test for subgroup differences was not significant ($\chi^2 = 0.62$, df = 2, $P = .730$). *PRP*, platelet-rich plasma; *RR*, risk ratio; *CI*, confidence interval.

consistent formulation-specific signal, with LR-PRP trending protective but nonsignificant; PRFM and gels showed no consistent advantage. The pattern supports LP-PRP as the leading candidate for structural protection, pending confirmation in larger, formulation-specific trials (Fig. 3). The consistent protective effect observed with LP-PRP suggests that its relevance extends beyond healing biology: preventing revision surgery not only reduces health care costs but also spares patients the pain, rehabilitation burden, and prolonged loss of quality of life associated with repeat operations. Taken together, these findings highlight LP-PRP as both a clinically and economically meaningful adjunct, whereas other formulations have not demonstrated the same level of reliability.

Biological rationale for leukocyte-rich platelet-rich plasma

The biologic plausibility of LP-PRP is well supported by preclinical evidence. Tendon-to-bone healing relies on a coordinated interplay between growth factors and immune cell phenotypes. LP-PRP delivers supraphysiologic concentrations of transforming growth factor-β, vascular endothelial growth factor, fibroblast growth factor, and platelet-derived growth factor, which promote fibroblast activity, collagen deposition, and angiogenesis.[44,45] Crucially, unlike LR formulations, LP-PRP dampens proinflammatory cytokines such as interleukin-1β, interleukin-6 and tumor necrosis factor-α, fostering a regenerative rather than inflammatory environment at the tendon–bone interface.[45,46]

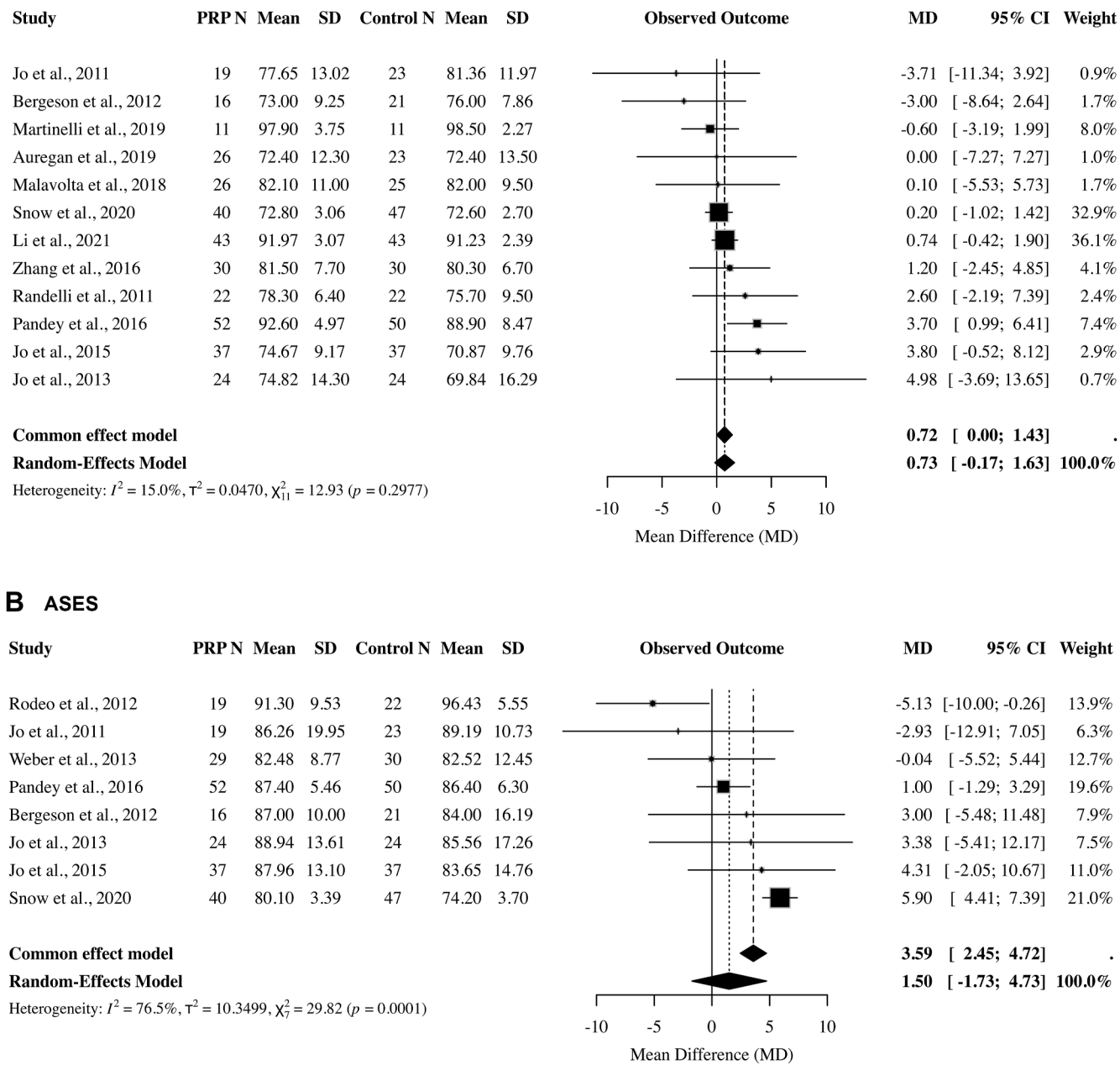


Figure 5 – Patient-reported outcome measures following PRP augmentation during rotator cuff repair. Forest plots of pooled MDs comparing PRP vs. control for (**A**) Constant–Murley score (MD: 0.7, 95% CI: −0.2 to 1.6; P = .112); (**B**) ASES score (MD: 1.5, 95% CI: −1.7 to 4.7; P = .363); (**C**) UCLA Shoulder Rating Scale (MD: 0.3, 95% CI: 0.0 to 0.6; P = .439); and (**D**) VAS for pain (MD: −0.1, 95% CI: −0.2 to −0.0; P = .028). All outcomes were pooled using random-effects models (REML; Hartung–Knapp confidence intervals). PRP augmentation did not result in clinically meaningful improvement in patient-reported outcome measures. Although VAS pain demonstrated a statistically significant difference favoring PRP, the effect size was below the established Minimal Clinically Important Difference threshold and is unlikely to be clinically meaningful. No statistically significant differences were observed for Constant-Murley, ASES, or UCLA scores. Squares represent study weights, and diamonds indicate pooled effects. *PRP*, platelet-rich plasma; *RR*, risk ratio; *CI*, confidence interval; *MD*, mean difference; *VAS*, visual analog scale; *UCLA*, University of California Los Angeles; *ASES*, American Shoulder and Elbow Surgeons; *REML*, restricted maximum likelihood; *SD*, standard deviation.

Animal models reinforce this mechanism: LP-PRP sustains M2 macrophage predominance and reduces inflammatory signaling, whereas LR-PRP increases cytokine-driven fibrosis.[28,31] Macrophage polarization studies similarly show that M1 phenotypes impede matrix regeneration, while M2 macrophages support angiogenesis and collagen alignment.[22]

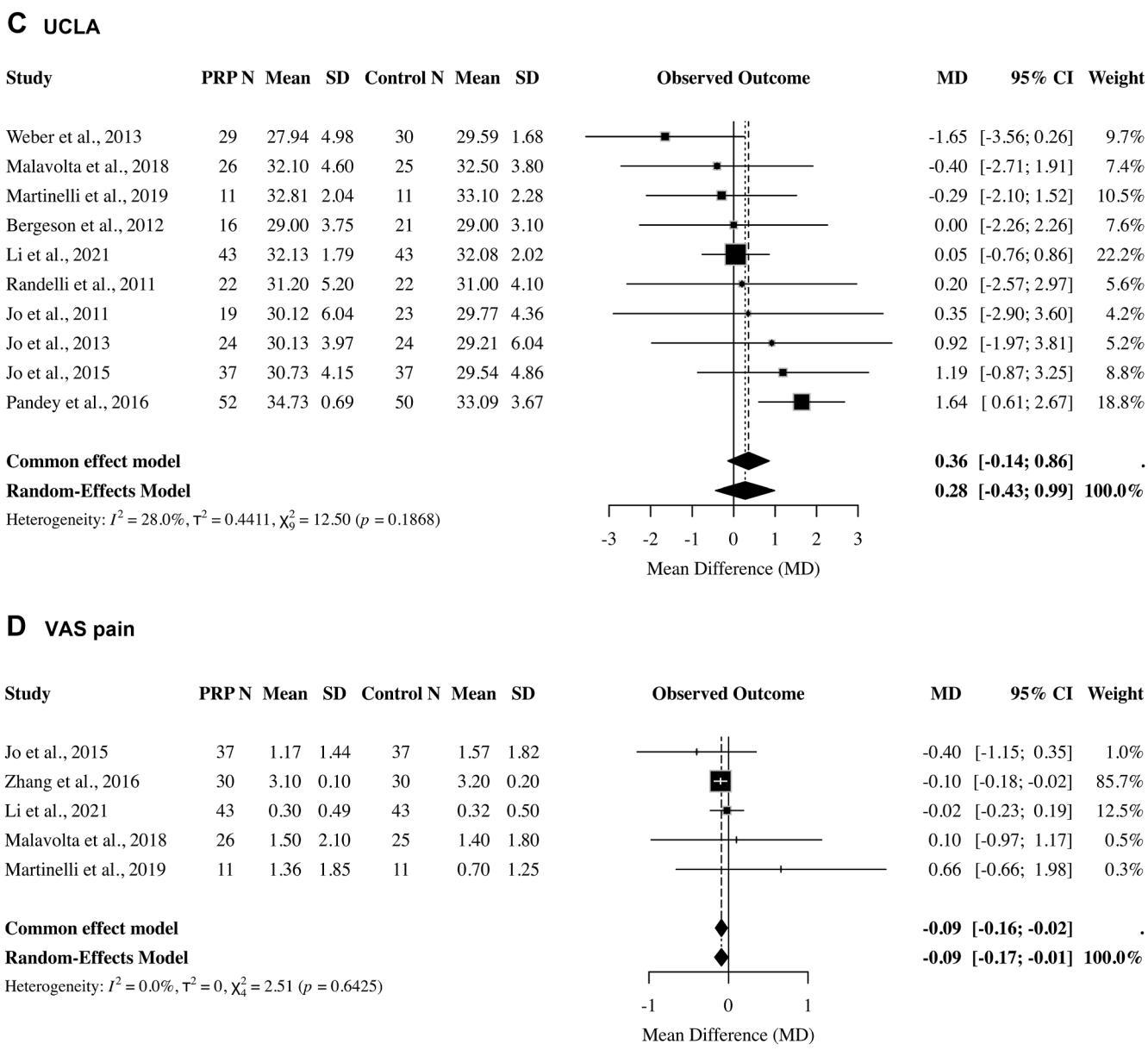


Figure 5 – *(continued)*.

Excessive transforming growth factor-β1, meanwhile, risks promoting scar-dominated healing with mechanically inferior collagen I/III ratios.[1] By shifting the immune response toward M2 predominance, LP-PRP appears to support organized tendon–bone integration rather than fibrotic scar. Collectively, these findings explain why LP-PRP, but not LR-PRP, reliably reduces structural retears: by steering healing toward organized enthesis regeneration rather than fibrotic encapsulation. (Fig. 3).

Clinical implications

Clinically, LP-PRP was associated with a meaningful reduction in retear risk, corresponding to an ARR of 11.8% and a NNT of 9 to prevent one retear based on a control event rate of 18.7%. The most pronounced effect was seen in medium-sized tears (Fig. 4), where repair durability remains a challenge. Large tears showed similar directional trends with wider CIs, and massive tears demonstrated no measurable benefit.

Although patient-reported outcome measures (ASES, Constant, UCLA, VAS) were not significantly improved (Fig. 5), this aligns with prior studies.[2,11,15,48] PROMs typically improve following any successful repair but tend to decline over time when retears occur. Prospective cohort studies confirm that structural failure predicts subsequent deterioration in pain and function scores.[17] Our findings suggest LP-PRP acts primarily as a structural safeguard, reducing failure risk without accelerating short-term symptomatic recovery. This interpretation is consistent with both the biologic mechanism and long-term clinical trajectory of retear-associated decline.

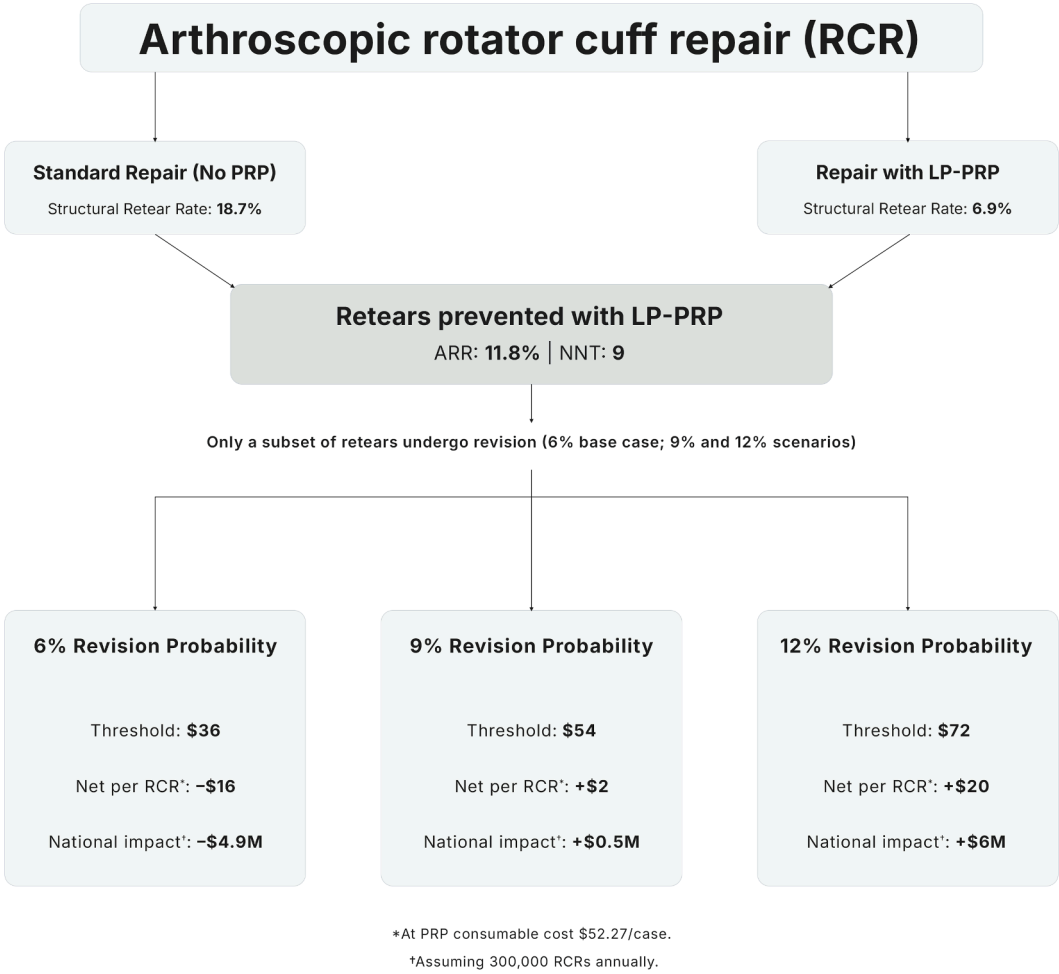


Figure 6 — Cost-consequence schematic for LP-PRP augmentation during arthroscopic rotator cuff repair. Decision-analytic flow diagram showing the modeled structural retear reduction with LP-PRP vs. standard repair and the downstream economic consequences when only a fraction of structural failures proceed to revision surgery. Using a control structural retear rate of 18.7% and an LP-PRP structural retear rate of 6.9% (ARR = 11.8%; NNT = 9), the model estimates cost-neutral (break-even) total PRP cost thresholds and net cost impact per repair and nationally under a base-case revision probability of 6% and scenario analyses at 9% and 12%. Model inputs (including revision cost, PRP preparation/consumable cost, and unit-cost assumptions) are provided in Supplementary Table S1. Net cost impact values are presented at a PRP consumable cost of $52.27 per case and assume 300,000 rotator cuff repairs performed annually in the United States. *LP-PRP*, leukocyte-poor platelet-rich plasma; *ARR*, Absolute risk reduction; *NNT*, number needed to treat.

Economic relevance

Revision RCR is resource intensive, costly, and disruptive to patient recovery, making even modest reductions in retear risk clinically and economically meaningful. Using a conservative, episode-of-care cost-consequence framework grounded in Medicare reimbursement data, the present analysis demonstrates that the economic impact of LP-PRP augmentation is highly sensitive to the proportion of structural failures that proceed to revision surgery. When revision probabilities ranging from 6% to 12% were incorporated, LP-PRP was associated with modeled outcomes spanning from modest net cost deficits to modest net cost savings at the national level, with near cost-neutrality at intermediate values.

These findings underscore that the economic value of LP-PRP is conditional rather than uniform. Importantly, the break-even total PRP cost per case fell within a relatively narrow range under plausible revision probabilities, suggesting that low-cost preparation strategies may achieve cost neutrality. Because commercial kit–based systems often have higher per-case costs than manual preparation, the break-even thresholds reported here can be interpreted as cost ceilings above which LP-PRP is unlikely to be cost-neutral under the modeled revision probabilities. In settings where PRP-related costs are not routinely reimbursed, financial responsibility may be transferred to patients, shifting the economic evaluation from a payer-centered framework toward shared physician–patient decision-making. Under these circumstances, even when structural benefit is observed, the

value of PRP augmentation may depend on individual patient preferences, financial capacity, and treatment priorities. Accordingly, the present economic results should be interpreted as illustrative of potential payer-side impact under defined assumptions, rather than as evidence of universal cost savings, and as highlighting the importance of cost-reduction strategies in facilitating real-world adoption.

Strengths and limitations

This review has several notable strengths. Chief among these is its formulation-specific approach, which distinguishes LP from LR-PRP rather than pooling heterogeneous biologic preparations as a single intervention. Structural failure was objectively defined using post-operative imaging, with outcomes harmonized to full-thickness retear equivalent to Sugaya grade IV. All analyses were conducted using standardized risk-of-bias assessment tools and prespecified subgroup and sensitivity frameworks. The analytic workflow and figures were generated using fully reproducible code, enhancing transparency and reproducibility. Findings remained consistent after exclusion of the single critically biased trial, supporting the robustness of the observed structural effect. In addition, the pragmatic economic model incorporated real-world cost inputs and readily implementable manual preparation methods, allowing evaluation across both hospital and ambulatory surgical center settings.

Several limitations warrant consideration. PRP preparation protocols and reporting methods varied across included studies, and despite outcome harmonization, definitions of retear were not fully standardized across trials. Subgroup analyses were limited by relatively small sample sizes, and a number of nonrandomized studies carried moderate to serious risk of bias. Publication bias cannot be excluded; funnel plot asymmetry suggested possible small-study effects, and bias-adjusted estimates should be interpreted as exploratory. Moreover, most trials lacked objective strength testing within age-adjusted Constant scores, limiting conclusions regarding functional recovery. Finally, the economic analysis captured short-term, episode-of-care health care expenditures only and did not incorporate indirect costs, long-term societal impact, or quality-of-life outcomes.

Conclusion

Intraoperative LP-PRP appears to reduce retear risk after arthroscopic RCR, with consistent benefits across study designs that strengthen when high-risk trials are excluded. Excluding the single critically-biased study reduced heterogeneity from 53.3% to 0%, clarifying a precise, formulation-specific effect. By linking biologic plausibility with structural protection and demonstrating favorable cost projections under conservative assumptions, this meta-analysis offers a formulation-specific framework to inform clinical adoption. LP-PRP represents a feasible, low-cost adjunct that improves repair durability without altering short-term recovery or patient-reported outcome measures, making it both a biologically rational and economically practical strategy in modern shoulder surgery. Taken together, these results position LP-PRP as a formulation-specific adjunct worthy of consideration in optimizing RCR outcomes at scale.

Declaration of generative AI and AI-assisted technologies in the writing process

ChatGPT (OpenAI, San Francisco, CA; GPT-5) was used under author supervision to assist with R code organization, syntax corrections, and minor language refinement. All statistical analyses, results, and interpretations were independently verified by the authors, who take full responsibility for the accuracy and integrity of the work.

Disclaimers:

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest: Brian J Cole: American Journal of Sports Medicine: editorial or governing board; Arthrex Inc: IP royalties, paid consultant, research support; Elsevier Publishing: IP royalties, publishing royalties, financial, or material support; National Institutes of Health (NIAMS & NICHD): research support; nd Ossio: stock or stock options. Any additional authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

Supplementary Data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jse.2026.02.018.

REFERENCES

1. Abdalla G, Pendegrass CJ. Biological approaches to the repair and regeneration of the rotator cuff tendon-bone enthesis: a literature review. Front Bioeng Biotechnol 2023;11:1176113. https://doi.org/10.3389/fbioe.2023.1176113.
2. Ahmad Z, Ang S, Rushton N, Harvey A, Akhtar K, Dawson-Bowling S, et al. Platelet-Rich plasma augmentation of arthroscopic rotator cuff repair lowers retear rates and improves short-term postoperative functional outcome scores: a systematic review of meta-analyses. Arthrosc Sports Med Rehabil 2022;4:e823–33. https://doi.org/10.1016/j.asmr.2021.12.012.
3. Aurégan J-C, Klouche S, Levy B, Bauer T, Rousselin B, Ferrand M, et al. Autologous conditioned Plasma for tendon healing following arthroscopic rotator cuff repair. Prospective comparative assessment with magnetic resonance arthrography at 6 months' follow-up. Orthop Traumatol Surg Res 2019;105:245–9. https://doi.org/10.1016/j.otsr.2019.01.003.
4. Barber FA, Hrnack SA, Snyder SJ, Hapa O. Rotator cuff repair healing influenced by platelet-rich plasma construct

augmentation. Arthrosc J Arthrosc Relat Surg 2011;27:1029–35. https://doi.org/10.1016/j.arthro.2011.06.010.
5. Barr J, Stern M, Hunter K, Gentile P, Clinton C. Analyzing disparities in platelet-rich plasma preinjection protocols for musculoskeletal injuries. Clin J Sport Med 2025;36:179–84. https://doi.org/10.1097/JSM.0000000000001384.
6. Bergeson AG, Tashjian RZ, Greis PE, Crim J, Stoddard GJ, Burks RT. Effects of platelet-rich fibrin matrix on repair integrity of At-Risk rotator cuff tears. Am J Sports Med 2012;40:286–93. https://doi.org/10.1177/0363546511424402.
7. Castricini R, Longo UG, De Benedetto M, Panfoli N, Pirani P, Zini R, et al. Platelet-Rich plasma augmentation for arthroscopic rotator cuff repair: a randomized controlled trial. Am J Sports Med 2011;39:258–65. https://doi.org/10.1177/0363546510390780.
8. Castro RLBD, Antonio BP, Manoel FGDOM. Is the manual preparation of platelet rich plasma safe? Res Soc Dev 2022 July 21;11:e19111032270. https://doi.org/10.33448/rsd-v11i10.32270.
9. Centers for Medicare & Medicaid Services. Medicare procedure price lookup. Available at: Medicare.gov. [Accessed 30 July 2025]. https://www.medicare.gov/procedure-price-lookup/.
10. Charousset C, Zaoui A, Bellaïche L, Piterman M. Does autologous Leukocyte-Platelet–Rich plasma improve Tendon healing in arthroscopic repair of large or massive rotator cuff tears? Arthrosc J Arthrosc Relat Surg 2014;30:428–35. https://doi.org/10.1016/j.arthro.2013.12.018.
11. Chen X, Jones IA, Togashi R, Park C, Vangsness CT. Use of platelet-rich plasma for the improvement of pain and function in rotator cuff tears: a systematic review and meta-analysis with bias assessment. Am J Sports Med 2020;48:2028–41. https://doi.org/10.1177/0363546519881423.
12. Dohan Ehrenfest DM, Rasmusson L, Albrektsson T. Classification of platelet concentrates: from pure platelet-rich plasma (P-PRP) to leucocyte- and platelet-rich fibrin (L-PRF). Trends Biotechnol 2009;27:158–67. https://doi.org/10.1016/j.tibtech.2008.11.009.
13. Duval S, Tweedie R. Trim and fill: a simple Funnel-Plot–Based method of testing and adjusting for publication bias in meta-analysis. Biometrics 2000;56:455–63.
14. Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. BMJ 1997;315:629–34.
15. Flury M, Rickenbacher D, Schwyzer H-K, Jung C, Schneider MM, Stahnke K, et al. Does pure platelet-rich plasma affect postoperative clinical outcomes after arthroscopic rotator cuff repair?: a randomized controlled trial. Am J Sports Med 2016;44:2136–46. https://doi.org/10.1177/0363546516645518.
16. Hackl M, Flury M, Kolling C, Nebelung W, Krauss CA, Kraemer NA, et al. Results of arthroscopic revision rotator cuff repair for failed open or arthroscopic repair: a prospective multicenter study on 100 cases. Am J Sports Med 2022;50:2203–10. https://doi.org/10.1177/03635465221097410.
17. Haque A, Pal Singh H. Does structural integrity following rotator cuff repair affect functional outcomes and pain scores? A meta-analysis. Shoulder Elb 2018;10:163–9. https://doi.org/10.1177/1758573217731548.
18. Jain NB, Higgins LD, Losina E, Collins J, Blazar PE, Katz JN. Epidemiology of musculoskeletal upper extremity ambulatory surgery in the United States. BMC Musculoskelet Disord 2014;15:4. https://doi.org/10.1186/1471-2474-15-4.
19. Jo CH, Kim JE, Yoon KS, Lee JH, Kang SB, Lee JH, et al. Does platelet-rich plasma accelerate recovery after rotator cuff repair? A prospective cohort study. Am J Sports Med 2011;39:2082–90. https://doi.org/10.1177/0363546511413454.
20. Jo CH, Shin JS, Lee YG, Shin WH, Kim H, Lee SY, et al. Platelet-Rich plasma for arthroscopic repair of large to massive rotator cuff tears: a randomized, Single-Blind, parallel-group trial. Am J Sports Med 2013;41:2240–8. https://doi.org/10.1177/0363546513497925.
21. 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 Sept;43:2102–10. https://doi.org/10.1177/0363546515587081.
22. Lana JF, Huber SC, Purita J, Tambeli CH, Santos GS, Paulus C, et al. Leukocyte-rich PRP versus leukocyte-poor PRP - the role of monocyte/macrophage function in the healing cascade. J Clin Orthop Trauma 2019;10:S7–12. https://doi.org/10.1016/j.jcot.2019.05.008.
23. Li M, Wang K, Zhang H, Fang C, Liu H, Zhang Y. Clinical evaluations of intraoperative injection of platelet-rich plasma in arthroscopic single-Row rotator cuff repair at 2-Year Follow-Up. Biomed Res Int 2021;2021:6675097. https://doi.org/10.1155/2021/6675097.
24. Mahure SA, Mollon B, Shamah SD, Zuckerman JD, Kwon YW, Rokito AS. Reoperation rate following isolated arthroscopic rotator cuff repair. J Shoulder Elbow Surg 2016;25:e322–3. https://doi.org/10.1016/j.jse.2016.07.045.
25. 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;46:3134–41. https://doi.org/10.1177/0363546518795895.
26. Martinelli D, Fornara P, Stecco A, Grassi FA. Does intraoperative platelet-rich plasma improve clinical and structural outcomes after arthroscopic repair of isolated tears of the supraspinatus Tendon? Indian J Orthop 2019;53:77–81. https://doi.org/10.4103/ortho.IJOrtho_35_17.
27. Mirzayan R, Weber AE, Petrigliano FA, Chahla J. Rationale for biologic augmentation of rotator cuff repairs. J Am Acad Orthop Surg 2019;27:468–78. https://doi.org/10.5435/JAAOS-D-18-00281.
28. Nishio H, Saita Y, Kobayashi Y, Takaku T, Fukusato S, Uchino S, et al. Platelet-rich plasma promotes recruitment of macrophages in the process of tendon healing. Regen Ther 2020;14:262–70. https://doi.org/10.1016/j.reth.2020.03.009.
29. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Syst Rev 2021;10:89. https://doi.org/10.1186/s13643-021-01626-4.
30. Pandey V, Bandi A, Madi S, Agarwal L, Acharya KKV, Maddukuri S, et al. Does application of moderately concentrated platelet-rich plasma improve clinical and structural outcome after arthroscopic repair of medium-sized to large rotator cuff tear? A randomized controlled trial. J Shoulder Elbow Surg 2016;25:1312–22. https://doi.org/10.1016/j.jse.2016.01.036.
31. Peng Y, Xu W, Li X, Shangguan H, Diao L, Ma H, et al. Effects of leukocyte-rich platelet-rich plasma and leukocyte-poor platelet-rich plasma on the healing of bone-tendon interface of rotator cuff in a mice model. Platelets 2022;33:1075–82. https://doi.org/10.1080/09537104.2022.2044462.
32. R Core Team. R: A Language and Environment for Statistical Computing [Internet]. 2024. Available at: https://www.R-project.org/. Accessed July 30, 2025.
33. Randelli P, Arrigoni P, Ragone V, Aliprandi A, Cabitza P. Platelet rich plasma in arthroscopic rotator cuff repair: a prospective RCT study, 2-year follow-up. J Shoulder Elbow Surg 2011;20:518–28. https://doi.org/10.1016/j.jse.2011.02.008.
34. Rodeo SA, Delos D, Williams RJ, Adler RS, Pearle A, Warren RF. The effect of platelet-rich fibrin matrix on rotator cuff Tendon Healing: a prospective, randomized clinical study. Am J Sports Med 2012;40:1234–41. https://doi.org/10.1177/0363546512442924.

35. Rossi LA, Gorodischer TD, Camino P, Brandariz RN, Tanoira I, Piuzzi NS, et al. Leukocyte-Poor platelet-rich plasma as an adjuvant to arthroscopic rotator cuff repair reduces the retear rate but does not improve functional outcomes: a double-blind randomized controlled trial. Am J Sports Med 2024;52:1403–10. https://doi.org/10.1177/03635465241239062.
36. Rossi LA, Murray IR, Chu CR, Muschler GF, Rodeo SA, Piuzzi NS. Classification systems for platelet-rich plasma. Bone Joint J 2019;101-B:891–6. https://doi.org/10.1302/0301-620x.101b8.bjj-2019-0037.r1.
37. Snow M, Hussain F, Pagkalos J, Kowalski T, Green M, Massoud S, et al. The effect of delayed injection of leukocyte-rich platelet-rich plasma following rotator cuff repair on patient function: a randomized double-blind controlled trial. Arthrosc J Arthrosc Relat Surg 2020;36:648–57. https://doi.org/10.1016/j.arthro.2019.09.026.
38. Sterne JA, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ 2016;12:i4919. https://doi.org/10.1136/bmj.i4919.
39. Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ 2019;28:l4898. https://doi.org/10.1136/bmj.l4898.
40. Sugaya H, Maeda K, Matsuki K, Moriishi J. Functional and structural outcome after arthroscopic full-thickness rotator cuff repair: Single-row versus dual-row fixation. Arthrosc J Arthrosc Relat Surg 2005;21:1307–16. https://doi.org/10.1016/j.arthro.2005.08.011.
41. Tashjian RZ, Shin J, Broschinsky K, Yeh C-C, Martin B, Chalmers PN, et al. Minimal clinically important differences in the American Shoulder and Elbow Surgeons, Simple Shoulder Test, and visual analog scale pain scores after arthroscopic rotator cuff repair. J Shoulder Elbow Surg 2020;29:1406–11. https://doi.org/10.1016/j.jse.2019.11.018.
42. Walsh MR, Nelson BJ, Braman JP, Yonke B, Obermeier M, Raja A, et al. Platelet-rich plasma in fibrin matrix to augment rotator cuff repair: a prospective, single-blinded, randomized study with 2-year follow-up. J Shoulder Elbow Surg 2018;27:1553–63. https://doi.org/10.1016/j.jse.2018.05.003.
43. Weber SC, Kauffman JI, Parise C, Weber SJ, Katz SD. Platelet-Rich fibrin matrix in the management of arthroscopic repair of the rotator cuff: a prospective, randomized, double-blinded study. Am J Sports Med 2013;41:263–70. https://doi.org/10.1177/0363546512467621.
44. Wen Y-H, Lin W-Y, Lin C-J, Sun Y-C, Chang P-Y, Wang H-Y, et al. Sustained or higher levels of growth factors in platelet-rich plasma during 7-day storage. Clin Chim Acta 2018;483:89–93. https://doi.org/10.1016/j.cca.2018.04.027.
45. Xu Z, Yin W, Zhang Y, Qi X, Chen Y, Xie X, et al. Comparative evaluation of leukocyte- and platelet-rich plasma and pure platelet-rich plasma for cartilage regeneration. Sci Rep 2017;7:43301. https://doi.org/10.1038/srep43301.
46. Yan R, Gu Y, Ran J, Hu Y, Zheng Z, Zeng M, et al. Intratendon delivery of leukocyte-poor platelet-rich plasma improves healing compared with leukocyte-rich platelet-rich plasma in a rabbit achilles tendinopathy model. Am J Sports Med 2017;45:1909–20. https://doi.org/10.1177/0363546517694357.
47. Yanik EL, Chamberlain AM, Keener JD. Trends in rotator cuff repair rates and comorbidity burden among commercially insured patients younger than the age of 65 years, United States 2007-2016. JSES Rev Rep Tech 2021;1:309–16. https://doi.org/10.1016/j.xrrt.2021.06.009.
48. Yao L, Pang L, Zhang C, Yang S, Wang J, Li Y, et al. Platelet-Rich plasma for arthroscopic rotator cuff repair: a 3-Arm randomized controlled trial. Am J Sports Med 2024;52:3495–504. https://doi.org/10.1177/03635465241283964.
49. 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;50:191–7. https://doi.org/10.3944/AOTT.2015.15.0113.
50. Zumstein MA, Rumian A, Thélu CÉ, Lesbats V, O'Shea K, Schaer M, et al. SECEC research Grant 2008 II: use of platelet- and leucocyte-rich fibrin (L-PRF) does not affect late rotator cuff tendon healing: a prospective randomized controlled study. J Shoulder Elbow Surg 2016;25:2–11. https://doi.org/10.1016/j.jse.2015.09.018.