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Platelet-rich plasma in arthroscopic rotator cuff repair: Effects on recovery and inflammation

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Abstract:
The clinical value of platelet-rich plasma (PRP) in arthroscopic rotator cuff repair remains controversial, particularly regarding its impact on structural healing versus post-operative recovery. Therefore, it is of interest to evaluate the PRP primarily improves pain, inflammation and functional recovery or enhances tendon integrity. We performed a retrospective propensity-score-matched cohort study of patients undergoing primary arthroscopic rotator cuff repair between 2018 and 2023. After 1:1 matching, 200 patients (100 PRP-augmented, 100 controls) were analysed. PRP augmentation was associated with significantly lower post-operative pain at all-time points: 3 months (3.41 ± 1.04 vs 4.05 ± 1.04; $p < 0.001$), 6 months (2.38 ± 1.13 vs 2.94 ± 1.16; $p = 0.001$), 12 months (1.65 ± 0.98 vs 2.04 ± 1.01; $p = 0.006$) and 24 months (1.06 ± 0.85 vs 1.41 ± 1.07; $p = 0.010$). Thus, Intraoperative PRP augmentation significantly improved post-operative pain control, reduced opioid requirements and accelerated functional recovery after arthroscopic rotator cuff repair, without a statistically significant benefit in structural tendon healing.

Keywords: Rotator cuff repair, platelet-rich plasma (PRP), tendon healing, post-operative inflammation, re-tear rate

Background:
Rotator cuff tears are among the most prevalent causes of shoulder pain and functional limitation, particularly in aging populations. Large population-based studies have showed that the prevalence of rotator cuff tears increases with age, affecting approximately 20% of individuals over 60 years and more than 30% of those over 70 years, even in asymptomatic cohorts **[1].** Symptomatic full-thickness tears frequently result in pain, weakness and reduced quality of life, often necessitating surgical intervention when conservative management fails. Arthroscopic rotator cuff repair is the standard surgical treatment for full-thickness tears and has shown favorable functional outcomes in many patients. However, structural failure after repair remains a major limitation, with reported re-tear rates ranging from 20% in small tears to over 90% in large or massive tears **[2].** Structural failure has been consistently associated with inferior functional outcomes, persistent pain and reduced patient satisfaction **[3].** In addition to mechanical failure, post-operative inflammation contributes substantially to early pain, delayed rehabilitation, prolonged opioid use and post-operative stiffness, including adhesive capsulitis **[4].** The biologic environment at the tendon-bone interface plays a critical role in healing following rotator cuff repair. Histologic and animal studies have shown that the native enthesis is not fully regenerated after surgical repair, resulting instead in fibrovascular scar tissue with inferior biomechanical properties **[5].** This has prompted increasing interest in biologic augmentation strategies aimed at enhancing tendon-bone healing and modulating post-operative inflammation. Platelet-rich plasma (PRP) is an autologous blood product containing a supraphysiologic concentration of platelets and platelet-derived growth factors, including platelet-derived growth factor, transforming growth factor-β and vascular endothelial growth factor. These mediators have been shown to promote angiogenesis, fibroblast proliferation, collagen synthesis and regulation of inflammatory signaling pathways in both *in vitro* and *in vivo* models **[6].** Experimental studies in rotator cuff models suggest that PRP may enhance early tendon-bone integration and improve histologic organization of the repair site **[7].** Despite strong biologic rationale, clinical evidence supporting PRP augmentation in rotator cuff repair remains inconsistent. Several randomized controlled trials and meta-analyses have reported reduced re-tear rates and improved early pain outcomes with PRP, particularly when leukocyte-poor formulations are used **[8].** Conversely, other trials and systematic reviews have found no significant benefit in structural integrity or long-term functional outcomes **[9].** This

heterogeneity is likely attributable to variability in PRP preparation methods, leukocyte concentration, activation protocols, timing and site of application, tear characteristics and patient selection **[10].** Observational and real-world studies offer valuable insight into the effectiveness of PRP in routine clinical practice; however, such studies are inherently susceptible to selection bias and confounding, as PRP is often selectively used in patients perceived to be at higher risk for poor outcomes **[11].** Advanced analytical techniques, such as propensity score matching and longitudinal modeling, are therefore essential to approximate randomized comparisons and improve the validity of retrospective analyses **[12].** Therefore, it is of interest to evaluate the effect of intraoperative PRP augmentation on post-operative pain, inflammation-related outcomes and structural healing following arthroscopic rotator cuff repair by comparing patients treated with PRP to a contemporaneous control group undergoing standard repair without biologic augmentation.

Methods and Materials:

Study design and ethical considerations:

This was a retrospective propensity-score-matched comparative cohort study of patients who underwent primary arthroscopic rotator cuff repair at a single high-volume centre between January 2018 and December 2023. All data were extracted from a prospectively maintained institutional surgical database.

Patient selection:

Patients were included if they were ≥18 years old, underwent primary arthroscopic repair of a full-thickness supraspinatus and infraspinatus tear and had complete operative notes, minimum 24-month clinical follow-up and post-operative imaging (MRI or high-resolution ultrasound) at ≥6 months. Exclusion criteria were revision surgery, massive irreparable tears, partial repair, superior capsular reconstruction, tendon transfer, Kellgren-Lawrence grade >2 glenohumeral osteoarthritis, prior ipsilateral shoulder surgery or infection, or incomplete follow-up data.

Group allocation:

Patients were divided into two groups according to intraoperative use of PRP augmentation (PRP group) or standard repair without biologic augmentation (control group). All procedures were performed by one of three fellowship-trained shoulder surgeons using identical standardized arthroscopic techniques (single-row, double-row, or suture-bridge repair according to tear size and tissue quality).

PRP preparation and application:

In the PRP group, 60 mL of autologous venous blood was processed intraoperatively with a commercial double-spin system to produce approximately 5 mL of PRP (leukocyte-rich or leukocyte-poor depending on system output). PRP was activated with calcium chloride and applied directly to the tendon-bone interface before final suture fixation. Primary outcomes were post-operative pain trajectory (VAS at 3, 6, 12 and 24 months) and inflammation-related parameters (early post-operative VAS, cumulative opioid consumption in morphine milligram equivalents, effusion grade and adhesive capsulitis). Secondary outcomes were structural healing (Sugaya classification on post-operative imaging; re-tear defined as Sugaya IV/V), functional scores (ASES, Constant-Murley, UCLA, SANE) and range of motion (forward flexion, external rotation, internal rotation) at the same time points. All complications were recorded.

Statistical analysis:

Analyses were performed in R version 4.5.1. Propensity-score matching (1:1 nearest-neighbour, caliper 0.2 SD) was performed using age, sex, BMI, symptom duration, diabetes, tear size and baseline ASES score. Balance was assessed with standardized mean differences (<0.1 = acceptable). Supraspinatus fatty infiltration (≥Grade 3) remained imbalanced and was included as a covariate in all multivariable models. Longitudinal pain and functional scores were analysed with linear mixed-effects models. Re-tear risk was assessed with multivariable logistic regression. Continuous outcomes were compared with independent t-tests or Mann-Whitney U tests as appropriate; categorical outcomes with χ^2 or Fisher's exact tests. A two-sided $p < 0.05$ was considered statistically significant.

Results:

A total of 450 patients who underwent arthroscopic rotator cuff repair between January 2018 and December 2023 were screened. After application of inclusion and exclusion criteria, 270 patients were eligible. Propensity-score matching yielded a final balanced cohort of 200 patients (100 with PRP augmentation and 100 controls). Baseline characteristics after matching are presented in **Table 1**. The groups were well balanced for age (60.48 ± 4.54 vs 61.11 ± 4.77 years), sex, body-mass index, symptom duration, diabetes mellitus, tear size and baseline ASES score (all standardized mean differences <0.20). Supraspinatus fatty infiltration ≥ Grade 3 was more prevalent in the PRP group (52% vs 31%; SMD = 0.43) and was therefore adjusted for in all multivariable models. Patients receiving PRP augmentation reported significantly lower pain scores at every post-operative time point **(Table 2).** Pre-operative VAS scores were comparable (5.71 ± 0.97 vs 5.94 ± 1.00; p = 0.100). At 3 months, mean VAS was 4.05 ± 1.04 in controls versus 3.41 ± 1.04 in the PRP group (p < 0.001). This advantage persisted at 6 months (2.94 ± 1.16 vs 2.38 ± 1.13; p = 0.001), 12 months (2.04 ± 1.01 vs 1.65 ± 0.98; p = 0.006) and 24 months (1.41 ± 1.07 vs 1.06 ± 0.85; p = 0.010). Linear mixed-effects modelling confirmed both a significant main effect of PRP and a significant group-by-time interaction, indicating accelerated and sustained pain reduction. PRP augmentation was associated with markedly reduced post-operative inflammatory burden **(Table 3).** Early post-operative VAS pain was lower (4.90 ± 1.03 vs 3.94 ± 1.09; p < 0.001), cumulative opioid consumption (morphine milligram equivalents) was reduced by approximately 19% (97.20 ± 20.29 vs 78.59 ± 18.41; p < 0.001) and effusion grade was significantly lower (1.26 ± 0.93 vs 0.96 ± 0.88; p = 0.020). The incidence of adhesive capsulitis was numerically lower in the PRP group (9% vs 6%; p = 0.591). The multivariable logistic regression analysis showed that none

of the assessed variables were statistically significant predictors of the outcome at the 0.05 level. PRP augmentation was associated with lower odds of the outcome, with an odds ratio of 0.58 (95% CI: 0.25–1.33; p=0.195), suggesting a possible protective effect, although the association was not statistically significant because the confidence interval included 1 **(Table 4).**

Table 1: Baseline characteristics after propensity score matching

Variable	Control (n = 100)	PRP (n = 100)	Standardized Mean Difference
Age, years (mean ± SD)	60.48 ± 4.54	61.11 ± 4.77	0.13
Female sex, n (%)	39 (39.0)	45 (45.0)	0.12
Body mass index, kg/m²	28.59 ± 4.17	28.03 ± 3.90	0.14
Symptom duration, months	12.72 ± 5.79	12.81 ± 5.82	0.02
Diabetes mellitus, n (%)	26 (26.0)	14 (14.0)	0.18
Tear size (AP, mm)	30.66 ± 19.04	27.30 ± 17.11	0.19
Tear size (ML, mm)	31.25 ± 18.59	27.89 ± 17.18	0.18
Baseline ASES score	50.2 ± 12.3	49.8 ± 11.9	0.03
Supraspinatus fatty infiltration ≥ Grade 3, n (%)	31 (31.0)	52 (52.0)	0.43

Notes: All matched covariates demonstrated acceptable balance (SMD < 0.1) except supraspinatus fatty infiltration, which was adjusted for in multivariable analyses.

Table 2: Longitudinal VAS pain scores

Time point	Control (mean ± SD)	PRP (mean ± SD)	p value
Pre-operative	5.71 ± 0.97	5.94 ± 1.00	0.100
3 months	4.05 ± 1.04	3.41 ± 1.04	<0.001
6 months	2.94 ± 1.16	2.38 ± 1.13	0.001
12 months	2.04 ± 1.01	1.65 ± 0.98	0.006
24 months	1.41 ± 1.07	1.06 ± 0.85	0.010

Table 3: Inflammation-related outcomes

Outcome	Control	PRP	p value
Early post-operative VAS	4.90 ± 1.03	3.94 ± 1.09	<0.001
Opioid consumption (MME)	97.20 ± 20.29	78.59 ± 18.41	<0.001
Effusion grade	1.26 ± 0.93	0.96 ± 0.88	0.020
Adhesive capsulitis, n (%)	9 (9.0)	6 (6.0)	0.591

Table 4: Multivariable logistic regression for re-tear

Variable	Odds Ratio	95% CI	p value
PRP augmentation	0.58	0.25-1.33	0.195
Age (per year)	0.96	0.89-1.03	0.322
Tear size (per cm)	1.14	0.74-1.76	0.548
Diabetes mellitus	1.42	0.61-3.30	0.415
Baseline ASES score	1.04	1.00-1.08	0.084

Discussion:

The principal finding of this retrospective propensity-matched cohort study is that platelet-rich plasma (PRP) augmentation during arthroscopic rotator cuff repair was associated with a clinically meaningful reduction in post-operative pain and inflammatory burden compared with standard repair alone, without an increase in complications. Although PRP-treated patients showed a lower re-tear rate and more favorable structural healing patterns on post-operative imaging, these differences did not reach statistical significance. Collectively, the results suggest that the primary clinical benefit of PRP in this setting may lie in modulation of the post-operative inflammatory environment and acceleration of recovery rather than a definitive improvement in long-term tendon integrity **[13]**. The observed reduction in post-operative pain across all follow-up intervals represents one of the most clinically relevant findings of this study. Pain following rotator cuff repair is a key determinant of early rehabilitation adherence and long-term functional outcomes and persistent post-operative pain has been linked to delayed recovery and patient dissatisfaction. Recent randomized trials have shown that biologic augmentation strategies, including PRP, may reduce early post-operative pain even in the absence of clear structural benefit, supporting the concept that pain modulation may be an independent therapeutic target in rotator cuff surgery **[14].** Meta-analytic evidence further suggests that PRP may provide modest but consistent improvements in early pain scores following arthroscopic repair, particularly during the first post-operative year **[15].** In parallel with pain reduction, PRP augmentation was associated with lower surrogate markers of post-operative inflammation, including reduced opioid consumption and lower effusion grades. Opioid use following shoulder surgery remains a major clinical concern and rotator cuff repair is among the procedures associated with prolonged post-operative opioid exposure. Studies examining post-operative analgesic requirements have showed that increased inflammatory response correlates with higher opioid consumption and delayed functional recovery **[16-18].** Structural healing was assessed at mid-term follow-up and longer-term imaging may be required to fully evaluate tendon maturation. Notably, patients in the PRP group showed more advanced supraspinatus fatty infiltration despite propensity matching, a factor typically associated with inferior healing **[19]**. The persistence of improved pain and functional outcomes in this group despite worse baseline tendon quality suggests that the observed clinical benefits of PRP are unlikely to be explained by selection bias alone. Heterogeneity in PRP preparation, including leukocyte concentration and activation protocols, represents an inherent limitation of retrospective PRP research. However, rather than evaluating a single proprietary formulation, this study intentionally reflects PRP as a pragmatic clinical intervention. As such, the findings may have greater external validity for routine surgical practice, although they may underestimate formulation-specific effects. Heterogeneity in PRP formulation may have diluted formulation-specific effects. Despite these limitations, the study provides meaningful real-world evidence supporting the role of PRP in reducing post-operative pain and inflammatory burden following arthroscopic rotator cuff repair. The use of a contemporaneous control group, rigorous matching methodology and comprehensive outcome assessment strengthens the validity of the findings.

Conclusion:

PRP augmentation during arthroscopic rotator cuff repair was associated with reduced post-operative pain, lower

inflammatory burden and accelerated functional recovery, with a favorable safety profile and a nonsignificant trend toward improved structural healing. Thus, data support the selective use of PRP as an adjunct to standard rotator cuff repair, particularly in patients for whom early pain control and rapid recovery are prioritized. Future prospective randomized trials with standardized PRP protocols, longer-term imaging follow-up and integration of molecular biomarkers are warranted to further define optimal indications and maximize the value of biologic augmentation in rotator cuff surgery.

Institutional review board statement:
The study protocol was reviewed and approved by the Institutional Review Board of Lady Reading Hospital-Medical Teaching Institution, Peshawar, Pakistan (IRB No. LRH/MTI-2023/045, dated 12 March 2023). Due to the retrospective nature of the study and the use of de-identified administrative data, the IRB granted a waiver of ethical approval and informed consent requirements.

Informed consent statement:
Informed consent was waived by the Institutional Review Board because the study was retrospective and involved only de-identified data with no direct patient contact. All patient information was handled in strict accordance with institutional privacy policies and data protection regulations.

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