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Original Article

A Trial of Platelet-Rich Plasma Versus Corticosteroid Injection for Managing Patellar Tendinopathy in Adolescent Athletes

Ausaf Chaudhary[1], Muhammad Faraz Tariq[2], Muhammad Inam[3], Muhammad Anas Ghazi[4], Muhammad Naveed[5], Shaikh Khalid Muhammad[6], Akif Saeed Ch[7]

[1] Ph.D (Human Kinesiology and Science), College of Physical Education, Yangzhou University, China
[2] FCPS Orthopaedics, Adil Hospital, Defence, Lahore, Pakistan
[3] FCPS, FRCS, Associate Professor, MTI Lady Reading Hospital, Peshawar, Pakistan
[4] Core Surgical Trainee, Trauma and Orthopaedics, North Manchester General Hospital, Manchester, United Kingdom
[5] PhD Infection and Immunity, Hazara University, Pakistan
[6] Professor of Medicine, MBBS, FCPS (Medicine), CMC Teaching Hospital Larkana @ SMBBMU, Larkana, Pakistan
[7] Director Medical Services & Research, Hope Family Clinic & Rehabilitation Research Institute, Faisalabad, Pakistan

***Corresponding author: Ausaf Chaudhary, ausaf.choudhary@gmail.com; Muhammad Inam, dr_mohammadinam@yahoo.co.uk**

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ABSTRACT

Background: Patellar tendinopathy can substantially impair pain-related function and athletic participation in adolescents, while comparative evidence for injection-based treatments in this population remains limited. Objective: To compare leukocyte-rich platelet-rich plasma (PRP) with corticosteroid injection for improving function and reducing pain in adolescent athletes with chronic patellar tendinopathy. Methods: This single-center, assessor-blinded, parallel-group randomized controlled trial was conducted at a sports medicine clinic in the Islamabad–Rawalpindi region from June 2025 to January 2026. Sixty-four athletes aged 12–19 years were randomized 1:1 to ultrasound-guided PRP or corticosteroid injection followed by the same six-week eccentric rehabilitation program; 60 participants were included in the final analysis. VISA-P, activity-related pain, and quadriceps strength were assessed at baseline, 4 weeks, and 12 weeks. Between-group differences, 95% confidence intervals, and repeated-measures comparisons were evaluated. Results: The mean baseline-to-12-week VISA-P improvement was 36.7 points with PRP and 21.9 points with corticosteroid, giving a between-group change difference of 14.8 points (95% CI 9.9–19.7; $p<0.001$). At 4 weeks, corticosteroid favored VISA-P scores by 9.4 points (95% CI 5.9–12.9; $p<0.001$), whereas at 12 weeks PRP favored VISA-P scores by 14.2 points (95% CI 9.6–18.8; $p<0.001$). Pain and quadriceps-strength outcomes similarly favored corticosteroid at 4 weeks and PRP at 12 weeks. Conclusion: Corticosteroid provided the favorable early response, whereas PRP produced superior 12-week clinical outcomes under the treatment protocol evaluated. Keywords: Adolescent; Athletes; Muscle Strength; Patellar Ligament; Platelet-Rich Plasma; Tendinopathy; Corticosteroids.

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INTRODUCTION

Patellar tendinopathy, commonly referred to as jumper's knee, is an overuse disorder characterized by activity-related anterior knee pain and impaired tendon-related function, particularly during repetitive jumping, running, and rapid deceleration activities. The disorder is associated with alterations in tendon structure and remodeling rather than a purely acute inflammatory process, with changes including collagen disorganization, increased cellularity, and neovascularization described in established tendinopathy (1). Adolescent athletes may represent a clinically distinct population because rapid musculoskeletal growth, high training loads, repeated exposure to jumping sports, and maturation of the bone–tendon interface may influence both the development and clinical course of patellar tendon symptoms (2). Persistent symptoms can interfere with training participation, competition, physical

performance, and continuation of sport, making effective management particularly important during adolescence.

Exercise-based rehabilitation, especially progressive tendon-loading and eccentric exercise programs, remains a central component of conservative management for patellar tendinopathy (3). Nevertheless, clinical response can vary, and some athletes continue to experience pain and functional limitations despite activity modification and structured rehabilitation. Management in adolescents may be especially challenging because treatment must address sport-related loading while accounting for ongoing musculoskeletal development and the need to avoid unnecessary interruption of athletic participation (4). A range of conservative and interventional strategies has therefore been used in young athletes with persistent patellar tendon symptoms, although the comparative evidence supporting many of these approaches remains limited (5). Injection-based interventions are generally considered when symptoms remain clinically important despite conservative care, but their relative short- and intermediate-term effects in adolescent athletes have not been clearly established.

Corticosteroid injections have historically been used for tendinopathy because of their ability to produce relatively rapid reductions in pain and local symptoms. However, the clinical benefit of corticosteroid treatment may be predominantly short term, and concerns remain regarding repeated exposure and potential adverse effects on tendon tissue, particularly when injections are delivered in or around load-bearing tendons (6). These concerns are especially relevant in adolescent athletes, for whom symptom reduction must be balanced against preservation of tendon function and safe progression of sporting activity. Consequently, an intervention that provides early analgesia may not necessarily produce the most favorable functional outcome over subsequent weeks, emphasizing the importance of directly comparing treatment trajectories rather than evaluating short-term symptom relief alone.

Platelet-rich plasma (PRP) has emerged as an alternative injection-based treatment intended to influence the biological environment of chronically symptomatic tendon tissue. PRP preparations contain concentrated autologous platelets and associated mediators that have been proposed to influence cellular activity and extracellular matrix remodeling; however, clinical outcomes across tendinopathy studies have been heterogeneous, and evidence specific to younger populations remains comparatively limited (7). Variability in PRP composition is also clinically important because leukocyte-rich and leukocyte-poor formulations differ in their cellular and inflammatory profiles, which may influence treatment response (8). In addition, technical factors such as ultrasound guidance, injection location, preparation technique, dose, and accompanying rehabilitation can affect the reproducibility and interpretation of studies evaluating injection therapies for patellar tendinopathy (9). Therefore, findings from adult cohorts or from studies using different PRP formulations and treatment protocols cannot automatically be assumed to apply to adolescent athletes.

An additional uncertainty concerns the time course of treatment response. Corticosteroid injection may provide comparatively rapid symptomatic improvement, whereas any clinical effect associated with PRP may develop more gradually. A clinically meaningful comparison should therefore assess both early and later outcomes using measures that capture tendon-related symptoms and function rather than relying solely on pain reduction. The Victorian Institute of Sport Assessment–Patella (VISA-P) score is a disease-specific measure used to quantify the severity and functional impact of patellar tendinopathy and is therefore suitable for evaluating changes in clinical status over time (10). Assessment of pain during activity and quadriceps strength can provide complementary information regarding symptomatic and functional recovery.

Despite increasing use of injection-based treatments for patellar tendinopathy, there remains insufficient randomized comparative evidence specifically addressing leukocyte-rich PRP and corticosteroid injection in adolescent athletes. In particular, it remains uncertain whether the more rapid symptomatic response potentially associated with corticosteroid treatment is sustained over time or whether PRP results in greater improvement in tendon-related function by a later follow-up point when both treatments are combined with the same rehabilitation program. Addressing this gap is important because treatment

decisions in adolescent sports medicine should be based on comparative clinical outcomes demonstrated in the relevant population rather than extrapolated solely from adult tendinopathy studies. Therefore, this randomized controlled trial aimed to determine whether a single ultrasound-guided leukocyte-rich PRP injection was more effective than a single corticosteroid injection for improving function and reducing pain in adolescent athletes with chronic patellar tendinopathy. The primary objective was to compare the change in VISA-P score from baseline to 12 weeks between treatment groups, with pain during activity and quadriceps strength evaluated as secondary outcomes.

MATERIALS AND METHODS

This study was conducted as a single-center, assessor-blinded, parallel-group randomized controlled trial to compare the clinical effects of a single leukocyte-rich platelet-rich plasma injection with those of a single corticosteroid injection in adolescent athletes with chronic patellar tendinopathy. The trial was undertaken at a specialized sports medicine clinic serving the Islamabad–Rawalpindi metropolitan region, Pakistan, over an eight-month period from June 2025 to January 2026. The study population comprised adolescent athletes aged 12–19 years with clinically and ultrasonographically confirmed patellar tendinopathy persisting for at least three months. Participants were excluded if they had undergone previous knee surgery, had a systemic inflammatory arthropathy, had received a corticosteroid or platelet-based injection during the preceding six months, or were receiving ongoing non-steroidal anti-inflammatory drug therapy.

A total sample of 64 participants was planned. The sample-size calculation was based on a previously published interventional study involving patellar tendinopathy and was designed to provide 80% statistical power at a 5% significance level to detect a minimum clinically important between-group difference of 13 points in the primary outcome measure. During recruitment, 88 adolescent athletes were screened for eligibility, of whom 64 fulfilled the eligibility criteria and were enrolled in the trial. Participants were allocated in a 1:1 ratio to the platelet-rich plasma group or corticosteroid group, resulting in 32 participants in each treatment arm at randomization.

The random allocation sequence was generated using a computer-based randomization procedure. Allocation concealment was maintained through sequentially numbered, opaque, sealed envelopes, which were opened by an unblinded clinician responsible for preparation and administration of the assigned injection. Because autologous platelet-rich plasma and the corticosteroid preparation were visually distinguishable, blinding of the treating clinician was not feasible. Outcome assessors responsible for post-baseline clinical evaluations remained unaware of treatment allocation throughout follow-up. Both groups underwent the same rehabilitation program to minimize systematic differences in post-injection management between treatment arms.

Participants allocated to the platelet-rich plasma group received a single ultrasound-guided intratendinous injection of 3 mL autologous leukocyte-rich platelet-rich plasma. The platelet-rich plasma preparation was produced using a standardized double-centrifugation procedure before administration. Participants assigned to the comparator group received a single ultrasound-guided intratendinous injection containing 40 mg triamcinolone acetonide combined with 1 mL of 1% lidocaine. Following injection, participants in both treatment groups completed an identical six-week eccentric exercise rehabilitation program based on progressive decline squats performed twice daily. Adherence to the prescribed rehabilitation program was monitored through weekly digital training logbooks.

Clinical outcomes were assessed before treatment and at 4 and 12 weeks after the intervention. The primary outcome was change in the Victorian Institute of Sport Assessment–Patella (VISA-P) score from baseline to 12 weeks. The VISA-P is a condition-specific measure of symptoms and functional limitation associated with patellar tendinopathy, with higher scores indicating better tendon-related function (10). The 4-week VISA-P assessment was used to characterize the earlier treatment response. Secondary outcomes included pain intensity during sporting activity, measured using a 10-cm Visual Analog Scale, and isometric quadriceps strength, assessed with a handheld knee-extension dynamometer. Pain and

quadriceps-strength outcomes were recorded at baseline and reassessed at 4 and 12 weeks following treatment.

Several measures were incorporated to reduce potential bias and improve comparability between groups. Random sequence generation and concealed allocation were used to minimize selection bias, while post-treatment assessments were performed by investigators blinded to intervention assignment. Ultrasound guidance was used for both injection procedures to standardize localization of treatment delivery. The same six-week eccentric rehabilitation protocol was prescribed to both groups, and adherence was prospectively monitored using weekly exercise logbooks. Baseline demographic and clinical characteristics, including age, sex, symptom duration, VISA-P score, and activity-related pain, were recorded before intervention to assess comparability between randomized groups.

Data distributions were examined for normality using the Shapiro–Wilk test before parametric analyses were performed. Continuous variables were summarized using means and standard deviations, whereas categorical variables were summarized using frequencies and percentages. Baseline continuous variables were compared between groups using independent-samples t-tests, and categorical characteristics were compared using the chi-square test as appropriate. Changes within each treatment group from baseline to subsequent assessments were evaluated using paired-samples t-tests, while between-group comparisons at individual follow-up points were performed using independent-samples t-tests. The principal treatment effect was evaluated by comparing changes in VISA-P score between treatment groups, with between-group estimates expressed as mean differences with 95% confidence intervals.

Longitudinal changes in clinical outcomes across baseline, 4 weeks, and 12 weeks were additionally examined using repeated-measures analysis of variance, incorporating time as the within-participant factor and treatment group as the between-participant factor. Particular attention was given to the time-by-group interaction to determine whether the pattern of change across follow-up differed between the two interventions. Pearson correlation analysis was used as an exploratory analysis to examine the relationship between baseline pain severity and the magnitude of functional improvement at 12 weeks. Statistical significance was defined as a two-sided p value <0.05.

The reported outcome analysis was based on participants who contributed evaluable follow-up data to the final analysis. Of the 64 randomized participants, two participants allocated to platelet-rich plasma were lost to follow-up because of relocation outside the study region, while two participants allocated to corticosteroid were not included in the final analysis because of non-compliance with the prescribed eccentric rehabilitation program. Consequently, the final analyzed cohort comprised 60 participants, with 30 participants in each treatment group. Institutional Review Board approval was obtained before participant enrollment, and the study was conducted under the approved research protocol.

RESULTS

A total of 88 adolescent athletes were screened for eligibility, of whom 64 were randomized equally to platelet-rich plasma (PRP; n = 32) or corticosteroid injection (n = 32). Four randomized participants were not included in the final analysis. Two participants in the PRP group were lost to follow-up because of relocation, and two participants in the corticosteroid group were excluded because of non-compliance with the prescribed eccentric rehabilitation program. The final analyzed sample therefore comprised 60 participants, with 30 participants in each treatment group. Among the 64 randomized participants, 42 (65.6%) were male, including 20 of 32 participants (62.5%) in the PRP group and 22 of 32 (68.8%) in the corticosteroid group; the between-group difference in sex distribution was not statistically significant (p = 0.60).

Both treatment groups demonstrated substantial increases in VISA-P score from baseline to 12 weeks. The mean increase was 36.7 points (95% CI 33.1 to 40.3) in the PRP group and 21.9 points (95% CI 18.4 to 25.4) in the corticosteroid group. The resulting between-group difference in change was 14.8 points (95% CI 9.9 to 19.7; $p < 0.001$), corresponding to a large standardized between-group effect (Cohen's d = 1.56). The

magnitude of this difference also exceeded the 13-point threshold used in the study sample-size calculation.

Table 1. Participant Flow Through the Randomized Trial

Trial stage	Total, n	PRP group, n	Corticosteroid group, n
Screened for eligibility	88	—	—
Excluded before randomization	24	—	—
Randomized	64	32	32
Lost to follow-up because of relocation	2	2	0
Excluded from final analysis because of rehabilitation non-compliance	2	0	2
Included in final analysis	60	30	30

PRP, platelet-rich plasma.

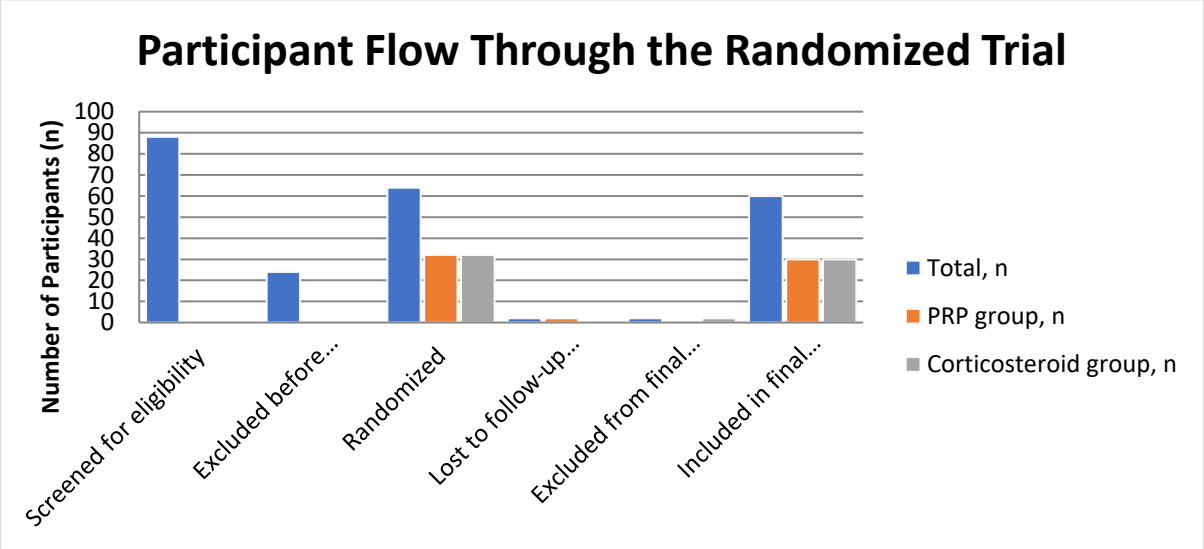

Figure 1 Participant Flow Through the Randomized Trial

Table 2. Reported Baseline Sex Distribution of Randomized Participants

Characteristic	Total (N = 64), n (%)	PRP group (n = 32), n (%)	Corticosteroid group (n = 32), n (%)	p-value
Male sex	42 (65.6)	20 (62.5)	22 (68.8)	0.60

PRP, platelet-rich plasma. Between-group comparison: chi-square test. Statistical significance: $p < 0.05$.

Table 3. Change in VISA-P Score from Baseline to 12 Weeks in the Final Analyzed Sample

Group	n	Mean change, points	95% CI	Between-group mean difference, points	95% CI	p-value	Cohen's d
PRP	30	36.7	33.1 to 40.3	14.8	9.9 to 19.7	<0.001	1.56
Corticosteroid	30	21.9	18.4 to 25.4	—	—	—	—

PRP, platelet-rich plasma; VISA-P, Victorian Institute of Sport Assessment–Patella; CI, confidence interval. Between-group comparison: independent-samples test. Positive differences favor PRP. Statistical significance: $p < 0.05$.

Table 4. Between-Group Differences in VISA-P Scores at Follow-up

Follow-up	n per group	Mean difference, points	95% CI	p-value	Cohen's d
4 weeks	30	−9.4	−12.9 to −5.9	<0.001	−1.39
12 weeks	30	14.2	9.6 to 18.8	<0.001	1.60

VISA-P, Victorian Institute of Sport Assessment–Patella; CI, confidence interval. Mean differences are calculated as PRP minus corticosteroid; negative values favor corticosteroid and positive values favor PRP. Between-group comparison: independent-samples test. Statistical significance: $p < 0.05$.

Table 5. Reported Between-Group Comparisons for Secondary Outcomes

Outcome	Follow-up	p-value
Activity-related pain VAS	4 weeks	<0.001
Activity-related pain VAS	12 weeks	<0.001
Quadriceps strength	4 weeks	0.001
Quadriceps strength	12 weeks	0.002

VAS, Visual Analog Scale. Between-group comparisons: independent-samples t tests. Statistical significance: $p < 0.05$.

The direction of the between-group VISA-P difference changed over follow-up. At 4 weeks, the PRP group had a mean VISA-P score 9.4 points lower than the corticosteroid group (95% CI −12.9 to −5.9; $p < 0.001$; Cohen's d = −1.39), indicating an early advantage for corticosteroid treatment. By 12 weeks, the direction had reversed, with the PRP group having a mean VISA-P score 14.2 points higher than the corticosteroid group (95% CI 9.6 to 18.8; $p < 0.001$; Cohen's d = 1.60).

Secondary outcomes followed a similar temporal pattern. At 4 weeks, the corticosteroid group had lower activity-related pain scores ($p < 0.001$) and greater quadriceps strength ($p = 0.001$) than the PRP group. At 12 weeks, the direction of these comparisons had reversed, with lower activity-related pain ($p < 0.001$) and greater quadriceps strength ($p = 0.002$) in the PRP group.

DISCUSSION

The present randomized controlled trial demonstrated different temporal patterns of clinical response to leukocyte-rich platelet-rich plasma and corticosteroid injection in adolescent athletes with chronic patellar tendinopathy. Corticosteroid treatment was associated with a more favorable early response at 4 weeks, whereas the PRP group demonstrated greater functional improvement by 12 weeks, together with lower activity-related pain and greater quadriceps strength at the later assessment. Both groups nevertheless showed improvement from baseline. These findings address the primary study objective by suggesting that the relative clinical benefit of the two injection strategies depends importantly on the timing of outcome assessment rather than being uniform throughout recovery.

The greater 12-week functional outcome observed with PRP is broadly consistent with previous literature evaluating PRP for patellar tendinopathy, although the published evidence has been heterogeneous across preparations, comparators, rehabilitation protocols, and follow-up periods. Previous randomized and synthesized evidence has suggested potential improvement in tendon-related symptoms and function following PRP treatment, but the magnitude and consistency of benefit have varied substantially between studies (11,12). Such variability is clinically relevant because PRP is not a uniform biological intervention; platelet concentration, leukocyte content, preparation technique, injection protocol, and accompanying rehabilitation may all influence the observed response. Consequently, the findings of the present trial should be interpreted as applying specifically to the leukocyte-rich PRP protocol and rehabilitation program evaluated rather than to all PRP formulations.

The early advantage observed with corticosteroid injection followed by a less favorable relative outcome at 12 weeks is also compatible with the broader pattern reported for corticosteroid treatment of tendinopathy, in which rapid symptomatic improvement may not necessarily persist over longer follow-up periods (13). Corticosteroids can reduce local inflammatory signaling and pain-related responses relatively rapidly, which may explain the favorable early clinical trajectory. Chronic tendinopathy, however, involves complex alterations in tendon matrix organization and load tolerance rather than a purely inflammatory disorder, and suppression of inflammatory pathways does not necessarily address all components of the underlying condition. The present study did not assess tendon histology or structural change; therefore, the divergence between groups should be interpreted as a difference in clinical outcomes rather than evidence of steroid-induced degeneration or PRP-mediated structural regeneration.

A delayed clinical response to PRP is biologically plausible because platelet-derived mediators have been proposed to influence cellular signaling, extracellular matrix turnover, angiogenesis, and tissue-repair processes over time. Literature concerning autologous PRP in patellar tendinopathy, including work focused on younger populations, has discussed these potential biological effects, while experimental and clinical studies of leukocyte-rich preparations have also suggested that an initial inflammatory response may precede subsequent remodeling processes (14,15). Nevertheless, these mechanisms were not directly evaluated in the present trial. No serial ultrasonography, magnetic resonance imaging, elastography, biochemical marker assessment, or histological evaluation was performed after treatment.

The superior 12-week VISA-P, pain, and strength outcomes in the PRP group should therefore be regarded as clinical findings and not as direct evidence of tendon regeneration.

The common eccentric rehabilitation program provided to both treatment groups is an important component of interpreting these findings. Progressive loading remains a key element in the management of patellar tendinopathy, and randomized evidence has demonstrated the importance of structured tendon-loading exercise in improving symptoms and function (16). Because both groups received the same planned six-week rehabilitation program, the trial compared two injection strategies delivered alongside active rehabilitation rather than injection therapy in isolation. This distinction is important clinically, as the results should not be interpreted as evidence that PRP can replace progressive loading rehabilitation. Furthermore, two participants in the corticosteroid group were excluded from the final analysis because of rehabilitation non-compliance, making adherence a potentially relevant source of bias. Future studies should report quantitative adherence data and, ideally, analyze all randomized participants according to their assigned groups.

The assessor-blinded randomized design and concealed allocation represent important methodological strengths. Randomization reduced systematic baseline differences between treatment groups, while allocation concealment helped limit selection bias. Ultrasound guidance was used for both injection procedures, and the same follow-up schedule, outcome measures, and rehabilitation framework were applied across groups. The use of VISA-P provided a condition-specific measure of symptoms and sport-related function, while assessment of activity-related pain and quadriceps strength provided complementary clinical information. The convergence of the 12-week findings across functional, pain, and strength outcomes strengthens the evidence that the treatment groups followed different clinical trajectories.

Several potential sources of bias nevertheless require consideration. Participants and the treating clinician could not be blinded because of the visibly different treatment preparations. This is particularly relevant because VISA-P and pain scores depend substantially on participant-reported symptoms and therefore may be influenced by treatment expectations. Methodological evaluations of PRP trials have emphasized the difficulty of maintaining effective blinding when biological preparations are compared with visibly distinct interventions (17). Although assessor blinding reduced detection bias for investigator-administered assessments, it could not eliminate expectation effects affecting patient-reported outcomes.

Safety and longer-term effectiveness also cannot be established from the current study. Concerns regarding local corticosteroid exposure and tendon integrity have been discussed in the tendinopathy literature, including reports of tendon rupture after local corticosteroid administration (18). However, the present trial was not designed or powered to compare uncommon adverse events and followed participants for only 12 weeks. Similarly, recurrence, reinjury, sustained return to competitive sport, subsequent treatment requirements, and structural tendon integrity were not assessed. It would therefore be inappropriate to infer from the present findings that PRP prevents recurrence, reduces tendon-rupture risk, or provides greater long-term safety than corticosteroid treatment.

The study has additional limitations. Four of the 64 randomized participants were not included in the final outcome analysis, resulting in a complete-case analysis of 60 participants rather than a full intention-to-treat analysis. Although attrition was numerically small and balanced between treatment groups, the reasons differed between groups, with relocation accounting for the two PRP losses and rehabilitation non-compliance accounting for the two corticosteroid exclusions. Post-randomization exclusion based on adherence may introduce attrition bias and should be considered when interpreting the treatment effect. The relatively small sample was recruited from a single metropolitan region, limiting the precision and broader generalizability of the findings across different sports, training levels, healthcare environments, and adolescent populations. The 12-week follow-up period was sufficient to demonstrate differing early and intermediate clinical trajectories but was insufficient to determine whether these differences persist over the longer term.

Another limitation was the absence of longitudinal structural imaging. Quantitative ultrasonography, shear-wave elastography, or magnetic resonance-based assessment could help determine whether changes in symptoms and function are accompanied by changes in tendon morphology or mechanical properties (19). Such measurements would be particularly valuable when investigating a treatment proposed to influence biological remodeling. Future trials should therefore combine validated clinical outcomes with longitudinal imaging, longer follow-up, systematic adverse-event surveillance, rehabilitation-adherence measurements, and return-to-sport outcomes.

The findings also reinforce the importance of integrating injection treatment with a standardized rehabilitation strategy rather than viewing injection as a stand-alone intervention. Structured rehabilitation after PRP treatment has been emphasized as an important component of clinical management for patellar tendinopathy (20). Larger multicenter randomized trials should evaluate whether the observed 12-week advantage persists at 6, 12, and 24 months and should directly compare different PRP formulations, including leukocyte-rich and leukocyte-poor preparations. Such trials should use prespecified intention-to-treat analyses and include recurrence, return to sport, treatment-related adverse events, and structural tendon outcomes. Within the limitations of the present trial, the findings support a clinically meaningful difference in the timing of response to the two interventions, with corticosteroid producing the more favorable early outcome and PRP demonstrating the more favorable clinical profile at 12 weeks.

CONCLUSION

In adolescent athletes with chronic patellar tendinopathy receiving a standardized eccentric rehabilitation program, corticosteroid injection was associated with a more favorable early clinical response at 4 weeks, whereas leukocyte-rich platelet-rich plasma was associated with greater improvement in tendon-related function and more favorable pain and quadriceps-strength outcomes at 12 weeks. These findings suggest that the comparative clinical response to the two injection strategies differs over time, with PRP providing the more favorable 12-week outcome under the treatment protocol evaluated.

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