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Investigating the Therapeutic Impact of Platelet-rich Plasma on Knee, Hip, and Traumatic Osteoarthritis: A Meta-analysis and Systematic Review

Running title: Platelet-rich Plasma and Osteoarthritis

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Abstract

Objective: This study aims to assess the therapeutic effectiveness and safety of platelet-rich plasma (PRP) in the management of primary and posttraumatic osteoarthritis (OA) patients.

Methods: A comprehensive literature search was conducted in the following databases: PubMed, Embase, Web of Science, Cochrane Library, China National Knowledge Infrastructure (CNKI), VIP database, Wanfang Database, and China Biology Medicine Disc for all double-blind randomized controlled trials (RCTs) on the use of PRP in TOA until November 2025. The data extraction and quality assessment were carried out independently by two researchers. The RevMan5.4 statistical software was used to perform a meta-analysis of the data that met the inclusion criteria.

Results: Eleven RCTs involving 851 participants were included. PRP injection resulted in a significant improvement in the WOMAC Total score compared to control treatments in primary OA (SMD: -8.53; 95% CI: -14.52 to -2.55; p = 0.005). Subgroup analyses revealed that this benefit was significant in patients younger than 60 years and with both single and double-dose regimens. However, no significant overall effects were observed for the WOMAC Pain, WOMAC Stiffness, VAS, or KOOS subscales. PRP was associated with more transient adverse events, primarily injection-site reactions.

Conclusions: Intra-articular PRP injection is an effective treatment for improving overall function in patients with primary OA, particularly in younger individuals. While it demonstrates a acceptable safety profile, its effects on specific pain and quality-of-life

measures require further investigation.

Keywords: Platelet-rich plasma (PRP); Traumatic osteoarthritis (TOA); Pain; Function; Randomized double-blind controlled trial; Meta-analysis

Introduction

Osteoarthritis (OA) is a chronic, progressive joint disorder characterized by cartilage degradation, synovial inflammation, subchondral bone remodeling, and functional impairment [1]. It represents one of the leading causes of pain and disability worldwide and imposes a substantial burden on individuals, healthcare systems, and society [2]. Although the knee and hip are most commonly affected, OA can involve any synovial joint and manifests clinically with pain, stiffness, swelling, reduced range of motion, and limitations in daily functioning [3]. The etiology of OA is multifactorial—encompassing age-related degeneration, mechanical overload, metabolic factors, obesity, and previous joint trauma—resulting in diverse clinical presentations and variable progression rates [3]. Among these contributing factors, joint trauma plays a particularly important role. Traumatic osteoarthritis (TOA), a form of secondary OA, develops following injuries such as meniscal tears, ligament ruptures, patellar dislocations, or intra-articular fractures [4]. These traumatic events can disrupt joint alignment, alter mechanical loading patterns, and trigger inflammatory cascades that accelerate cartilage breakdown [5]. Patients also experience limitations in their normal behavior and activities, characterized clinically by joint deformity, swelling, and the presence of active frictional sounds [6]. Currently, non-surgical treatment is advised for patients with mild symptoms, while surgical intervention, such as joint debridement and fusion, is necessary for those with severe symptoms or who have not responded to conservative therapy [7]. Yet, total knee arthroplasty (TKA) is more appropriate for elderly patients with limited mobility needs [7]. Traumatic osteoarthritis

(TOA) presents as a degenerative joint condition characterized primarily by osteoarthritic pain and functional limitations. Conservative treatments such as functional exercises, physical therapy, nonsteroidal anti-inflammatory drugs (NSAIDs), and intra-articular hyaluronic acid (HA) injections are recommended [8].

Currently, platelet-rich plasma (PRP) has demonstrated the potential to enhance the prognostic effectiveness and safety for elderly patients with slow healing abilities [9]. PRP is a platelet concentrate isolated from whole blood using a centrifugal method [10]. Following activation, various types of cell growth factors and inflammatory regulatory factors can be released, contributing positively to maintaining the metabolic balance of articular cartilage [11, 12]. Drawing upon numerous foundational studies and results from animal experiments, the intra-articular injection of autologous PRP has been implemented in the clinical treatment of TOA [13, 14]. However, in terms of both efficacy and safety of PRP, many clinical studies have not arrived at entirely consistent conclusions [9, 15, 16]. In 2013, the American Medical Association, for the first time, investigated the therapeutic effects of PRP in its TOA treatment guidelines, ultimately neither endorsing nor rejecting it, thus leaving the recommendation level uncertain[17]. However, the evidence sources for this guideline consisted solely of case-control studies conducted before 2012 and one randomized controlled trial (RCT) [17]. In recent years, multiple meta-analyses have examined the effectiveness of PRP in treating OA [18-20]. However, methodological limitations in previous syntheses—particularly the inclusion of non-randomized studies, uncontrolled trials, and heterogeneous patient populations with mixed osteoarthritis

etiologies—have potentially compromised the reliability and clinical applicability of their findings [18-20].

This study systematically reviewed the available clinical evidence on intra-articular PRP injections to determine their therapeutic value. The objectives of this review were: (1) to evaluate the efficacy of intra-articular PRP across primary and post-traumatic OA populations; (2) to compare PRP with commonly used conservative treatments; and (3) to assess the safety profile of PRP based on reported adverse events.

Materials and Methods

The present investigation followed the principles outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [21].

Search Strategy

A comprehensive and up-to-date literature search was conducted in the following databases from their inception to November 2025: PubMed, Embase, Web of Science, the Cochrane Library, China National Knowledge Infrastructure (CNKI), Wanfang Data, the VIP Database, and the China Biology Medicine Disc (CBM). The search strategy combined MeSH/Emtree terms and free-text keywords relating to traumatic osteoarthritis (TOA) and platelet-rich plasma (PRP). The updated search terms included: ("traumatic osteoarthritis" OR "post-traumatic osteoarthritis" OR "post-traumatic arthritis" OR "knee injury" OR "hip injury" OR "ACL reconstruction" OR "intra-articular trauma") AND ("platelet-rich plasma" OR "PRP") AND ("randomized controlled trial" OR "double-blind" OR "triple-blind"). The reference lists of all eligible studies and relevant reviews were manually

screened to identify additional eligible trials. Two reviewers independently screened the titles, abstracts, and full texts, with any discrepancies resolved by consensus or by a third evaluator.

Literature criteria

After completing the searches, two authors independently reviewed the titles and abstracts of the identified articles to exclude any clearly irrelevant ones. Subsequently, the full texts of the remaining articles were retrieved, and all relevant studies were identified using this approach. This meta-analysis included studies that met the following criteria(1) PRP was administered via intraarticular injection; (2) Patients were diagnosed with TOA; (3) Randomized controlled clinical trials.

Studies were excluded if they met any of the following criteria: (1) PRP administered in conjunction with surgery; (2) Absence of a control group without PRP; (3) Incomplete literature data (such as solely conference abstracts); (4) Duplicate literature; (5) Non-randomized controlled studies and retrospective studies; (6) Presence of obvious errors in the data and incomplete relevant information.

Data Extraction

Two researchers independently extracted the data, and any disagreements were resolved through consultation. In instances where data were not available, we reached out to the corresponding author via email to request the required information. The following particulars were extracted from each included study: the name of the first author, publication year, study location, study duration, participant demographics including mean

age and mean body mass index (BMI), K-L Grade, clinical indicators of the study population, and sample size in each group.

When multiple osteoarthritis scores were collected in the research and were integral to the analysis, priority was given to the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the Osteoarthritis Research Society International (OARSI) score. Supplementary scores such as the Knee Injury and Osteoarthritis Outcome Score (KOOS), visual analog scores (VAS), and adverse events (AEs) were selected in that order. Furthermore, adverse reactions from each study were identified, analyzed, and used to compute the relative risk. In investigations with multiple treatment groups, the group demonstrating superior efficacy was chosen for quantitative analysis.

Data Synthesis

All statistical analyses were performed using STATA software. Standardized mean differences (SMDs) with corresponding 95% confidence intervals were calculated, and a random-effects model was applied to account for methodological and clinical variability across studies, including differences in PRP preparation protocols and outcome measures. Heterogeneity among the included studies was evaluated using the I^2 statistic. Pre-specified subgroup analyses were conducted based on age (<60 vs ≥60 years), PRP injection frequency (single, two-dose, or three-dose regimens), and population type (knee vs hip osteoarthritis). To assess the robustness of the pooled estimates, leave-one-out sensitivity analyses were performed for all major outcomes. The evaluated outcome measures included WOMAC (pain, stiffness, function, and total scores), KOOS (pain, symptoms,

activities of daily living, sport/recreation, and quality of life), and VAS pain intensity. All outcomes were analyzed using the latest available follow-up time point reported in each study (ranging from 1 to 12 months).

Quality assessment

Following the Cochrane bias risk assessment criteria [22], two investigators independently evaluated the literature included in the study. If a paper demonstrated low risk bias across each of the six items outlined in the criteria, it was categorized as having low bias risk. However, if high-risk bias or uncertainty was observed in one or two items, the literature was classified as moderately biased. If more than two items exhibited high risk bias or uncertainty, the literature was deemed highly biased. Furthermore, the modified Jadad scale was employed to classify randomized controlled trials (RCTs), scoring 0-3 as low-quality studies and 4-7 as high-quality studies [23]. In instances where the two researchers held differing opinions, a third investigator participated in the discussion, and a final decision was reached through consensus.

Result

Literature search and screening results

The initial search yielded 4236 articles, which decreased to 1926 after eliminating duplicates. Out of these, 2310 articles were excluded based on the inclusion criteria, leaving 187 articles for full-text screening. Following this assessment, 176 articles lacking sufficient information, including unrelated titles and abstracts (n=141), animal studies (n=26), and review articles (n=9), were excluded. Consequently, 11 studies meeting all inclusion criteria were included in the meta-analysis and systematic review. The search process and study selection are visually depicted in **Figure 1**, utilizing the PRISMA flow diagram.

Study Characteristics

Overall, 11 studies, with 851 participants (425 cases and 426 controls), were included. The included studies were published between 2013 and 2024. The follow-up period ranged from 1 to 12 months.The age range of participants encompassed individuals aged 52.64 to 72.49 years. The included cases' imaging K-L scale ranged from grade I to IV. The studies were conducted across various countries, including Brazil [24], Italy [25, 26], India [27, 28], Iran [29-31], Ukraine [32], Australia [33], and the USA [34]. The control groups

received interventions such as hyaluronic acid (HA), normal saline (NS), corticosteroids, or prolotherapy. **Table 1** summarizes the characteristics of the nine studies included in the meta-analysis and systematic review.

Results of systematic review

Among the studies assessing post-traumatic osteoarthritis, Havryliuk et al. (2019) provided detailed VAS outcomes over a 48-week follow-up period. A total of 62 participants—32 receiving PRP and 30 receiving standard conservative management—underwent three intra-articular PRP injections. In the PRP group, the baseline VAS score was 4.56 (SD=0.27), decreasing markedly to 1.21 (SD=0.25) at the final assessment, corresponding to a mean reduction of −3.35 (SD=0.17). In contrast, the control group showed only a modest reduction, from 4.63 (SD=0.28) to 3.73 (SD=0.21), yielding a mean change of −0.90 (SD=0.17). Each PRP administration consisted of 4 mL of autologous product, and all participants had clinically confirmed post-traumatic osteoarthritis [32].

Across the trauma-related trials, consistent trends of improvement were observed in KOOS Pain scores following PRP therapy. In Baria et al. (2022) [34], KOOS Pain increased from 50.9 to 80.38 (change: 29.48) in the PRP group, closely mirroring the 30.13-point improvement in the control group. In the randomized trial by Mirco Lo Presti et al. (2024) [26], the PRP group improved from 62.5 to 92.9 (change: 30.4), whereas the control group improved by 26.3 points. Similarly, Havryliuk et al. (2019) reported a substantial increase from 47.22 to 76.82 (change: 29.6) in the PRP group, compared with only a 0.56-point change in the control group.

Parallel patterns were noted in KOOS Symptoms scores. Baria et al. documented improvements of 22.46 (PRP) versus 25.73 (control), while Lo Presti et al. observed comparable gains (21.9 vs. 21.4). Havryliuk et al., however, reported a striking difference, with an increase of 29.17 in the PRP group compared with only 2.82 in controls. KOOS ADL subscale scores improved across all studies, with changes of 28.75 vs. 26.74 (Baria et al.), 21.2 vs. 21.5 (Lo Presti et al.), and 21.32 vs. 5.52 (Havryliuk et al.).

For KOOS Sport/Recovery, Baria et al. reported changes of 36.29 (PRP) versus 37.36 (control), while Lo Presti et al. found improvements of 33.1 vs. 24.8. The largest differential appeared in Havryliuk et al., with increases of 42.1 in the PRP group compared with 2.95 in the control group. Finally, KOOS QoL scores showed numerical gains in all studies: Baria et al. reported improvements of 32.26 vs. 37.89, Lo Presti et al. reported 39.6 vs. 41.0, and Havryliuk et al. noted a substantial contrast of 48.95 vs. 4.0. Collectively, all trauma-focused studies demonstrated meaningful improvements across multiple KOOS domains following PRP administration, though the magnitude of benefit varied between trials.

Results of Meta-analysis

WOMAC scores

Five studies [24, 27, 29-31] including 274 participants (138 cases and 136 controls), assessed WOMAC scores. The meta-analysis for the WOMAC Total score showed that PRP injection was associated with a significant improvement in functional outcomes (SMD: -8.53; 95% CI: -14.52 to -2.55; $p = 0.005$). A high level of heterogeneity was

observed among the studies (I2=89.5%) (**Fig 2a**). Subgroup analyses identified age as a significant effect modifier, with patients under 60 years showing superior improvement (p = 0.005; **Sup Fig S1**). Both single-dose and two-dose PRP regimens demonstrated significant efficacy (**Sup Fig S2**), while consistent therapeutic benefits were observed across joint types, including both hip (p = 0.001) and knee (p = 0.017) osteoarthritis (**Sup Fig S3**).

WOMAC Pain Subscale

Analysis of the WOMAC pain subscale across six studies showed no significant overall treatment effect for PRP (SMD = –0.06; 95% CI: –0.50 to 0.38; p = 0.758) (**Fig 2b**) [24, 25, 27, 29-31]. Subgroup analyses by joint involvement revealed no significant pain improvement in either hip OA (p = 0.426) or knee OA (p = 0.077) populations (**Sup Fig S4**). However, significant pain improvement was observed in patients younger than 60 years (**Sup Fig S5**) and with both single-dose and triple-dose PRP regimens (**Sup Fig S6**).

WOMAC Function Subscale

Analysis of the WOMAC function subscale demonstrated a non-significant overall treatment effect (SMD: -3.40; 95% CI: -7.39 to 0.59; p = 0.095) (**Fig 3a**). However, subgroup analyses revealed protocol-dependent efficacy, with significant functional improvement observed specifically in knee OA (p = 0.001; **Sup Fig S7**) and with three-dose PRP regimens (p = 0.046; **Sup Fig S8**). Significant functional improvement was exclusively observed in patients younger than 60 years (p = 0.002; **Sup Fig S9**).

WOMAC Stiffness Subscale

Analysis revealed no significant overall improvement in joint stiffness (SMD: 0.81; 95% CI: -3.09 to 4.71; p = 0.684) (**Fig 3b**). However, subgroup analyses showed significant reduction in stiffness with triple-dose PRP regimens (p < 0.001; **Sup Fig S10**) and among knee OA patients (p = 0.048; **Sup Fig S11**). No significant benefits were found when analyzed by age subgroups (**Sup Fig S12**).

VAS score

The meta-analysis of VAS scores across six studies revealed no significant overall treatment effect for PRP in pain reduction (SMD: 0.47; 95% CI: -12.48 to 13.43; p = 0.943) (**Fig 4a**) [24, 25, 27-30]. The heterogeneity test revealed significant heterogeneity (I2=100%). Subgroup analyses demonstrated no significant differences in treatment efficacy based on age stratification (**Sup Fig S13**), joint involvement (**Sup Fig S14**), or PRP dosing regimens (**Sup Fig S15**).

KOOS Pain Subscale

The meta-analysis of two studies assessing the KOOS Pain subscale demonstrated no statistically significant treatment effect for PRP therapy (SMD: -0.12; 95% CI: -0.80 to 0.57; p = 0.828) (**Fig 4b**) [24, 33].

KOOS Symptoms Subscale

Analysis of the KOOS Symptoms subscale across three included trials revealed no significant difference between the PRP and control groups (SMD: -0.12; 95% CI: -0.10 to 0.34; p = 0.933) (**Fig 5a**) [24, 33].

KOOS ADL Subscale

For the Activities of Daily Living (ADL) subscale, the pooled results from two studies showed no significant functional improvement with PRP treatment (SMD: -0.02; 95% CI: -0.36 to 0.31; p = 0.662) (**Fig 5b**) [24, 33].

KOOS Sport/Rec Subscale

The analysis of the Sport and Recreation function subscale indicated no significant benefit from PRP intervention (SMD: -0.02; 95% CI: -0.24 to 0.19; p = 0.674) (**Fig 6a**) [24, 33].

KOOS QoL Subscale

The meta-analysis of the Quality of Life (QoL) subscale showed no significant treatment effect for PRP (SMD: 0.0; 95% CI: -0.44 to 0.044; p = 0.572) (**Fig 6b**) [24, 33].

Adverse event

Two included studies (Bennell et al. and Dório et al.) consistently reported a greater incidence of adverse events in the PRP intervention groups. These events were typically transient and localized, predominantly consisting of injection-site reactions such as pain, swelling, and erythema. While no serious treatment-related adverse events were reported [24, 33].

Sensitivity analysis

Sensitivity analysis was performed for all outcome measures by systematically excluding each study sequentially. The results demonstrated that the overall effect estimates remained stable and consistent across all analyses. For none of the outcomes did the exclusion of any single study materially alter the statistical significance or direction of the pooled results, confirming the robustness of our findings.

Quality assessment

All the included studies were double-blind RCTs and evaluated using bias risk assessment tools [22]. Using the Cochrane Risk of Bias tool, the evaluation revealed that seven studies maintained low risk of bias across key domains [24-29, 31], while four studies raised some concerns [30, 32-34], primarily due to issues in blinding procedures and allocation concealment (**sup fig 16).**

Discussion

The present systematic review and meta-analysis synthesized evidence from nine randomized controlled trials evaluating the therapeutic effects of PRP in patients with hip or knee osteoarthritis or post-traumatic osteoarthritis . PRP demonstrated a significant improvement only in the WOMAC Total score, whereas no statistically significant effects were observed for WOMAC pain, stiffness, or function subscales, nor for KOOS domains or VAS pain scores. These findings underscore the complexity of PRP's therapeutic role and highlight the importance of considering patient characteristics, dosing protocols, and joint type when interpreting treatment outcomes.

The significant improvement in the WOMAC Total score suggests that PRP may provide global functional benefits rather than isolated improvements in specific dimensions such as pain or stiffness. This pattern aligns with the biological rationale of PRP, which involves modulation of joint homeostasis, stimulation of cartilage repair processes, and reduction of inflammatory mediators. Such mechanisms may yield gradual and multidimensional improvements that are better captured by composite indices like WOMAC Total. However, the lack of significant effects on individual subdomains, particularly pain, contrasts with earlier trials reporting meaningful short-term analgesic benefits. One plausible explanation is the high heterogeneity in PRP preparation methods—including leukocyte concentration, platelet counts, activation protocols, and injection volumes—which likely influenced between-study variability and diluted the effect sizes in pooled analyses.

Subgroup analyses provided important insights into factors modifying PRP responsiveness.

Age emerged as a key determinant, with patients younger than 60 years showing significant improvements across multiple outcomes, including WOMAC Total, pain, and function. This age-dependent response likely reflects greater regenerative capacity, healthier cartilage matrix, and more active tissue repair mechanisms in younger individuals. Similarly, dosing frequency substantially affected treatment outcomes. Contrary to expectations, single-dose and two-dose PRP regimens produced stronger effects than multiple-dose protocols for several WOMAC domains. Excessive or repeated PRP injections may alter the balance of growth factors or contribute to joint irritation, potentially diminishing therapeutic benefit. This finding highlights the need for optimized, evidence-based dosing strategies, an area currently lacking standardization in clinical practice.

Joint type also influenced treatment response. While PRP significantly improved WOMAC Total scores in both knee and hip osteoarthritis, functional and pain-related improvements were more prominent in knee OA. This difference may be related to biomechanical factors, joint accessibility, and variability in PRP retention within the synovial environment. Hip OA, with its deeper joint space and more advanced structural degeneration at diagnosis, may respond less predictably to intra-articular biologic therapies.

Importantly, despite the expectation that PRP would reduce pain intensity, the pooled VAS results demonstrated no significant benefit, even in subgroup analyses. The extremely wide confidence intervals and high heterogeneity suggest substantial inconsistency among studies. Variations in comparator interventions, particularly the inclusion of corticosteroid

and hyaluronic acid controls, may have contributed to these inconsistent pain outcomes. Corticosteroids, for example, exhibit potent but short-lived analgesic effects that could mask or overshadow PRP's gradual mechanism of action in short-term follow-up assessments.

Studies have indicated that PRP can effectively reduce pro-inflammatory factors including IL-1β, IL-6, and TNF-α in synoviocytes, while simultaneously suppressing matrix metalloproteinase expression in chondrocytes, thereby mitigating inflammatory responses and promoting synovial tissue proliferation and cartilage protection [35]. The therapeutic efficacy of PRP primarily stems from its high concentration of platelets containing abundant growth factors such as transforming growth factor beta (TGF-β), platelet-derived growth factor (PDGF), and fibroblast growth factor (FGF) [35-37]. Upon activation, these growth factors bind to transmembrane receptors on target cells, initiating cellular proliferation, matrix formation, collagen synthesis, and ultimately facilitating tissue repair [38]. Additionally, PRP exhibits antibacterial properties that may reduce infection incidence [39], while its relatively high white blood cell concentration further contributes to infection prevention [40].

The findings from the trauma-focused studies included in the systematic review provide additional insight into the potential role of PRP in post-injury osteoarthritis, revealing improvement patterns that are broadly consistent with, yet distinct from, those observed in primary OA populations. Across all trauma-related trials, PRP was associated with substantial reductions in pain intensity, as reflected by the large VAS decrease reported by

Havryliuk et al., alongside consistent numerical gains across multiple KOOS domains. Although the magnitude of improvement varied among studies, the convergence of pain, symptom, and functional enhancements—including KOOS Pain, Symptoms, ADL, Sport/Recovery, and QoL—suggests that PRP may confer clinically meaningful benefits in patients with joint degeneration following trauma or meniscal injury. Notably, studies such as those by Havryliuk and Lo Presti demonstrated larger between-group differences than those observed in Baria et al., which may be attributable to variations in study design, treatment protocols, comparator interventions, chronicity of trauma, and baseline functional status. These differences highlight the heterogeneous nature of post-traumatic OA and indicate that treatment response may depend on factors such as injury mechanism, residual joint pathology, and biological healing capacity. Taken together, the systematic evidence suggests that PRP has the potential to improve pain and functional outcomes in traumatic OA, although the variability across trials underscores the need for rigorously designed, adequately powered RCTs that specifically target well-defined post-traumatic phenotypes to clarify the consistency, durability, and comparative effectiveness of PRP in this distinct patient population.

Current conservative management strategies for TOA typically include intra-articular injections of hyaluronic acid and glucocorticoids, alongside oral non-steroidal anti-inflammatory drugs (NSAIDs) [29]. However, these conventional approaches face limitations including potential toxicity, side effects, and inability to halt the progression of articular cartilage degeneration [41]. In contrast, PRP offers several distinct advantages. Its

autologous nature eliminates risks of immune rejection and disease transmission, and since cytokines act on cell membranes rather than directly affecting nuclear gene expression, this further ensures clinical safety [42]. Particularly in TOA, where articular cartilage destruction occurs alongside surrounding soft tissue inflammation, PRP's cytokine release effectively counteracts inflammatory cytokines such as IL-1 and TNF, suggesting its potential as a viable treatment alternative [43].

Despite promising mechanisms and advantages, PRP therapy remains contentious in clinical practice. Significant challenges persist, including the lack of long-term comprehensive research regarding adverse reactions such as pain and swelling following PRP injection. Substantial variations in PRP injection protocols regarding dosage, timing, frequency, and technique among patients at different stages of cartilage degeneration further complicate standardized efficacy and safety assessments. Substantial variations in PRP injection protocols regarding dosage, timing, frequency, and technique among patients at different stages of cartilage degeneration further complicate standardized efficacy and safety assessments. Although current evidence suggests that PRP injection safety profiles are generally favorable with primarily self-limited adverse events like pain and swelling, and while overall clinical benefits may be time-limited (typically lasting less than one year), potential cyclic treatment applications might prolong therapeutic effects [44-46].

Our review boasts several strengths, including an exhaustive search across various electronic search engines and topic-specific databases, blinded duplicate evaluation of the methodological quality of included studies conducted independently by two review

authors, meta-analysis, and aggregated summary estimates for the outcomes. Additionally, subgroup analysis was performed considering various factors that could influence the association between PRP and the outcome, and a comprehensive summary of the body of evidence was provided using the Cochrane approach for each outcome.

Despite the strengths of the present work, several important limitations should be considered. First, substantial methodological and clinical heterogeneity remained across the included studies, largely due to variations in PRP preparation techniques, injection frequency, follow-up duration, and the type of comparator used. Second, although the updated search strategy included an explicit focus on post-traumatic osteoarthritis, only a small number of trauma-related studies were eligible, and none consisted of RCTs exclusively enrolling post-traumatic OA patients. As a result, most pooled analyses were based on general knee and hip OA populations, which limits the ability to extrapolate findings to the unique biological and structural profile of trauma-induced OA. Third, several trials had modest sample sizes, reducing precision and increasing the likelihood of small-study effects. Finally, PRP preparation methods—which play a critical role in determining therapeutic efficacy—were inconsistently described across studies, preventing identification of an optimal preparation or dosing strategy. Future rigorously designed RCTs, particularly those targeting clearly defined post-traumatic OA cohorts, are needed to address these gaps.

Conclusion

PRP therapy demonstrates modest overall functional benefits, particularly reflected in

improvements in WOMAC Total scores, with more pronounced effects in younger patients and those with knee osteoarthritis. However, when the evidence is separated by etiology, it becomes clear that the current body of high-quality randomized trials primarily represents primary OA, whereas data for post-traumatic OA remain limited to a small number of heterogeneous clinical studies that were not initially designed as RCTs. As a result, while PRP may offer symptomatic improvement in TOA—as suggested by the consistently positive trends across KOOS and VAS outcomes in the trauma-focused studies—these findings cannot be generalized confidently due to methodological variability and limited sample sizes. Therefore, strong conclusions regarding PRP efficacy in TOA cannot yet be drawn, and dedicated RCTs targeting clearly defined TOA populations are urgently needed. Future research should prioritize standardized PRP preparation protocols, stratification by OA etiology (primary vs. post-traumatic), and uniform reporting to better determine which patients may derive meaningful benefit from PRP therapy.

Declarations

Not applicable.

Authors' contributions

SL and TW designed research; SL and TW conducted research; TW performed statistical analysis; and SL, and TW wrote paper. SL and TW had primary responsibility for final content. All authors have read and approved the final manuscript.

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None

Ethical approval

Ethical approval was not applicable for this systematic review and meta-analysis.

Consent for publication

Not applicable.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

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None.

Conflict of interest

There are no conflicts of interest related to the study design or its results.

Consent to participate: Not applicable. This study is a meta-analysis based on previously published data and did not involve direct participation of human subjects

Clinical trial number: not applicable

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Legend to figure(s):

Figure 1. PRISMA flow diagram of study selection, showing records identified, screened,

excluded, and included in the final meta-analysis.

Figure 2. Forest plot of the pooled effect of PRP versus control on WOMAC Total score (SMD, 95% CI) (a), the effect of PRP on the WOMAC Pain subscale (b).

Figure 3. Forest plot of the pooled effect of PRP on the WOMAC Function subscale (a), effect of PRP on the WOMAC Stiffness subscale (b).

Figure 4a. Forest plot showing the pooled effect of PRP on VAS pain scores (a), pooled effect of PRP on KOOS Pain scores (b).

Figure 5. Forest plot showing the effect of PRP on KOOS Symptoms (a), effect of PRP on KOOS ADL scores (b).

Figure 6. Forest plot of the effect of PRP on KOOS Sport/Rec function (a), pooled effect of PRP on KOOS Quality of Life (b).

Supplementary Figure Legends

S1. Subgroup analysis of WOMAC Total by age group.

S2. Subgroup analysis of WOMAC Total by PRP dosing regimen.

S3. Subgroup analysis of WOMAC Total for knee vs hip OA.

S4. WOMAC Pain subgroup by joint type.

S5. WOMAC Pain subgroup by age.

S6. WOMAC Pain subgroup by PRP dose.

S7. WOMAC Function subgroup by joint type.

S8. WOMAC Function subgroup by PRP dose.

S9. WOMAC Function subgroup by age.

S10. WOMAC Stiffness subgroup by PRP dose.

S11. WOMAC Stiffness subgroup by joint type.

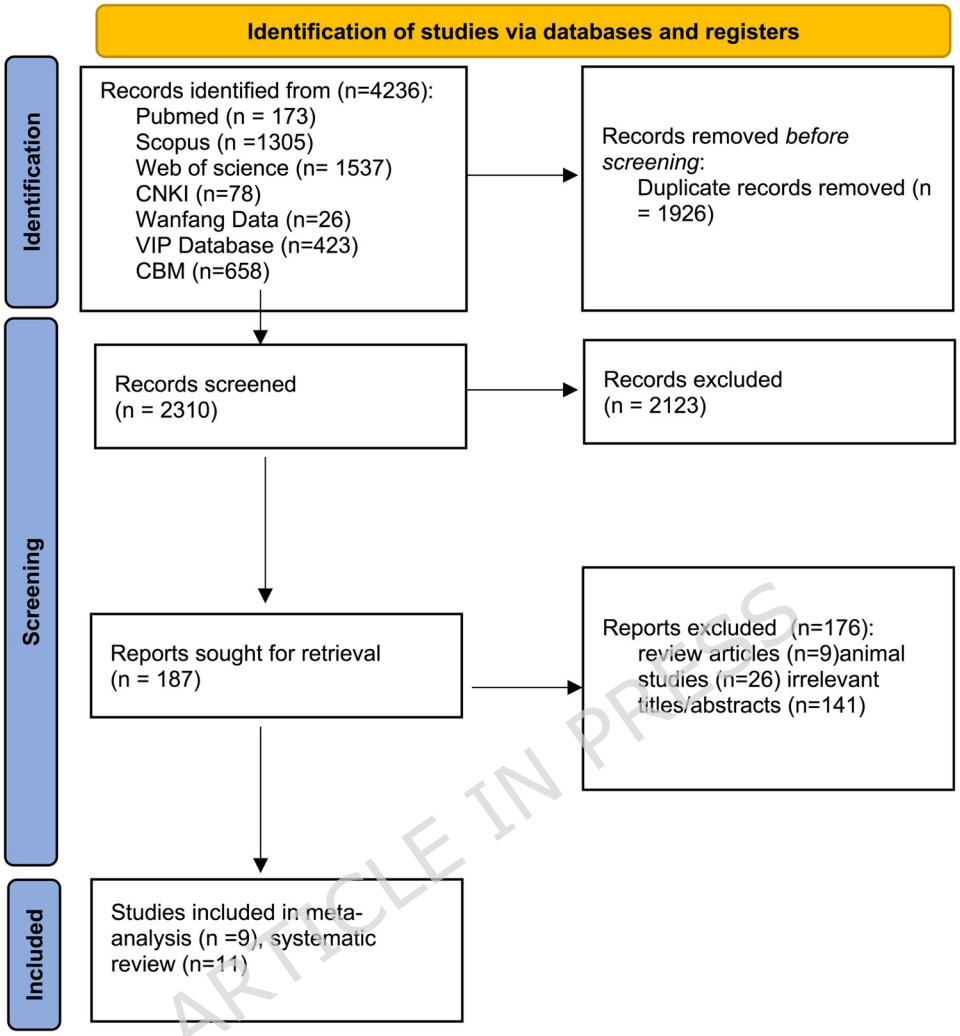
S12. WOMAC Stiffness subgroup by age.

S13. VAS pain subgroup by age.

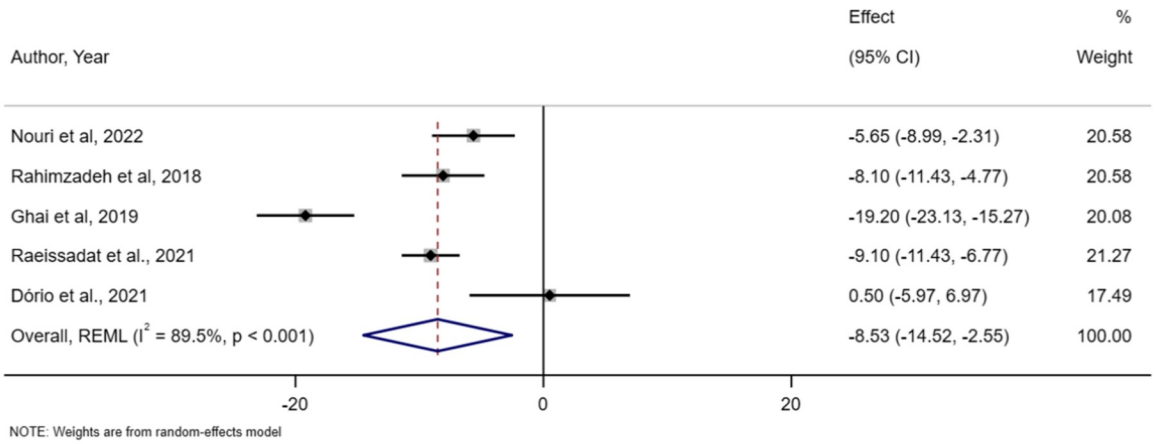
S14. VAS pain subgroup by joint type.

S15. VAS pain subgroup by PRP dose.

S16. Risk of bias assessment diagram (Cochrane tool).

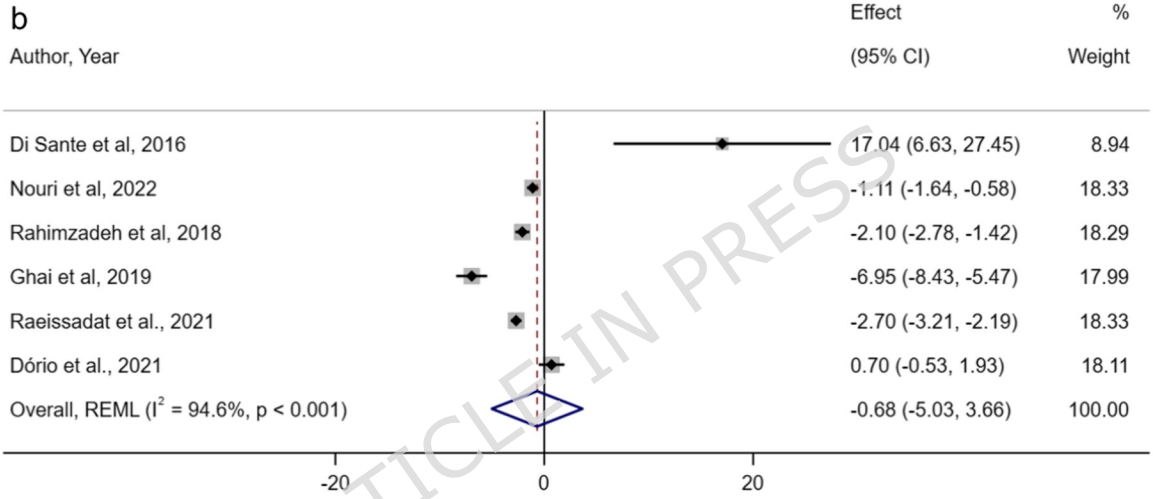


a



NOTE: Weights are from random-effects model

b



NOTE: Weights are from random-effects model