INTRAARTICULAR AUGMENTATION AS AN ADJUVANT POST ACL RECONSTRUCTION : A SCOPING REVIEW

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Abstract

Background: Anterior Cruciate Ligament (ACL) ruptures are integral contributors to all ligamentous knee injuries. The primary management is anterior cruciate ligament reconstruction (ACLR). Despite a high success rate, significant efforts are dedicated to improving healing, functional outcomes, and minimizing complications, including biological augmentation. This scoping review aims to collect, summarize, and investigate the biological modalities commonly utilized as the adjuvant therapy after ACLR.

Methodology: A comprehensive search was conducted for this review in the following databases: Pubmed, Cochrane, and Sciencedirect. The inclusion criteria were all individuals who received ACLR with intraarticular injection of biological augmentation postoperatively. Only articles published between 2016 and 2025 were retained. Injection of PRP, hyaluronic acid and stem cells were included. Reviews and non-original studies were excluded.

Results: Nine studies were selected for review and a descriptive analysis was performed. The most common injection was platelet rich plasma (PRP). The presented data highlighted a lack of consensus regarding the positive impact of adjuvant therapy within existing studies, as determined by the identification of graft maturation and knee functional performance. While the long-term benefits of this method require further study, the short-term effects (such as enhance graft healing, reduce inflammation, and support early functional recovery, and better VAS score) could be assessed comparatively, thus clarifying substance selection.

Conclusion: Despite the favorable safety and efficacy outcomes regarding biological augmentation via intra-articular injection post-ACLR, significant long-term effects failed to demonstrate benefit. Moreover, short-term advantages may vary for each substance. Therefore, further research is vital to unravel the augmentation with the most benefit after ACLR.

Keywords: Anterior Cruciate Ligament Injury; Biological Augmentation; Intra Articular Injection;

1. Main text

1.1. Introduction

The study of biological augmentation techniques for the reconstruction of the anterior cruciate ligament has grown popularity as the incidence regarding knee injuries in athletes and the general populace displayed marked increased, necessitating for prompt surgery(1). Restoring the knee function followed by injury due to ACL reconstruction is an essential part of the surgical procedure, which can be attain through ligament grafting and arthroscopic repair. However, numerous limitations of surgery has been addressed, encompassing long recovery time and complications possibility, including deep vein thrombosis and unsatisfactory healing(2,3).

Contemporary research interest focuses on improving recovery and healing, mainly through biological augmentation. Therefore, this article aims to review all studies published within the past ten years regarding the utilization of biological augmentation, including but not limited to PRP, Hyaluronic Acid, and stem cell for patients who acquired ACL reconstruction.

1.2. Methods

This scoping review follows the protocol (Figure 1) from PRISMA for Scoping Review(4). In this scoping review, we analyzed articles published on two databases, namely PubMed, Cochrane, and Science Direct. The search terms used were “Intraarticular Injection” AND “post ACL Reconstruction”. Utilizing the website's filtering tools, the authors excluded all articles published before 2016. Furthermore, the authors only included studies with english language. After retrieving potential studies, the authors extracted the outcomes and synthesize the findings from each studies. Lastly, to guarantee the quality of the articles and reduce any potential bias in the scoping review, the included studies will be evaluated using the "JBI Critical Appraisal Check-list for Case Reports"(5).

Titles and abstracts were independently screened in duplicate by two reviewers (MI and TM). Subsequently, potentially eligible articles underwent a comprehensive full-text assessment. To ensure literature saturation, the reference lists of all included publications were manually scrutinized to identify additional relevant studies. Disagreements were resolved through consensus. Fig. 1 describes this search strategy.

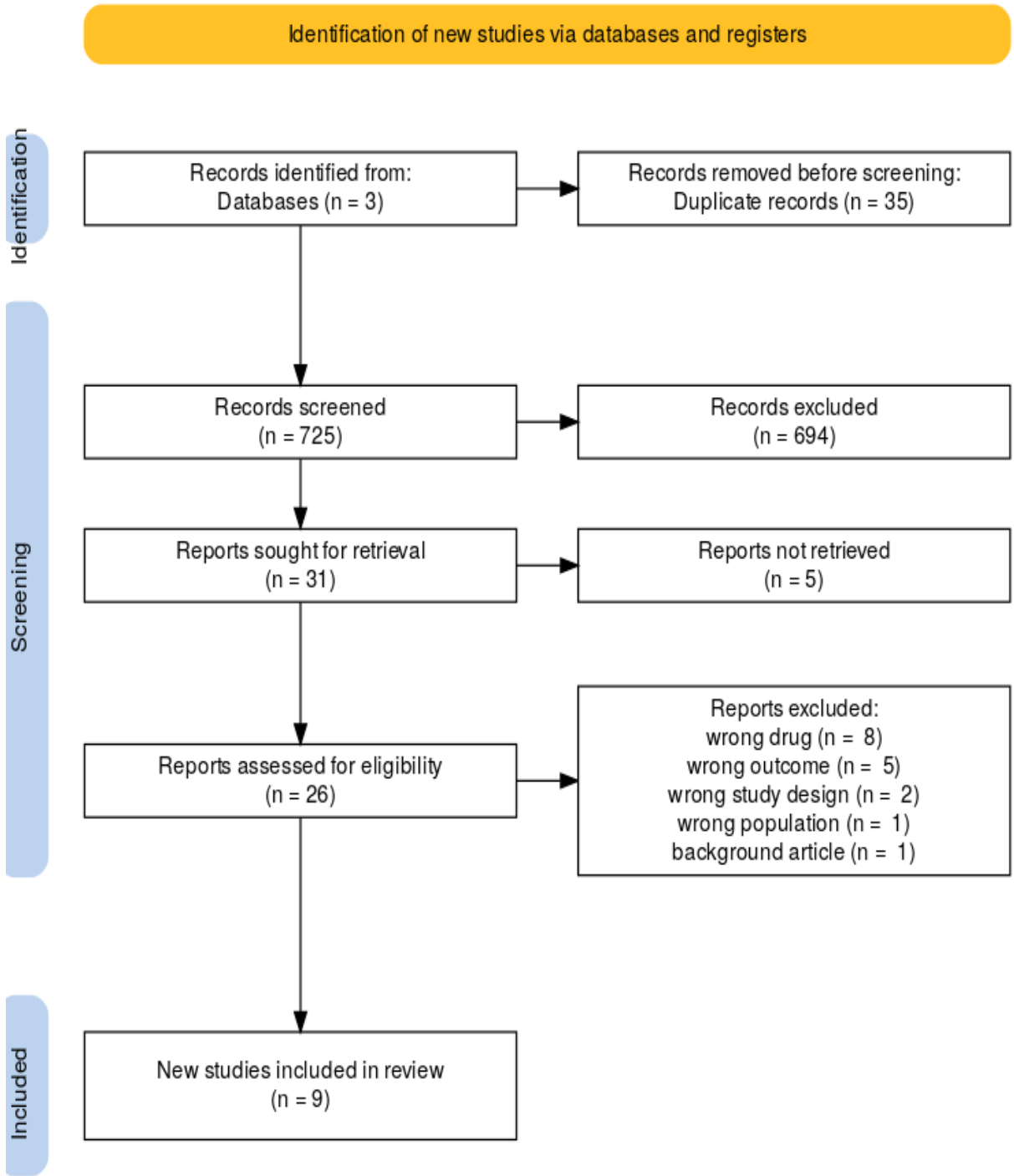

Fig. 1. PRISMA Flow Diagram

1.3. Results & Discussion

A comprehensive review of the literature was conducted using the PubMed, Cochrane, and ScienceDirect databases, resulting in the inclusion of nine randomized controlled trials (RCTs). Of these, five studies evaluated Platelet-Rich Plasma (PRP) as a biological augmentation in Anterior Cruciate Ligament Reconstruction (ACLR), while the remaining four addressed Mesenchymal Stem Cells (MSCs) and hyaluronic acid. The detailed characteristics and demographics of these studies are summarized in Table 1.

Title	Year	Study design	Intervention	Key Points
Effects of Platelet Rich Plasma on tendon Bone Healing After Anterior Cruciate Ligament Reconstruction	2021	RCT	Platelet Rich Plasma (PRP)	This study investigated the efficacy of PRP at 3, 6, and 12 months postoperative using The Lysholm and International Knee Documentation Committee scores. The result demonstrated a superiority in experimental group compared to the control group only at 3 months postoperatively, suggesting PRP ability to improve early postoperative knee joint function and promote tendon-bone healing in grafts
Intra-Articular Platelet-Rich Plasma Injection After Anterior Cruciate Ligament Reconstruction: A Randomized Clinical Trial.	2024	RCT	Platelet Rich Plasma	PRP as an adjuvant therapy did not demonstrate notable KOOS4 scores difference between control group and experimental group
Clinical Use of Platelet-Rich Plasma to Promote Tendon-Bone Healing and Graft Maturation in Anterior Cruciate Ligament Reconstruction-A Randomized Controlled Study	2022	RCT	Platelet Rich Plasma	PRP had no significant effect on reducing bone tunnel widening, accelerating tendon-bone healing, or improving knee function. Nevertheless, PRP may improve IAG maturation.
Texture analysis to differentiate anterior cruciate ligament in patients after surgery with platelet-rich plasma.	2021	RCT	Platelet Rich Plasma	PRP interferes with morphological parameters of the ACL as patients who received PRP presented with texture changes compared to the control group.
Nanosurgical and Bioengineering Treatment of Human Anterior Cruciate Ligament Tears with Ultrasound-Guided Injection of Modified Platelet-Rich Plasma Using Human Cell Memory Based on Clinical, Ultrasound, MRI, and Nanoscope Analyses: A Double-Blind Randomized Trial.	2024	RCT	Modified Platelet Rich Plasma with Human Cell Memory (RP-hCM)	RP-hCM demonstrated superior clinical outcomes; in contrast, the control group receiving platelet-rich plasma (PRP) exhibited no significant alterations in knee stability post-intervention. These findings suggest that nanosurgical and bioengineered treatments utilizing RP-hCM possess greater therapeutic efficacy relative to conventional PRP injections.

Effect of Intraoperative Platelet-Rich Plasma Treatment on Postoperative Donor Site Knee Pain in Patellar Tendon Autograft Anterior Cruciate Ligament Reconstruction: A Double-Blind Randomized Controlled Trial	2018	RCT	Platelet Rich Plasma	Throughout the follow-up time, the IKDC scores, kneeling pain, and pain with activities of daily living demonstrated no notable different between control group and experimental group.
Early Viscosupplementation After Anterior Cruciate Ligament Reconstruction: A Randomized Controlled Trial.	2016	RCT	Hyaluronic Acid	Experimental group and control group obtained hyaluronic acid and saline solution respectively. Patients were evaluated using : Short Form-36 Health Survey (SF-36), International Knee Documentation Committee (IKDC) subjective score, visual analog scale (VAS) for pain, VAS for general health status, and Tegner score. The result demonstrated some benefit regarding ROM recovery and transpatellar circumference reduction in experimental group. Nevertheless, both viscosupplementation failed to exhibit significant improvement in clinical scores after ACL reconstruction
Safety, tolerability, clinical, and joint structural outcomes of a single intra-articular injection of allogeneic mesenchymal precursor cells in patients following anterior cruciate ligament reconstruction: a controlled double-blind randomized trial.	2017	RCT	Mesenchymal Stem Cells	The intra-articular administration of a single allogeneic MPC injection following ACL reconstruction was safe and well tolerated, hence possessing the ability to improve symptoms and structural outcomes.

The Efficacy of Platelet-Rich Plasma (PRP)

Current clinical investigations into the efficacy of biologic augmentation—specifically PRP—suggest a divergence between biological maturation and subjective functional recovery. While PRP is hypothesized to accelerate tissue repair through the localized release of bioactive growth factors, the clinical evidence remains equivocal. For instance, functional outcomes such as the KOOS4 and Lysholm scores showed no significant improvement at the 12-month follow-up when compared to control groups (7, 8). Furthermore, PRP integration did not appear to mitigate bone tunnel widening (8).

Subsequently, the focus has shifted toward structural analysis. Evidence indicates that while clinical scores remain comparable, PRP-treated grafts may exhibit superior structural alterations; specifically, an improved MRI signal/noise quotient was noted at six months (P=0.06) (9). This suggests that while PRP may facilitate earlier graft maturity, this biological "head start" does not immediately manifest in superior patient-reported outcomes. Notably, emerging nanosurgery and bioengineered PRP delivery methods (RP-hCM) have

demonstrated significant improvements in WOMAC and Lysholm scores (P<0.001), suggesting that the method of delivery is as critical as the substance itself (7).

Mesenchymal Stem Cells and BMAC

Parallel to PRP research, Bone Marrow Aspirate Concentrate (BMAC) and MSCs represent novel procedures demonstrating potential in animal models. Following which, human trials have attempted to replicate these advantages. However, a 2021 RCT indicated that BMAC-augmented ACLR failed to exhibit a significant distinction in KOOS4 or IKDC scores compared to traditional techniques (10). Despite the rigorous infusion methodologies employed, the current data regarding comparative outcomes remain insufficient to support widespread clinical adoption.

Hyaluronic Acid Integration

Furthermore, hyaluronic acid, traditionally utilized for the management of osteoarthritis, has been latterly incorporated into ACLR protocols due to its efficacy in treating acute joint environments. Unlike autologous substances harvested directly from the patient, hyaluronic acid is produced via synthetic laboratory synthesis or bacterial biofermentation. Despite its theoretical benefits, a 2016 RCT reported no significant differences in SF-36 subscales, IKDC subjective scores, or VAS pain scales when compared to a saline placebo.

1.4. Conclusion

In summation, the integration of biological augmentations—specifically PRP, MSCs, and hyaluronic acid—into ACL reconstruction protocols has yet to demonstrate a definitive clinical superiority over standard surgical techniques. While certain advanced delivery methods, such as bioengineered PRP (RP-hCM), show promise in accelerating graft maturation and improving MRI-verified structural outcomes, these findings do not consistently translate into statistically significant improvements in subjective functional scores (KOOS, IKDC, or Lysholm). Furthermore, the lack of significant differentiation between hyaluronic acid or BMAC and placebo groups underscores the current limitations in biological efficacy. Consequently, while biological adjuncts remain a dynamic area of orthopedic research, their routine clinical application for ACLR requires more robust, long-term evidence to justify the additional procedural complexity and cost.

Acknowledgements

None

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