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Case Report

Image-guided bone marrow aspirate concentrate and platelet-rich plasma therapy for a chronic high-grade anterior cruciate ligament tear: a case report

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ABSTRACT

The anterior cruciate ligament (ACL) is a critical stabilizing structure of the knee joint, responsible for maintaining both anteroposterior and rotational stability. ACL injuries are among the most common sports-related ligamentous injuries to cause debilitating condition. Surgical reconstruction forms the end point of recommendation, nevertheless emerging techniques like orthobiologics using bone marrow aspirate concentrate (BMAC) and platelet-rich plasma (PRP) form alternate therapy. A 26-year-old male cyclist and fitness enthusiast presented with chronic knee instability and functional limitation secondary to a high-grade ACL tear. The patient continued to experience recurrent episodes of instability and was advised to undergo ACL reconstruction. Reluctant to pursue surgical intervention, the patient opted to undergo image-guided orthobiologic treatment. BMAC and high-concentration PRP were administered under ultrasound and fluoroscopic guidance directly into the injured ACL fibers, infrapatellar region, and intra-articular compartment. The procedure was performed on an outpatient basis. Clinical follow-up demonstrated progressive functional improvement over six months. Resting pain resolved within the first month, while objective clinical examination revealed improvement in ligament stability as reflected by Lachman test (Grade II to Grade I) with a firm endpoint. At six months, the patient reported approximately 90% functional recovery, complete resolution of subjective instability episodes, and successful return to long-distance cycling, aerobic exercise, and agility-based activities without pain or stiffness which was noteworthy. The observed clinical and functional improvements suggest that targeted regenerative intervention(s) offer feasible line of treatment in the management of ACL tear where conventional conservative management has failed.

Keywords: Anterior crucial ligament, Bone marrow aspirate concentrate, Platelet rich plasma, Regenerative Orthobiologics

INTRODUCTION

The anterior cruciate ligament (ACL) is one of the primary stabilizing ligaments of the knee joint, playing a crucial role in maintaining both anteroposterior and rotational stability. Anatomically, the ACL originates from the posteromedial aspect of the lateral femoral condyle and inserts into the anterior intercondylar region of the tibia. It consists of two functional bundles, the anteromedial and posterolateral bundles, which work synergistically to resist anterior tibial translation and rotational forces during dynamic activities.[1] Due to its essential biomechanical function, injury to the ACL can significantly compromise knee stability, resulting in acute pain being recurrent and reduction in the athletic performance causing day to day disability physical activity.[2]

ACL injuries are among the most common ligamentous injuries of the knee, with an estimated annual incidence ranging from 68 to 250 per 100,000 individuals worldwide.[3] These injuries predominantly affect young and physically active individuals, particularly athletes participating in pivoting sports such as football, basketball, soccer, and skiing.[4] Non-contact mechanisms, including sudden deceleration, pivoting, landing from a jump, and abrupt changes in direction, account for nearly 70% of ACL injuries.[5] Beyond immediate instability and functional impairment, ACL rupture is associated with secondary meniscal injury, articular cartilage degeneration, and an increased risk of developing post-traumatic osteoarthritis, even following successful reconstruction.[6]

The intrinsic healing capacity of the ACL is limited compared with extra-articular ligaments because of its intra-articular location and poor vascularity resulting in fibrin clot which necessitates for tissue repair.[7] Consequently, complete and high-grade ACL tears rarely heal spontaneously. Current treatment strategies include conservative rehabilitation for partial tears and low-demand individuals, while arthroscopic ACL reconstruction remains the gold standard for patients with symptomatic instability resulting in high functional demands.[8] Although ACL reconstruction can effectively restore mechanical stability, it does not regenerate the native ligament and is associated with several limitations, including donor-site morbidity, graft failure, infection, tunnel widening, prolonged rehabilitation, and a persistent risk of post-traumatic osteoarthritis.[9,10]

Recognition of these limitations has prompted increasing interest in regenerative therapies aimed at restoring the native ligament rather than replacing it. Orthobiologics represent a rapidly evolving field encompassing biological products that enhance tissue healing and regeneration through cellular, molecular, and biochemical mechanisms being autologous.[11] Commonly used orthobiologic therapies include platelet-rich plasma (PRP), bone marrow aspirate concentrate (BMAC), adipose-derived biologics, and bone marrow derived mesenchymal stem cells (BM-MSCs). These therapies seek to augment the body's intrinsic repair mechanisms and improve structural and functional recovery following musculoskeletal injury.[12]

Recent advances in interventional orthobiologics have facilitated the precise image-guided delivery of regenerative therapies directly into injured musculoskeletal tissues. Ultrasound- and fluoroscopy-guided injection techniques enable targeted administration of biologic products into the ACL substance and surrounding structures while minimizing procedural morbidity and improving treatment accuracy.[13] Emerging clinical evidence suggests that image-guided MSC therapy may improve pain, function, and structural healing in selected patients with partial and high-grade ACL injuries, potentially offering a minimally invasive alternative to surgical reconstruction. We hypothesize that BMAC and PRP forming orthobiologics approach would be a feasible strategy to induce regeneration and repair in the effected ACL tear.

CASE REPORT

Patient information

A 26-year-old male presented with major complaint of chronic left knee instability, recurrent swelling, and a deep, aching pain during exertion.

Medical history and clinical findings

One year prior, the patient sustained a non-contact pivoting injury during an athletic event. He was an avid long-distance cyclist and regularly engaged in high-intensity aerobic exercises, both of which had to be completely ceased during the period of injury. Patient presented with major complaint of chronic left knee instability, recurrent swelling, and a deep, aching pain during exertion.

Family history

No significant family history was reported.

Psycho-social history

Persistent knee pain significantly limited the patient's mobility and contributed to psychological stress. However, no formal psychiatric consultation was sought.

Genetic information

No relevant genetic testing was performed.

Relevant past interventions

The patient underwent 12 months of dedicated physical therapy focusing on hamstring/quadriceps strengthening and neuromuscular proprioceptive training. Despite excellent compliance, he experienced recurrent "giving way" episodes and was ultimately advised by an orthopaedic surgeon to undergo an ACL reconstruction.

Diagnostic assessment

Physical examination

Positive Lachman test (Grade II with a soft endpoint) and a positive Pivot-Shift test, indicating significant translational and rotational instability.

Imaging (baseline)

A magnetic resonance imaging (MRI) scan obtained at the time of injury, which confirmed high degree of near-total tear of mid-substance ACL fibers associated with bone bruising of the lateral femoral condyle.

Therapeutic intervention

The patient wishing to avoid surgery, opted for an autologous, targeted orthobiologic intervention. The procedure was performed in a single-day as outpatient setting.

Harvest and processing

BMAC: Bone marrow was harvested from the posterior superior iliac spine (PSIS) under local anesthesia and conscious sedation. The aspirate was centrifuged to isolate the buffy coat, which contain BMAC constituting growth factors, MSCs, Hematopoietic stem cells and cytokines.[14]

High-concentration PRP: Autologous whole blood was drawn and processed to yield a leukocyte-poor plasma (LPP), resulting in highly concentrated platelet product which was used for the administration to the patient.[15]

Targeted placement

Using ultrasound and fluoroscopic guidance BMAC and PRP were administered posterolateral approach at the site of ACL injury to ensure absolute anatomical precision into three distinct zones.

Intra-substance ACL deployment: BMAC was precisely injected via a posterolateral approach directly into the proximal and mid-substance damaged ACL fibers.

Infrapatellar region: Sub-patellar and fat pad micro-injections were performed to address chronic micro-instability and localized anterior compartment inflammation.

Intra-articular space: The highly concentrated PRP was delivered intra-articularly *insitu* of the joint environment and may support with growth factors and angiogenesis.

Follow-up and outcomes

Post-procedure rehabilitation

The patient was recommended for the functional knee brace for the first two weeks to prevent excessive shear stress while maintaining a progressive weight-bearing status. This was followed by rehabilitation to improve the controlled range of motion and strengthening.

Month 1: Resolution of baseline resting pain; trace joint effusion noted only after prolonged walking.

Month 3: Clinical examination revealed a significant improvement in the endpoint on the Lachman test and the patient was recommended to begin low-resistance stationary cycling.

Month 6: The patient showed 90% improvement at the functional level. Upon final evaluation, the patient reported zero subjective episodes of the knee "giving way." He successfully returned to his primary passions. Indeed, the patient elicited confidence to go for long-distance cycling (>50 km) outdoor rides without experiencing pain or stiffness in addition to aerobic exercises, workouts and agility drills.

Outcome Measure	Baseline (Failed Conservative Management)	6-Month Post-Orthobiologic Therapy
Lachman Test	Grade II (Soft Endpoint)	Grade I (Firm Endpoint)
Subjective Instability	Frequent ("Giving way" events)	Resolved
Cycling Tolerance	0 km (Unable to tolerate resistance)	>50 km (Symptom-free)
Aerobic Activity Level	Completely Restricted	Returned to 90% Normal

Worse vs. Improved

Figure 1: Patient outcome data and functional status (6-months follow-up).

DISCUSSION

This case highlights the therapeutic potential of image-guided orthobiologic intervention for the management of chronic high-grade anterior cruciate ligament (ACL) injury. High-grade ACL tears are generally considered to have limited intrinsic healing potential because of the ligament's poor vascularity and the inflammatory intra-articular synovial environment, making surgical reconstruction the standard treatment for young, active individuals.[16] However, emerging regenerative approaches have demonstrated promising biological effects that may facilitate tissue repair and functional recovery.

Preclinical evidence supports the regenerative potential of combining BMAC with PRP. Canapp et al demonstrated significant functional improvement and ligament healing following treatment with BMAC and PRP in naturally occurring cranial cruciate ligament injuries in dogs.[17] Likewise, Kim et al reported enhanced tendon and ACL healing with combined BMAC and PRP therapy, suggesting that orthobiologic interventions promote tissue regeneration through anti-inflammatory, pro-angiogenic, and reparative signalling pathways.[18,19]

BMAC provides an additional regenerative advantage owing to its heterogeneous cellular composition, which includes mesenchymal stromal (MSCs), hematopoietic stem cells, monocytes, platelets, and other progenitor cell populations. Although MSCs constitute only approximately 0.001-0.01% of nucleated cells in BMAC, they exert significant biological effects through paracrine and immunomodulatory mechanisms rather than direct tissue replacement.[14,15] The coordinated actions of these cellular components may attenuate inflammation, promote angiogenesis, and facilitate extracellular matrix re-modelling, thereby enhancing the regenerative process.[20] The therapeutic efficacy of PRP is largely attributed to its high concentration of platelets that release numerous bioactive molecules, including platelet-derived growth factor (PDGF), transforming growth factor-β (TGF-β), fibroblast growth factor (FGF), vascular endothelial growth factor (VEGF), insulin-like growth factor-1 (IGF-1), and anti-inflammatory mediators such as interleukin-1 receptor antagonist (IL-1RA) and interleukin-10. These factors collectively stimulate cell proliferation, extracellular matrix synthesis, angiogenesis, and modulation of inflammation, thereby creating a favourable microenvironment for tissue repair.[21]

In the present case, a 26-year-old physically active patient with a chronic high-grade ACL tear demonstrated substantial clinical and functional improvement following image-guided intra-ligamentous administration of autologous BMAC combined with high-concentration PRP. At six months of follow-up, improvements were observed in knee stability as assessed by the Lachman test, cycling tolerance, and overall improved aerobic activity, restoration of high-level cycling performance, together with enhanced overall functional response, suggest the efficacy towards meaningful clinical recovery. Although objective imaging evidence of ligament regeneration was limited, the favourable clinical outcome supports the biological rationale for orthobiologic therapy in carefully selected patients.

Regenerative medicine has introduced a paradigm shift in the management of musculoskeletal disorders by focusing on restoration of tissue function rather than symptomatic relief alone. Orthobiologic therapies, including BMAC and PRP, have emerged as promising minimally invasive treatment options for ligament, tendon, cartilage, and other musculoskeletal injuries.[22,23] The present case contributes to the growing body of evidence suggesting that combined BMAC and PRP therapy may serve as a potential alternative for selected patients with chronic ACL injuries who remain symptomatic despite comprehensive conservative management or who wish to delay or avoid surgical reconstruction.

CONCLUSION

Image-guided orthobiologic therapy using autologous BMAC with PRP advocates a promising minimally invasive treatment option for selected young, active patients with chronic high-grade ACL tears who have failed structured conservative management. In this case, treatment was associated with restoration of knee stability, marked improvement in functional performance, and return to high-level physical activity without surgical intervention. Nevertheless, the findings should be interpreted with caution because this report represents and has been based on based on a single case report. Larger prospective clinical studies with objective imaging, validated functional outcome measures, and long-term follow-up would undoubtedly establish the efficacy, safety, optimal treatment protocols, and duration of combining BMAC and PRP as targeted therapy for ACL injuries.

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