

# In Vivo Measurements Demonstrate Functional Benefits of Orthobiologic Injections on ACL Reconstruction

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**INTRODUCTION:** Even with state-of-the-art surgical techniques and rehabilitation protocols, recovery from Anterior Cruciate Ligament Reconstruction (ACLR) can take over 1 year before return to full function. Orthobiologic injections such as Platelet Rich Plasma (PRP) and Bone Marrow Aspirate Concentrate (BMAC) are promising regenerative medicine treatments to accelerate the healing of the ACL graft. However, *in vivo* evidence for their benefits in humans is mixed, and most studies have focused on patient-reported outcomes.<sup>1</sup> While multiple studies have reported abnormal knee mechanics after ACLR,<sup>2,3</sup> the effects of PRP and BMAC on dynamic knee function have not been assessed. Thus, the goal of this analysis was to evaluate the effects of PRP and BMAC on muscle strength as well as knee and ACL graft mechanics during downhill running, a dynamic, high-loading activity using Dynamic Stereo Xray (DSX).

**METHODS:** Forty-three patients (22 Female, Age = 29±7 years) were enrolled in an IRB-approved clinical trial investigating the use of PRP and BMAC to accelerate the healing of unilateral anatomical bone-patellar tendon-bone (BTB) ACLR (IRB# 2019-13, NCT04205656). Participants were randomized into three groups: control, PRP, and BMAC. The PRP and BMAC injections were performed at the time of surgery and all other surgical and rehabilitation treatments followed standard of care. The participants underwent a DSX assessment of knee joint function, a CT scan, and muscle strength testing at 6 and 12 months after surgery. DSX imaging was collected using 1ms pulsed exposures (90 kVp, 120mA) at 120 frames/s during downhill running (10° decline, 2.5 m/s) on an instrumented, dual-belt treadmill (Bertec), with acquisitions triggered just before foot-strike. The CT scans were registered to the biplanar x-ray images to assess knee joint kinematics, reported using ISB standards. ACL strain was calculated based on the length between the tunnel aperture centers, and the ACL slack length was calculated from the knee posture in the CT scan. The asymmetry was calculated between the intact and ACLR knee at corresponding image frames and averaged over time. Due to the imaging field of view, the DSX data was analyzed from 0-30% of stance, including the impact and loading response phases. Isokinetic knee flexion/extension strength tests (HUMAC) were performed and summarized by calculating the asymmetry in the peak torque between the intact and ACLR limbs. Group differences in limb asymmetry were assessed separately at 6 and 12 months using one-way ANOVA, followed by Tukey's post hoc tests for pairwise comparisons. Effect sizes were calculated using Cohen's d to quantify clinically meaningful differences. Statistical Parametric Mapping (SPM) was used to perform an ANOVA to assess the differences in ground reaction forces, knee kinematics, and ACLR graft strain between the treatment groups.

**RESULTS:** At 6 months post-ACLR (Visit 1), the PRP group exhibited significantly smaller side-to-side asymmetries in quadriceps peak torque compared to the control group (mean difference = -19.80%, 95% CI [-40.07%, 0.48%],  $p = 0.046$ , Cohen's  $d = -1.40$ ), indicating a large effect size favoring improved limb symmetry. The BMAC treatment showed a similar trend to reduce quadriceps peak torque asymmetry, but it was not significant. During downhill running at 6 months post-ACLR, SPM revealed significantly increased ground reaction forces in the BMAC group compared to the control group ( $p < 0.001$ ) across 14-48% of the stance phase. The PRP group exhibited a similar trend, though it did not reach statistical significance. Compared to the control group, the ACL strain was increased during running at 6 months in both the PRP ( $p < 0.001$ , 6-30% stance) and BMAC ( $p < 0.001$ , 12-30% stance) groups. At 12 months after ACLR, there were no differences in muscle strength or ACL strain and only a small difference in ground reaction forces (75-95% stance phase). No differences were found between the PRP and BMAC groups in any of the statistical comparisons.

**DISCUSSION:** The results of our clinical trial indicate that compared to a control group, both PRP and BMAC injections at the time of ACLR lead to increased muscle strength, ground reaction forces, and ACL strain at 6 months, indicating accelerated healing and loading of the injured knee. This suggests that these orthobiologic treatments may complement early-loading rehabilitation to improve recovery of function.

**SIGNIFICANCE/CLINICAL RELEVANCE:** PRP and BMAC injections led to improved functional recovery at 6 months after ACLR.

**REFERENCES:** <sup>1</sup>Kon et al, JOR (2021). <sup>2</sup>Tashman et al, KSSTA, (2021) <sup>3</sup> Erhart-Hledik et al, JOR (2017)

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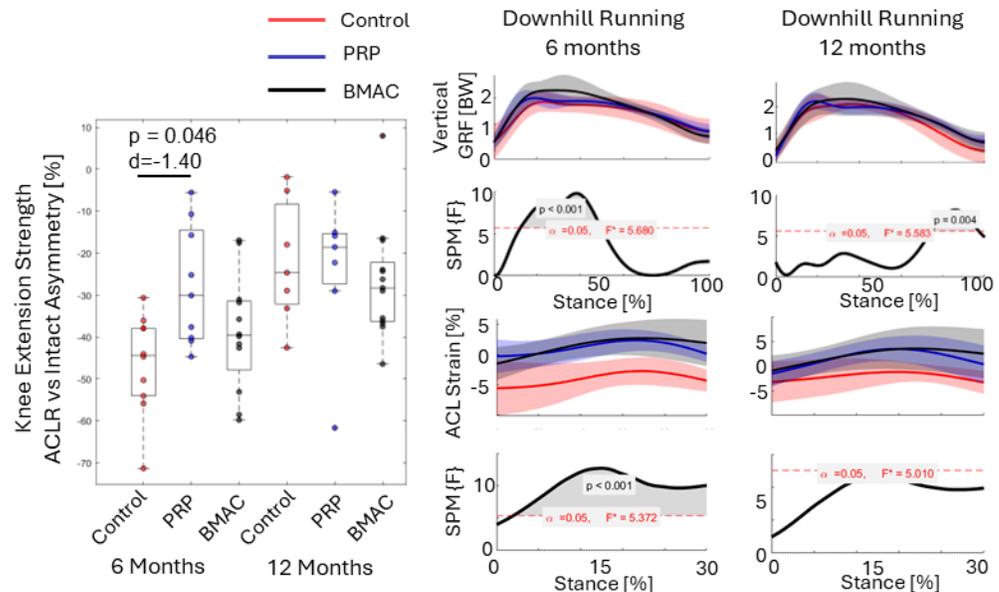


Figure 1 – (Left) The PRP and BMAC groups showed improved strength in the ACLR limb compared to the control at 6 months. (Right) Compared to the control, the PRP and BMAC groups showed increased ground reaction forces on the ACLR limb and strain in the ACLR graft during downhill running at 6 months indicating an accelerated recovery of function.