The Effect of Platelet-Rich Fibrin Matrix on Rotator Cuff Tendon Healing

A Prospective, Randomized Clinical Study

Scott A. Rodeo,*† MD, Demetris Delos,** MD, Riley J. Williams,** MD, Ronald S. Adler,** MD, PhD, Andrew Pearle,** MD, and Russell F. Warren,** MD

Investigation performed at Sports Medicine and Shoulder Service, The Hospital for Special Surgery, New York, New York

Background: There is a strong need for methods to improve the biological potential of rotator cuff tendon healing. Platelet-rich fibrin matrix (PRFM) allows delivery of autologous cytokines to healing tissue, and limited evidence suggests a positive effect of platelet-rich plasma on tendon biology.

Purpose: To evaluate the effect of platelet-rich fibrin matrix on rotator cuff tendon healing.

Study Design: Randomized controlled trial; Level of evidence, 2.

Methods: Seventy-nine patients undergoing arthroscopic rotator cuff tendon repair were randomized intraoperatively to either receive PRFM at the tendon-bone interface (n = 40) or standard repair with no PRFM (n = 39). Standardized repair techniques were used for all patients. The postoperative rehabilitation protocol was the same in both groups. The primary outcome was tendon healing evaluated by ultrasound (intact vs defect at repair site) at 6 and 12 weeks. Power Doppler ultrasound was also used to evaluate vascularity in the peribursal, peritendinous, and musculotendinous and insertion site areas of the tendon and bone anchor site. Secondary outcomes included standardized shoulder outcome scales (American Shoulder and Elbow Surgeons [ASES] and L'Insalata) and strength measurements using a handheld dynamometer. Patients and the evaluator were blinded to treatment group. All patients were evaluated at minimum 1-year follow-up. A logistic regression model was used to predict outcome (healed vs defect) based on tear severity, repair type, treatment type (PRFM or control), and platelet count.

Results: Overall, there were no differences in tendon-to-bone healing between the PRFM and control groups. Complete tendon-to-bone healing (intact repair) was found in 24 of 36 (67%) in the PRFM group and 25 of 31 (81%) in the control group (P = .20). There were no significant differences in healing by ultrasound between 6 and 12 weeks. There were gradual increases in ASES and L'Insalata scores over time in both groups, but there were no differences in scores between the groups. We also found no difference in vascularity in the peribursal, peritendinous, and musculotendinous areas of the tendon between groups. There were no differences in strength between groups. Platelet count had no effect on healing. Logistic regression analysis demonstrated that PRFM was a significant predictor (P = .037) for a tendon defect at 12 weeks, with an odds ratio of 5.8.

Conclusion: Platelet-rich fibrin matrix applied to the tendon-bone interface at the time of rotator cuff repair had no demonstrable effect on tendon healing, tendon vascularity, manual muscle strength, or clinical rating scales. In fact, the regression analysis suggests that PRFM may have a negative effect on healing. Further study is required to evaluate the role of PRFM in rotator cuff repair.

Keywords: platelet-rich plasma; platelet-rich fibrin matrix; rotator cuff

It is well established that there is a substantial failure rate after surgical reattachment of rotator cuff tendon to bone. Although numerous factors have an effect on the rate of tendon-to-bone healing, ultimately, the underlying cellular and molecular processes are insufficient to reform a functional attachment between tendon and bone. The native insertion site is a highly specialized tissue consisting of zones of mineralized and unmineralized fibrocartilage between the tendon and bone. The structure and composition of the native insertion site are not reformed after tendon-to-bone repair. Rather, a fibrovascular scar tissue interface with inferior material properties is formed. Given this, there is a strong need for methods to improve the biological potential of rotator cuff tendon healing.

Various cytokines have been shown to have myriad effects on basic cellular processes involved in tissue healing and regeneration, including positive effects on cell proliferation, angiogenesis, cell chemotaxis, and matrix synthesis. Basic laboratory studies demonstrate a positive...

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treatment are not affected by the sex of the athlete, it is not possible to tell when sex is relevant unless we perform the appropriate analyses. Sports medicine studies should be properly planned and powered to allow for identification of factors that may affect risk or prognosis; sex is an obvious candidate for scrutiny.

Bruce Reider, MD
Chicago, Illinois

REFERENCES


effect of cytokines on tendon cells and tendon explants in culture as well as in animal models of tendon healing. There remain several important obstacles to the use of cytokines to improve healing in patients, including the need to identify the optimal dose and timing of application of a specific factor, the ideal delivery vehicle to allow factor availability for an appropriate length of time, and the risk of adverse effects.

Despite a growing body of research that has identified numerous cytokines that can positively affect tendon healing, there are significant limitations to single-factor therapy. Healing is a highly complex biological process with precise coordination. Application of a single exogenous factor does not mimic the highly coordinated spatial and temporal expressions of various factors that are required for cell proliferation, differentiation, matrix synthesis, and eventual remodeling. This limitation of single-factor therapy forms the rationale for the use of platelet-rich plasma (PRP) and related substances to improve healing. Because the alpha granules and dense granules in platelets contain several cytokines and other bioactive factors, PRP allows delivery of numerous cytokines in "physiological balance."

There is currently some limited evidence to suggest a positive effect of PRP on tendon biology. For example, McCarrell and Fortier1 reported positive effects on gene expression (increased collagen I and decreased MMP-13) in flexor tendon explants cultured in PRP. Peerbooms et al6 reported a positive effect of an autologous platelet concentrate in lateral epicondylitis in a double-blind randomized controlled trial. On the basis of these data, we hypothesized that platelet-rich fibrin matrix (PRFM) would accelerate rotator cuff tendon healing. To test this hypothesis, we carried out a prospective, randomized, double-blinded clinical study to evaluate the effect of PRFM on tendon-to-bone healing after surgical repair of the rotator cuff tendons.

MATERIALS AND METHODS

This study was performed after receiving institutional review board approval. This was a phase III trial (ClinicalTrials.gov identifier: NCT00198185). Patients 40 years of age and older who had failed nonoperative treatment for a full-thickness rotator cuff tear were eligible for inclusion. Patients undergoing revision, mini-open, or open procedures were excluded. Patients undergoing concomitant labral repairs were also excluded. Seventy-nine patients were included in the study. Forty patients were randomized to receive the experimental treatment, and 39 were randomized to no implant. The primary outcome was tendon healing evaluated by ultrasound (intact vs defect at repair site) at 6 and 12 weeks. Secondary outcomes included standardized shoulder outcome scales and strength measurements using a handheld dynamometer. We measured strength of elevation in the scapular plane.

Randomization and Surgical Technique

Arthroscopic inspection of the shoulder was first carried out to verify the presence of a rotator cuff tear and to grade the size of the tear. Tears were graded as small (0-1 cm), medium (1-3 cm), or large (>3 cm). After the tear size was graded, an envelope was opened to determine if the patient would receive the PRFM implant (experimental group) or no implant (control group). Standard arthroscopic repair techniques were used to repair the rotator cuff tendon. All repairs included tendon-to-bone reattachment using suture anchors. Side-to-side or margin convergence sutures were used as deemed necessary. Acromioplasty was routinely performed. To place the PRFM material at the tendon-bone interface, a suture anchor was placed in the tuberosity, and the suture was retrieved through a large working cannula. A free needle was then attached to the suture, and this was used to pass the suture through the PRFM (Figure 1). The PRFM implant was then gently pushed down the suture to the bone surface. The same suture was then placed through the tendon using standard suture-passing techniques, and then the sutures were tied. This allowed the PRFM implant to be trapped between the tendon and bone at the tendon-bone interface (Figure 2). Patients randomized to the control group underwent an identical repair without placement of the PRFM implant.

We followed our standard postoperative rehabilitation protocol. The first 6 weeks consisted of the protection phase. Patients began passive Godman and pendulum exercises within the first few days after surgery. Only passive motion was allowed during this initial phase. During the second 6-week period, the goal was to re-establish motion. Active-assisted elevation in the plane of the scapula was initiated at 6 weeks, followed by progression to active elevation. The third phase began at 12 weeks and emphasized strengthening of the rotator cuff and scapular muscles. Formal physical therapy typically continued for at least 4 to 5 months, followed by progression to a home exercise program.

Platelet-Rich Fibrin Matrix

All patients in the experimental group received PRFM (Cascade Autologous Platelet System, Musculoskeletal Transplant Foundation, Edison, New Jersey). The PRFM...
is a PRP variant whereby a fibrin matrix is formed by activation of the fibrin-clotting cascade by addition of CaCl₂ and a second centrifugation step. This process minimizes platelet activation and traps unactivated platelets in the fibrin matrix, allowing sustained release of cytokines. The PRFM was made intraoperatively using 9 mL of peripheral venous blood, which was collected at the start of the case.

Ultrasound Evaluation

The primary outcome was rotator cuff tendon-to-bone healing evaluated with ultrasound at 6 and 12 weeks postoperatively. We performed ultrasound at these early times because we were interested in assessing the early response to PRFM to test the hypothesis that PRFM would accelerate healing. An early time point was chosen because it was possible that PRFM would lead to an early effect at the healing tendon-bone junction. Targeted shoulder ultrasounds were performed by one musculoskeletally trained radiologist experienced in performing ultrasounds, who was blinded to the treatment group. Scans were performed using a 12.5-MHz linear transducer in a Philips IU22 scanner (Philips Medical Systems, Bothell, Washington). Power Doppler imaging was performed using the ultrasound scanner low-flow sensitivity settings maintained throughout the study. The arm was placed in an internally rotated position and minimally hyperextended to ensure patient comfort. The cuff repair was then examined in the long and short axes. All images were stored digitally on the scanner hard drive and subsequently transferred as DICOM images to a PACS workstation (Philips Medical Systems) for subsequent review.

The presence of a continuous band of tissue extending to the suture anchor was considered an intact repair. The following gray-scale features were documented: (1) the presence of discretely marginated hypoechoic defects according to size and whether they were intrasubstance, partial thickness (bursal or articular surface), or full thickness; (2) the presence of bursal or joint fluid; and (3) the location of the suture anchors.

Power Doppler analysis consisted of examining 6 specific areas of the repair: (1) peribursal, above the peribursal fat stripe; (2) peritendinous, along the periphery of the repair and deep to the fat stripe; (3) musculotendinous, within the repair and proximal to the anatomic neck of the humerus; (4) intratendinous, within the repair and distal to the anatomic neck of the humerus; (5) pericortical, along the cortical margin, distal to the surgical trough; and (6) suture anchor site, along the cortical trough, including the anchor sites (Figure 3).

A subjective scoring system was employed to assess blood flow in each region as being absent (0), sparse (1), moderate (2), or prominent (3). Namely, sparse blood flow was characterized as the presence of a few scattered vessels. Moderate blood flow was determined to be thin (<2 mm in width), long segments (>5 mm) of vessels that were not engorged. Prominent vascular findings were characterized by the presence of larger vessels in continuity or the presence of a frank blush. Sporadic spectral
Figure 3. Power Doppler analysis was used to assess blood flow in 6 specific regions of the repair site: (1) peribursal, above the peribursal fat stripe; (2) peritendinous (PT), along the periphery of the repair and deep to the fat stripe; (3) musculotendinous (MT), within the repair and proximal to the anatomic neck of the humerus; (4) intratendinous (T), tendon adjacent to the repair site; (5) pericortical, along the cortical margin, distal to the surgical trough; and (6) suture anchor site, along the cortical trough, including the anchor sites.

Clinical Outcomes Evaluation
Secondary outcomes included the American Shoulder and Elbow Surgeons (ASES) patient survey and the L'Insalata shoulder score, which were completed preoperatively and at 6 weeks, 3 months, and 12 months postoperatively. Other secondary outcomes included manual muscle testing (MMT) using a dynamometer performed preoperatively and at 3 months postoperatively.

A Priori Power Analysis
Based on previous experience at our institution using ultrasound as an outcome measure, approximately 50% of rotator cuff repairs (of all sizes) demonstrate the presence of a defect upon postoperative evaluation. We assumed that augmentation of the rotator cuff repair with PRFM would reduce the rate of recurrence by 50%; therefore, based on this assumption (and with a set to .05), our analysis showed that we would need to enroll 65 patients into each group to obtain a beta value of .80. We stopped the trial short of this number of patients once our interim analysis demonstrated that PRFM did not have a positive effect.

Statistical Analysis
A 2-tailed $t$ test was used to compare MMT, ASES, and L'Insalata results between groups. $\chi^2$ analysis and Fisher exact tests were performed for categorical data. Nonparametric data were evaluated with the Mann-Whitney test. Analysis of variance (ANOVA) was used to evaluate the vascular response in the repaired cuff between groups and over time. Significance was set at $P = .05$. Logistic regression analysis was also conducted, using tear size, repair construct, platelet count, and treatment type as variables.

RESULTS
In total, 99 patients were approached for inclusion; 20 were excluded (Figure 4), leaving 79 patients who participated in the study. Forty patients were randomized to receive the experimental treatment, and 39 were randomized to the control group. The mean age for patients in the PRFM group was 58.9 ± 9.9 years, while the mean age in the control group was 57.2 ± 9.4 years ($P = .33$). There were 23 men and 17 women in the PRFM group, while there were 21 men and 18 women in the control group (Table 1).

Tear Size Distribution
In the PRFM group, 10 patients had small-sized tears, 20 had medium-sized tears, and 10 had large-sized tears. In the control group, 10 patients had small-sized tears, 19 had medium-sized tears, and 10 had large-sized tears (Table 1). There were no significant differences in the distribution of tear sizes between the 2 groups ($P = .99$).

Repair Construct Distribution
In the PRFM group, 12 patients had single-row repairs, and 25 had double-row or transosseous-equivalent repairs. In the control group, 14 patients had single-row repairs, and 17 had double-row or transosseous-equivalent repairs (Table 1). Data were unavailable for 3 patients in the experimental group and 3 patients in the control group. There were no significant differences in the distribution of repair construct type between the 2 groups ($P = .26$).
TABLE 1

<table>
<thead>
<tr>
<th>Patient Demographics</th>
<th>Platelet-Rich Fibrin Matrix (n = 40)</th>
<th>Control (n = 39)</th>
<th>P Value</th>
</tr>
</thead>
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<tr>
<td>Gender distribution</td>
<td>23 male/17 female</td>
<td>21 male/18 female</td>
<td>.82</td>
</tr>
<tr>
<td>Age, mean ± SD, y</td>
<td>58.80 ± 9.86</td>
<td>57.21 ± 9.42</td>
<td>.33</td>
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<tr>
<td>Preoperative platelet count, mean ± SD</td>
<td>246 ± 61 x 10^9/μL</td>
<td>263 ± 69 x 10^9/μL</td>
<td>.27</td>
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<tr>
<td>Small: n = 10</td>
<td>263 ± 69 x 10^9/μL</td>
<td>270 ± 69 x 10^9/μL</td>
<td>.99</td>
</tr>
<tr>
<td>Medium: n = 20</td>
<td>263 ± 69 x 10^9/μL</td>
<td>263 ± 69 x 10^9/μL</td>
<td>.28</td>
</tr>
<tr>
<td>Large: n = 10</td>
<td>263 ± 69 x 10^9/μL</td>
<td>263 ± 69 x 10^9/μL</td>
<td>.28</td>
</tr>
<tr>
<td>Single row: n = 12</td>
<td>263 ± 69 x 10^9/μL</td>
<td>263 ± 69 x 10^9/μL</td>
<td>.28</td>
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<tr>
<td>Double row: n = 25</td>
<td>263 ± 69 x 10^9/μL</td>
<td>263 ± 69 x 10^9/μL</td>
<td>.28</td>
</tr>
</tbody>
</table>

Figure 5. Manual muscle test results.

Preoperative Platelet Count

Mean preoperative platelet count was 246 ± 61 x 10^9/μL in the PRFM group and 263 ± 69 x 10^9/μL in the controls. There were no statistically significant differences (P = .27) (Table 1).

Manual Muscle Testing

The mean MMT ratio between the operated extremity and the contralateral extremity was 0.69 ± 0.33 in the control group versus 0.74 ± 0.46 in the PRFM group at the preoperative time point (Figure 5). Mean MMT ratio increased to 1.06 ± 0.45 in the control group versus 1.07 ± 0.35 in the PRFM group at final follow-up (12 months) (Figure 5 and Table 2). There were no statistically significant differences between the groups at any of the time points.

Subjective Outcomes

ASES Scores. Mean ASES scores in the control group increased from 54.74 ± 18.44 preoperatively to 96.43 ± 5.55 at 12 months postoperatively. Mean ASES scores in the PRFM-treated group increased from 56.22 ± 18.86 preoperatively to 91.30 ± 9.53 at 12 months postoperatively (Figure 6 and Table 2). There were no significant differences between the 2 groups at any of the time points.

Ultrasound Evaluation of Tendon Healing

At 6 weeks, 30 of 36 (83%) rotator cuff tendons were intact in the control group, and 28 of 34 (82.4%) rotator cuff tendons were intact in the PRFM group (P = .913). At 12 weeks, 25 of 31 (80.6%) rotator cuff tendons were intact in the control group compared with 24 of 36 (66.7%) in the PRFM group (P = .198) (Table 2). No statistically significant differences were found in the tendon healing rate within groups over time.

Power Doppler sonography analysis using a vascular grading scale demonstrated no statistically significant differences between PRFM-treated patients and controls in any of the 6 regions evaluated (peribursal, peritendinous, myotendinous, intratendinous, pericortical, and suture anchor) at either 6 or 12 weeks postoperatively. Longitudinal assessment (ie, comparison of the 6- and 12-week grayscale ultrasound studies) of echogenicity and fibrillar architecture at the repair site using a grading system as follows (worse, -1; no change, 0; slightly improved, 1; moderately improved, 2; markedly improved, 3) demonstrated no significant differences in distribution between the PRFM and control groups (P = .44).

Relationship of Ultrasound Findings and Tear Size Classification

Based on ultrasound findings, at 6 weeks postoperatively (data available for 70 patients), 17 of 18 (94.4%) small tears were intact. 33 of 36 (91.7%) medium tears were intact, and 8 of 16 (50%) large tears were intact. At 12 weeks (data available for 65 patients), 10 of 16 (71.4%) small tears, 27 of 33 (81.8%) medium tears, and 10 of 18 (55.6%) large tears were intact.
### TABLE 2
Clinical Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Platelet-Rich Fibrin Matrix, Mean ± SD</th>
<th>Control, Mean ± SD</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual muscle testing ratio (operative:nonoperative)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>0.74 ± 0.46</td>
<td>0.69 ± 0.33</td>
<td>.664</td>
</tr>
<tr>
<td>3 mo</td>
<td>0.69 ± 0.25</td>
<td>0.59 ± 0.23</td>
<td>.136</td>
</tr>
<tr>
<td>12 mo</td>
<td>1.07 ± 0.35</td>
<td>1.06 ± 0.45</td>
<td>.546</td>
</tr>
<tr>
<td>American Shoulder and Elbow Surgeons</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>66.22 ± 18.86</td>
<td>54.74 ± 18.64</td>
<td>.747</td>
</tr>
<tr>
<td>6 wk</td>
<td>60.41 ± 17.86</td>
<td>57.23 ± 16.53</td>
<td>.192</td>
</tr>
<tr>
<td>3 mo</td>
<td>72.47 ± 15.23</td>
<td>71.13 ± 18.46</td>
<td>.770</td>
</tr>
<tr>
<td>12 mo</td>
<td>91.30 ± 9.53</td>
<td>96.43 ± 8.25</td>
<td>.054</td>
</tr>
<tr>
<td>L'Insalata</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>50.55 ± 13.47</td>
<td>50.57 ± 13.99</td>
<td>.994</td>
</tr>
<tr>
<td>6 wk</td>
<td>45.75 ± 15.01</td>
<td>52.53 ± 12.24</td>
<td>.082</td>
</tr>
<tr>
<td>3 mo</td>
<td>66.93 ± 13.64</td>
<td>69.69 ± 14.26</td>
<td>.860</td>
</tr>
<tr>
<td>12 mo</td>
<td>90.33 ± 8.11</td>
<td>94.11 ± 5.73</td>
<td>.127</td>
</tr>
</tbody>
</table>

**Figure 6.** Mean American Shoulder and Elbow Surgeons scores.

**Figure 7.** Mean L'Insalata scores.

**Logistic Regression Analysis**

Logistic regression analysis using tear size, repair construct, platelet count, and treatment type as variables demonstrated that PRFM was a significant predictor ($P = .037$) for a tendon defect at 12 weeks, with an odds ratio of 5.81 (95% CI, 1.12-30.45). No other variable was a significant predictor.

**DISCUSSION**

This study was undertaken to evaluate the role of PRFM on augmentation of rotator cuff tendon healing, given the significant rate of failure of rotator cuff tendon healing. We found that autologous PRFM applied to the tendon-bone interface at the time of surgery did not have a positive effect on the healing tendon-bone interface, tendon vascularity, muscle strength, or shoulder symptoms. In fact, regression analysis suggests that the PRFM may have an inhibitory effect on tendon healing, although the relatively small patient number limits the ability to draw firm conclusions.
The finding of increased failure preferentially in the PRFM group could be caused by several possible factors. This finding could be related to the altered biological milieu due to PRFM (eg, increased presence of inflammatory mediators), which could adversely affect healing. It is also possible that the clot may have a space-occupying effect between the tendon and bone, resulting in a gap once the material dissolves. Another possible reason for the lack of an effect of PRFM may relate to the underlying biological effects of cytokines on connective tissues. Extensive growth factor research demonstrates that exogenous growth factor therapy generally improves the structural properties of healing tissue by inducing more scar tissue formation, while not improving the material properties. A large body of data shows that cytokines can increase production of tendon matrix proteins, but a critical deficiency is that tendon microstructure is not reformed. Thus, it appears that growth factors (PRP) still do not provide the proper cellular and molecular signals to drive regenerative healing. We hypothesize that pluripotent cells are needed to provide the proper signals to reconstitute both tendon composition and structure. Ultimately, pluripotent cells may be combined with growth factors such as PRP. Similar to our study, Bergeson et al recently reported an increased failure rate in rotator cuff repairs augmented with PRFM.

Interestingly, failure was significantly more likely in the PRFM-treated double-row/transosseous-equivalent repairs than in the control double-row repairs at 12 weeks. We speculate that the reason for the apparent decrease in healing of double-row repairs at 12 weeks is because of double-row/transosseous-equivalent repairs being used by the treating surgeon for tears judged intraoperatively to have poorer healing potential (larger size tear, older patient, poorer tendon quality, etc). When combined with the increased propensity for failure with PRFM, this analysis suggests that there is a negative effect of a combined double-row/PRFM repair on healing. We do not believe that there is anything specific to double-row repairs that would make failure more likely than single-row repair constructs.

Another possible reason for the development of a recurrent defect between 6 and 12 weeks is that active motion begins at the 6-week time point in the rehabilitation protocol that we followed. Failure of the repair after the onset of active motion suggests that the tissue at the repair site does not yet have adequate strength to withstand the loads due to active muscle firing. In support of this finding, 2 recent studies that have evaluated healing using ultrasound after rotator cuff repair reported that the majority of failures occurred in the first 3 months.

Several recent studies have examined the role of PRP in rotator cuff tendon healing. Castricini et al performed a randomized, double-blind trial to evaluate the effect of the same PRF formulation as we used in rotator cuff repair. They found no significant difference in functional outcomes (Constant score) when compared with controls. These authors also used magnetic resonance imaging (MRI) to evaluate tendon healing, and they reported no significant differences in defect rate between PRF-treated repairs and controls that did not receive PRP (P = .07). However, there was a significant difference in tendon signal intensity in favor of the PRF-treated repairs (P < .01) and a trend for a difference in size of the healed tendon footprint (P = .05). Arnoczky has pointed out that an alternative analysis of the MRI data whereby only those individuals considered to have normal values in each MRI outcome measure are compared to all the rest demonstrates that tendon footprint area was significantly better in the PRF group (P = .02), suggesting a positive effect of PRF.

Randelli et al also performed a randomized, double-blind trial to evaluate PRP combined with autologous thrombin (Bliomet GPS) in arthroscopic rotator cuff repair. The PRP group had earlier improvement in pain scores compared with controls, and scores on standardized outcome scales (University of California, Los Angeles; Constant; Simple Shoulder Test) and external rotation strength were better in the PRP group at 3 months but not after 6 months. Magnetic resonance imaging at a mean 23 months showed no difference in healing rate between groups. Subgroup analysis of patients with smaller tears demonstrated greater external rotation strength at all times to 24 months, with a trend for a lower defect rate on MRI (P = .05).

There are several possible reasons for the lack of an effect of PRFM, but we believe that the fundamental limitation to the use of blood products such as PRP is the...
variability in PRP between individual patients. We do not truly know exactly what we are delivering to the tendon repair site when using PRP products. This variability derives from numerous factors including both the patient and the particular commercial system used. Differences in platelet count, growth factor concentration, white blood cell concentration, and platelet activation between various preparations, as well as the effect of cytokines on connective tissue and the anatomic site chosen for treatment, all may play a role in the success or failure of a given preparation.

To begin to answer questions about the effect of PRP/PRFM on tendon healing, we need to first identify what we are putting into the patient. We suggest that a sample aliquot of the material delivered to the patient be taken to measure platelet count, white blood cell count, platelet activation status, and a sentinel cytokine (TGF-β) or other relevant protein. This would provide important information. Further optimization of PRP/PRFM may also require use of a carrier vehicle to localize the material to the delivery site as well as identification of the optimal dosing regimen. For example, serial injections over a longer period of time may be required. This information may eventually allow a more refined use of PRP and other autologous blood products to improve soft tissue healing.

Our study has several limitations that require careful consideration. The principal limitation of this study is the absence of information about the composition of the actual PRFM that each patient received (platelet number, presence of white blood cells, cytokine content, etc). The ultrasound analyses were done at a relatively early time point, and it is possible that further tendon healing could occur over time. For example, a prior study from our institution using ultrasound to evaluate rotator cuff tendon healing found 65% intact at 12 months and 76% intact at 24 months in the same group, indicating that continued tissue formation may occur at the repair site. Use of a contrast agent would also increase the sensitivity of the Doppler assessment of vascularity. Our goal when designing the study was to determine if PRFM accelerated healing compared with untreated repairs; thus, we examined early time points. It was thought that the untreated controls may all “catch up” eventually and achieve an equivalent healing rate, and thus, any differences may not have been detected if we had only used a longer time point. Evaluation at later time points would add further insight into the eventual outcomes of repairs augmented with PRFM. Given the relatively short follow-up, the data should be considered preliminary. Our study included a relatively small number of patients and was thus underpowered.

However, our primary goal was to determine if PRFM accelerated healing, and when it became evident that this was not the case, we did not continue to add patients.

In conclusion, we found that PRFM applied at the time of rotator cuff tendon repair did not improve tendon healing, muscle strength, or clinical outcome scores. Furthermore, our data suggest that the PRFM method used in our repairs resulted in lower healing rates. Further study is required before such autologous blood-derived preparations can be recommended for augmentation of tendon repair.

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Survival Comparison of Allograft and Autograft Anterior Cruciate Ligament Reconstruction at the United States Military Academy

LTC Mark Pallis,* DO, LTC Steven J. Svoboda,† MD, Kenneth L. Cameron,‡ PhD, MPH, ATC, and LTC Brett D. Owens,‡ MD
Study performed at John A. Feagin Jr. Sports Medicine Fellowship, Orthopedic Surgery Service, Keller Army Hospital, United States Military Academy, West Point, New York

Background: There is recent evidence that use of allograft tendons for anterior cruciate ligament (ACL) reconstruction in young patients may result in increased failure rates compared with autologous grafts.

Hypothesis: Allograft ACL reconstruction will result in higher failure rates in young athletes compared with autograft reconstruction.

Study Design: Cohort study; Level of evidence, 2.

Methods: A prospective cohort study of cadets at the United States Military Academy (USMA) was performed to assess performance of ACL reconstructions performed before entrance to service. Members of the classes of 2007 through 2013 who had undergone prior ACL reconstruction were identified through the Department of Defense Medical Evaluation Review Board reporting and waiver process and evaluated on the first day of matriculation. These participants were followed during their tenure at the academy with revision ACL reconstruction as the primary outcome measure of interest. Kaplan-Meier survival analysis was performed for all graft types using STATA with significance set as \( P < .05 \).

Results: A total of 120 cadets underwent 122 ACL reconstructions (2 bilateral) before matriculation and compose the prospective cohort. This cohort included 30 female and 90 male cadets. Of these 122 knees with prior ACL reconstructions, the grafts used were 61 bone-patellar tendon-bone (BTB), 45 hamstring, and 16 allograft. A total of 20 failures occurred among this cohort at an average of 545 days from matriculation. Of the failures requiring revision, 7 were BTB (11% of all BTB), 7 were allograft (44% of all allograft), and 6 were hamstring (13% of all hamstring). There was no significant difference in the graft failure between the BTB and hamstring autograft groups. In contrast, those who entered the USMA with an allograft were 7.7 times more likely to experience a subsequent graft failure during the follow-up period when compared with the BTB autograft group (hazard ratio = 7.74; 95% confidence interval [CI], 2.67-22.38; \( P < .001 \)). When allografts were compared with all autografts combined, a similar increase failure was noted in the allograft group (hazard ratio = 6.71; 95% CI, 2.64-17.06; \( P < .001 \)).

Conclusion: In this young active cohort, individuals having undergone an allograft ACL reconstruction were significantly more likely to experience clinical failure requiring revision reconstruction compared with those who underwent autologous graft reconstruction. The authors recommend the use of autograft in ACL reconstruction in young athletes.

Keywords: anterior cruciate ligament; reconstruction; allograft; autograft; revision

Anterior cruciate ligament (ACL) injuries are common in athletic and military populations. A recent study of collegiate athletes reported a 4-year incidence of 3.24 per 100 men and 3.51 per 100 women. Reconstruction is a reliable treatment that restores stability to the knee and allows a return to activity for most patients. Rupture rates have been reported between 5% and 7% for autograft reconstructions and between 7% and 13% for allograft reconstructions.

A meta-analysis by Krych et al comparing bone-patellar tendon-bone (BPTB) autograft and allograft noted significantly more graft ruptures in the allograft group. When they excluded the results of a study by Gorschewsky et al in which the allografts were irradiated and chemically treated by acetone drying, no significant difference between the rupture rates of the autograft and allograft groups was noted. Similarly, a meta-analysis of autograft versus allograft by Carey et al excluded the Gorschewsky et al study and found no significant difference in rupture rates, although there was a trend favoring autograft. None of the studies included in these 2 meta-analyses stratified outcomes according to age or used mathematical modeling to control for age or activity level.