Treatment of Partial Ulnar Collateral Ligament Tears in the Elbow With Platelet-Rich Plasma

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Treatment of Partial Ulnar Collateral Ligament Tears in the Elbow With Platelet-Rich Plasma

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Background: Studies have demonstrated the potential of platelet-rich plasma (PRP) to heal damaged tissue. To date, there are no published reports of clinical outcomes of partial ulnar collateral ligament (UCL) tears of the elbow treated with PRP.

Hypothesis: Platelet-rich plasma will promote the healing of partial UCL tears and allow a return to play.

Study Design: Case series; Level of evidence, 4.

Methods: Thirty-four athletes with a partial-thickness UCL tear confirmed on magnetic resonance imaging were prospectively followed. All patients had failed at least 2 months of nonoperative treatment and an attempt to return to play. Baseline questionnaires, including the Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow (KJOC) and Disabilities of the Arm, Shoulder and Hand (DASH) measures, were completed by each patient before injection. Baseline ultrasound measurement of the humeral-ulnar joint space was assessed with 10 lb of valgus stress on the elbow. Each patient received a single type 1A PRP injection at the UCL under ultrasound guidance. The same treating physician at a single institution performed all injections with the same PRP preparation used. Patients completed a course of guided physical therapy and were allowed to return to play based on their symptoms and physical examination findings. Outcome scores, including KJOC and DASH scores, were collected after return to play and were compared with baseline scores. Ultrasound measurements were collected at final follow-up and compared with preinjection values.

Results: At an average follow-up of 70 weeks (range, 11-117 weeks), 30 of 34 athletes (88%) had returned to the same level of play without any complaints. The average time to return to play was 12 weeks (range, 10-15 weeks). The average KJOC score improved from 46 to 93 ($P < .0001$). The average DASH score improved from 21 to 1 ($P < .0001$). The sports module of the DASH questionnaire improved from 69 to 3 ($P < .0001$). Medial elbow joint space opening with valgus stress decreased from 28 to 20 mm at final follow-up ($P < .0001$). The difference in medial elbow joint space opening (stressed vs nonstressed) decreased from 7 to 2.5 mm at final follow-up ($P < .0001$). One player had persistent UCL insufficiency and underwent ligament reconstruction at 31 weeks after injection.

Conclusion: The results of this study indicate that PRP is an effective option to successfully treat partial UCL tears of the elbow in athletes.

Keywords: platelet-rich plasma; ulnar collateral ligament

The anterior bundle of the ulnar collateral ligament (UCL) is the primary stabilizer to valgus stress at the elbow.[25-27,36] This ligament is under tremendous stress during high velocity throwing, and numerous studies have shown that repeated throwing can lead to partial or complete tearing of the ligament.[6,7,12,17,18] Athletes with UCL insufficiency demonstrate medial elbow pain, decreased throwing velocity, weakness, and loss of stamina.[4,6,17,20] In general, surgery is reserved for patients with complete tears of the ligament or partial tears that have failed nonoperative treatment.

There is little information in the literature regarding nonsurgical treatment of UCL insufficiency. Rettig et al[33] reported on a series of 31 athletes with UCL insufficiency who underwent nonoperative treatment. All players completed a minimum of 3 months of rest and rehabilitation. Of the 31 players, only 42% were able to return to play. Furthermore, the average time to return to play was 24.5 weeks. They found that duration of symptoms, acuity of injury, and age were not predictive of the ability to return to play. It is important to note that Rettig et al[33] did not distinguish between those players who had complete or partial UCL tears. Nevertheless, when we look at these somewhat dismal results with only a 42% rate of return

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to play, we must ask ourselves what we can do to improve the results of nonoperative management of these injuries.

One potential therapy that has been proposed is platelet-rich plasma (PRP), which is defined as an ultrafiltrate of autologous whole blood with concentrations of platelets above baseline values.[15] Platelet concentrations can vary greatly, ranging from 2.5 to 8.0 times the concentration found in whole blood depending on the commercial system used. When these platelets release their contents, there is a 3- to 5-fold increase in the number of growth factors, including platelet-derived growth factor (PDGF), transforming growth factor β (TGF-β), vascular endothelial growth factor (VEGF), basic fibroblast growth factor (bFGF), epidermal growth factor (EGF), and insulin-like growth factor (IFG). These growth factors act as powerful chemoattractants, are involved in cell proliferation and immune cell regulation, and can stimulate endothelial growth and angiogenesis.[15,22] Numerous studies have demonstrated the ability of PRP to heal damaged tissue. These included medial collateral ligament injuries of the knee,[13] chronic elbow tendinitis,[8,23,24,29] Achilles tendon tears,[14,34] bone healing,[9,19,35] muscle strains,[16] patellar tendinopathy,[11,21] and rotator cuff repair.[31,32] To date, there are no studies looking at PRP injection for UCL insufficiency. The purpose of this study was to report the clinical outcome of patients who have undergone a single leukocyte-rich PRP injection for treatment of a partial UCL tear.

MATERIALS AND METHODS

After institutional review board approval was obtained, 34 healthy overhand-throwing athletes (28 male, 6 female; age range, 12-33 years) with partial UCL tears who were not taking medication consented to PRP treatment of the UCL injury. The UCL injury was diagnosed by physical examination and confirmed by magnetic resonance imaging (MRI) (Figure 1). All patients had sustained symptomatic MRI grade 1 and 2 partial UCL lesions (32 at the UCL origin on the medial humeral epicondyle, 2 at both the medial humeral epicondyle and sublime tubercle). Grade 1 lesions were those exhibiting fluid along the ligament or edema within the ligament on MRI. Grade 2 lesions were those exhibiting thinning and or irregularities of the ligament without complete disruption of the ligamentous fibers, and grade 3 lesions were complete tears of the ligamentous fibers on MRI. Dynamic musculoskeletal ultrasound (MSKUS) examination was used to measure elbow humeral-ulnar joint space before PRP treatment and at monthly intervals after PRP treatment. All MSKUS measurements, before and after PRP treatments, were compared with those in the normal elbow (Ciccotti et al, unpublished data). Patients were excluded if they had a full-thickness UCL injury. All patients had failed at least 2 months of nonoperative treatment, including relative rest, nonsteroidal anti-inflammatory drugs (NSAIDs), icing, and over 6 weeks of rehabilitation exercises in supervised physical therapy. In addition, all players failed an attempt to return to throwing in a progressive interval-throwing program.

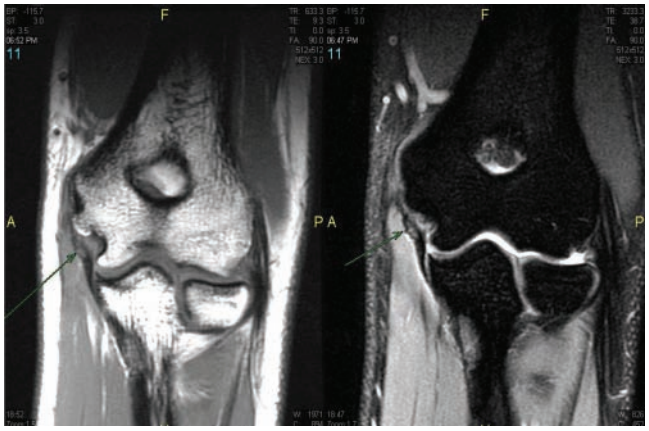

Figure 1. Magnetic resonance imaging scans of proximal partial ulnar collateral ligament tears (arrows).

Baseline questionnaires, including the Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow (KJOC) and Disabilities of the Arm, Shoulder and Hand (DASH) scores, were completed for each patient before injection. Each patient also underwent a baseline ultrasound measurement of the humeral-ulnar joint space with and without 10 lb of valgus stress on the elbow at 30° of elbow flexion (Figure 2) in comparison with the noninjured elbow.

Each patient received a single leukocyte-rich PRP injection into the UCL under ultrasound guidance (Figure 3). Each injection was performed by the same treating physician at a single institution. The same system of PRP preparation was used for each injection (Magellan, Arteriocyte, Hopkinton, Massachusetts). No cell counts were measured at the time of the whole blood draw, and no quantification of platelet or white blood cell concentrations specific to the commercial device was measured. The mean platelet concentration was estimated to be $780.2 \pm 246.5 \times 10^3/\mu L$, mean white blood cell concentration to be $11.0 \pm 8.2 \times 10^3/\mu L$, and mean platelet capture efficiency to be 65.5% ± 19.6% for the Magellan system.[5] This PRP preparation was a leukocyte-rich, platelet-rich preparation that was not activated before injection. This preparation is classified as type 1A (increased concentration of platelets and white blood cells without activation greater than 5 times the baseline concentration).[23]

PRP Procedure

Sixty milliliters of blood was drawn from the cubital fossa of the noninjured arm with a 17-gauge hemodialysis fistula needle and spun in a centrifuge for approximately 15 minutes to separate the platelets from the red blood cells and serum using the Arteriocyte PRP system. The injured medial elbow was sterilely prepared. The UCL injury was identified by MSKUS examination. A 25-gauge needle was inserted adjacent to and into the UCL, and the area was anesthetized with 3 mL of 1% lidocaine. Upon completion of the separation process, the leukocyte-rich PRP concentrate was prepared for injection. Using a 22-gauge needle, approximately 5 mL of

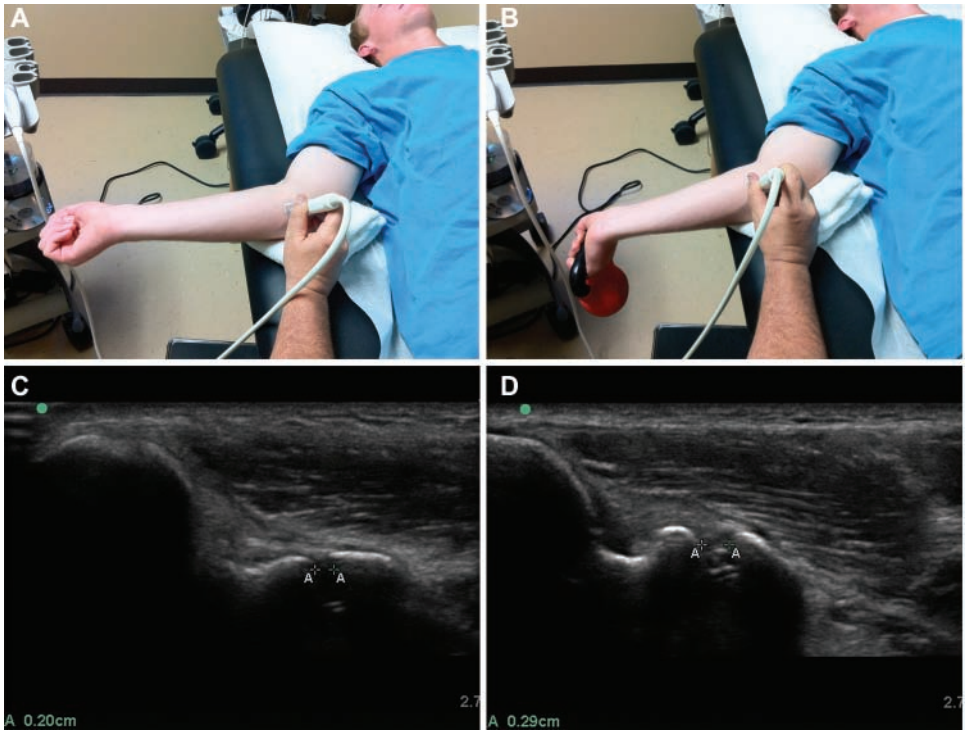

Figure 2. Each patient underwent ultrasound measurement of the medial elbow joint space: (A) without valgus stress and (B) with 10 lb of valgus stress on the elbow. The ultrasound images show ulnar collateral ligament and humeral-ulnar joint measurements (C) without valgus stress and (D) with 10 lb of valgus stress.

the leukocyte-rich PRP was then injected under direct ultrasound visualization into the pathological site of the UCL. A bandage was applied, and postinjection instructions were discussed with the patient including the application of moist heat packs every 3 hours for 15 minutes' duration over the first 24 hours after injection, use of analgesic pain medications for postprocedural pain, and active-assisted and active range of motion exercises of the treated area. The patient was also instructed not to take any NSAIDs after the procedure.

Rehabilitation

After injection, each patient underwent a course of guided physical therapy (see the Appendix, available online at http://ajsm.sagepub.com/supplemental). This consisted of 2 weeks of rest and gentle range of motion exercises. During the first week after treatment, no resisted exercises or loading was performed. Isometric strengthening twice a day was performed with light to midrange submaximal loads. Formal physical therapy began at week 2 with an emphasis on regaining motion. At week 3 after treatment, elbow-, wrist-, and hand-resisted concentric exercises began, avoiding valgus loading or UCL stretching. By week 5 after treatment, if pain free with UCL stress testing (eg, moving valgus stress, milking maneuver), light stretching and valgus loading of the elbow were initiated. At 8 to 10 weeks after treatment, strengthening progressed, and controlled overhand throwing (progressive

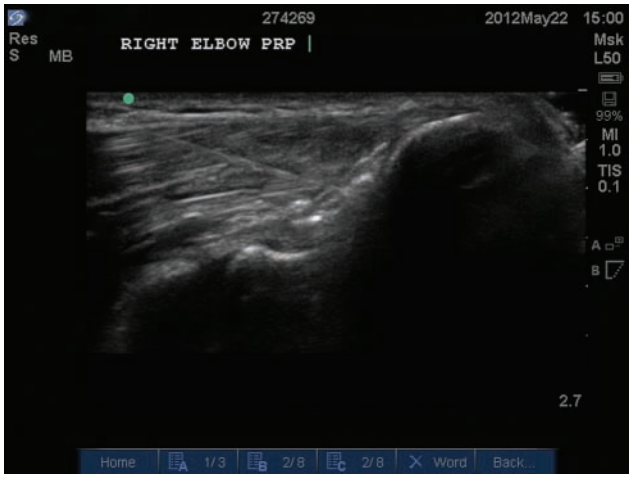

Figure 3. Each patient underwent a single platelet-rich plasma injection at the ulnar collateral ligament under ultrasound guidance.

interval throwing program) began. During weeks 10 to 12 after treatment, sport-specific training was progressed for eventual return to play around 12 to 14 weeks.

Outcome scores, including KJOC and DASH scores, were collected every 4 weeks and after return to play at 12 weeks (range, 10-15 weeks) and were compared with baseline scores using a Student *t* test (Table 1).

TABLE 1
Summary of Results[a]

Outcome Measure	Before Injection	Final Follow-up	*P* Value
KJOC	46 ± 15	93 ± 7	<.0001
DASH	21 ± 16	1 ± 6	<.0001
DASH-sports	69 ± 24	3 ± 16	<.0001
Medial joint space in dominant arm, stressed, mm	28.7 ± 0.6	20.0 ± 1.8	<.0001
Medial joint space difference, stressed vs nonstressed, mm			
Dominant arm	7.0 ± 0.6	2.5 ± 0.5	<.0001
Nondominant arm	1.8 ± 1.2	1.8 ± 1.2	.488

[a]Values are expressed as mean ± standard deviation. DASH, Disabilities of the Arm, Shoulder and Hand; KJOC, Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow.

Additionally, ultrasound measurements were collected every 4 weeks and at the final follow-up and compared with preinjection values.

RESULTS

Of the 34 patients in the study, 28 were male, and 6 were female. Twenty-seven of the athletes were baseball players, 3 played softball, 2 played tennis, and 2 played volleyball. Two of the 27 baseball players played professionally, 11 played at the collegiate level, 10 played at a high school level, 1 played on a Little League team, 1 was on a junior college team, and 2 were recreational athletes. Sixteen of the 27 baseball players pitched, and 6 of the 16 pitchers also reported playing another field position when not pitching. One of the 3 softball players was a pitcher. The average age of these players was 18 years (range, 14-34 years), and the average number of years playing was 10 years (range, 6-22 years). Each athlete had clinical examination findings of a UCL tear that was confirmed by MRI.

At an average follow-up of 70 weeks (range, 11-117 weeks), 30 of the 34 athletes (88%) had returned to play without any complaints. The average time to return to play was 12 weeks (range, 10-15 weeks). For the purpose of this study, patients were followed through re-integration into their throwing sports. A statistically significant improvement was noted in the mean KJOC score from 46 ± 15 to 93 ± 7 ($P < .0001$). A significant improvement was also noted in the mean DASH score, with an improvement from 21 ± 16 to 1 ± 6 ($P < .0001$). When looking specifically at the sports module of the DASH, a statistically significant improvement was noted with a mean score from 69 ± 24 to 3 ± 16 ($P < .0001$). Data from the dynamic MSKUS examination revealed that the mean humeral-ulnar joint space measurement with applied valgus stress significantly decreased from 28.7 ± 0.6 mm before injection to 20 ± 1.8 mm at final follow-up ($P < .0001$). Comparing the stressed versus nonstressed humeral-ulnar joint space difference before PRP injection and at final follow-up, the mean space measurement decreased from 7 ± 0.6 mm to 2.5 ± 0.5 mm ($P < .0001$). One player had persistent UCL insufficiency and underwent ligament reconstruction 31 weeks after injection. At the time of surgery, the UCL appeared attenuated with marked scarring. One player had persistent ipsilateral shoulder problems despite recovering from a UCL injury after PRP injection, precluding him from returning to play. Therefore, we excluded him from the data set because the KJOC score does not take into account other injuries unrelated to the elbow injury that preclude the player's ability to return to the same level of competition. We were unable to obtain ultrasound data from 4 players at final follow-up, but the remaining scores were gathered from telephone interviews.

No complications were observed after the PRP procedure. Patients did experience variable degrees of postinjection inflammation at the injection site, including localized mild swelling that was controlled by moist heat application and analgesic pain medication for the first 24 hours after treatment. None of the patients developed postprocedure infections, ulnar nerve irritation, or neuropathy.

DISCUSSION

The results of surgical reconstruction of the UCL are quite good, with a success rate of 80% to 95% return to play reported in the literature.[§] There are, however, significant risks associated with surgery. Furthermore, surgical reconstruction requires a substantial rehabilitation period of up to 12 months. In those patients in whom UCL reconstruction may not be indicated, such as younger aged athletes and older recreational athletes or in-season professional athletes with partial tears who do not want to undergo season-ending UCL reconstruction and extended time from play, PRP is a viable and safe option. Ideally, PRP-treated patients would be able to return to play sooner and without the risks and significant rehabilitation periods associated with surgery. There are a number of benefits of treatment with PRP including the fact that it is the patient's own autologous blood cells utilized, therefore mitigating the risk of rejection. Platelet-rich plasma injections can be conveniently conducted in the office under ultrasound guidance, ensuring exact placement of the PRP without exposing the patient to ionizing radiation. Dynamic MSKUS can also be utilized to help document UCL instability as well as measure changes in the

[§]References 1-3, 7, 10, 18, 20, 28, 30, 38, 39.

ligament and humeral-ulnar joint instability, comparing differences between treated and nontreated elbows and different time points during posttreatment rehabilitation. Furthermore, PRP treatment does not preclude later UCL reconstruction, if necessary. This was demonstrated in our study by the 1 patient who underwent successful reconstruction at 31 weeks after injection.

The post-PRP rehabilitation program should not be understated. The rehabilitation program requires careful progression, allowing for tissue maturation. This was accomplished by limiting applied stress across the UCL and medial elbow during the early stages of rehabilitation.

It is important to remember that not all PRP is the same. Castillo et al[5] published an analysis of 3 commercially available PRP systems. While they found no difference in mean platelet, red blood cell, active TGF-β1, or fibrinogen concentrations, they did find that the leukocyte-rich preparations had a significantly greater concentration of certain growth factors such as PDGF-αβ, PDGF-ββ, and VEGF. Another study by Sundman et al[37] found that a leukocyte-rich preparation had increased growth factors but also contained greater catabolic signaling molecules when compared with a leukocyte-poor preparation. The clinical implications of this are not known, and the role of white blood cells in PRP is not clear. Advocates of leukocyte-rich PRP believe that the increased concentration of growth factors with leukocyte-rich preparations is beneficial when treating soft tissue injuries. Some have also noted the potentially beneficial antimicrobial properties of leukocyte-rich preparations. Opponents of leukocyte-rich PRP feel that leukocyte-rich preparations may lead to increased inflammation, which may impede tissue recovery. Further research is needed on this controversial point.

We believe that there are a number of strengths to this study, including the fact that the same system of PRP was used for all injections; the same person, under ultrasound guidance, performed each of the injections at a single institution. In addition, each patient completed preinjection questionnaires. Despite the strengths of this study, there are limitations. This study is limited by the lack of a control group. However, each of these patients had failed at least 2 months of nonoperative treatment with an unsuccessful attempt to return to play. Future prospective, randomized controlled studies in which venipuncture and blinded, randomized injections are performed are necessary in the future. Unfortunately, this is extremely difficult to execute especially in the elite or professional athlete. A large prospective trial measuring the response to PRP treatment of the UCL in this unique group of patients is necessary.

Treatment with PRP is a very exciting area of research, and a number of questions need to be answered. We still do not know the optimal concentration of PRP, nor the number and timing of injections. There is debate over the appropriate timing of growth factor release. We have already referred to the controversy over the role of white blood cells in PRP. The role of ultrasound or image guidance when performing these injections needs to be defined. Finally, developing rehabilitation and activity guidelines after PRP injections is paramount. The remodeling and regenerating tissue needs to be nurtured without applying unnecessary stress across the treated tissue. Despite these future questions, this study indicates that PRP is an effective option to successfully treat partial UCL tears of the elbow in athletes.

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