AJSM PreView, published on July 3, 2013 as doi:10.1177/0363546513494359

Platelet-Rich Plasma Significantly Improves Clinical Outcomes in Patients With Chronic Tennis Elbow

A Double-Blind, Prospective, Multicenter, Controlled Trial of 230 Patients

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Background: Elbow tenderness and pain with resisted wrist extension are common manifestations of lateral epicondylar tendinopathy, also known as tennis elbow. Previous studies have suggested platelet-rich plasma (PRP) to be a safe and effective therapy for tennis elbow.

Purpose: To evaluate the clinical value of tendon needling with PRP in patients with chronic tennis elbow compared with an active control group.

Study Design: Randomized controlled trial; Level of evidence, 1.

Methods: A total of 230 patients with chronic lateral epicondylar tendinopathy were treated at 12 centers over 5 years. All patients had at least 3 months of symptoms and had failed conventional therapy. There were no differences in patients randomized to receive PRP (n = 116) or active controls (n = 114). The PRP was prepared from venous whole blood at the point of care and contained both concentrated platelets and leukocytes. After receiving a local anesthetic, all patients had their extensor tendons needled with or without PRP. Patients and investigators remained blinded to the treatment group throughout the study.

Results: Patient outcomes were followed for up to 24 weeks. At 12 weeks (n = 192), the PRP-treated patients reported an improvement of 55.1% in their pain scores compared with 47.4% in the active control group ($P = .094$). At 24 weeks (n = 119), the PRP-treated patients reported an improvement of 71.5% in their pain scores compared with 56.1% in the control group ($P = .027$). The percentage of patients reporting significant elbow tenderness at 12 weeks was 37.4% in the PRP group versus 48.4% in the control group ($P = .036$). At 24 weeks, 29.1% of the PRP-treated patients reported significant elbow tenderness versus 54.0% in the control group ($P < .001$). Success rates for patients with 24 weeks of follow-up were 83.9% in the PRP group compared with 68.3% in the control group ($P = .012$). No significant complications occurred in either group.

Conclusion: Treatment of chronic tennis elbow with leukocyte-enriched PRP is safe and results in clinically meaningful improvements compared with an active control group.

Keywords: platelet-rich plasma (PRP); tennis elbow; lateral epicondylitis; tendinopathy; platelet

Pain with resisted wrist extension and local elbow tenderness are the characteristic complaints of patients who present with chronic lateral epicondylar tendinopathy (tennis elbow). This pain has been ascribed to microtears within the extensor carpi radialis brevis muscle and the subsequent development of angiofibroblastic dysplasia.[31] Other theories about the source of the pain include altered neurogenic pathways and up-regulation of substance P.[21,47] Recently, an association with an abnormal vascular response within the extensor carpi radialis brevis muscle has also been reported.[40]

Since this common disorder was first described in 1883, a wide variety of treatments has been proposed.[23] Rest, activity or equipment modification, nonsteroidal anti-inflammatory medication, bracing, and physical therapy have all been described as initial interventions. If these treatments fail to improve the pain and tenderness, second-line treatments such as cortisone injections, prolotherapy, autologous blood injections, platelet-rich plasma (PRP) injections, and needling of the extensor tendon origin have been recommended. If patients continue to report pain and dysfunction despite

The American Journal of Sports Medicine, Vol. XX, No. X
DOI: 10.1177/0363546513494359

these measures, surgery is then considered. Only 10% to 15% of patients with chronic lateral epicondylar tendinopathy consider surgery. Surgical options include open tendon debridement and repair, percutaneous or open tendon release, and arthroscopic debridement. Reviews of the surgical literature note few differences in the outcomes of these approaches overall, with a success rate of approximately 85%.[22]

Platelets are, in part, mediators of the coagulation process, but they also contain more than 300 bioactive cytokines and growth factors that act via autocrine and paracrine mechanisms to help coordinate cellular communication.[7] Platelets also release vasoactive substances such as serotonin, calcium, histamine, and adenosine via their dense granules.[27,29] Importantly, several preclinical studies suggest that PRP enhances human tendon cell proliferation, differentiation, and maturation.[16,41-43]

It is crucial to note that not all PRPs are the same. Some preparations contain only concentrated platelets in a small volume of plasma. Others contain various concentrations of platelets and white blood cells. Equally important is the influence of platelets on the behavior and function of white blood cells.[39] Activation of the platelets with thrombin and/or calcium to initiate release of the contents of the granules ex vivo has been recommended in the wound healing literature.[37] Recent information, however, strongly suggests that PRP without activation promotes a better healing response.[37] All these different formulations of PRP make comparison between studies difficult and have led to the development of a PRP classification system[25] (Table 1). This system has 4 types and incorporates white blood cell concentration, activation status, and platelet concentration (A: >5 times the baseline platelets; B: <5 times the baseline platelets). Such classification now permits investigators and clinicians to replicate research results and standardize the use of different formulations of PRP for various conditions.

In 2006, Mishra and Pavelko[26] published a pilot study suggesting that unactivated concentrated platelets with concentrated white blood cells may be effective for patients who had failed nonoperative treatment for lateral epicondylar tendinopathy and who were considering surgery. That specific formulation of PRP consisted of unactivated platelets concentrated at about 5 times the baseline with concentrated white blood cells (type 1 PRP[25]). In a small group of patients (n = 15), there were statistically significant improvements compared with an active control group (bupivacaine with epinephrine, n = 5) at 8 weeks and a 93% reduction in pain scores for the PRP-treated patients at an average of 25.6 months.

TABLE 1
Platelet-Rich Plasma Classification System

Type	White Blood Cells	Activated?
1	Increased over baseline	No
2	Increased over baseline	Yes
3	Minimal or no white blood cells	No
4	Minimal or no white blood cells	Yes
	A: Platelets >5× baseline	
	B: Platelets <5× baseline	

That investigation was followed by a study by Gosens et al[13] and Peerbooms et al[33] using the same techniques and indications in a prospective, randomized trial of PRP versus cortisone in 100 patients. The results were published in 2 separate works.[13,33] At 2 years, the PRP-treated patients reported an improvement of 69% in pain scores compared with only 36% for patients treated with corticosteroid injections ($P < .0001$). When the patients were evaluated via the Disabilities of the Arm, Shoulder and Hand (DASH) scores at 2 years, the PRP group had an improvement of 67.6% compared with 15.7% in the cortisone group ($P < .0001$).

The pilot study of Mishra and Pavelko[26] was underpowered and only suggested some value for unactivated PRP in patients with chronic lateral epicondylar tendinopathy who were considering surgery when all other nonoperative measures had failed. The studies of Gosens et al[13] and Peerbooms et al[33] had excellent methodology and execution but have been criticized for using cortisone as a control group because of its potential negative effects. Overall, however, these 2 controlled studies reported no safety

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One or more of the authors has declared the following potential conflict of interest or source of funding: This study was sponsored by Biomet Biologics. A.K.M. receives royalties for patents from Biomet and ThermoGenesis and owns stock in BioParadox and ThermoGenesis. N.V.S. has received payment for speaking and as a consultant from Auxilium and receives research support from Biomet, DePuy, Ferring Pharmaceuticals, Biomemetic, Pfizer, Smith & Nephew, Zimmer, and Wyeth. S.G.E. is a paid consultant and receives research support from Medartis, owns stock or stock options in Mylad, and receives research support from Biomet. G.L.J. is an unpaid consultant for Arthrotek and receives research support from Biomet and Genzyme. S.S. has made presentations for Sonosite. D.A.V. has made presentations for Genzyme and receives research support from Biomet. M.L.R. receives royalties from and is a paid consultant for Integra (Ascension) and Zimmer and has made presentations for Arthrex. D.C.K. is an employee of and receives royalties from Greyledge Technologies. A.C.R. receives research support from Biomet.

issues and supported the use of unactivated PRP with leukocytes as an alternative to surgery. The second set of studies also clearly showed that cortisone has little or no long-term value in the treatment of chronic tennis elbow. Furthermore, recently presented data confirmed the cost-effectiveness of unactivated PRP with leukocytes compared with cortisone (unpublished data).

Needling of the extensor tendon under a local anesthetic has been described in the literature as an effective treatment for chronic tennis elbow.[24] The objective of the present investigation was to evaluate the efficacy of needling with and without a specific type of PRP as a treatment for chronic lateral epicondylar tendinopathy. We hypothesized that the addition of PRP would result in more improvement in pain and lower levels of tenderness at the elbow compared with needling alone.

MATERIALS AND METHODS

The study design was a double-blinded, prospective, multicenter, randomized trial (ClinicalTrials.gov trial number: NCT 00587613). The study sponsor, physician-evaluators, and patients were blinded to the treatment assignment and results until the end of the investigation. Thirteen investigational sites received local institutional review board approval for this study. Twelve sites enrolled patients. Trained study site personnel entered the source information into an electronic database, and informed consent was obtained from all patients.

Patient Selection

The patients had to fail at least 1 conventional therapy as listed below. There was considerable variability in the types and amount of treatment. The inclusion criteria, however, were uniformly applied to both the PRP and active control groups.

The following inclusion criteria were employed:

1. Pain by palpation at the lateral epicondyle of the elbow
2. Baseline elbow pain $\geq$50 mm/100 mm using a visual analog scale (VAS) during resisted wrist extension
3. History of elbow pain for at least 3 months
4. Pain unresponsive to 1 of 3 conventional therapy programs (local steroid injections, physical/occupational therapy, nonsteroidal anti-inflammatory medications)
5. Patient-informed consent

The following exclusion criteria were employed:

1. Pregnancy
2. Age <18 years
3. History of anemia
4. History of bleeding disorder
5. History of carpal tunnel syndrome on the affected side within 1 year before randomization
6. Cervical radiculopathy
7. Systemic disorders such as diabetes, rheumatoid arthritis, or hepatitis
8. Uncooperative patient or patient with neurological disorders who is incapable of following directions or who is predictably unwilling to return for follow-up examinations
9. Previous surgery for elbow tendinosis
10. Active bilateral elbow tendinosis within 4 weeks before randomization
11. Hypothyroidism
12. History of any blood disorder
13. Hemoglobin <11 g/dL
14. Hematocrit <33%
15. Platelet count outside of the normal range of 150 to 400 $\times$ 1000/uL
16. Participation in a workers' compensation program or planning to apply for the program and/or any ongoing, pending, or planned legal action as a result of elbow pain
17. History of arthritis or fracture of the affected elbow
18. Received local steroid injections within 6 weeks, physical/occupational therapy within 4 weeks, or nonsteroidal anti-inflammatory medications within 1 week of randomization
19. Intolerance to acetaminophen

Informed consent was obtained from 301 patients; 48 failed initial screening, and 22 dropped out before any treatment. The remaining 231 patients were then randomized via a computerized protocol. There were no differences between the 2 groups with regard to weight, age, height, sex, or race. The mean patient age in the active control group was 47.4 years compared with 48.4 years in the PRP group (P = .375). All patients had normal radiograph findings. Baseline measurements of pain and forearm function were also not different. One patient was excluded because of blood draw failure. Therefore, a total of 230 patients with chronic lateral epicondylar tendinopathy received treatment. The investigation was conducted over a period of 5 years from 2006 to 2011. Two patients (1 PRP, 1 active control) were treated and voluntarily withdrew with no postbaseline measurements. Three patients (all PRP) were treated but were lost to follow-up. This left 225 patients (97.8% of the total) with postbaseline data that were included in the analysis (Figure 1).

PRP Preparation and Procedure Technique

Approximately 30 mL of whole blood was drawn from a peripheral vein of each patient. In the PRP group, the blood was mixed with an anticoagulant (ACD-A) and placed into a sterile separator canister (GPS, Biomet Biologics, Warsaw, Indiana). This canister was then placed in a desktop-sized centrifuge and processed for 15 minutes at 3200 rpm (Figure 2). The PRP was then removed and buffered to physiological pH using 8.4% sodium bicarbonate to neutralize the acidic ACD-A in the PRP. The injection site was blocked using 0.5% bupivacaine with epinephrine, and then, 2 to 3 mL of the prepared PRP was injected into the extensor carpi radialis brevis tendon and surrounding area using a peppering technique. This technique consisted of 5 penetrations of the tendon as the

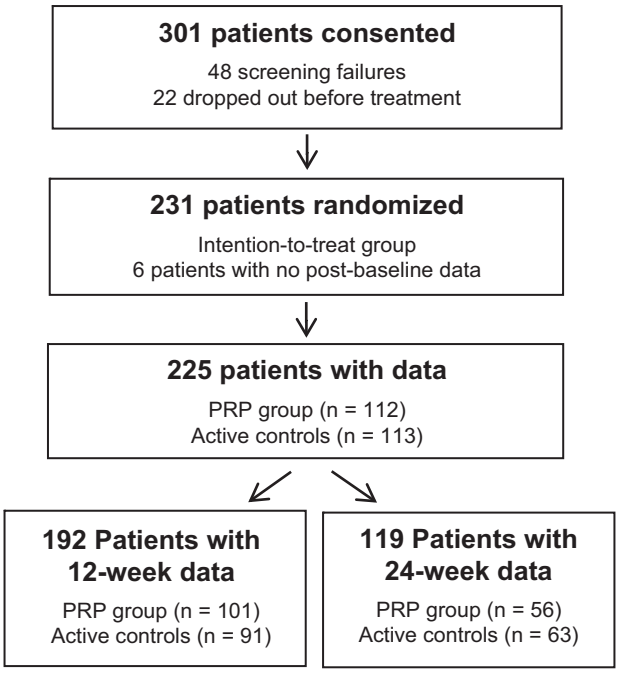


Figure 1. Flow diagram of the study patients.

PRP was injected via a single skin penetration. The active control group was injected with 2 to 3 mL of bupivacaine using the same peppering technique as the PRP group. To maintain blinding in both groups, the entire 10-mL syringe including the needle hub was wrapped in black tape to obscure its contents. The patient's arm was also draped to prevent inadvertent unblinding of the patient during the injection.

Outcome Measurements and Statistical Analysis

The VAS with resisted wrist extension was the most clinically relevant end point measured. Patients indicated their pain score on a 100-mm VAS. The Patient-Rated Tennis Elbow Evaluation (PRTEE, formerly known as the Patient-Rated Forearm Evaluation Questionnaire) and extended wrist examination were secondary measurements of outcome. The extended wrist examination evaluates the patient for signs of infection, local tenderness, and sensation. Successful treatment was prospectively defined as a reduction of greater than 25% of the VAS pain score with resisted wrist extension compared with baseline in patients who did not require pain medication beyond 48 hours and did not require escape therapy. The original design of this study included only a 12-week follow-up protocol. This was subsequently amended to include a 24-week follow-up. This method of measuring success required imputing the results of the 12-week study cohort in combination with the 24-week study cohort using the last available follow-up data for all of the patients as their final end point. The success rates (>25% reduction in pain score) of those patients with data available at 12 weeks and 24 weeks are also presented separately.

Figure 2. Disposable cylinder containing blood components after separation.

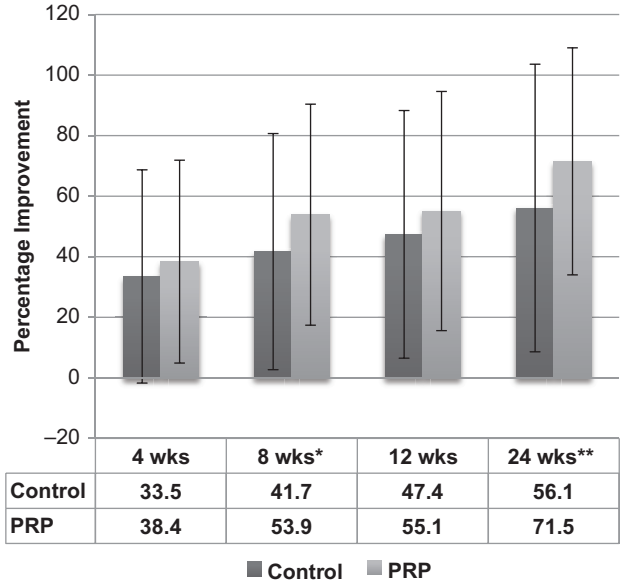
The Student t test was used to analyze the pain score data. The Fisher exact test was used to evaluate the success rates and other measurements as appropriate. A P value of $<.05$ was considered significant. Ideally, there would have been 115 patients in each group with 24 weeks of follow-up according to power calculations designed with at least 80% power to detect a treatment success rate difference of 20%. Unfortunately, only 119 patients (PRP, n = 56; control, n = 63) had 24-week data available for analysis.

RESULTS

Safety

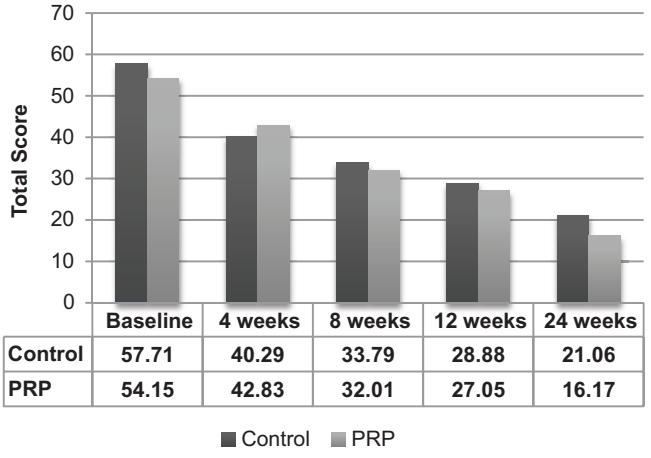
A total of 5 significant adverse events were reported during the study. Two PRP-treated patients had severe pain (1 for 2 days, 1 for 4 days). These events were reported as probable or likely related to the treatment. The remaining 3 events were reported as unlikely or not related to the treatment. They included 1 patient in the PRP group with unstable angina 4 months after treatment and 2 patients in the active control group; one patient had a radial/ulnar fracture, and the other underwent shoulder arthroscopic surgery with decompression.

Total adverse events, pain being the most common, occurred in 18% (n = 20) of the active control patients and 19% (n = 22) of the PRP-treated patients. There were no statistical differences between the active control and PRP groups in the incidence of adverse events, need for pain medication beyond 48 hours, or escape therapy.



	4 wks	8 wks*	12 wks	24 wks**
Control	33.5	41.7	47.4	56.1
PRP	38.4	53.9	55.1	71.5

Figure 3. Improvement in pain score. *Eight-week improvement in pain score (P = .010). **Twenty-four–week improvement in pain score (P = .027).



	Baseline	4 weeks	8 weeks	12 weeks	24 weeks
Control	57.71	40.29	33.79	28.88	21.06
PRP	54.15	42.83	32.01	27.05	16.17

Figure 4. Tennis elbow questionnaire. Both the platelet-rich plasma–treated and active control groups had improved functionality over baseline at each follow-up as measured by the Patient-Rated Tennis Elbow Evaluation.

Pain Scores (VAS With Resisted Wrist Extension)

Patients reported a baseline level of pain with resisted wrist extension. This value was then compared with their reported scores at 4, 8, 12, and 24 weeks. At each follow-up, the PRP-treated patients reported more improvement in their pain scores relative to the active control group. These differences were statistically significant at 8 and 24 weeks. Specifically, at 4 weeks after treatment, the PRP-treated patients reported an improvement of 38.4% compared with 33.5% in the active control group (P = .142). At 8 weeks, the PRP-treated patients reported an improvement of 53.9% versus 41.7% in the active control group (P = .010). At 12 weeks, the PRP-treated patients reported an improvement of 55.1% compared with 47.4% in the active control group (P = .094). At the final follow-up at 24 weeks, the PRP-treated patients reported an improvement of 71.5% compared with 56.1% in the active control group (P = .027) (Figure 3).

Tennis Elbow Questionnaire (PRTEE)

There were no major differences in scores between the 2 groups on the patient-rated elbow questionnaire. Both groups showed improvement with time. At 8-, 12-, and 24-week follow-up, the PRP group reported more improvement over baseline, but these differences were not statistically significant (Figure 4).

Extended Wrist Examination

There were no notable differences between the groups in terms of signs of infection or sensation. There were, however, significant differences in terms of local tenderness. At each posttreatment follow-up, the PRP group had a lower percentage of patients reporting significant local tenderness at the elbow. These differences were statistically different at 4 weeks but not at 8 weeks after treatment. At 12 weeks after treatment, 48% of the active control group versus 37% of the PRP group reported significant local tenderness (P = .036). At 24 weeks after treatment, 54% of the active control group versus 29% of the PRP group reported significant local tenderness (P < .001) (Figure 5).

Success Rates

Using the preplanned measurement of success that required combining the results of the 12- and 24-week cohorts, the success rate of the control group was 54.0% compared with 63.4% for the PRP group (P = .139). When all patients with 12-week follow-up data (control, n = 91; PRP, n = 101) were analyzed for $\geq$25% reduction in pain score compared with baseline, the success rate for the control group was 65.9% compared with 74.3% for the PRP group (P = .280). Evaluating the 119 patients with 24 weeks of follow-up data (control, n = 63; PRP, n = 56) revealed significant and clinically relevant differences. At this time point, the success rate for the control group was 68.3% compared with 83.9% for the PRP group (P = .012) (Figure 6).

DISCUSSION

Chronic lateral epicondylar tendinopathy, also known as tennis elbow, is a common problem seen by primary care physicians, physiatrists, and orthopaedic surgeons. It is often self-limiting or responsive to nonoperative measures such as rest, anti-inflammatory medication, physical

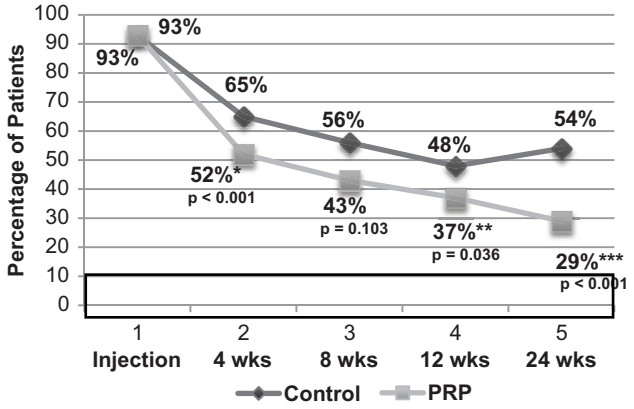


Figure 5. Percentages of patients reporting elbow tenderness were significantly lower in the platelet-rich plasma–treated group versus active control group at 4 weeks ($P < .001$), 8 weeks ($P = .103$), 12 weeks ($P = .036$), and 24 weeks ($P < .001$).

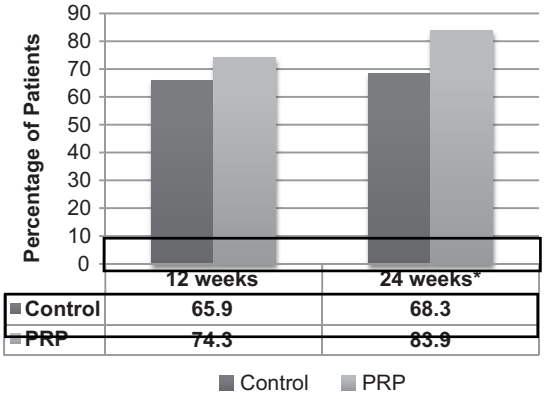


Figure 6. Clinically significant success rates, as measured by a ≥25% reduction in pain score versus baseline, were found in platelet-rich plasma–treated patients at 24 weeks after treatment ($P = .012$).

therapy, and activity modification. Home-based stretching and eccentric strengthening exercises can also be effective if the patient is compliant. In approximately 10% to 15% of patients, however, symptoms of local elbow tenderness and pain with resisted wrist extension persist. In this cohort of patients, corticosteroid injections are often considered. A survey of 400 members of the American Academy of Orthopaedic Surgeons found that 93% had administered a corticosteroid injection for this type of problem.[14] Cortisone injections have demonstrated short-term pain improvements but also result in high rates of symptom recurrence.[1,20]

Unfortunately, dexamethasone inhibits tenocyte proliferation and tendon progenitor cell recruitment with reduced collagen synthesis.[38] Furthermore, dexamethasone depletes the pool of human tendon stem cells, suppresses type I collagen, and enhances fatty and cartilage-like tissue changes that can lead to tendon ruptures.[48] This treatment can also result in dermal depigmentation and cause subcutaneous atrophy that may exacerbate local elbow tenderness. A plethora of alternative injection treatment options has arisen because of the limited data supporting cortisone. Autologous blood, botulinum toxin, polidocanol, prolotherapy, hyaluronic acid, and PRP injections have all been utilized with varying degrees of success.[17] Autologous blood injections have been shown to have value in some studies, but often, more than 1 injection is needed.[10] Direct comparison of PRP against whole blood also suggests a higher conversion rate to surgery in whole blood–treated patients. The higher levels of growth factors in PRP compared with whole blood help explain some of these clinical differences.[27]

A recently published study suggested that there is no difference in treatment effectiveness between PRP, cortisone, and saline injections at 12 weeks after treatment.[18] This investigation enrolled patients who had not failed other treatments. A high volume of lidocaine (10-15 mL) was also injected into the tendon before treatment. This treatment protocol is different from the present investigation and previous published studies.[13,26,33] There were also dramatic differences in outcome when the PRP-treated patients were compared with the steroid-treated patients at 6 months and 1 year in favor of significantly more pain reduction in the PRP group ($P = .005$ and $P = .006$, respectively). The steroid-treated group also was found to have a 15% chance of developing skin atrophy at the injection site. This confirms that steroid injections are not benign and have little long-term value in terms of alleviation of pain.

Surgery is typically recommended for patients with chronic lateral epicondylar tendinopathy who fail to respond to nonoperative measures. Percutaneous, open, and arthroscopic techniques have been described. Most of the surgical literature consists of case series of fewer than 50 patients (type 4 evidence), reporting varying degrees of success ranging from 80% to 90%.[22] Five years after surgery, however, up to 28% of patients may complain of persistent symptoms, and 9% report moderate to severe pain.[6] A recent prospective, randomized surgical trial in a small number of patients suggested that a simple skin incision at the area of tendon dysfunction may yield the same outcome as a more invasive procedure.[19] In addition, surgical treatment rarely can result in serious complications such as a nerve injury especially with an arthroscopic approach.[2]

The total cost of a surgical solution must also be addressed. If an equally effective treatment is available with less expense and risk, it should be considered before surgical intervention. Peerbooms et al (unpublished data) recently presented data, suggesting that PRP treatment for chronic lateral epicondylar tendinopathy was a cost-effective treatment at a price of about US$1200. This price is about 10% to 15% of the charges associated with surgical intervention that include the surgeon's fee, the anesthesiologist's fee, and the surgical center or hospital fees. These charges vary considerably with geography and by type of insurance. An informal poll of the authors of this study found the costs of surgery to be between $10,000 and

$12,000 at our institutions. Significant cost savings could be realized by payers if they were to initiate coverage for PRP for the treatment of chronic tennis elbow.

Successful treatment was predetermined in this investigation to be a greater than 25% reduction in the VAS pain score with resisted wrist extension. This required imputing the results of the 12- and 24-week cohorts to the last recorded end point. This is an inherent weakness of the study. Ideally, all patients would have had at least 24 weeks of follow-up. Another weakness was the 24-week follow-up time point. A later evaluation, such as 1 or 2 years after treatment, would have been better. The study would also have been stronger if a standardized rehabilitation protocol was implemented. None was used because it was not possible to confirm compliance across so many centers.

The multicenter approach was one of the strong points of the study. By standardizing the PRP preparation, using the same separation device and injection protocol, the study was able to enroll patients in 12 different centers. There were no differences in success rates across these centers. Therefore, this technique can be translated beyond a single investigator or center. Reproducibility of results across multiple centers is crucial if a new therapy is to become available and useful to a wide range of patients. The results from this clinical trial, however, may not be generalizable to other types of PRP that differ from the one used in this study.

Another strength of the study was the complete blinding of the study sponsor, treating physician, evaluator, and patient by masking the syringes and drawing blood from all patients. Using the active control of needling the extensor origin without PRP also enhanced results. This study confirms the value of needling alone, but the clinical importance may be limited because 54% of the active control group still reported significant elbow tenderness compared with 29% in the PRP group ($P < .001$) at 6 months. Longer follow-up level I studies would be helpful in clarifying the relative value of needling alone.

In the present investigation, superior results were demonstrated when PRP was added to the needling technique. It would not have been practical or ethical to deny treatment to patients still complaining of pain and tenderness despite other nonoperative treatments. Therefore, a control group of doing nothing would not have been possible.

Similar to previous studies, this investigation fails to explain how PRP improves pain. It has been postulated that the bioactive molecules within PRP enhance or improve the tendon physiology in a manner that allows for improved function and decreased pain. Some small series have suggested that PRP can improve the morphological characteristics of the tendon as evaluated by ultrasound.[5] Large studies, however, have not yet shown any significant structural changes when patients are treated with PRP. Pain reduction may also be the result of some alteration in neural pain responses or substance P metabolism. Also, PRP may enhance the microvascular circulation within the tendon and surrounding muscle, therefore decreasing pain. This theory is supported by studies confirming enhanced capillary density and angiogenesis when unactivated PRP is applied to wounds.[37] A previous report has also shown how specific formulations of PRP can enhance myocardial function after an ischemic injury.[28] Recent data further suggest that an intratendinous injection of the same type of PRP used in this study may lead to a systemic elevation of vascular endothelial growth factor for several days.[44] Together, these reports support the hypothesis of PRP working to improve blood flow into and around the tendon and surrounding muscle. Further investigation of these potential mechanisms of action is still needed.

Platelet-rich plasma has also been used as a primary or adjuvant treatment for a variety of musculoskeletal injuries and disorders. Several formulations have been used in rotator cuff disease with conflicting results.[3,15,34,36,45] A recent randomized controlled trial, however, revealed the value of PRP over dry needling for this problem.[35] Treatment of patellar tendinopathy, Achilles tendinopathy, and knee osteoarthritis with PRP has also been investigated with variable results based on the specific degree of pathological changes.[4,9,11,12,30,32] Graft donor site and anterior cruciate ligament healing using PRP have also been studied.[8,46]

In the present level I multicenter investigation of patients with chronic tennis elbow, leukocyte-enriched, unactivated PRP (type 1 PRP) was shown to produce clinically meaningful improvements in pain scores and a significant reduction in elbow tenderness compared with an active control group with no reported significant complications. At 24 weeks after treatment, the PRP group also had a statistically significant success rate of 83.9% compared with 68.3% in the active control group ($P = .012$). This study, in combination with the prospective, randomized controlled trial of PRP versus cortisone by Gosens et al[13] and the initial pilot study by Mishra and Pavelko,[26] provides clinicians and patients with practice-changing evidence supporting the use of this type of PRP and device for patients who have failed standard nonoperative treatments. Together, these 3 studies have evaluated a total of 350 patients in a prospective, controlled fashion using the same treatment protocol. Additional studies of this type of PRP compared with surgical intervention have already been initiated. Future investigations should also consider utilizing ultrasound guidance for enhanced needle placement and noninvasive means of measuring tendon remodeling.

There is now more than a decade of experience using PRP to effectively treat chronic tennis elbow with a safe biological protocol at the point of care. Based on these data, it is now possible to recommend treating patients with unactivated, leukocyte-enriched PRP (type 1 PRP) before considering surgical intervention primarily because it provides a similar rate of success with lower cost and less risk. Clinicians, researchers, and patients must be cautioned that positive results may take more than 12 weeks and are specific to chronic lateral epicondylar tendinopathy using the techniques and the PRP system discussed in this article.

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