

## ORIGINAL RESEARCH

# Effectiveness of Platelet-rich Plasma Injection for Rotator Cuff Tendinopathy: A Prospective Open-label Study

对肩袖肌腱病 (RCT) 进行富含血小板血浆注射的有效性: 预期的开放标签研究

Eficacia de la inyección de plasma rico en plaquetas para la tendinopatía del manguito de los rotadores: estudio abierto prospectivo

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## ABSTRACT

**Objective:** Assess platelet rich plasma (PRP) injection for rotator cuff tendinopathy (RCT).

**Design:** Prospective open label study with 1-year follow-up.

**Methods:** Participants recruited from an outpatient sports medicine clinic had clinically and magnetic resonance image (MRI)-demonstrated RCT refractory to physical therapy and corticosteroid injection. They received one ultrasound-guided injection of 3.0 mL of 1% xylocaine followed by 3.5 mL of PRP at the lesion and surrounding tendon. Primary outcome: 0-10 visual analog scale (VAS; baseline, 8, 12, and 52 weeks). Secondary outcomes: functional shoulder tests assessing rotator cuff strength and endurance (at baseline and 8 and 12 weeks), MRI severity (1-5 points [at baseline and 4 and 8 weeks]), and patient satisfaction (52 weeks).

**Results:** Eighteen participants with 19 assessed shoulders reported VAS pain score improvement from  $7.5 \pm 0.3$  points to  $0.5 \pm 0.3$  points by week 12 and  $0.4 \pm 0.2$  ( $P = .0001$ ) points at week 52. Functional outcomes significantly improved; the largest effect was seen in the external rotation test:  $33.5 \pm 5.7$  seconds to  $62.6 \pm 7.2$  seconds at week 12 ( $P = .0001$ ). MRI appearance improved by 1 to 3 points in 16 of 18 assessed shoulders. Seventeen participants were "completely satisfied" (12) or "satisfied" (5). One participant was "unsatisfied."

**Conclusions:** A single ultrasound-guided, intralesional injection of PRP resulted in safe, significant, sustained improvement of pain, function, and MRI outcomes in participants with

refractory RCT. Randomized multidisciplinary effectiveness trials that add ultrasound and validated clinical outcome measures are needed to further assess PRP for RCT.

## 摘要

目标: 评估针对肩袖肌腱病的富含血小板血浆 (PRP) 注射。

设计: 预期的开放标签研究, 附 1 年跟进期。

方法: 从运动医学门诊诊所招募的参与者历经临床及磁共振成像 (MRI), 证明物理治疗和糖皮质激素注射治疗对 RCT 呈现出难治性他们接受了一次超声波 (US) 引导的注射, 对病变和周围肌腱进行 1% 利多卡因的 3.0 mL 注射和后续 PRP 的 3.5 mL 注射。主要结果: 0-10 可视模拟量表 (VAS; 基线、8、12 和 52 周)。次要结果: 评估肩袖强度和耐受力的肩部功能测试 (基线、8 和 12 周)、MRI 严重度 (1-5 分; (基线、4 和 8 周) 和患者满意度 (52 周)。

结果: 对 18 名参与者进行了 19 个肩部的评估, 报告 VAS 疼痛得分改善, 至 12 周时从  $7.5 \pm 0.3$  分改善到  $0.5 \pm 0.3$  分, 以及在第 52 周改善到  $0.4 \pm 0.2$  ( $P = 0.0001$ ) 分。功能得到大大改进; 最大的效果在外旋测试中得到印证: 第 12 周时从  $33.5 \pm 5.7$  秒到  $62.6 \pm 7.2$  秒 ( $P = 0.0001$ )。在 18 个评估的肩部中有 16 个的 MRI 表现改善了 1 到 3 分。17 个参与者为 "完全满意" (12) 或 "满意" (5)。一个参与者为 "不满意"。

结论: 单一超声波引导的 PRP 腔内注射导致了对难治 RCT 参与者在疼痛、功能和 MRI 结果方面的

安全、重大且持续的改善。有必要进行随机化多学科研究有效性试验, 加进超声波和经验证的临床结果测量指标, 以进一步就 RCT 而评估 PRP。

## SINOPSIS

**Objetivo:** Evaluar la inyección de plasma rico en plaquetas (PRP) para la tendinopatía del manguito de los rotadores.

**Diseño:** Estudio abierto prospectivo con 1 año de seguimiento.

**Métodos:** Los pacientes captados de un consultorio ambulatorio de medicina deportiva presentaban pruebas clínicas y por resonancia magnética (RM) de tendinopatía del manguito de los rotadores resistente a la fisioterapia y a la inyección de corticosteroides. Recibieron una inyección guiada por ecografía de 3,0 ml de xilocaína al 1 %, seguida de 3,5 ml de PRP, en la lesión y en el tendón circundante. Criterio de valoración principal: escala visual analógica de 0 a 10 (EVA; al inicio y a las 8, 12 y las 52 semanas). Criterios de valoración secundarios: pruebas de la función del hombro que evalúan la fuerza y resistencia del manguito de los rotadores (en el momento inicial, y a las 8 y 12 semanas), la gravedad determinada por RM (1-5 puntos; momento inicial, 4 y 8 semanas) y la satisfacción de los pacientes (52 semanas).

**Resultados:** Dieciocho (18) participantes, en quienes se habían evaluado 19 hombros, notificaron mejora en la puntuación del dolor medido por una EVA de  $7,5 \pm 0,3$  puntos a  $0,5 \pm 0,3$  puntos a la semana 12 y  $0,4 \pm 0,2$  ( $P = 0,0001$ ) puntos a la

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## Key Words

Platelet rich plasma, PRP, rotator cuff tendinopathy

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semana 52. Los resultados funcionales mejoraron de forma significativa; el máximo efecto se observó en la prueba de rotación externa: 33,5 ffl 5,7 segundos a 62,6 ffl 7,2 segundos en la semana 12 ( $P = 0,0001$ ). El aspecto por RM mejoró de 1 a 3 puntos en 16 de 18 hombros evaluados. Diecisiete (17) participantes

estaban «totalmente satisfechos» (12) o «satisfechos» (5). Un participante estaba «insatisfecho».

**Conclusiones:** Una inyección de PRP única intralesional guiada mediante ecografía produjo una mejora segura, significativa y sostenida del dolor, la función y los resultados por RM en participantes con tendi-

nopatía del manguito de los rotadores resistente al tratamiento. Se necesitan ensayos aleatorizados multidisciplinares sobre eficacia que agreguen medidas de los resultados clínicos validadas y por ecografía para evaluar en mayor detalle el PRP en la tendinopatía del manguito de los rotadores.

## INTRODUCTION

Rotator cuff tendinopathy (RCT) is an important condition of the upper extremity, affecting 1 in 50 adults<sup>1</sup>; incidence increases with age, making shoulder pain a common musculoskeletal complaint in adults over age 65.<sup>2,3</sup> Its greatest impact is on workers with repetitive and high-load upper extremity tasks and on athletes; shoulder pain and weakness are associated with significant morbidity, affecting activities of daily living, recreation, and work life.<sup>4</sup>

The pathophysiology of RCT is characterized by progressive, degenerative changes within the tendon as a result of overuse, altered shoulder mechanics, and a limitation of the normal tendon repair system with a fibroblastic and a vascular response known as angiofibroblastic degeneration.<sup>5</sup> Reduced pain and improved function are the goals of conventional therapy, which includes relative rest, pain medication, physical therapy, corticosteroid injections, and surgery. However, many patients are refractory to standard care, particularly in severe cases; rehabilitation time can be lengthy. The effectiveness of conservative compared to surgical intervention is unclear. No therapy has been shown to uniformly improve clinical, functional, and radiological outcomes across severity grades of RCT, and no therapy specifically targets the presumed degenerative pathology of RCT.<sup>6</sup>

Platelet-rich plasma (PRP) is a preparation of concentrated autologous platelets containing growth factors and bioactive substances essential to musculoskeletal healing.<sup>7</sup> In vitro and animal model studies suggest that direct in vitro application of PRP to injured tissue may address the structural failure of the tendon in RCT<sup>8</sup> and that PRP might thereby accelerate healing and repair of injured tissue.<sup>9-11</sup> PRP has been suggested as a treatment option for refractory tendinopathies,<sup>5</sup> including RCT.<sup>12</sup> Early clinical evidence suggests that PRP improves pain and function outcomes in some tendinopathies compared to control injection<sup>13</sup> and baseline status.<sup>14</sup> One study has assessed PRP as an adjunct to arthroscopic shoulder repair,<sup>15</sup> but no rigorous study has assessed PRP as primary therapy for RCT. We therefore evaluated PRP for refractory RCT in a pilot-level prospective open-label study to test the hypothesis that a single ultrasound-guided PRP injection improves clinical, functional, and radiological outcome measures compared to baseline status.

## METHODS

The study protocol was approved by the Allegheny General Hospital (Pittsburgh, Pennsylvania) Institutional Review Board. Participants were enrolled and followed from April 2005 to December 2009. Adult persons aged 20 to 70 years were recruited from a referral-based outpatient sports medicine practice. Inclusion criteria were a clinical diagnosis of RCT with symptoms for 3 months or more, failed conservative treatment of at least 4 weeks of formal physical therapy (including rotator cuff strengthening and scapular and proprioceptive stabilization), at least one corticosteroid injection, shoulder x-ray to rule out adhesive capsulitis, and magnetic resonance imaging (MRI) study indicating RCT but no significant acromio-clavicular joint impingement, retracted tears, significant labral lesions, or significant glenohumeral arthrosis. Exclusion criteria included joint instability defined by positive apprehension and relocation test, pregnancy, immune system compromise, significant upper extremity comorbidity, anticoagulation therapy, history of shoulder surgery, and corticosteroid injection within 3 months. Patients could have both shoulders injected if both shoulders met criteria. Interested persons attended an informational meeting about the study; consent was obtained from eligible participants.

The primary outcome measure for all participants was a score on a 0-10 visual analog scale (VAS) assessing current resting pain at baseline and at 8, 12, and 52 weeks. The VAS is widely used in clinical medicine and as a research tool. Its utility as an outcome measure in chronic pain has been formally assessed.<sup>16</sup> Secondary outcomes included functional tests commonly performed in clinical settings to assess baseline RCT status and response to therapy (Table 1).<sup>17-20</sup>

Secondary outcomes also included MRI and were performed using a 0.6 Tesla scanner (Philips, Amsterdam, Netherlands) at baseline and 4 and 8 weeks. Axial (T1/T2), coronal (proton density, T2, T2 fat-saturated), and sagittal (T2 and proton density fat-saturated) views were obtained. All sequences were performed with a 16-cm field of view, 256 x 512 matrix and 3-mm slice thickness. MRIs were scored on a 0-5 severity scale using a rubric modified from Lewis et al<sup>12</sup>: 0, no tendinopathy; 1, mild tendinopathy; 2, moderate tendinopathy; 3, moderate tendinopathy + partial thickness tear present; 4, severe tendinopathy ± partial thickness tear present; 5, severe tendinopathy + full thickness tear present. Patient

**Table 1** Functional Outcome Measures Were Performed at Baseline and at 8 and 12 Weeks

Functional Exercise Test	Description	Main Parameter Assessed
Empty can exercise with dumbbell resistance	Arm held in position of scaption (30 degrees of horizontal adduction with shoulder abducted to 90 degrees) with weighted resistance, measured as number of seconds to fatigue (unable to maintain arm at 90 degrees)	Supraspinatus muscle strength and stamina
Drop arm exercise with dumbbell resistance	Arm held in position of 90 degrees of shoulder abduction with weighted resistance, measured as number of seconds to fatigue (unable to maintain arm at 90 degrees)	Supraspinatus muscle strength and stamina
Side-lying external rotation with dumbbell resistance	Side-lying on opposite side, with weight held in hand with elbow flexed to 90 degrees adducted to the side, participant externally rotates through full range of motion at the shoulder. The number of repetitions during a 30-second period are recorded.	Infraspinatus strength and stamina
Full can exercise with dumbbell resistance	Participant parallel to wall with the hand held in a fist and shoulder forward flexed parallel to the floor. A measuring stick is used to measure forward-reach distance. The patient is instructed to reach forward along the yardstick. The patient repeatedly reaches to a maximal distance. The number of repetitions during a 60-second period are recorded.	Rotator cuff strength and stamina, ability to forward flex the shoulder
External rotation at 0 and 90 degrees with Thera-Band resistance	Test 1: Performed at 0 degrees of shoulder abduction. Test 2: Performed at 90 degrees of abduction and external rotation of the shoulder.  (Thera-Band resistance was selected according to the patient's ability to perform 20 repetitions with good eccentric control.) The patient is instructed to perform rapid oscillations in a 30-degree arc of external rotation motion until fatigue. The examiner records the number of seconds to fatigue.	Rotator cuff strength and stamina, ability to externally rotate and abduct the shoulder

satisfaction was assessed at 52 weeks using a three-item scale (unsatisfied, partially satisfied, or completely satisfied), and patients were asked whether they would consider PRP injection therapy again (yes/no).

Demographics and information about duration of RCT pain and prior therapies for RCT were collected at baseline to characterize the sample and to evaluate as covariates for statistical analysis. MRIs were assessed by a fellowship-trained musculoskeletal radiologist (JFB) using the rubric above.

Assessors (physical therapist and radiologist) were not blinded to the order of any assessments.

**INTERVENTION**

Each participant underwent a single injection of PRP. At baseline, an antecubital blood draw of 20 mL was concentrated in a SmartPreP (Harvest Technologies Corp, Plymouth, Massachusetts) to yield 3.5 cc of PRP and a supra-physiological concentration of white blood cells. Using the baseline MRI as a guide, the patient underwent a manual and ultrasound shoulder exam by the principal investigator (MS). The lesion was marked and the area sterilely prepped. All injections were done under ultrasound guidance. A two-part injection process was used. An advancing 25 G 2-in needle first placed 3 mL of 1% xylocaine proximal to the tendinopathic area or tear. The needle was then re-inserted at the proximal aspect of the lesion and slowly removed while infiltrating of 3.5 mL of PRP without activation with CaCl/thrombin at the lesion and surrounding tendon. No repeated needling (tenotomy) was done. Posttreatment pain control (hydrocodone/acetaminophen #20 5/500 mg) was used.

In-person assessment occurred at 2, 8, and 12 weeks and by phone at 52 weeks. Patients were discouraged

from using nonsteroidal anti-inflammatory medications and starting new therapies for RCT. Participants were advised to use relative rest including 2 days off work, then to slowly advance activities of daily living progressively over 2 weeks and return to activity as tolerated.

**ANALYSIS**

Data were analyzed using SAS 9.1 statistical software (SAS Institute Inc, Cary, North Carolina). Distributional data characteristics were assessed; primary and functional outcome secondary continuous variables were normally distributed. No studies of PRP for RCT existed prior to the start of the current study on which to base a sample-size calculation; therefore, the sample size of the current study was chosen by convenience. Routine descriptive statistics were carried out using measures of central tendency (mean, median, standard deviation). To measure change over time, mixed model regression was used. All models were adjusted for age and gender.

**Table 2** Baseline Participant Characteristics

	Baseline Participant Characteristics (SD)
Males (n=15)	16 shoulders (80%)
Females (n=4)	4 shoulders (20%)
Age, y	46.2 (12.2)
Duration of shoulder pain, mo	16.8 (16.9)
<b>Prior Therapy</b>	
Physical therapy	100%
Corticosteroid injection	100%
Surgery	0%
Baseline pain score ( 0-10 VAS)	7.5 (0.3)

**Table 3** Visual Analog Scale Pain and Functional Outcome Measures<sup>a</sup>

Measure (units)	Baseline Mean (SE)	Week 8 Mean (SE)	Week 12 Mean (SE)	Week 52 Mean (SE)	% Δ	P Value
VAS pain (0-10 points)	7.5 (0.3)	3.4 (0.4)	0.5 (0.3)	0.4 (0.2)	95%	.0001
Side-lying external rotation (no. of repetitions)	18.3 (1.6)	24.9 (.9)	31.3 (3.5)		71%	.0001
Empty can (sec to fatigue)	59.3 (7.9)	72.1 (4.7)	76.4 (10.5)		30%	.67
Drop arm (sec to fatigue)	45.2 (7.9)	68.0 (6.5)	79.2 (12.5)		76%	.0002
Full can exercise (no. of repetitions)	27.5 (3.9)	38.7 (4.0)	47.2 (5.2)		72%	.0001
Thera-Band External Rotation at 0 degrees (sec)	38.1 (4.3)	55.0 (5.6)	62.2 (3.3)		63%	.0001
Thera-Band External Rotation at 90 degrees (sec)	33.5 (5.7)	49.9 (3.2)	62.6 (7.2)		87%	.0001

<sup>a</sup> All models adjusted for age and gender. Abbreviations: SE, standard error; VAS, visual analog scale.

Correlations with the MRI results and pain and functional measures were examined using the Spearman test. Two-tailed *P* values less than .05 were considered statistically significant for main and interaction effects.

**RESULTS**

Forty-eight patients were assessed for eligibility. Twenty-nine patients declined participation, 19 enrolled, and both shoulders of one participant met entry criteria; therefore, the study sample at baseline consisted of 19 patients (15 male) with a mean age of 46.2 ± 12.2 years who received treatment on 20 shoulders (Table 2). Duration of shoulder pain ranged from 3 to 72 months (mean 16.8 ± 16.9 months, median 12 months). The baseline VAS of 7.5 ± 0.3 points indicated a moderate to severe mean pain level prior to injection.

One participant was not helped by the intervention, withdrew from the study at 6 weeks after intervention, and had surgical intervention; two participants could not be scheduled for all or some of their follow-up MRIs.

The primary outcome VAS score improved by 95% compared to baseline, from 7.5 ± 0.3 points at baseline to 0.5 ± 0.3 points by week 12 and 0.4 ± 0.2 (*P* = .0001) by week 52 (Table 3). Secondary outcome functional measures also improved significantly. The largest effect was seen with testing of the rotator cuff using external rotation Thera-Band (The Hygenic Corp, Akron, Ohio) resistance at 90 degrees in which the mean was 33.5 ± 5.7 seconds at baseline and improved to 62.6 ± 7.2 seconds by week 12 (*P* = .0001). The Drop Arm testing also improved dramatically, from a baseline mean score of 45.2 ± 7.9 seconds to 79.2 ± 12.5 seconds at week 12 (*P* = .0002) (Table 3). MRI severity scores at baseline ranged from mild tendinopathy (score of 1) to tendinopathy with full thickness tear (score of 5) (Table 4). There was improvement in MRI severity scores in 16 of 18 shoulders for which a baseline and any follow-up scan was available. Two participants' MRIs did not improve; however, both of these participants' pain scores improved from 9 at baseline to

1 at 52 weeks. Their functional scores also improved over 12 weeks. The average change in VAS pain severity was correlated with the Sidelying External Rotation test (*P* = .006) but not with the other functional measures or with changes in the MRI scores. Improvement in MRI scores were correlated with external rotation Theraband resistance at 90 degrees (*P* = .03) and trended to correlation with the Side-lying External Rotation test (*P* = .08). Baseline and follow-up pain and functional score data had high variability (Table 3).

**Table 4** Shoulder MRI Severity Scores and Overall Change in Score<sup>a</sup>

Shoulder ID#	MRI Baseline	MRI 4 weeks	MRI 8 weeks	Change in MRI
1	2	1	1	-1
2	3	2	1	-2
3	3	2	1	-2
4	5	5	4	-1
5	5	5	5	0
6	3	2	0	-3
7	5	5	4	-1
8	4	4	4	0
9	3	1	1	-2
10	3	3	2	-1
11	3	2	2	-2
12	4	3	3	-1
13	4	4	2	-2
14	2	1	1	-1
15	4	2	1	-3
16	5	3		-2
17	3	3	2	-1
18	3			
19	3			
20	2		1	-1

<sup>a</sup> Rotator cuff tendinopathy on magnetic resonance imaging (MRI) was graded using a 0-5 severity scale: 0, normal; 1, mild tendinopathy; 2, moderate tendinopathy; 3, moderate tendinopathy + partial thickness tear present; 4, severe tendinopathy ± partial thickness tear present; 5, severe tendinopathy + full thickness tear present.

There were no adverse events or unexpected side effects. Twelve participants reported that they were “completely satisfied” with care, five were “satisfied,” and one responded that he/she was “unsatisfied.” Seventeen of eighteen participants completing the study would undergo the procedure again. Immediate posttreatment pain was not recorded. The clinical impression was that pain as a result of the injections was modest and that post-procedural pain spontaneously resolved in 2 to 3 days. No participant indicated that pain would prevent future use of PRP therapy.

## DISCUSSION

This prospective pilot-level open-label study reports a large, consistent effect size across multidisciplinary outcomes for a single injection of PRP under ultrasound guidance for refractory RCT; pain scores, functional testing, and appearance of the RCT lesion on MRI all improved. These results, in the context of no significant side effects or adverse events, provide level II evidence (prospective cohort study)<sup>21</sup> that PRP is effective for refractory RCT. It is the first study to report effectiveness of PRP as a primary therapy for RCT across multidisciplinary outcomes and suggests that PRP may assist tendon remodeling on MRI imaging.

A mean pain score improvement of 7.1 (7.5-0.4) points on a 10-point VAS at 52 weeks following a single PRP injection represents a 95% reduction in pain level over the course of the study. While the minimal clinically important difference for RCT pain on the VAS is not established, a recent review concluded that a reduction of two points on a 0-10 Likert scale corresponded to a significant clinical difference across a variety of chronic pain conditions<sup>16</sup>; these data therefore suggest a strong clinical effect. Improved pain scores were accompanied by improved functional and MRI outcomes, suggesting that healing occurred at the tissue level. We might have expected stronger and more consistent statistical correlations between pain and functional and MRI outcomes; however, while outcomes were consistently positive, high variability in individual baseline and follow-up scores in the context of small sample size may have prevented the detection of such associations. In addition, MRI findings may not correlate well with patient-reported symptoms related to rotator cuff disease in all circumstances.<sup>22</sup>

Improvements in pain and function outcomes are consistent with those reported in other studies of PRP for chronic musculoskeletal pain.<sup>13,23</sup> PRP is an evolving treatment modality gaining momentum in primary care, rehabilitation, and sports medicine applications. In vivo studies suggest that concentrated growth factors and biologically active substances within PRP can initiate a healing cascade within the area of tendon injury.<sup>10</sup> This mechanism of tendon healing and regeneration may be responsible for the clinical and structural improvement seen in this study.

This study also suggests that PRP may improve upon standard of care for RCT. Physical therapy is often

### Relevance of This Article to *Global Advances In Health And Medicine*

Preliminary data suggest that administration into injured tissues of concentrated autologous platelets supports natural healing mechanisms by release of growth factors and other bioactive substances. Nevertheless, platelet-rich plasma (PRP) injection for orthopedic injuries, though widely studied in Europe and Asia, is not widely accepted in North America. This case series demonstrates that a single ultrasound-guided PRP injection resulted in markedly improved clinical, functional, and radiological outcomes that persisted for 1 year.

the first line of management for symptomatic RCT. Although the optimal physical therapy protocol is not well established and significant heterogeneity exists between rehabilitation programs, two systematic reviews reported short- and long-term improvements using physical therapy for RCT pain and function.<sup>24,25</sup> One randomized controlled trial reported 2.5-year follow-up data demonstrating sustained improvements in validated shoulder quality-of-life scores.<sup>26</sup> Given that all participants in this cohort were refractory to prior physical therapy, PRP seems to have provided additional benefits compared to physical therapy alone. The outcomes of surgery for refractory RCT compared to outpatient management are not definitive; a systematic review, however, suggested that there are no significant differences in outcome between open or arthroscopic subacromial decompression and active nonoperative treatment for rotator cuff disease.<sup>27</sup> PRP may provide a minimally invasive outpatient treatment for refractory RCT providing a less expensive alternative to surgery with reduced potential for operative side effects and adverse events.

Limitations include a small sample size and lack of a control group for comparison. It is therefore impossible to know the extent to which these subjects would have improved without PRP injection. However, chronic RCT refractory to corticosteroid injection and physical therapy would not be expected to show as dramatic clinical, functional, and morphological improvements as rapidly as these subjects did.<sup>5</sup> The primary 0-10 point VAS outcome measure is not validated for RCT; however, VAS scores are an accepted measure of pain and have been used as primary outcomes in studies of chronic pain<sup>16</sup> and injection therapy specifically.<sup>28</sup> The secondary outcome measures, while clinically relevant, also are not validated. Immediate posttreatment pain score and use of narcotic pain medication were not recorded; therefore, it is unclear how painful PRP therapy for RCT is. The study also was limited by lack of MRI follow-up beyond the 8-week period. Although MRI imaging during this short follow-up period demonstrated structural improvements in the majority of tendons, the long-term

tissue-modifying potential of PRP on RCT is not known. Tendon healing models suggest that tendon remodeling continues for up to 1 year or more following acute injury. It is possible that imaging findings lag behind the improvement of pain and function.<sup>29</sup> Assessors were not blinded to order of assessments. The 52-week follow-up was via phone, precluding collection of functional, MRI, and ultrasound data. Strengths include ultrasound-guided needle placement and injection, multiple patient-oriented assessments, minimal missing data, and a large, consistent effect size for pain and improvement in functional and MRI outcomes compared to baseline status.

Determination of clinical utility of PRP for RCT will require assessment in a larger randomized controlled setting, ideally in comparison to current conventional therapy and not necessarily to blinded sham injections, a control intervention which may affect outcomes.<sup>30</sup> Consideration should be given to the use of more formal biomechanical outcome measures and to longitudinal ultrasound follow-up to assess the extent of tissue healing such as that used in other tendinopathy studies.<sup>31</sup>

## CONCLUSION

A single intralesional injection of PRP under ultrasound guidance resulted in a safe, significant, sustained improvement in pain, function, and MRI outcomes for participants with refractory RCT. This suggests that PRP has the potential to heal the muscle-tendon unit of the rotator cuff at the level of degenerative tissue and may be a primary nonsurgical treatment for refractory RCT. Randomized multidisciplinary effectiveness trials that add ultrasound and validated functional and imaging outcome measures are needed to further assess the effect of PRP for severe RCT compared to current therapy.

## PRACTICAL IMPLICATIONS

- PRP injections were associated with decreased rotator cuff–related pain at 8, 12, and 52 weeks.
- PRP injections were associated with improved functional and magnetic resonance image outcomes.
- Based on better-than-expected healing on follow-up MRI, PRP injection may have a disease-modifying, tissue-level effect on rotator cuff tendinopathy.

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