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Original research

Efficacy of a platelet-rich plasma injection for the treatment of proximal hamstring tendinopathy: A pilot study[☆]

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ABSTRACT

Objectives: To determine the efficacy of an ultrasound-guided platelet-rich plasma (PRP) injection in the treatment of patients with proximal hamstring tendinopathy (PHT).

Design: Pilot prospective cohort study

Methods: Administration of a single PRP injection under ultrasound guidance to 29 patients with PHT confirmed on magnetic resonance imaging (MRI). Pain, function and sporting activity were measured via the Victorian Institute of Sport Assessment-Proximal Hamstring Tendons (VISA-H) questionnaire, administered before injection and at 8-weeks follow-up.

Results: The study sample consisted of 22 females and 7 males with a mean age of 45.2 years (95% CI 40.8–49.5). When comparing pre-injection VISA-H scores (mean: 43.90; 95% CI 37.77–50.03) with 8-week post-injection VISA-H scores (mean: 51.14; 95% CI 43.39–58.88) in the total sample of patients, no statistically significant difference was found ($p = 0.14$). When performing separate analyses for patients with mild ($n = 9$), moderate ($n = 16$) or marked ($n = 4$) PHT, no statistically significant difference was found in pre- and post-injection VISA-H scores for any of the groups ($p = 0.86$, $p = 0.13$, $p = 0.28$ respectively). 69% of patients reported no change in their ability to undertake sport or other physical activity at 8-weeks follow-up.

Conclusions: Patients with PHT receiving a PRP injection did not improve on clinical outcomes at 8-weeks follow-up.

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1. Introduction

Proximal hamstring tendinopathy (PHT) can cause severe dysfunction and chronic disability.¹ PHT refers to an overuse injury affecting the attachment of the hamstring tendons onto the ischial tuberosity.² Whilst PHT may occur in the non-athletic population,^{1,3,4} it primarily affects the athletic population.⁵ It is especially common in runners, including long distance runners, sprinters and hurdlers, as well as occurring in activities involving a change-of-direction.^{1,3,6} The typical clinical presentation of PHT is deep lower gluteal pain that may radiate into the posterior thigh and is exacerbated by sustained sitting, exercise and hamstring stretching.^{7–9}

Due to the potential chronic disability experienced by patients with PHT, identification of appropriate treatment options for patients with PHT is vital. Whilst several treatment options have been suggested, few have been validated.⁹ Proposed non-surgical treatment options for PHT are scarce¹⁰ and lacking in high-powered study designs, yet have included conservative management, a corticosteroid injection, and shockwave therapy.

There is limited evidence as to the value of a platelet-rich plasma (PRP) injection in the treatment of patients with PHT.⁹ The proposed mechanism of PRP is that cytokines and growth factors secreted by platelets accelerate the healing process, and this has been suggested in both acute tendon injuries^{11,12} and chronic tendinopathies.¹³ Whilst studies have demonstrated patients with PHT receiving a PRP injection to improve on clinical outcomes,^{9,14} limitations in study design and sample size may have affected the validity of their results. At present, the clinical indications for administering a PRP injection for PHT are not well defined, with no previous studies exploring the relationship between PRP efficacy and pre-injection PHT severity.

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The aim of this study is to determine whether a PRP injection is associated with a change in pain, function and ability to undertake sport or other physical activity at 8-weeks follow-up in patients with different pre-injection grades of PHT severity. We hypothesised that patients with PHT receiving a PRP injection would improve on clinical outcomes at 8-weeks follow-up, and that this would be the case in all pre-injection grades of PHT severity.

2. Methods

A pilot prospective cohort study of patients with PHT treated with a single ultrasound-guided PRP injection. The study protocol was given ethical clearance by the local Human Research Ethics Committee and all patients provided written informed consent prior to enrolment into the study.

Patients were recruited from various sports medicine clinics between December 2016 and November 2017. To be considered for enrolment into the study, patients were required to have a confirmed MRI diagnosis of chronic mild, moderate or marked PHT by a certified interventional radiologist. The following MRI grading classification system for PHT was used: (a) Mild (minimal signal change); (b) Moderate (intrasubstance tear or detachment $\leq 50\%$ of cross section); (c) Marked (intrasubstance tear or detachment $>50\%$ of cross section).

Additionally, patients were required to meet the following inclusion and exclusion criteria to be considered for enrolment;

Inclusion criteria:

- (1) Male and female patients aged 20–75 years.
- (2) Symptomatic for ≥ 3 weeks prior to PRP injection.
- (3) No previous PRP injection into the affected hamstring.
- (4) Cessation of analgesia at least 24 h prior to PRP injection.
- (5) No corticosteroid injection into the affected hamstring during the 12 months prior to enrolment.

Exclusion criteria:

- (1) Acute injury to the affected proximal hamstring or symptoms of <3 weeks duration.
- (2) Past or current history of cancer.
- (3) Diabetes mellitus.
- (4) Bleeding disorder.
- (5) Currently on anti-coagulant or immunosuppressive treatment.

The outcome measure implemented was the Victorian Institute of Sport Assessment-Proximal Hamstring Tendons (VISA-H) questionnaire (Supplementary Appendix A). This is an 8-item questionnaire that has been validated for assessing pain, function and ability to undertake sport or other physical activity in patients with PHT.¹⁵ The VISA-H questionnaire is scored out of a maximum of 100 points, with a minimum clinically significant difference of 22 points, and a score of 100 points representing the *least* disability.¹⁵

Baseline data was collected via patients completing a written VISA-H questionnaire immediately prior to receiving the PRP injection. Follow-up responses were obtained at 8-weeks post injection via patients completing the VISA-H questionnaire in writing or over the phone. Patients who elected to provide follow-up data over the phone were contacted by a researcher at 8 weeks. Prior to enrolment into the study, all patients were instructed to not engage in physiotherapy, massage, acupuncture or another form of physical therapy. This information was collected at 8-weeks follow-up and patients who engaged in any of the above modalities were excluded from the final analysis.

The treatment technique involved withdrawing 10 mL of venous blood from the patient's cubital fossa using the RegenKit[®] BCT-3 (Regenlab[®], Le Mont-sur-Lausanne, Switzerland). This technology removes $>96\%$ of the granulocytes and $>99.7\%$ of the red blood cells. The specialised Regen PRP tube containing 10 mL of patient

blood was then centrifuged for 5 min at 1400 rpm resulting in 7 mL of platelet-rich plasma. We removed 1 mL of the upper layer of the platelet-poor supernatant, leaving 6 mL of platelet-rich plasma with a mean platelet concentration of $910 \times 10^9/L$ (normal platelet range $150\text{--}400 \times 10^9/L$). Administration of the PRP injection into the affected proximal hamstring was performed under ultrasound guidance by a certified interventional radiologist using a 12-MHz transducer on a Toshiba Aplio 500 ultrasound machine. Patients were positioned in prone and sterile preparation of the skin was performed at the level of the ischial tuberosity. Following the administration of 4 mL of 1% Xylocaine (AstraZeneca) into the skin and bursa with a 22-gauge spinal needle, an anaesthetic needle was advanced into the areas of tearing or degeneration in the hamstring entheses, both at the conjoined tendon and semimembranosus, and 6 mL of PRP was 'peppered' into these areas of tearing or degeneration.

Since no previous tendinopathy studies have utilised the VISA-H questionnaire as their outcome measure, we performed a post-study power analysis to approximate the minimum sample size required to attain 80% power at a 5% level of significance for the 100-point VISA-H questionnaire. This analysis was performed using our pre- and post-injection standard deviation (pre-injection SD: 16.838; post-injection SD: 21.283) and the validated minimum clinically important difference of 22 points.¹⁵ Results of this analysis demonstrated a minimum of 12 patients required in the study sample.

We first investigated whether a PRP injection is associated with a change in VISA-H scores at 8-weeks follow-up in the total sample of patients regardless of pre-injection grading of PHT severity. We then examined whether a PRP injection is associated with a change in VISA-H scores at 8-weeks follow-up in patients with different pre-injection grades of PHT severity. This involved performing a separate analysis for patients with mild, moderate and marked PHT. Finally, we conducted an analysis on question 7 of the VISA-H questionnaire to determine whether a PRP injection is associated with a change in the ability to undertake sport or other physical activity at 8-weeks follow-up in the total sample of patients. Statistical analyses were undertaken using Kruskal–Wallis tests and paired t-tests as appropriate, with data considered statistically significant when $p < 0.05$.

3. Results

Of the 61 patients initially assessed for eligibility, 12 patients declined to participate, 11 patients did not meet the inclusion and exclusion criteria, 3 patients engaged in physiotherapy and 6 patients were lost to follow-up due to failure to respond to the 8-week post-injection VISA-H questionnaire. 29 patients were included in the final analysis (Fig. 1) and the study sample characteristics are shown in Table 1. One patient reported a large increase in pain lasting for a duration of 72 h following PRP. There were no other complications reported.

In the total sample of patients, when comparing pre-injection VISA-H scores (mean: 43.90; 95% CI 37.77–50.03) with 8-weeks post-injection VISA-H scores (mean: 51.14; 95% CI 43.39–58.88), no statistically significant difference was found ($p = 0.14$). Pre- and post-injection VISA-H scores for all 29 patients are shown in Fig. 2. When performing separate analyses for patients with mild, moderate and marked PHT, and comparing mean pre-injection and post-injection VISA-H scores for each group, no statistically significant difference was found in any of the groups ($p = 0.86$, $p = 0.13$, $p = 0.28$ respectively) (Table 2).

When analysing pre- and post-injection data for question 7 only of the VISA-H scale, 5 patients (17.2%) reported an increased ability to undertake sport or other physical activity, 4 patients (13.8%)

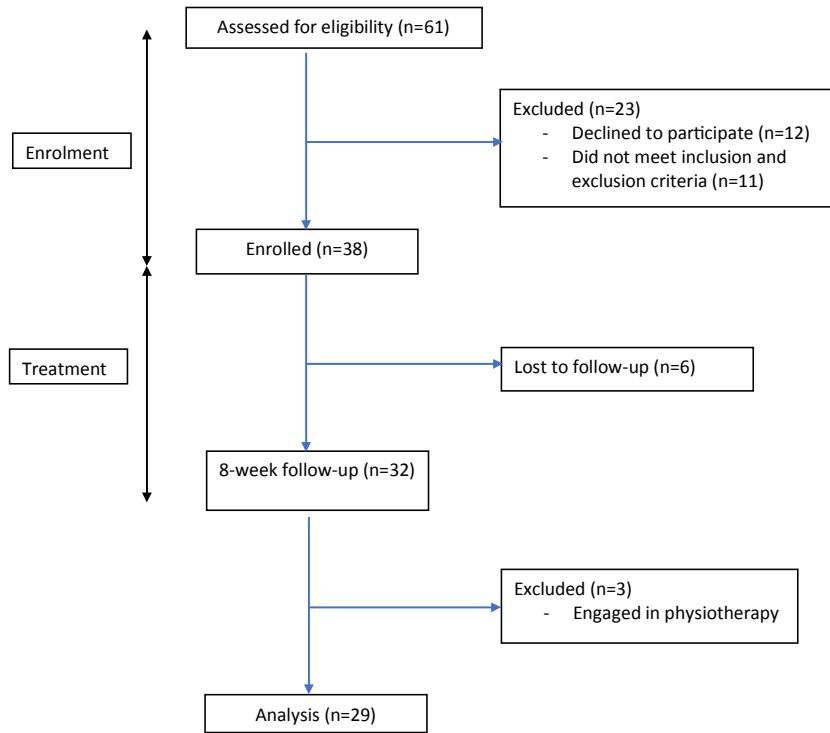
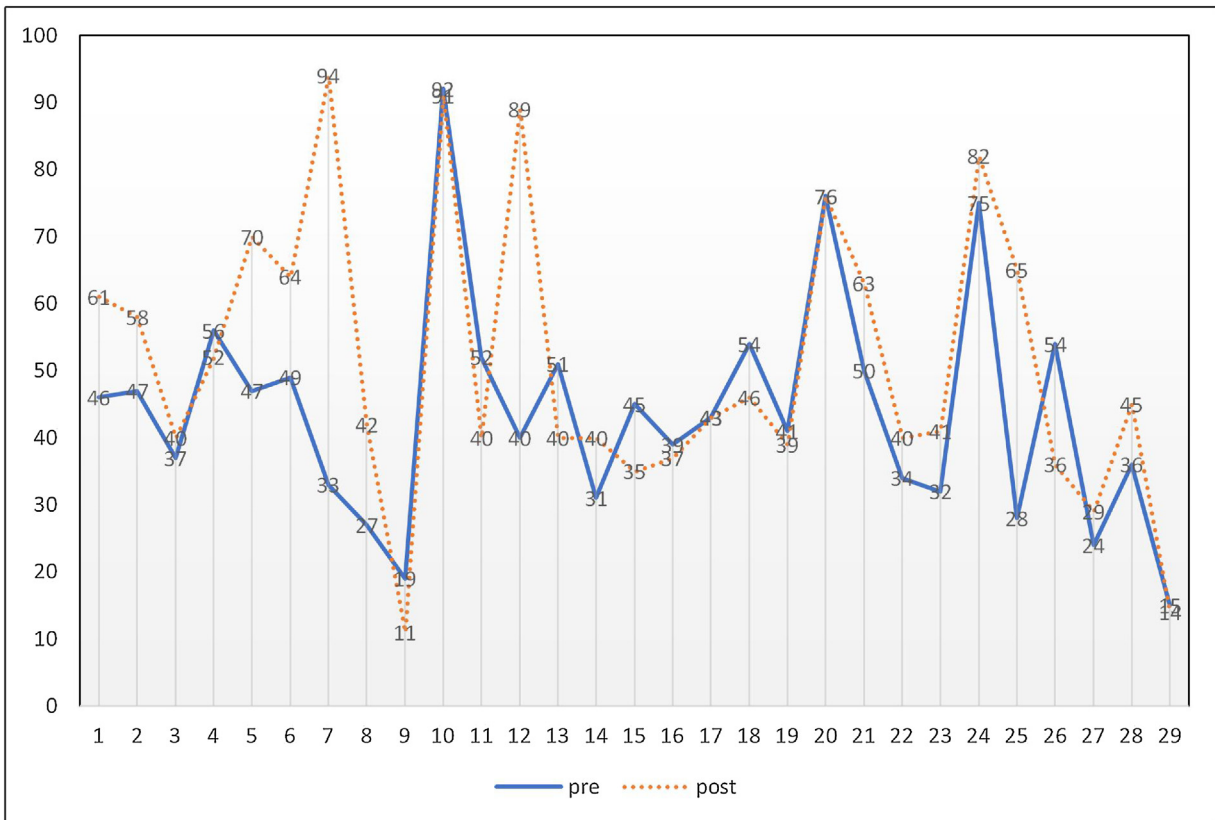


Fig. 1. Patient eligibility, enrolment, follow-up and analysis.



X-axis: patient number 1, 2, 3....., 28, 29

Y-axis: VISA-H score (0-100 points)

Fig. 2. Pre-and post-injection VISA-H scores for all 29 patients.

Table 1
Study sample characteristics.

	Total
n (%)	29 (100)
Males: n (%)	7 (24.1)
Females: n (%)	22 (75.9)
Age: mean (95% CI)	45.2 (40.8; 49.5)
Level of sport or other physical activity pre-injection: n (%) ^a	
Not at all	6 (20.7)
Modified training	17 (58.6)
Full training (at a lower level)	5 (17.2)
Full training (at same or higher level)	1 (3.4)
Level of sport or other physical activity 8-weeks post-injection: n (%) ^a	
Not at all	6 (20.7)
Modified training	16 (55.2)
Full training (at a lower level)	4 (13.8)
Full training (at same or higher level)	3 (10.3)
Tendinopathy grade: n (%)	
Mild	9 (31.0)
Moderate	16 (55.2)
Marked	4 (13.8)

CI: Confidence Interval; n: number of patients.

^aLevel of sport or other physical activity based on question 7 of the VISA-H scale:

- Are you currently undertaking sport or other physical activity?
- Not at all
- Modified training ± modified competition
- Full training ± competition but not at the same level as when symptoms began
- Competing at the same or higher level as when symptoms began

Table 2
Pre-and post-injection VISA-H scores.

	Pre-injection: mean (95% CI)	Post-injection: mean (95% CI)	p-Value
Total Sample	43.90 (37.77; 50.03)	51.14 (43.39; 58.88)	0.14
Mild PHT	40.67 (32.68; 48.65)	39.56 (30.46; 48.65)	0.86
Moderate PHT	47.13 (37.15; 57.10)	59.19 (47.54; 70.84)	0.13
Marked PHT	38.25 (31.68; 44.82)	45.0 (35.91; 54.09)	0.28

CI: Confidence Interval; PHT: Proximal Hamstring Tendinopathy; VISA-H: Victorian Institute of Sport Assessment-Proximal Hamstring Tendons.

Comparisons are presented for the total sample of patients and separately for patients with either mild, moderate or marked proximal hamstring tendinopathy.

reported a decreased ability and 20 patients (69.0%) reported no change in their ability to undertake sport or other physical activity at 8-weeks follow-up.

4. Discussion

In this pilot prospective cohort study, we utilised the VISA-H questionnaire as a validated tool for assessing pain, function and ability to undertake sport or other physical activity in patients with PHT.¹⁵ Results of our study have illustrated that patients with PHT receiving a PRP injection did not improve on clinical outcomes at 8-weeks follow-up. These findings were demonstrated in both the total sample of patients and when we subdivided the analyses into patients with mild, moderate and marked PHT. However, with results of the power analysis demonstrating a minimum of 12 patients required per group, our study was not sufficiently powered to detect a possible clinically significant difference in patients with mild or marked PHT.

Importantly, patients in our study engaged in a variety of sports and other physical activity for recreational purposes and were not competitive athletes. Therefore, whilst the mean age of patients in our study was relatively high at 45.2 years, results of our study are

representative of patients involved in sport and physical activity for recreational purposes rather than a typical athletic population.

To our knowledge, only the studies by Davenport et al.⁹ and Fader et al.¹⁴ are similar to ours in their investigation of the efficacy of a PRP injection in treating patients with PHT. In the study by Davenport et al.,⁹ a PRP injection was demonstrated to be statistically significant in improving function and quality of life in patients with PHT. However, the study by Davenport et al.⁹ implemented a 6-month follow-up in the absence of a control group (e.g. a saline injection) making it likely that natural recovery played a large role in affecting their overall findings. Additionally, the study by Davenport et al.⁹ excluded patients with the most severe PHT (tendon tear of >50%) and it is plausible that these patients would have responded differently to the PRP injection compared to patients with less severe PHT. In the study by Fader et al.,¹⁴ a PRP injection was associated with a statistically significant 63% average decrease in pain scores on visual analogue scale. However, as was the case in the study by Davenport et al.,⁹ the study by Fader et al.¹⁴ also utilised a 6-month follow-up without a control group, thereby increasing the likelihood of natural recovery significantly impacting on their results. Additionally, the only outcome measure reported on in the study by Fader et al.¹⁴ was the visual analogue scale. This is a relatively simplistic outcome measure that does not factor into account function or sporting activity and therefore does not provide a broad indication of the effectiveness of the PRP injection. Therefore, whilst the findings of Davenport et al.⁹ and Fader et al.¹⁴ differ from our results, it is plausible that limitations in their methodology may have contributed to this discrepancy.

There is conflicting evidence as to the effectiveness of a PRP injection in the treatment of a range of chronic tendinopathies,^{16–18} with some studies demonstrating an improvement in clinical outcomes following PRP and other studies showing no benefit. A recent systematic review¹⁹ identified gender as an important factor influencing the effectiveness of a PRP injection in the treatment of various tendinopathies, with females shown to experience greater benefits with PRP compared to males. Despite our study being predominantly female, our results did not demonstrate an improvement in clinical outcomes in patients with PHT who received a PRP injection. However, the aforementioned systematic review¹⁹ did not incorporate studies on patients with PHT, and it is possible that gender may play a critical role in certain tendinopathies and not in others.

Similarly, there is differing evidence regarding the efficacy of a PRP injection in the treatment of acute tendon injuries,^{12,20} with some studies illustrating a beneficial outcome following PRP and other studies demonstrating no value. For example, in achilles tendon ruptures, one study²¹ demonstrated both a PRP injection and surgical repair to be more effective at improving patient functional outcomes compared with surgical repair alone, whereas another study²⁰ found the combination of a PRP injection and surgical repair to be no more effective than surgery alone.

There is debate within the literature as to whether serial PRP injections are more efficacious than a single PRP injection in the treatment of chronic tendinopathies.¹² In our study, we administered a single PRP injection as this approach was consistent with the current literature on PRP for PHT.^{9,14} Whilst there is limited evidence comparing a single with multiple PRP injections for the treatment of chronic tendinopathies, a recent systematic review and meta-analysis²² concluded that multiple PRP injections were more effective than a single PRP injection for improving clinical outcomes at 6-months follow-up in patients with patella tendinopathy. Nevertheless, further evidence comparing a single with multiple PRP injections in the treatment of a range of other chronic tendinopathies is still required.

Whilst few treatment options have been validated for PHT, various treatments have been suggested,⁹ such as conservative

management, a corticosteroid injection and shockwave therapy. Although not currently validated with further research, two case reports^{10,23} have identified conservative management in the form of a hamstring eccentric exercise program to be beneficial in decreasing pain in patients with PHT. The efficacy of a corticosteroid injection for treating PHT is limited and conflicting, with one study⁷ reporting a sustained reduction in pain at 2 years follow-up, and another study⁸ demonstrating symptom recurrence following short-term pain relief. Despite limited evidence, studies^{24,25} have demonstrated shockwave therapy to be beneficial in reducing pain in patients with PHT. The effectiveness of surgery for treating PHT has only been studied retrospectively, with two studies demonstrating return to pre-symptom level of sporting activity following surgery.^{3,5} However, surgical repair is associated with a higher risk of complications including sciatic nerve damage, infection and hamstring origin rupture, as well as longer recovery times compared with non-surgical treatment.

There were several limitations that require consideration when interpreting the results of our study. Firstly, the absence of a control group may have underestimated the impact of natural recovery on our results. However, whilst natural recovery may have affected our results at 8-weeks follow-up, it is likely that natural recovery played an even larger role in the studies by Davenport et al.⁹ and Fader et al.¹⁴ which implemented 6-month follow-ups. Secondly, our study imposed no restrictions on the volume and intensity of physical activity and/or sport that patients could perform in the period between receiving the PRP injection and obtaining follow-up data. Similarly, a pilot study exploring the effectiveness of a PRP injection in rotator cuff tendinopathy¹³ and the study by Davenport et al.⁹ imposed no limitations on physical activity and/or sport in this period. Conversely, a high-powered randomised controlled trial²⁶ exploring the efficacy of a PRP injection in achilles tendinopathy did implement restrictions. Whilst difficult to quantify, it is plausible that engagement in physical activity and/or sport in the period between receiving a PRP injection and obtaining follow-up data may reduce the effectiveness of the PRP injection, thereby impacting on our results. Thirdly, there is a high risk of bias being introduced into our study due to the placebo effect. This is especially the case since the VISA-H questionnaire is a subjective outcome measure. It is therefore plausible that a placebo response caused our results to be overstated in favour of the PRP injection. Fourthly, our study did not include data pertaining to the mean duration of symptoms experienced by patients prior to receiving the PRP injection. With our inclusion criteria specifying patients to have been symptomatic for ≥ 3 weeks prior to PRP injection, it is possible that patients experiencing symptoms for a longer duration prior to PRP would have responded differently compared with patients having only had symptoms for 3 weeks. Fifthly, whilst there is no current standardised amount of PRP that should be used, patients in our study were administered 6 mL of PRP. This is a relatively large volume of PRP and it is therefore possible that surrounding soft tissues may have been affected. Finally, our study involved a relatively small sample size of 29 patients. However, our sample size was still comparatively larger than the sample sizes used in the studies by Davenport et al.⁹ and Fader et al.,¹⁴ making our study the largest study to date exploring the efficacy of a PRP injection for PHT.

5. Conclusion

Given the paucity of evidence for the usage of a PRP injection in the treatment of patients with PHT, we suggest that our study is an important addition to the current literature. To our knowledge, our study is the first to have explored the efficacy of a PRP injection in the treatment of patients with different pre-injection grades of PHT

severity. Results of our study have demonstrated that patients with PHT receiving a PRP injection did not improve on clinical outcomes, and this was the case for all pre-injection grades of PHT severity. Our results differ from our original hypothesis and are at variance with other studies exploring a PRP injection for PHT.^{9,14} However, these studies are limited by study design and sample size. Additionally, the evidence exploring the efficacy of a PRP injection in the treatment of various other chronic tendinopathies, such as patella tendinopathy, remains conflicting throughout the literature. Since the evidence base for the efficacy of a PRP injection in the treatment of patients with PHT is limited by the number of studies, their design and sample size, we suggest higher powered randomised controlled trials that include varying pre-injection grades of PHT may prove a fruitful avenue of further investigation.

Practical implications

- A platelet-rich plasma injection was not associated with a reduction in pain in patients with proximal hamstring tendinopathy.
- A platelet-rich plasma injection was not associated with an improvement in function in patients with proximal hamstring tendinopathy.
- Most patients with proximal hamstring tendinopathy had no change in their ability to undertake sport or other physical activity following a platelet-rich plasma injection.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.jsams.2018.08.001>.

References

1. Goom TSH, Malliaras P, Reiman MP et al. Proximal hamstring tendinopathy: clinical aspects of assessment and management. *J Orthop Sports Phys Ther* 2016; 46(6):483–493.
2. Cacchio A, Borra F, Severini G et al. Reliability and validity of three pain provocation tests used for the diagnosis of chronic proximal hamstring tendinopathy. *Br J Sports Med* 2012; 46(12):883–887.
3. Lempainen L, Sarimo J, Mattila K et al. Proximal hamstring tendinopathy: results of surgical management and histopathologic findings. *Am J Sports Med* 2009; 37(4):727–734.
4. Puranen J, Orava S. The hamstring syndrome. A new diagnosis of gluteal sciatic pain. *Am J Sports Med* 1988; 16(5):517–521.
5. Benazzo F, Marullo M, Zanon G et al. Surgical management of chronic proximal hamstring tendinopathy in athletes: a 2 to 11 years of follow-up. *J Orthop Traumatol* 2013; 14(2):83–89.
6. Fredericson M, Moore W, Guillet M et al. High hamstring tendinopathy in runners: meeting the challenges of diagnosis, treatment, and rehabilitation. *Phys Sportsmed* 2005; 33(5):32–43.
7. Nicholson LT, DiSegna S, Newman JS et al. Fluoroscopically guided peritendinous corticosteroid injection for proximal hamstring tendinopathy: a retrospective review. *Orthop J Sports Med* 2014; 2(3), 2325967114526135–35.
8. Lempainen L, Johansson K, Banke IJ et al. Expert opinion: diagnosis and treatment of proximal hamstring tendinopathy. *Muscles Ligaments Tendons J* 2015; 5(1):23–28.
9. Davenport KL, Campos JS, Nguyen J et al. Ultrasound-guided intratendinous injections with platelet-rich plasma or autologous whole blood for treatment of proximal hamstring tendinopathy: a double-blind randomized controlled trial. *J Ultrasound Med* 2015; 34(8):1455–1463.
10. Cushman D, Rho ME. Conservative treatment of subacute proximal hamstring tendinopathy using eccentric exercises performed with a treadmill: a case report. *J Orthop Sports Phys Ther* 2015; 45(7):557–562.
11. Anitua E, Andia I, Ardanza B et al. Autologous platelets as a source of proteins for healing and tissue regeneration. *Thromb Haemost* 2004; 91(1):4–15.

12. Nguyen RT, Borg-Stein J, McInnis K. Applications of platelet-rich plasma in musculoskeletal and sports medicine: an evidence-based approach. *PMR* 2011; 3(3):226–250.
13. Wesner M, Defreitas T, Bredy H et al. A pilot study evaluating the effectiveness of platelet-rich plasma therapy for treating degenerative tendinopathies: a randomized control trial with synchronous observational cohort. *PLoS One* 2016; 11(2), e0147842-e42.
14. Fader RR, Mitchell JJ, Traub S et al. Platelet-rich plasma treatment improves outcomes for chronic proximal hamstring injuries in an athletic population. *Muscles Ligaments Tendons J* 2015; 4(4):461–466.
15. Cacchio A, De Paulis F, Maffulli N. Development and validation of a new visa questionnaire (VISA-H) for patients with proximal hamstring tendinopathy. *Br J Sports Med* 2014; 48(6):448–452.
16. Balasubramaniam U, Dissanayake R, Annabell L. Efficacy of platelet-rich plasma injections in pain associated with chronic tendinopathy: a systematic review. *Phys Sportsmed* 2015; 43(3):253–261.
17. Liddle AD, Rodríguez-Merchán EC. Platelet-rich plasma in the treatment of patellar tendinopathy: a systematic review. *Am J Sports Med* 2015; 43(10):2583–2590.
18. Di Matteo B, Filardo G, Kon E et al. Platelet-rich plasma: evidence for the treatment of patellar and Achilles tendinopathy—a systematic review. *Musculoskeletal Surg* 2015; 99(1):1–9.
19. Miller LE, Parrish WR, Roides B et al. Efficacy of platelet-rich plasma injections for symptomatic tendinopathy: systematic review and meta-analysis of randomised injection-controlled trials. *BMJ Open Sport Exerc Med* 2017; 3(1), e000237-e37.
20. Schepull T, Kvist J, Norrman H et al. Autologous platelets have no effect on the healing of human achilles tendon ruptures: a randomized single-blind study. *Am J Sports Med* 2011; 39(1):38–47.
21. Zou J, Mo X, Shi Z et al. A prospective study of platelet-rich plasma as biological augmentation for acute Achilles tendon rupture repair. *BioMed Res Int* 2016; 2016, 9364170-70.
22. Andriolo L, Altamura SA, Reale D, Candrian C, Zaffagnini S, Filardo G. Nonsurgical treatments of patellar tendinopathy: multiple injections of platelet-rich plasma are a suitable option: a systematic review and meta-analysis. *Am J Sports Med* 2018. <http://dx.doi.org/10.1177/0363546518759674>. ISSN: 1552-3365, PMID: 29601207.
23. Jayaseelan DJ, Moats N, Ricardo CR. Rehabilitation of proximal hamstring tendinopathy utilizing eccentric training, lumbopelvic stabilization, and trigger point dry needling: 2 case reports. *J Orthop Sports Phys Ther* 2014; 44(3):198–205.
24. Standaert CJ. Shockwave therapy for chronic proximal hamstring tendinopathy. *Clin J Sport Med* 2012; 22(2):170–171.
25. Cacchio A, Rompe JD, Furia JP et al. Shockwave therapy for the treatment of chronic proximal hamstring tendinopathy in professional athletes. *Am J Sports Med* 2011; 39(1):146–153.
26. de Vos RJ, Weir A, van Schie HTM et al. Platelet-rich plasma injection for chronic Achilles tendinopathy: a randomized controlled trial. *JAMA* 2010; 303(2):144–149.