Systematic Review

Platelet-Rich Plasma Versus Surgery for the Management of Recalcitrant Greater Trochanteric Pain Syndrome: A Systematic Review

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Purpose: To perform a systematic review of the outcomes of platelet-rich plasma (PRP) injections as an in-office procedure versus surgical treatment for recalcitrant greater trochanteric pain syndrome (GTPS). **Methods:** The MEDLINE and Embase databases were searched in June 2019 following the Preferred Reporting Items for Systematic Reviews and Meta-analyses statement. Clinical studies on patients with recalcitrant GTPS treated with PRP or surgery were included. Demographic characteristics, patient-reported outcomes (PROs), and complications were compared. A qualitative analysis using the Methodological Index for Non-randomized Studies and Cochrane Risk of Bias Tool scores was performed. **Results:** A total of 5 PRP and 5 surgery studies met the inclusion criteria, contributing 94 and 185 patients, respectively. The mean follow-up time was shorter for the PRP studies (range, 2-26 months) than with surgery (range, 12-70 months). The mean Methodological Index for Non-randomized Studies scores for the PRP and surgery groups were 11.25 and 11.4, respectively, and the only randomized trial had a low risk of bias. Two studies in the PRP group (n = 56) reported improvements in the modified Harris Hip Score at final follow-up (from 53.8 to 82.6 and from 56.7 to 74.2). The other PRP studies reported improvements using other measures. In the surgery group, 2 studies reported improvements in the Harris Hip Score (from 53.0 to 80 and from 53.3 to 88) whereas 3 used unique PROs (Oxford score, from 20.4 to 37.3; modified Harris Hip Score, from 54.9 to 76.2; and Merle d'Aubigné and Postel score, from 10.9 to 16.7). Although significant improvement was reported in all studies included, PRP showed a large effect size whereas surgery showed a moderate to large effect size. No major complications were associated with PRP treatment; however, the surgery group reported a higher rate of complications including recurrent external snapping hip, retears resulting from falls, trochanteric fracture, venous thrombosis, and wound-related problems. **Conclusions:** Both PRP and surgical intervention for the treatment of recalcitrant GTPS showed statistically and clinically significant improvements based on PROs. Although not covered by most medical insurance companies, PRP injections for recalcitrant GTPS provides an effective and safe alternative after failed physical therapy. If surgery is indicated, endoscopy is safer than the open technique. **Level of Evidence:** Level IV, systematic review of Level I to IV studies.

Greater trochanteric pain syndrome (GTPS) is characterized by lateral hip pain due to trochanteric bursitis, gluteal tendinosis, gluteal tendon tears, and external snapping hip.[1,2] This condition has been shown to affect as many as 24% of women older than 50 years.[3] Failure of first-line treatment (i.e., activity modification, anti-inflammatory medications, and physical therapy) results in recalcitrant GTPS. This is a

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debilitating condition comparable to hip osteoarthritis, causing disability and decreasing quality of life and activities of daily living.[4] Gluteal tendinopathy has been identified as the most prevalent underlying pathologic finding in recalcitrant GTPS.[5-7] A lack of inflammatory cells and the presence of angiofibroblastic hyperplasia are characteristic of this condition.[4,8-10] The pathomechanics of recalcitrant GTPS is similar to that causing rotator cuff tears of the shoulder and includes decreased stress shielding, increased tensile loads, and compression of the terminal tendon.[7,11-15]

Failure of first-line management is followed by second-line alternatives such as pain control with lidocaine patches, shock wave therapy, corticosteroid or platelet-rich plasma (PRP) injections, and surgical treatment.[16] Although popular in practice, corticosteroid injections only show good short-term outcomes that diminish with time.[17] A recent increase in the use of biologics, such as PRP, is supported by their effectiveness and their longer-term benefits in managing tendinopathies.[17-22] PRP is a preparation of autologous blood that achieves 4 to 10 times the baseline concentration of platelets. These platelets deliver a high number of growth factors that induce an anabolic response consisting of cellular chemotaxis, proliferation, angiogenesis, tendon collagen synthesis, and ultimately a healing response.[20,23,24] In 2014, a Cochrane Review of 19 small single-center trials, of which 17 were randomized, concluded that there is currently insufficient evidence to support the use of platelet-rich therapies for treating musculoskeletal soft-tissue injuries.[25] Since then, a great number of clinical studies on the preparation and clinical application of PRP have been published on this topic, including 4 of the 5 PRP studies reviewed in our study.[17,20,21,26] Despite covering a myriad of clinical conditions such as degenerative tears and tendinopathies of the shoulder, elbow, knee, and ankle, the Cochrane Review did not include studies specifically aimed at gluteal tendinopathy.[25] It has been suggested that PRP treatment may have a different response for different tendons.[27]

The biological effects of PRP treatment can vary according to the proportion of its cellular components after preparation.[28] The heterogeneity introduced by multiple PRP preparations and different modes of delivery further contributes to the already controversial use of PRP for tendinopathies by compromising reproducibility and generalizability. Leukocyte-rich PRP (LR-PRP) and leukocyte-poor PRP are 2 commonly used formulations that show varying biological effects.[28] Some studies have suggested that LR-PRP might have harmful effects on tenocytes by producing a greater acute inflammatory response, which can lead to greater scar formation.[29-31] Furthermore, minimization of leukocytes in PRP preparations is thought to be more important than maximizing platelets with respect to enhancing matrix gene synthesis.[32] On the other hand, clinical studies do not seem to correlate these findings. A randomized clinical trial on the use of LR-PRP for the treatment of recalcitrant GTPS reported significant benefits in functional outcomes with minimum 2-year follow-up.[33] Other series have reported similar outcomes.[20,26] Another study compared LR-PRP and leukocyte-poor PRP in patients with chronic Achilles tendinopathy and showed comparably high probabilities of reaching the minimal clinically important change in patient-reported outcomes (PROs) for both interventions.[34] Although superiority among different PRP preparations has not been determined, the differential anabolic and proinflammatory effects on tendinopathic tissue have led to the belief that specific preparations should be tailored to the specific temporal or biological needs of the affected tissue.[28] Additionally, image-guided delivery of PRP into the tendinopathic portion can not be overemphasized.[20,22,26,33]

Surgical treatment for GTPS has been described through open and endoscopic techniques. The presence and severity of an insertional gluteal tendon tear most often dictate the preferred technique, which can include debridement only, repair with sutures or suture anchors, or tendon transfers as a means of augmentation.[8,35] Other adjuvants, such as needle tendon fenestrations or greater trochanter micro-punctures, are aimed at improving the healing potential of the primary intervention.[19,36]

Gluteal tendinopathy is increasingly recognized as a source of persistent lateral hip pain, and it remains a challenging condition to treat when surgical indications are not clear or when nonsurgical options fail to improve patient symptoms. With an increasing number of studies reporting improved PROs after PRP injection in patients with recalcitrant GTPS, comparing its effectiveness with that of surgical treatment may be warranted. The purpose of this study was to perform a systematic review of the outcomes of PRP injections as an in-office procedure versus surgical treatment for recalcitrant GTPS. We hypothesized that both PRP injections and surgical treatment would improve PROs in patients with recalcitrant GTPS.

Methods

Search Strategy

This study was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement.[37] For this systematic review of PRP injections and surgery for the treatment of recalcitrant GTPS, a search of the MEDLINE (via PubMed) and Embase databases was performed on June 26, 2019, for studies that were published in the English language in the past 10 years, using the following search terms: ((((((((((greater) AND

trochanteric) AND pain) AND syndrome)) OR (((lateral) AND hip) AND pain)) OR ((gluteal) AND tear)) OR ((gluteal) AND tendinosis)) OR ((gluteal) AND tendinopathy))) AND (((((((platelet) AND rich) AND plasma)) OR prp) OR ((surgical) AND treatment)) OR arthroscopy) OR endoscopy).

The inclusion criteria were as follows: clinical outcome studies of recalcitrant GTPS as defined by failure of nonsurgical measures (i.e., physical therapy or corticosteroid injections) and imaging evidence of gluteal tendinopathy by ultrasound and/or magnetic resonance. The exclusion criteria were as follow: conference abstracts or technical reports, a diagnosis of trochanteric bursitis only, full-thickness tears of the gluteal tendons with retraction, or a traumatic cause. Studies reporting on duplicate patient populations were included once.

Study Screening

The identified articles were initially screened by title and abstract and were subsequently screened by full-text review via 2 independent reviewers (R.W.S., N.M.W.), with a third reviewer (A.C.L.) to resolve any disagreement. Articles without abstracts were chosen for full-text review by default. Studies found to meet all criteria were reviewed for quality assessment and data extraction. The reference sections of the included studies and other published systematic reviews related to the topic were also reviewed to identify additional articles for inclusion consideration.

Quality Assessment

The Methodological Index for Non-randomized Studies and the Cochrane Risk of Bias Tool for Randomized Controlled Trials[38] were used to evaluate observational and randomized trials, respectively, and used as a framework to determine the risk of bias of individual studies (Table 1). Assessment of heterogeneity according to the Cochrane systematic review guidelines and qualitative analysis was also performed.

Data Extraction

Two reviewers (R.W.S., N.M.W.) independently extracted data from each publication, and a third reviewer (A.C.L.) was available to reach a consensus on any disagreements. The following data were extracted from each study: author and year of publication, patient demographic characteristics, duration of symptoms, diagnosis and method of diagnosis, intervention technique for PRP injections or surgery, follow-up time, PROs, and complication rate. Outcome data were not pooled given the heterogeneity of studies, and a meta-analysis could not be conducted. All data were reported descriptively. The minimal clinically important difference (MCID) and patient acceptable symptomatic state (PASS) were also recorded for each study when available.[39]

The standardized mean difference (SMD) was calculated to estimate the effect size for PRO scores to show the change from preoperative to postoperative outcome scores on different questionnaires while accommodating for variability within studies.[40] The SMD was calculated by dividing the difference between the mean postoperative outcome score and the mean preoperative outcome score by the standard deviation of the mean preoperative outcome score. If no range, standard deviation, or standard error was given, the SMD was estimated using the sample size and P value of the t test used in a study. The 95% confidence intervals were calculated using the following formula: SMD $\pm$ 1.96 $\times$ Standard error. A large effect size was interpreted as an SMD of 0.8 or greater; a moderate effect size, between 0.5 and less than 0.8; and a weak effect size, between 0.2 and less than 0.5.[40]

Results

Study Selection

Of the 618 unique studies generated using our search strategy, 10 ultimately met the inclusion criteria, as shown in Figure 1. Studies that did not report on the use of PRP or surgery for recalcitrant GTPS were excluded based on title and abstract screening (n = 601). A total of 7 studies were excluded after full-text article review because they failed to include PROs (3), focused on pathology other than that included in recalcitrant GTPS (1), or reported on the same study population (2). A total of 5 articles using PRP injections[20-22,26,33] and 5 articles using surgical treatment[8,35,41-43] were included in this systematic review.

The number of patients who previously underwent corticosteroid injections was not specified in 4 of the 5 PRP studies and 3 of the 5 surgical studies. As many as 77.5% of patients treated with PRP injections by Fitzpatrick et al.[33] received at least 1 corticosteroid injection prior to PRP injections. In 2 studies reporting on surgical treatment, all patients had undergone at least 1 corticosteroid injection prior to undergoing surgery. The included articles were Level of Evidence (LOE) I to IV studies reporting on treatment with PRP injections or surgery, either open or endoscopic.

Quality Assessment

The PRP group had the 2 highest LOE studies in this review: a randomized controlled trial (LOE I) comparing corticosteroid injections versus PRP injections in the tendon with a 2-year follow-up period[33] and a case-controlled series (LOE III) comparing PRP injections in the tendon versus tendon fenestration.[26] All other studies in this review, including those in the surgery group, were retrospective case series (LOE IV).

Table 1. Level of Evidence, Quality-Assessment Scores, and Demographic and Preoperative Data

	LOE	Type of Study	MINORS Score	Patients, n (% Female)	Age, yr	Duration of Symptoms	Radiographic Workup	Type of Tendinopathy	Interventions Prior to Study Enrollment
PRP injections									
Fitzpatrick et al.,[33] 2019	I	RCT	*	40 (85)	Mean, 60.3 (range, 27-76)	Mean, 14.8 mo	US and MRI	Trochanteric bursitis: 20 Gluteal tendinopathy: 6 Partial-thickness tear: 14	PT, CSI: 27 of 40
Jacobson et al.,[26] 2016	III	CC	13	15 (93)	Mean, 53 (range, 23-72)	NR	US	Gluteal tendinopathy or partial-thickness tear (<50% depth)	PT, NSAIDs
Lee et al.,[20] 2016	IV	CS	10	21 (81)	Mean, 48 (range, 25-68)	Minimum, 3 mo	MRI	Gluteal tendinopathy and/or partial-thickness tear	PT
Mautner et al.,[22] 2013	IV	CS	10	16 (NR)	NR	Minimum, 6 mo	US or MRI	Gluteal tendinopathy with partial- or full-thickness tear and/or tendon calcification	PT, NSAIDs
Unlu et al.,[21] 2017	IV	CS	12	7 (86)	Mean ± SD, 37.7 ± 9.7 (range, 18-47)	Mean, 8.6 mo (range, 6.9-10.8 mo)	US or MRI	Gluteal tendinopathy	PT, NSAIDs
Surgery									
Coulomb et al.,[41] 2016	IV	CS	11	17 (94)	Mean ± SD, 53.5 ± 13.8 (range, 17-71)	Mean, 2.9 yr (range, 0.5-9 yr)	US and MRI	Gluteal tendon calcification: 2 Gluteal tendinopathy in remainder	PT; CSI and/or PRP, shock wave therapy
Davies et al.,[42] 2013	IV	CS	11	22 patients, 23 hips (91)	Mean, 67.7 (range, 45-85)	Range, 6-144 mo	MRI	Partial-thickness tear: 14 Nearly full-thickness tear: 9	NR
Drummond et al.,[43] 2016	IV	CS	12	49 (86)	Mean, 65 (range, 26.7-88.6)	Minimum, 6 mo	US and/or MRI	Full-thickness tear: 8 Bursal inflammation, gluteal tendinopathy and/or gluteal tendon tear in remainder	PT, CSI
Hartigan et al.,[35] 2018	IV	CS	12	25 (96)	Mean, 53.5 (range, 38.4-70.7)	NR	MRI	Partial-thickness tear: 25	PT, NSAIDs, activity modification, home exercises, CSI
Walsh et al.,[8] 2011	IV	CS	11	72 (93)	Mean, 62 (range, 36-88)	Mean, 22.4 mo (range, 6-144 mo)	MRI	Gluteal tendinopathy: 59 Full-thickness tear: 6 Either undersurface or partial-thickness tear in remainder	NR

CC, case-controlled study; CS, case-series study; CSI, corticosteroid injection; LOE, level of evidence; MINORS, Methodological Index for Non-randomized Studies; MRI, magnetic resonance imaging; NR, not reported; NSAIDs, nonsteroidal anti-inflammatory drugs; PRP, platelet-rich plasma; PT, physical therapy; RCT, randomized controlled trial; SD, standard deviation; US, ultrasound.

*The Cochrane Risk of Bias Tool was used for evaluation.

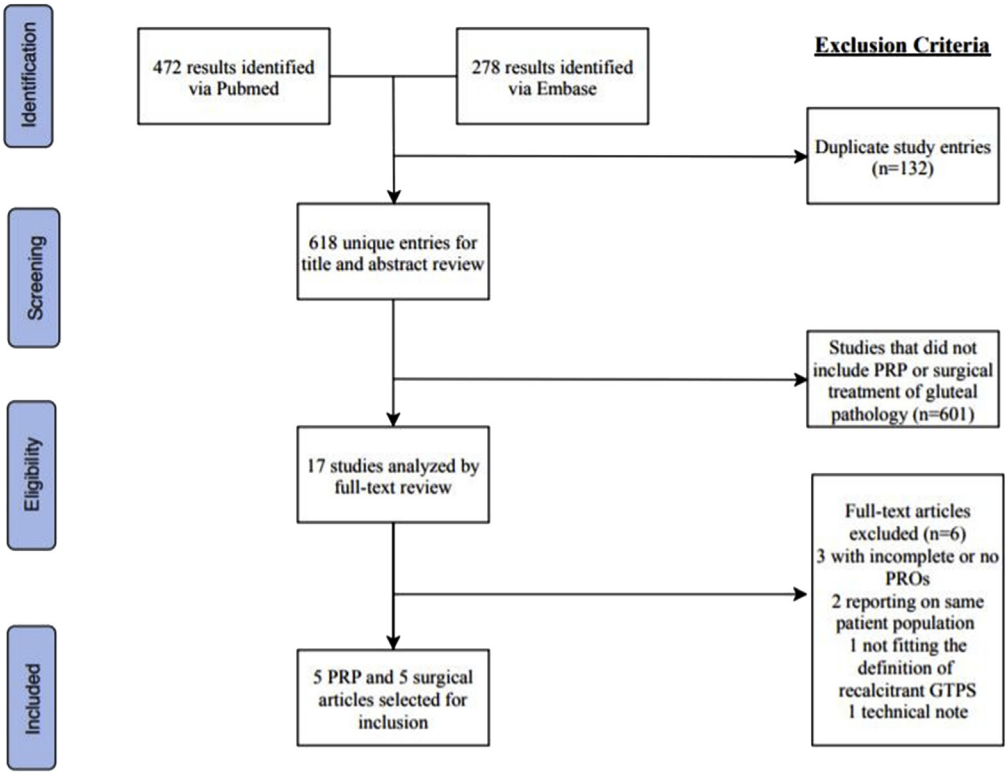

Fig 1. Flow diagram of literature search undertaken in December 2018 by PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) method. (GTPS, greater trochanteric pain syndrome; PROs, patient-reported outcomes; PRP, platelet-rich plasma.)

LOEs and quality scores for each included study are summarized in Table 1. The mean Methodological Index for Non-randomized Studies scores were 11.25 for the PRP group and 11.4 for the surgery group. The only randomized controlled trial in this review had a low risk of bias based on the Cochrane Risk of Bias Tool.[33] Both clinical heterogeneity and methodologic heterogeneity were present among the included studies. Differences in surgical technique and PRP protocols were found among the included studies. Furthermore, the included studies varied on the PROs collected and time points of collection.

Demographic Characteristics

This systematic review included 284 patients with recalcitrant GTPS. Of these patients, 94 were in the PRP group, with the number of patients ranging from 7 to 40 patients per study, and 185 were in the surgery group, with individual studies including between 17 and 72 patients. The age range for patients undergoing PRP injections or surgery were 18 to 76 years and 17 to 88.6 years, respectively. Female patients comprised 86% and 91% of patients in the PRP and surgery groups, respectively. One study in the PRP group did not report age or sex.[22] In the PRP group, the mean duration of symptoms before intervention ranged from 3 to 14.8 months, with 1 study not reporting on this[26]; in the surgery group, the mean duration ranged from 6 to 36 months, also with 1 study not reporting on this.[35] The mean follow-up period among the PRP studies ranged from 2 to 26 months, whereas that for the surgery studies ranged from 12 months up to 70 months. Demographic and pretreatment data are summarized in Table 1.

Diagnosis

In all studies, diagnoses were clinically confirmed by ultrasound and/or magnetic resonance imaging. Relevant imaging findings for recalcitrant GTPS in this group of studies included tendon thickening, edema, calcification, and partial-thickness tears, with or without associated trochanteric bursitis.

Outcomes

The PROs reported varied among studies. The modified Harris Hip Score (mHHS) was the most commonly used PRO across studies.[33,35,41,42] Additional PROs included the Oxford score and Merle d'Aubigné system.[8,43] Clinically relevant changes were reported by use of the MCID (as a percentage) and/or PASS (as a percentage), but these were only reported for 2 PRP studies.[20,33]

The 2 studies in the PRP group reporting PROs, those of Fitzpatrick et al.[33] and Lee et al.,[20] reported statistically significant improvements in the mHHS from 53.8 to 82.6 and from 56.7 to 74.2, respectively. In addition,

Table 2. MCID and PASS Outcomes for Studies in PRP Group

	PRO	Patients Meeting MCID, n (%)	Patients Meeting PASS, n (%)
Fitzpatrick et al.,[33] 2019	mHHS	NR	31 of 35 (88.6)*
Lee et al.,[20] 2016	mHHS	13 of 21 (62)	NR
	HOS-ADL	15 of 21 (71)	NR
	HOS-SSS	14 of 20 (70)	NR
	iHOT-33	18 of 20 (90)	NR

HOS-ADL, Hip Outcome Score—Activities of Daily Living; HOS-SSS, Hip Outcome Score—Sports-Specific Score; iHOT-33, International Hip Outcome Tool-33; MCID, minimal clinically important difference; mHHS, modified Harris Hip Score; NR, not reported; PASS, patient acceptable symptom state; PRO, patient-reported outcome; PRP, platelet-rich plasma.
*At 104 weeks after treatment.

Fitzpatrick et al. reported a PASS of 88.6%, whereas Lee et al. reported an MCID of 62% (Table 2).

All 5 studies in the surgery group, including open and endoscopic techniques, also reported statistically significant improvements in PROs.[8,35,41-43] Two studies in the surgery group reported Harris Hip Score improvements from 53.0 to 80 and from 53.3 to 88.[41,42] The other 3 surgery group studies reported unique PROs unable to be compared jointly (Oxford score, from 20.4 to 37.3; mHHS, from 54.9 to 76.2; and Merle d'Aubigné and Postel score, from 10.9 to 16.7). All PROs are summarized in Table 3.

SMD analysis could be performed for 2 of 5 studies in the PRP group[20,33] and 4 of 5 studies in the surgery group[35,41-43]; the findings are shown in Figure 2. All but 2 studies in both the PRP group and surgery group reported pain scale scores. All 6 of the remaining studies reported significant improvements in pain using their respective scales.[21,22,26,35,41,43]

Techniques

The technique for PRP preparation varied across the reviewed studies, with the amount of blood drawn from a peripheral vein ranging from 25 to 60 mL, which yielded approximately 4 to 10 mL of LR-PRP, equaling 4 to 10 times the number of platelets found in normal serum. The surgical techniques used among the studies in this review are summarized in Table 4.

Complications

Within the PRP group, 2 studies did not report on complications.[21,22] Of the remaining 3 studies, 2 reported only minor adverse effects related to the injection site[20,33] whereas 1 reported no complications.[26]

In the surgery group, Walsh et al.[8] reported the highest rate of complications, at 19%, with an open approach. They reported on 72 patients who underwent open surgical treatment of gluteal tendinopathy. Complications included deep venous thrombosis (n = 6), pulmonary embolism (n = 1), wound hematoma (n = 3) with 1 patient requiring vacuum-assisted closure dressing and antibiotics, trochanteric fracture (n = 1), and early repair failure that required revision surgery (n = 4). The 4 patients who underwent revision surgery were pain free at the most recent follow-up.

Coulomb et al.[41] reported 3 instances of occasional surgical-site pain (17.6%) and 1 case of lateral snapping hip recurrence (5.8%) after endoscopic treatment with a diamond-shaped iliotibial band decompression as previously described by other authors.[44] Davies et al.[42] reported 2 cases of hip abductor tendon retear resulting from falls (8.6%). Two other studies reported no complications,[35,43] each of which were endoscopy-only surgery cohorts. Complications in both the PRP and surgery groups are summarized in Table 3.

Discussion

The clinical studies included in this systematic review on the use of PRP injections for the treatment of recalcitrant GTPS show statistically and clinically significant improvements based on PROs comparable to surgical treatment. Multiple study design differences and overall heterogeneity were noted, including type of intervention, grading of GTPS, and outcome scores. These differences did not allow statistically sound data pooling or meta-analysis.[45] On the other hand, calculations of SMDs showed a large effect size for the PRP group and a moderate to large effect size for the surgery group. Both the severity and rate of complications shown in both groups in this report favor PRP over surgical intervention.

In 2014, a Cochrane Review recommended against the use of platelet-rich therapies for musculoskeletal soft-tissue injuries because of insufficient evidence.[25] Since then, evidence has mounted suggesting that PRP may in fact have a role in the treatment of musculoskeletal soft-tissue injuries. The aforementioned report did not include studies focused on gluteal tendinopathy, and the authors did not entertain the fact that different tendons may respond differently to platelet-rich therapies. In a systematic review, Ali et al.[18] summarized the evidence on the use of PRP injections in the management of GTPS. Their review included 5 full-text articles and 4 published conference abstracts. Clinical improvement was observed at 3 months, and this benefit persisted through 12 months after the intervention. Fitzpatrick et al.[33] published a

Table 3. PRO Scores for All Studies

	Follow-up	PRO Measure	PRO Score		Pain Measure	Pain Score		Complications
			Before Intervention	Final Follow-up		Before Intervention	Final Follow-up	
PRP Injections								
Fitzpatrick et al.,[33] 2019	104 wk	mHHS	53.77 ± 12.08 (23-77)	82.59 ± 9.71	NR	NR	NR	Minor adverse events, self-limited localized soreness at target site resolved in 48 h
Lee et al.,[20] 2016	19.7 mo (12.1-32.33 mo)	mHHS	56.73 ± 11.19 (35.20-73.70)	74.17 ± 15.07 (42.90-95.70)	NR	NR	NR	Minor adverse events, with most common being self-limited localized soreness at target site
		HOS-ADL	68.93 ± 16.48 (20.59-100.0)	84.14 ± 12.44 (48.53-100.00)				
		HOS-SSS	45.54 ± 23.40 (5.56-94.40)	66.72 ± 24.61 (28.13-100.00)				
		iHOT-33	34.06 ± 15.33 (6.45-74.06)	66.33 ± 23.12 (19.60-94.60)				
Jacobson et al.,[26] 2016	2 mo ± 27.7 d (21-108 d)				Mean pain score estimate	31.4 ± 7.3 (11-41)	19.4 ± 10.26 (4-42)	No complications
Mautner et al.,[22] 2013	NR	Moderate improvement to complete resolution of symptoms		81%				NR
Unlu et al.,[21] 2017	6 mo				VAS	6.29 ± 0.49 (6.00-7.00)	1.14 ± 0.38 (1.00-2.00)	NR
Surgery								
Coulomb et al.,[41] 2016	37.6 ± 10.4 mo (20-62 mo)	HHS	53.5 ± 8.4 (36-68)	79.8 ± 14.7 (45-96)	VAS	7.2 ± 1.1 (5-9)	3.3 ± 1.9 (1-7)	No major complications Occasional pain at incision site: 3 Recurrent external snapping hip: 1
Davies et al.,[42] 2013	70.8 mo (61-100 mo); 19 patients (83%)	HHS	53 ± 10.9	88 ± 11.5	NR	NR	NR	Retear after fall: 2
		LEAS	6.7 ± 0.5					
Drummond et al.,[43] 2016	20.7 mo (5.3-41.2 mo)	Oxford	20.4	37.3	VAS	7.8	2.8	No complications
		iHOT-33	23.8	70.2				
Hartigan et al.,[35] 2018	38 mo (26.6-68 mo)	mHHS	54.9	76.2	VAS	7.1	2.7	No complications
		HOS-ADL	50.2	80.6				
		HOS-SSS	30.9	67.3				
		NAHS	51.9	82.4				
		Trendelenburg sign (+)	14 of 25 patients	2 of 25 patients				

(continued)

Table 3. Continued

	Follow-up	PRO Measure	PRO Score		Pain Measure	Pain Score		Complications
			Before Intervention	Final Follow-up		Before Intervention	Final Follow-up	
Walsh et al.,[8] 2011	Minimum, 12 mo	Merle d'Aubigné and Postel hip score	10.85 ± 0.30 (2-12)	16.65 ± 0.35 (9-18)	NR	NR	NR	Overall complication rate: 19% DVT: 6 PE: 1 Pressure sore: 1 Wound hematoma: 3 Tendon retear: 4 Greater trochanter fracture: 1 Wound infection: 1

NOTE. Data for follow-up, PRO scores, and pain scores are presented as mean, mean (range), mean ± SD, or mean ± SD (range) unless otherwise indicated.
DVT, deep venous thrombosis; HHS, Harris Hip Score; HOS-ADL, Hip Outcome Score—Activities of Daily Living; HOS-SSS, Hip Outcome Score—Sports-Specific Score; iHOT-33, International Hip Outcome Tool 33; LEAS, Lower Extremity Activity Scale; mHHS, modified Harris Hip Score; NAHS, Non-arthritic Hip Score; NR, not reported; PE, pulmonary embolism; PRO, patient-reported outcome; PRP, platelet-rich plasma; VAS, visual analog scale for pain.

follow-up report on an ongoing randomized clinical trial comparing PRP with corticosteroid injections for GTPS; they reported that the benefit previously shown by PRP at 3 months continued to improve even from the 12-month mark to the 24-month mark after intervention. On the other hand, the benefit initially provided by the corticosteroid declined at 6 months.

Likewise, multiple studies have shown the effectiveness of surgical treatment in the management of recalcitrant GTPS. Chandrasekaran et al.[46] compared open and endoscopic management of hip abductor tendon tears. A total of 3 open-technique and 4 endoscopic-technique studies met the inclusion criteria, and both types of interventions were found to result in similar PROs, pain scores, and improvements in abduction strength. The only difference noted was related to the rate of complications, which was higher after open surgical treatment versus arthroscopy. Similarly, in our review, both the PRP and surgery groups showed statistically significant improvements in PROs and pain scales.

The rate of complications was found to be the most important differentiating factor in this study. The PRP group reported only minor adverse effects that were related to the site of injection, which habitually resolved in a timely manner.[17,20] No other complications were reported.[26] In contrast, surgical treatment studies reported numerous complications, such as those related to medical comorbidities, thromboembolic disease, and postoperative status (i.e., recumbency, need for assistive devices, and falls), as well as related to the procedure itself. Complications included wound infections and hematoma, trochanteric fracture, and abductor tendon retears. Some complications required a second intervention (i.e., wound debridement, fracture fixation, or repair of tendon retears) and, hence, resulted in prolongation of the treatment time.

An increasing number of articles on the use of endoscopic techniques to address the peritrochanteric area has been noted. Endoscopic techniques have helped reduce the incidence of wound problems and the overall rate of complications, but judicial monitoring of intraoperative pump pressures as well as compartment checks must be used. Moreover, routine use of sequential compressive devices, chemical thromboprophylaxis, and early mobilization has contributed to this overall decrease in complications. Of the 5 studies in the surgery group in this review, 3 used peritrochanteric endoscopy to address recalcitrant GTPS, performing a variety of techniques, such as bursectomy, iliotibial release, gluteal tendon debridement or repair, and trochanteric micro-puncture.[35,41,43] Only negligible wound problems and a single incidence of recurrent external snapping hip were reported among the endoscopic-technique studies.[41]

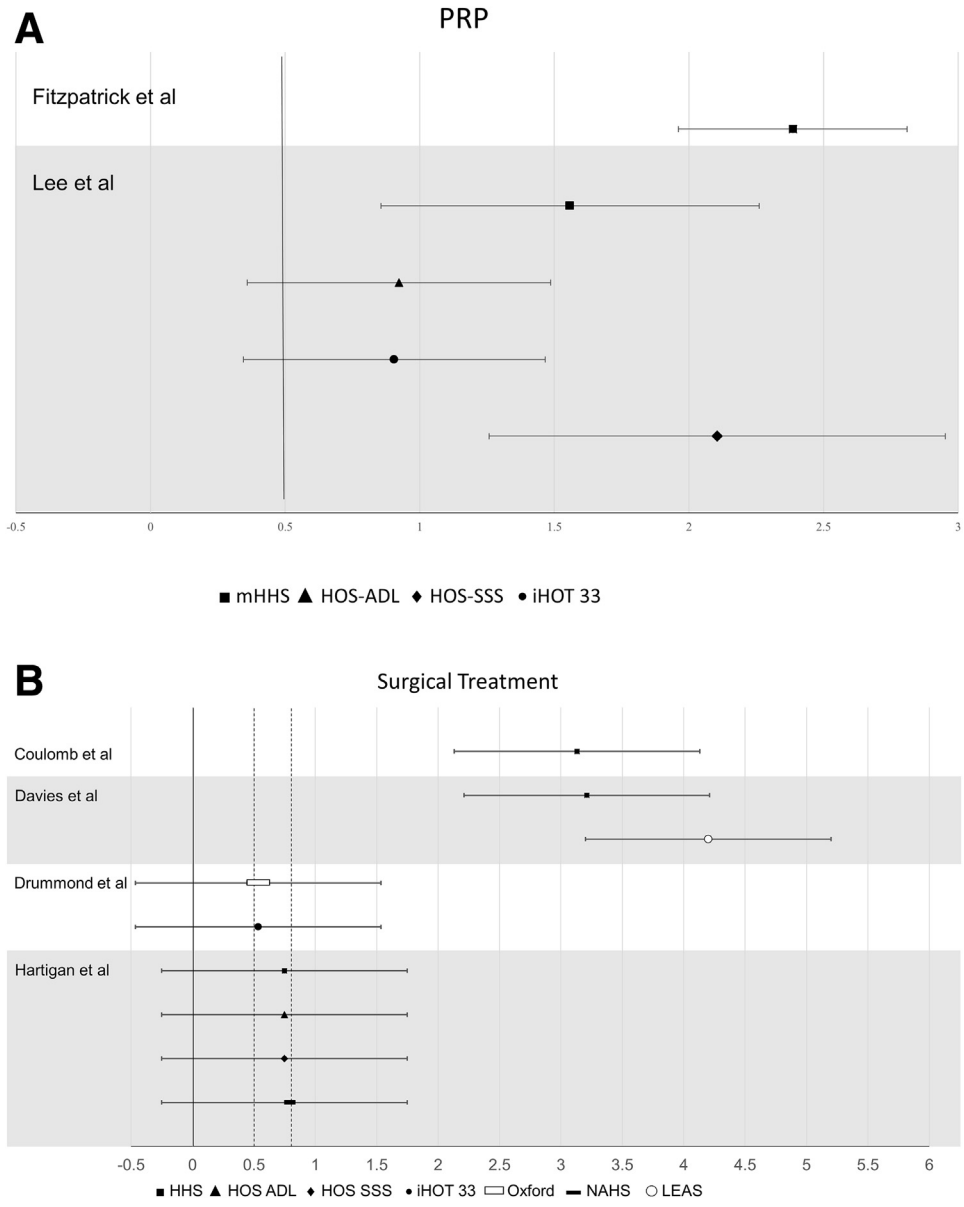

Fig 2. Standardized mean differences in commonly used outcome measures in platelet-rich plasma (PRP) group (A) and surgical treatment group (B). The effect size is charted on the x-axis, with heuristic cutoffs included (0.2 to <0.5, weak effect size; 0.5 to <0.8, moderate effect size; and ≥0.8, large effect size). It should be noted that the study by Walsh et al.[8] is not included because of the use of a PRO measure that does not allow calculation of the effect size. (HOS-ADL, Hip Outcome Score—Activities of Daily Living; HOS-SSS, Hip Outcome Score—Sports-Specific Score; iHOT 33, International Hip Outcome Tool-33; LEAS, Lower Extremity Activity Scale; mHHS, modified Harris Hip Score; NAHS, Non-arthritic Hip Score.)

The heterogeneity of gluteal tendinopathy and tear classification systems among all studies in this systematic review is noteworthy and is summarized in Table 5. Factors considered in these include timing of assessment (i.e., preoperative vs intraoperative), quantification of tear size (i.e., clock-face reference vs footprint detachment percentage), and whether they included a qualitative assessment (fraying, tendon color changes and others). Little is known about the diagnostic or therapeutic value of these classifications, and the not uncommon incidence of undersurface tears[35,47-50] makes treating the recalcitrant GTPS patient even more challenging.

Use of adjuvant interventions in both the PRP group and the surgery group was remarkable. Within the PRP group, tendon fenestrations were used routinely in 3 studies,[20,26,33] which might introduce a confounding bias due to local stimulation of a healing response via biological factors. It is interesting to note that Jacobson et al.[26] evaluated PRP injections versus tendon fenestrations for the treatment of gluteal tendinosis in a blinded comparative study. They reported 71% and 79% improvements in pain at final follow-up in the fenestration and PRP groups, respectively, but there were no significant differences between the treatment arms ($P > .99$). In a retrospective review, Drummond et al.[43] reported on patients with recalcitrant GTPS managed endoscopically. Interventions included trochanteric bursectomy and a partial, vertical iliotibial band release for all patients, as well as a single-row suture anchor repair for those with abductor tendon tears. Adjuvant PRP injection at the

Table 4. Techniques for Procedure and Rehabilitation Protocols

	Technique	Rehabilitation Protocol
PRP injection		
Fitzpatrick et al.,[33] 2019	Approximately 55 mL of autologous blood obtained; GPS III kit (Zimmer Biomet, Warsaw, IN) used to prepare 6-7 mL of leukocyte-rich PRP (5× normal blood WBCs) over 15-min centrifuge process; local anesthetic administered, and PRP injected into affected area of tendon in 5-6 passes using ultrasound guidance	After the procedure, participants followed a 12-wk unsupervised rehabilitation program with directed activity modification. Week 1-4: avoid all aggravating activities including walking for exercise, stairs, squats, lunges, and abduction exercises. Week 6: begin progressive walking program, which also included use of stairs, return to gymnasium, and other sports Week 12: no further restrictions on activity
Lee et al.,[20] 2016	Approximately 60 mL of autologous blood obtained; Magellan Autologous Platelet Separator System (Hopkinton, MA) used to prepare 3-4 mL of leukocyte-rich PRP; local anesthetic administered, and PRP injected using 22-gauge, 3.5-inch spinal needle into affected area of tendon in 6-9 passes using ultrasound guidance	After the procedure, participants were instructed to rest for a minimum of 2 wk; no NSAIDs were used for 6 wk; and patients followed a structured PT program. PT focused on core stabilization, hip abductor strengthening, eccentric strengthening, and balance training.
Jacobson et al.,[26] 2016	Discontinued NSAIDs for 2 wk prior to procedure; approximately 60 mL of autologous blood obtained; kit (Harvest Technologies, Lakewood, CO) used to prepare 10 mL of leukocyte-rich PRP (concentration of 4× to 8× that in whole blood) over 14-min period of centrifuge at 2,650 rpm; local anesthetic administered, and PRP injected using 20-gauge, 3.5-inch spinal needle with trocar into affected area of tendon with <10 passes using ultrasound guidance	After the procedure, NSAIDs were avoided for 2 wk. Patients avoided strenuous activity regarding the hip for the first week and then gradually increased activity as tolerated during the second week.
Mautner et al.,[22] 2013	Unspecified manufacturer of PRP preparation equipment; approximately 20-60 mL of autologous blood obtained; ultrasound-guided tendon injection; used following criteria for number of injections: 80% global improvement: no further injections 80% global improvement but still improving: no further injections 80% global improvement and plateau in progress: additional injection recommended	Rehabilitation program including eccentric exercises no earlier than 4 wk after PRP injection
Unlu et al.,[21] 2017	Approximately 20 mL of peripheral blood obtained; centrifugation with single spin at 460*g* for 8 min; total of 6 mL of leukocyte-poor PRP with 29- to 39-fold increase in platelet concentration; aimed at greater trochanter at point of maximal tenderness, no ultrasound, with 22-gauge spinal needle; determination of number of PRP injections similar to Mautner et al.[22]	NR
Surgery		
Coulomb et al.,[41] 2016	Endoscopic; no repair of partial-thickness tendon tears; trochanteric bursectomy; micro-perforations in enthesis; calcifying tendinopathy debridement; iliotibial band diamond-shaped partial release in patient with snapping hip	PWB for 6 wk PT, transverse deep fiber massage, active-passive mobilization of hip, and stretching of abductor mechanism
Davies et al.,[42] 2013	Open technique; tendon repair, with suture anchors (Milwaukee grade I and II tears); trochanteric bursectomy; iliotibial band repair	PWB (25%) for 6 wk Strengthening exercises after FWB

(continued)

Table 4. Continued

	Technique	Rehabilitation Protocol
Drummond et al.,[43] 2016	Endoscopic; no tendon repair (49 of 57 cases); trochanteric bursectomy; iliotibial band, vertical release; adjuvant PRP (38 of 57 cases) at gluteal musculotendinous junction	WBAT with crutches No strenuous activity for 6 wk No formal PT
Hartigan et al.,[35] 2018	Endoscopic; transtendinous repair, with suture anchors; trochanteric bursectomy	PWB (20 lb) for 6 wk, with abduction brace PT at 2 wk postoperatively
Walsh et al.,[8] 2011	Open technique; transtendinous (splitting) technique; bone tunnels and No. 5 nonabsorbable suture repair	NWB for 6 wk

FWB, full weight bearing; NR, not reported; NSAIDs, nonsteroidal anti-inflammatory drugs; NWB, non-weight bearing; PRP, platelet-rich plasma; PT, physical therapy; PWB, partial weight bearing; WBAT, weight bearing as tolerated; WBC, white blood cell.

musculotendinous junction was administered in 38 of 57 patients, and the authors found no statistically significant difference in outcomes between those who received PRP and those who did not. In another study, Coulomb et al.[41] described PROs after endoscopic surgery with the addition of micro-perforations at the tendinous insertion, which was meant to stimulate a healing response. Average PRO improvement was significant at longest follow-up, with a mean satisfaction rating of 6.2. The heterogeneous adjuvant therapy being used during treatment of recalcitrant GTPS may be a source of confounding bias when attempting to compare studies. However, it also highlights physicians' acknowledgment that biological factors influence the management of gluteal tendinopathy.

Comparison of the clinical outcome studies on the use of PRP injections versus surgical treatment to manage recalcitrant GTPS might be worthwhile and could impact clinical practice. First, this is a highly relevant topic mainly owing to the condition's prevalence and to projected increases in the affected age group. Second, much progress has been reported on the assessment of the roles played by osteoarthritis, tendinopathy, and other intra-articular pathology (i.e., labral tears) in lateral hip pain. Third, the use of PRP as a biological tool that potentiates a healing response continues to be recognized.

Future studies should (1) focus on prospective, matched case-control trials comparing PRP injection versus treatment alternatives such as endoscopic treatment with limitation of confounding bias introduced by overlapping techniques (tendon fenestration, greater trochanter micro-puncture, and so on); (2) define an updated GTPS classification scheme that takes into account the tendinopathic nature of this recalcitrant condition and integrates management options; (3) define a treatment algorithm that emphasizes the difference between inflammatory and tendinopathic conditions, as well as the role of nonsurgical and surgical options for both; and (4) include long-term follow-up regarding the natural history of tendinopathy and the effectiveness of PRP in well-selected patients with recalcitrant GTPS who are not surgical candidates.

Limitations

This systematic review has several limitations. (1) Most studies included in this review are LOE IV and heterogeneous regarding diagnosis, classification, and surgical technique. (2) None of the included studies directly compares PRP injections with surgery for the treatment of recalcitrant GTPS. (3) Patient baseline characteristics between the PRP and surgery groups might suggest an intervention bias of surgery for older patients with a longer duration of symptoms at presentation. (4) The mean follow-up period is longer in

Table 5. Classification Systems for Gluteal Tendinopathy Used by Studies

Study	Classification System
PRP injections	
Fitzpatrick et al.,[33] 2019	Grade 1: bursitis only Grade 2: tendinopathy of 1 or both tendons Grade 3: partial-thickness tear Grade 4: full-thickness tear of either tendon
Lee et al.,[20] 2016	NR
Jacobson et al.,[26] 2016	NR
Mautner et al.,[22] 2013	Sonography criteria for tendinopathy Tendon tear: well-defined hypoechoic area with partial or complete tendon fiber disruption Calcification: hyperechoic intratendinous focus with posterior acoustic shadowing MRI criteria for tendinopathy Partial tendon tear: intratendinous high signal intensity Full tear: absence of segment of tendon Intratendinous scarring: low signal intensity
Unlu et al.,[21] 2017	NR
Surgery	
Coulomb et al.,[41] 2016	NR
Davies et al.,[42] 2013	Milwaukee classification for tears of hip abductors, based on clock-face hour involvement Grade I: 1 h Grade II: 2 h Grade III: 3 h Grade IV: nearly complete tear or complete detachment of tendons
Drummond et al.,[43] 2016	NR
Hartigan et al.,[35] 2018	Classification based on tear size relative to width of insertion tendon bed Grade 1: 0%-25% Grade 2: 25%-50% Grade 3: 50%-75% Grade 4: 75%-100%
Walsh et al.,[8] 2011	Classification based on qualitative characteristics of tissue Type 1: normal bursa, appearance of gluteus medius tendon, but deep surface detachment anteriorly; gluteus minimus normal Type 2: normal bursa, thickening of tendons, grayish discoloration, loss of normal striations, detachment may extend posteriorly; gluteus minimus stretched Type 3: bursa scarred and may have free fluid, tendon changes as in type 2; bursal disruption exposing underlying trochanter observed; partial tear of detachment of gluteus minimus Type 4: total disruption of gluteus medius and minimus tendons exposing entire trochanter front and back; ulceration of fascia lata may also be observed

MRI, magnetic resonance imaging; NR, not reported; PRP, platelet-rich plasma.

the surgery studies versus the PRP studies. (5) Long-term data on the histologic effects of PRP on gluteal tendinopathy are lacking. (6) Despite the evidence in favor of the use of PRP in cases of gluteal tendinopathy, PRP injections are not covered by most medical insurance companies, which might result in direct costs to the patient. (7) As shown in this report, the physical therapy protocols after PRP injections have not been standardized and might represent a source of bias. In addition, details on what entails "failed" physical therapy for the patient selection criteria were not described in this group of studies. Future studies should consider including patients undergoing physical therapy alone as a comparison group.

Conclusions

Both PRP and surgical intervention for the treatment of recalcitrant GTPS showed statistically and clinically significant improvements based on PROs. Although not covered by most medical insurance companies, PRP injections for recalcitrant GTPS provide an effective and safe alternative after failed physical therapy. If surgery is indicated, endoscopy is safer than the open technique.

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