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## Preparation Methods and Clinical Outcomes of Platelet-Rich Plasma for Intra-articular Hip Disorders: A Systematic Review and Meta-analysis of Randomized Clinical Trials.

Flávio Luís Garcia

*Rush University Medical Center, Instituto Brasil de Tecnologias de Saude, Ribeirão Preto Medical School*

Brady T Williams

*Rush University Medical Center*


Evan M Polce

*Rush University Medical Center*

Daniel B Heller

*Rush University Medical Center*

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**Authors**

Flávio Luís Garcia, Brady T Williams, Evan M Polce, Daniel B Heller, Zachary S Aman, Benedict U Nwachukwu, Shane J Nho, and Jorge Chahla

# Preparation Methods and Clinical Outcomes of Platelet-Rich Plasma for Intra-articular Hip Disorders

## A Systematic Review and Meta-analysis of Randomized Clinical Trials

Flávio Luís Garcia,<sup>\*†‡</sup> MD, PhD, Brady T. Williams,<sup>\* MD</sup>, Evan M. Polce,<sup>\* BS</sup>, Daniel B. Heller,<sup>\* BA</sup>, Zachary S. Aman,<sup>§ BA</sup>, Benedict U. Nwachukwu,<sup>|| MD, MBA</sup>, Shane J. Nho,<sup>\*¶ MD, MS</sup>, and Jorge Chahla,<sup>\*||# MD, PhD</sup>

*Investigation performed at the Section of Young Adult Hip Surgery, Division of Sports Medicine, Department of Orthopedic Surgery, Rush University Medical Center, Chicago, Illinois, USA*

**Background:** Despite its increasing use in the management of musculoskeletal conditions, questions remain regarding the preparation methods of platelet-rich plasma (PRP) and its clinical applications for intra-articular hip disorders, including femoroacetabular impingement syndrome (FAIS), labral pathology, and osteoarthritis (OA).

**Purpose:** To systematically review and assess the preparation methods and clinical outcomes from randomized clinical trials (RCTs) on the use of PRP for intra-articular hip disorders.

**Study Design:** Systematic review; Level of evidence, 2.

**Methods:** A systematic review in accordance with the 2009 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines was performed in September 2019. The Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, PubMed, Ovid Medline, and Embase were queried for studies regarding the use of PRP to treat intra-articular hip disorders. Qualifying articles were English-language RCTs describing the use of PRP for intra-articular hip disorders, either as standalone treatment or surgical augmentation. Two authors independently assessed article eligibility. Data pertaining to patient characteristics, indication for treatment, PRP preparation method, follow-up period, and clinical outcomes were extracted. Study results were qualitatively reported and quantitatively compared using meta-analysis when appropriate.

**Results:** Seven RCTs met inclusion criteria. Four studies described the use of PRP for hip OA and 3 utilized PRP at arthroscopy for FAIS and labral tears. Outcomes after PRP for OA demonstrated improvement in validated patient-reported outcome measures for up to 1 year; however, pooled effect sizes found no statistically significant difference between PRP and hyaluronic acid (HA) regarding pain visual analog scale scores at short-term ( $\leq 2$  months;  $P = .27$ ), midterm (4-6 months;  $P = .85$ ), or long-term (1 year;  $P = .42$ ) follow-up. When injected at arthroscopy, 1 study reported improved outcomes, 1 reported no difference in outcomes, and 1 reported worse outcomes compared with controls. The meta-analysis demonstrated no statistically significant difference on the modified Harris Hip Score (mHHS) between PRP and control cohorts at a minimum 1-year follow-up. There were considerable deficiencies and heterogeneity in the reporting of PRP preparation methods for both indications.

**Conclusion:** Treatment of OA with PRP demonstrated reductions in pain and improved patient-reported outcomes for up to 1 year. However, there was no statistically significant difference between PRP and HA in pain reduction. Likewise, for FAIS and labral surgery there was no statistically significant difference in mHHS outcomes between patients treated with PRP and controls. Given the limited number of studies and variability in PRP preparations, additional high-quality randomized trials are warranted.

**Keywords:** platelet-rich plasma; osteoarthritis; hip arthroscopy; femoroacetabular impingement; outcomes

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Intra-articular hip pathologies, notably osteoarthritis (OA) and femoroacetabular impingement syndrome (FAIS), represent a major cause of disability and pain for many patients and a substantial economic burden on society.<sup>32</sup>

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This has led to increased interest in disease-modifying and hip joint preservation treatments, such as orthobiologics, over the past few decades. News coverage and media reporting of outcomes after orthobiologic treatments in elite athletes have also drawn considerable attention, further increasing the demand for these therapies and potentially generating unrealistic patient expectations.<sup>2</sup>

Platelet-rich plasma (PRP) is one of the most commonly used orthobiologics. The term “PRP” broadly describes autologous preparations of peripheral blood that have undergone centrifugation to increase the platelet concentration; however, the other constituents can be quite variable, including the concentration of leukocytes.<sup>7</sup> The clinical use of PRP aims to promote tissue regeneration through the effects of growth factors and cytokines released by activated platelets<sup>24</sup> and has been described for the treatment of a wide spectrum of musculoskeletal conditions, such as acute muscle injuries,<sup>21,43</sup> degenerative<sup>6,10,18,26,28,45</sup> and traumatic<sup>9</sup> cartilage lesions, meniscal disorders,<sup>5,39</sup> ligamentous injuries,<sup>5,19,36,40</sup> rotator cuff injuries,<sup>20,46</sup> plantar fasciitis,<sup>31</sup> lateral epicondylitis,<sup>34,38</sup> and other tendinopathies.<sup>16</sup> Likewise, PRP has been increasingly used to treat a variety of hip disorders, either alone or as an augmentation for hip arthroscopic procedures.<sup>8,13,41,42</sup>

Despite its increased utilization in the treatment of intra-articular hip disorders, the efficacy of PRP on the treatment of these pathologies has not been completely elucidated, and its use remains controversial. Furthermore, the influence of composition on the regenerative characteristics of PRP has yet to be determined.<sup>30,35</sup> The primary purpose of this systematic review was to examine and provide a comprehensive review of the evidence from randomized clinical trials (RCTs) on PRP preparation methods for the treatment of intra-articular hip pathologies, including FAIS, labral pathology, and OA and clinical outcomes. The secondary aim of this review was to describe the range of PRP preparation methods. Correspondingly, it was hypothesized that there would be considerable heterogeneity in the reporting of PRP preparation methods, and that there would be a significant benefit in patients who received PRP injections, as indicated by statistically significant differences in patient-reported outcomes.

## METHODS

### Article Identification and Selection

A systematic review of PRP application for the treatment of intra-articular hip disorders was conducted in accordance with the 2009 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. A comprehensive literature search was performed using the Cochrane Database of Systematic Reviews, the Cochrane Central Register of Controlled Trials, PubMed (1980 to present), Medline (1980 to present), and Embase (1980 to present). Queries were performed and screened between September and November 2019. The following Boolean search terms were used: “platelet rich plasma” AND (“hip arthroscopy” OR “hip pathology” OR “femoroacetabular impingement” OR “osteoarthritis” OR “biomechanics”). The systematic review protocol was registered with the PROSPERO prospective registrar of systematic reviews (No. CRD42020159802).

Inclusion criteria were English-language literature and randomized clinical studies reporting on the use of PRP for intra-articular hip disorders, either as a standalone treatment or as an augmentation for arthroscopic hip procedures. Publications were excluded if they involved the treatment of extra-articular hip disorders, tendon and/or muscle injection of PRP, animal studies, or nonrandomized studies, or did not include at least 1 patient-reported outcome. There was no minimum duration of follow-up that was required for inclusion.

Two investigators (F.L.G. and D.B.H.) independently reviewed the abstracts from all identified articles. If necessary, full-text articles were reviewed to appropriately identify articles for inclusion. Additionally, reference lists from the included studies were reviewed to verify that all eligible articles were considered.

### Data Extraction

Data were extracted from the full text of all eligible articles using standardized data collection forms and included patient characteristics, indication for treatment, PRP preparation method, control group and treatment (eg, placebo, hyaluronic acid [HA], and corticosteroid), follow-up period, and clinical outcomes. For continuous variables, the means, standard deviations, and ranges were collected when

#Address correspondence to Jorge Chahla, MD, PhD, Department of Orthopaedics, Rush University Medical Center, Midwest Orthopaedics at Rush, 1611 W Harrison Street, Suite 300, Chicago, IL 60612, USA (email: Jorge.chahla@rushortho.com).

\*Section of Young Adult Hip Surgery, Division of Sports Medicine, Department of Orthopaedic Surgery, Rush University Medical Center, Chicago, Illinois, USA.

†Instituto Brasil de Tecnologias de Saude, Rio de Janeiro, Brazil.

‡Ribeirão Preto Medical School, Ribeirão Preto, Brazil.

§Sidney Kimmel Medical College, Philadelphia, Pennsylvania, USA.

||Department of Orthopedic Surgery, Hospital for Special Surgery, New York, New York, USA.

¶Chicago White Sox/Chicago Bulls, Chicago, Illinois, USA.

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reported. Data were recorded into a custom spreadsheet using a modified information extraction table.<sup>23</sup>

### Assessment of Methodological Quality

The methodologic quality of each included study was assessed with the Coleman Methodology Score (CMS).<sup>11</sup> The CMS is a 10-item questionnaire scored from 0 to 100 points that has been used in the rating of RCTs<sup>22</sup> and is based on the CONSORT (Consolidated Standards of Reporting Trials) statement.<sup>1</sup> A perfect score of 100 points represents a study design that largely avoids the influence of chance, biases, and confounding factors.<sup>11</sup>

### Statistical Analysis

A series of meta-analyses were conducted for outcomes reported in at least 3 studies. The meta-analyses were performed using a random-effects model with inverse variance for data pooling and weighting. Forest plots were constructed for visual presentation of the results from individual studies and pooled summary estimates. A *P* value <.05 was considered statistically significant. Study heterogeneity was assessed through *I*<sup>2</sup> tests. All statistical analyses were performed using Review Manager 5 (Version 5.3; The Nordic Cochrane Center).<sup>44</sup>

For the variables that did not meet the aforementioned criteria (reported in a minimum of 3 studies), a meta-analysis was considered methodologically inappropriate, and the data were qualitatively synthesized and reported in both narrative fashion and table format. Extracted data were presented as means, medians, and ranges, where appropriate.

## RESULTS

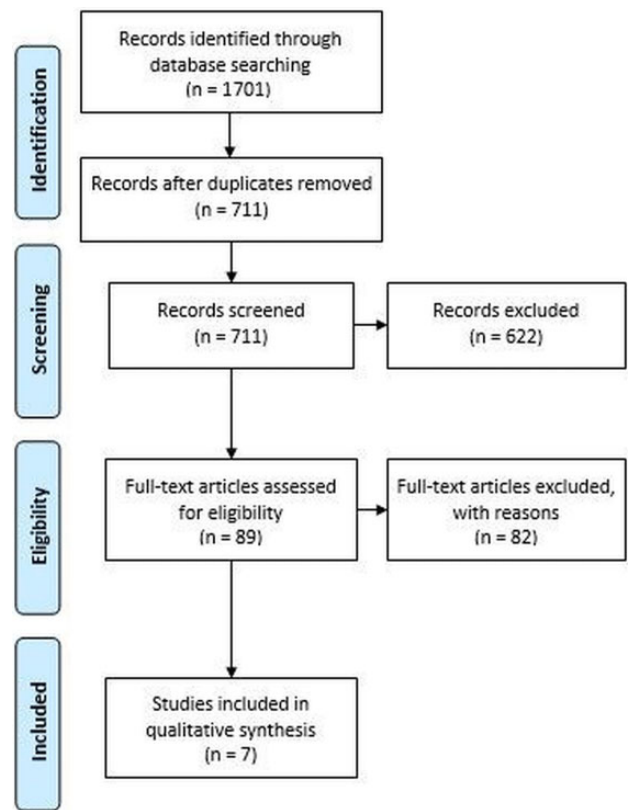
### Study Characteristics

The literature search identified 1701 studies through the initial database query. After duplicates and non-English titles were removed, 711 articles were screened, with 7 articles<sup>3,13-15,29,41,42</sup> ultimately meeting the inclusion criteria (Figure 1). The mean CMS for the 7 studies assessed in this review was 87.2 (range, 83-93).

Four studies<sup>3,13-15</sup> described the use of PRP for hip OA treatment, and 3 studies<sup>29,41,42</sup> reported on PRP augmentation at the time of arthroscopic FAIS and labral surgery. The weighted mean age was 45.3 years (range, 34.6-72.5 years), and the weighted mean number of PRP injections per patient was 1.9 (range, 1-3 injections). Detailed study characteristics are reported in Table 1.

### PRP Preparation and Processing Protocols

Among the included studies, there was heterogeneity in PRP preparation and processing protocols. The initial whole blood volume, centrifugation rate, and duration were reported in 5 studies<sup>3,13-15,42</sup> (71.4%). For the first centrifugation, the median rate was 1500 rpm (range,



**Figure 1.** PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart showing application of the selection criteria to the studies identified with the search strategy.

1480-3100 rpm) and the median duration was 6 minutes (range, 5-15 minutes). For the second centrifugation, the median rate was 3400 rpm (range, 3100-3500 rpm) and the median duration was 12.5 minutes (range, 9-15 minutes). The mean whole blood volume extracted was 94.8 mL (range, 8-150 mL). The volume of PRP injected into each hip joint was reported in all studies, with a mean injected PRP volume of 4.9 mL (range, 3-7 mL). The mean PRP platelet concentration after preparation was reported in 3 studies<sup>3,14,42</sup> with a mean platelet concentration 3.8 times greater than that of whole blood (range, 2-7 times).

An exogenous activation method used to induce platelet degranulation and release of growth factors and cytokines into the PRP solution was reported in 3 studies (42.9%).<sup>3,13,41</sup> Two studies used 10% calcium chloride,<sup>3,13</sup> and 1 study used an undisclosed exogenous activator.<sup>41</sup> Three studies<sup>14,15,29</sup> (42.9%) did not mention whether an activator was used, and 1 study<sup>42</sup> (14.3%) specifically reported not using an activator. Detailed PRP preparation information is reported in Table 2.

### PRP for OA Treatment

There were 4 studies<sup>3,13-15</sup> that evaluated outcomes after intra-articular injection of PRP for the management of OA

TABLE 1  
Study Characteristics<sup>a</sup>

Author (Year)	Pathology/Treatment	Total No. of Cases (No. of Cases per Group)	Mean Age, y (Range)	Number of PRP Injections (Interval Between Injections)	Control Group(s): (Type and No. of Injections; Interval Between Injections)	Follow-up	Coleman Methodology Score
<i>PRP for OA treatment</i>							
Battaglia (2013) <sup>3</sup>	OA K-L grades 2-4/ US-guided injections	100 (PRP group: NR; HA group: NR)	53 (25-76)	3 intra-articular injections (2 wk apart)	HA (3 intra-articular injections; 2 wk apart)	1, 3, 6, and 12 mo	89
Dallari (2016) <sup>13</sup>	OA K-L grades 1-4/ US-guided injections	111 (PRP group: 44; PRP + HA group: 31; HA group: 36)	NR (18-65)	3 intra-articular injections (1 wk apart)	a. PRP + HA b. HA (3 intra-articular injections; 1 wk apart)	2, 6, and 12 mo	93
Di Sante (2016) <sup>14</sup>	OA K-L grades 2-3/ US-guided injections	43 (PRP group: 21; HA group: 22)	72.5 (NR)	3 intra-articular injections (1 wk apart)	HA (3 intra-articular injections; 1 wk apart)	1 and 4 mo	84
Doria (2017) <sup>15</sup>	OA K-L grades 0-2/ US-guided injections	80 (PRP group: 40; HA group: 40)	67.6 (40-72)	3 intra-articular injections (1 wk apart)	HA (3 intra-articular injections; 1 wk apart)	6 and 12 mo	83
<i>PRP augmentation for FAIS and labral surgery</i>							
Redmond (2015) <sup>42</sup>	FAIS + labral tear/ arthroscopic labral repair or debridement with or without acetabuloplasty, femoroplasty, microfracture, and/or capsular repair	271 (PRP group: 91; bupivacaine group: 180)	36.2 (NR)	Single intra- articular injection at the end of surgery	0.25% bupivacaine (single intra-articular injection at the end of surgery)	3 and 24 mo	86
LaFrance (2015) <sup>29</sup>	FAIS + labral tear/ arthroscopic labral repair + femoral osteochondroplasty	35 (PRP group: 20; normal saline group: 15)	34.6 (18-63)	Single intra- articular injection at the end of surgery	0.9% normal saline (single intra-articular injection at the end of surgery)	1, 3, 6, and 12 mo	83
Rafols (2015) <sup>41</sup>	FAIS + labral tear/ arthroscopic labral repair + femoral osteochondroplasty	57 (PRP group: 30; no injection group: 27)	35.3 (16-52)	Single intra- articular injection at the end of surgery	No injection	2 d; 3, 6, and 24 mo	93

<sup>a</sup>FAIS, femoroacetabular impingement syndrome; HA, hyaluronic acid; K-L, Kellgren-Lawrence classification; NR: not reported; OA, osteoarthritis; PRP, platelet-rich plasma; US, ultrasound.

(Tables 1 and 3). All 4 studies, a total of 334 patients, compared the efficacy of PRP with that of hyaluronic acid (HA). The severity of symptomatic hip OA included across the studies varied considerably, ranging from grade 0 to grade 4 according to the Kellgren-Lawrence (KL) classification.<sup>27</sup>

Battaglia et al<sup>3</sup> and Dallari et al<sup>13</sup> reported improvement in pain visual analog scale (VAS) from pretreatment to short-term (up to 2 months) and midterm (between 4 and 6 months) follow-up time points. Di Sante et al<sup>14</sup> reported improvement in VAS from pretreatment to short-term follow-up, but not at the midterm follow-up. Doria et al<sup>15</sup> did not evaluate patients at the short-term follow-up but reported improvement in the VAS from pretreatment to midterm and long-term (12 months) follow-ups. In 2 studies,<sup>3,13</sup> the VAS at the long-term follow-up demonstrated increased pain compared with the short-term follow-up; however, these were still significantly improved compared with pretreatment pain scores. The remaining 2 studies did not allow such temporal comparison because the VAS was not assessed at either the short-term<sup>15</sup> or long-term<sup>14</sup> follow-up.

Three studies<sup>3,13,15</sup> evaluated patients with the Harris Hip Score (HHS). Both Battaglia et al<sup>3</sup> and Doria et al<sup>15</sup>

demonstrated statistically significant improvements in HHS after treatment. In contrast, Dallari et al did not find any significant improvement in HHS in either group. However, none of the studies reported statistically significant differences between control and treatment groups for post-treatment changes in HHS.

Three studies<sup>13-15</sup> evaluated patients with the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) questionnaire. Dallari et al<sup>13</sup> reported significantly greater improvement in the WOMAC scores from pretreatment to short-term and midterm follow-ups for the PRP-treated group, but a loss of statistical significance compared with HA and PRP + HA at the long-term follow-up. Di Sante et al<sup>14</sup> evaluated patients only at short-term and midterm follow-ups and found no statistically significant difference in the WOMAC scores before and after PRP treatment, while HA treatment resulted in statistically significant improvements in WOMAC scores at 4 weeks; however, these results were not sustained at 16 weeks. Finally, Doria et al<sup>15</sup> evaluated the patients only at midterm and long-term follow-ups, reporting improvement of the WOMAC scores compared with pretreatment;

TABLE 2  
PRP Preparation and Composition Data for the Included Studies<sup>a</sup>

Author (Year)	PRP Preparation Method	Volume Blood Drawn (mL)	PRP Volume for Each Injection (mL)	Platelet Concentration in the PRP	Platelet Activation	PAW Classification
<i>PRP for OA treatment</i>						
Battaglia (2013) <sup>3</sup>	2-spin method (1800 rpm for 15 min + 3500 rpm for 10 min)	150	5	7× baseline	10% calcium chloride	P3-x-A
Dallari (2016) <sup>13</sup>	2-spin method (1480 rpm for 6 min + 3400 rpm for 15 min)	150	5	NR	10% calcium chloride	NA-x-NA
Di Sante (2016) <sup>14</sup>	2-spin method (3100 rpm for 9 min + 3100 rpm for 9 min)	8	3	2× baseline	NR	P2-NA-B
Doria (2017) <sup>15</sup>	2-spin method (1480 rpm for 6 min + 3400 rpm for 15 min)	150	5	NR	NR	NA-NA-NA
<i>PRP augmentation for FAIS and labral surgery</i>						
Redmond (2015) <sup>42</sup>	1-spin method (1500 rpm for 5 min)	16	4-7	2.5× baseline	No	P2-Bβ
LaFrance (2015) <sup>29</sup>	Accelerate Concentrating System (Exactech Biologics)	NR	5	NR	NR	P3-NA-Aα
Rafols (2015) <sup>41</sup>	GPS III System (Biomet Biologics)	NR	6	NR	Yes (undisclosed)	P4-x-Aα

<sup>a</sup>FAIS, femoroacetabular impingement syndrome; NR, not reported; OA, osteoarthritis; PAW, platelets, activation, and white cells; PRP, platelet-rich plasma.

however, no statistically significant difference was found between the PRP- and HA-treated groups (Table 3).

A meta-analysis was performed, and the pooled effect sizes showed no statistically significant difference between PRP and HA in terms of pain reduction as determined by the VAS, either at the short-term ( $P = .27$ ), midterm ( $P = .85$ ), or long-term ( $P = .42$ ) follow-up (Figure 2). Heterogeneity, as evaluated by  $I^2$  tests, demonstrated values of 62%, 90%, and 77% at the short-, mid-, and long-term follow-ups, respectively.

### PRP Augmentation for FAIS and Labral Surgery

Three studies<sup>29,41,42</sup> evaluated the efficacy of PRP injection as an augmentation for FAIS and labral surgery (Tables 1 and 4). Arthroscopic labral repair plus femoral osteochondroplasty was performed in 92 hips, and arthroscopic labral repair or debridement with or without acetabuloplasty, femoroplasty, microfracture, and/or capsular repair was done on 271 hips.

LaFrance et al<sup>29</sup> compared the efficacy of PRP with that of 0.9% normal saline injection. The authors described improvement in all patient-reported outcome measures throughout the study period; however, no statistically significant difference between the groups was observed.

Rafols et al<sup>41</sup> compared PRP injection and no injection. The authors found some differences in outcomes between the groups, with the PRP group reporting lower VAS scores only on the second day after surgery and a lower incidence of joint effusion at the 6-month follow-up. All other outcomes showed no statistically significant differences between the groups.

Redmond et al<sup>42</sup> evaluated the efficacy of PRP injection compared with bupivacaine injection. Surgeries included

either labral repair or labral debridement, as well as other intra-articular procedures, including acetabuloplasty, femoroplasty, microfracture, and capsular repair. The authors reported that the PRP group demonstrated a lower mean modified HHS (mHHS) and a higher VAS score than the bupivacaine group 2 years after surgery (Table 4), but the reason for these findings could not be identified.

A meta-analysis was performed, and the pooled effect sizes showed no statistically significant difference between PRP and controls for mHHS at a minimum 12-month follow-up ( $P = .25$ ) (Figure 3). Heterogeneity was assessed with  $I^2$  tests, with a calculated value of 13%.

### DISCUSSION

The most important finding of this investigation was the absence of statistically significant differences between PRP, HA, and combined therapies in the treatment of hip OA. The treatment of hip OA with PRP accounted for the majority of relevant publications, representing 57.1% of RCTs identified by this systematic review. In this patient population, PRP injection resulted in improvements in both pain and select patient-reported outcome measures for up to 1 year after injection. However, meta-analysis and pooled effect sizes demonstrated no statistically significant difference between PRP- and HA-treated groups in terms of pain reduction, as determined by the VAS, for up to 1 year after injection in patients with hip OA.

Although the pain reduction and improvements in patient-reported outcome measures may last for up to 12 months after PRP injection for hip OA, this effect was most evident in the first 4 to 6 months after treatment and seemed to decrease after that period.<sup>3,13</sup> Systematic reviews and meta-analyses of RCTs have similarly reported

TABLE 3  
Patient-Reported Outcomes After PRP Treatment  
for Hip Osteoarthritis<sup>a</sup>

Outcome Score	Pretreatment	Follow-up		
		Short-term (≤2 mo)	Midterm (4-6 mo)	Long-term (12 mo)
<i>Battaglia (2013)</i> <sup>3</sup>				
VAS				
PRP	5.47	3.72	4.29	4.75
HA	5.97	3.58	4.04	4.59
HHS				
PRP	58.11	73.72	70.23	65.73
HA	62.90	78.02	75.79	72.55
<i>Dallari (2016)</i> <sup>13</sup>				
VAS				
PRP	—	2.3	2.1	2.4
HA	—	3.8	4.4	4.2
PRP + HA	—	3.5	3.5	3.8
WOMAC				
PRP	—	73	72	—
HA	—	59	59	—
PRP + HA	—	59	59	—
HHS				
PRP	—	—	—	—
HA	—	—	—	—
PRP + HA	—	—	—	—
<i>Di Sante (2016)</i> <sup>14</sup>				
VAS				
PRP	7.08	4.73	6.36	NR
HA	6.32	5.27	3.63	
WOMAC—pain				
PRP	58.8	44.2	53.4	NR
HA	42.3	29.6	19.9	
WOMAC—stiffness				
PRP	53.7	46.4	47.2	NR
HA	57.6	47.6	32.9	
WOMAC—physical function				
PRP	59.8	49.1	50.8	NR
HA	45.8	39.1	28.3	
<i>Doria (2017)</i> <sup>15</sup>				
VAS				
PRP	7.5	NR	6.3	6.4
HA	7.8	NR	6.3	6.1
WOMAC—pain				
PRP	23.7	NR	7.8	7.4
HA	24	NR	9.7	9
WOMAC—stiffness				
PRP	3.8	NR	2.1	2
HA	4.3	NR	3.1	3.1
WOMAC—physical function				
PRP	29.4	NR	12.3	12
HA	28.5	NR	11.3	10.9
HHS				
PRP	64	NR	75	78
HA	62	NR	74	75

<sup>a</sup>HA, hyaluronic acid; HHS, Harris Hip Score; NR, not reported; PRP, platelet-rich plasma; VAS, visual analog scale (scaled to 0-10); WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; —, data were reported as box plot graphs only.

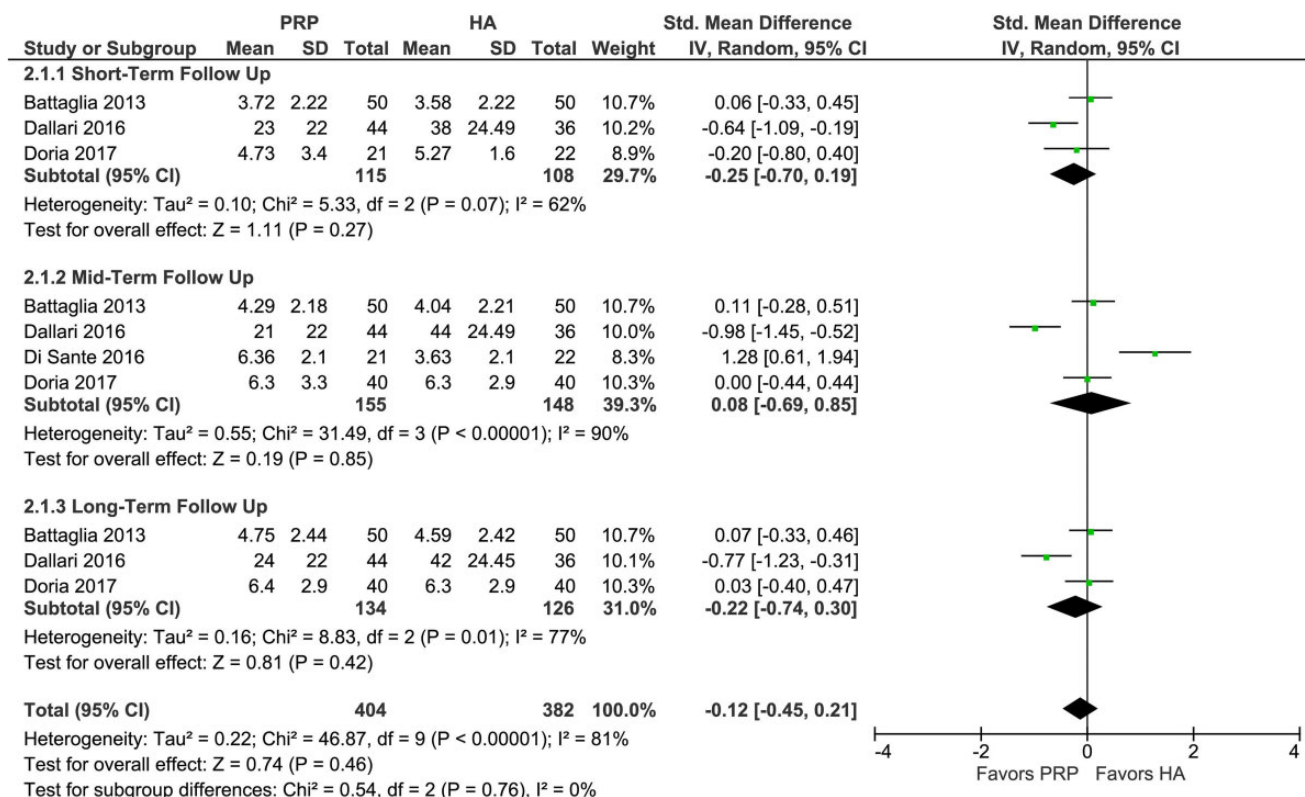
that PRP can reduce pain and improve functional status in patients affected by knee OA.<sup>12,33,45</sup> However, indications and results from knee OA treatment with PRP cannot be immediately extrapolated to the hip, since cartilage characteristics and biomechanics are disparate among joints.<sup>4,17,37</sup>

In addition, PRP is increasingly being used as augmentation for hip arthroscopy<sup>8,13,41,42</sup>; however, the relevant literature is still limited and controversial. In this review, 3 such studies met inclusion criteria. Rafols et al<sup>41</sup> reported lower postoperative pain scores at 48 hours and fewer joint effusions at 6 months in patients receiving PRP at the time of arthroscopic FAIS and labral surgery. Conversely, LaFrance et al<sup>29</sup> compared the efficacy of PRP with that of a 0.9% normal saline injection and reported that PRP injection did not improve the clinical outcomes up to 1 year postoperatively in patients undergoing arthroscopic FAIS and labral surgery. Finally, Redmond et al<sup>42</sup> compared the efficacy of PRP with that of bupivacaine injection for arthroscopic FAIS and labral surgery and reported that the PRP group had higher pain scores and lower mHHS than the bupivacaine group 2 years after surgery. Pooled effect sizes from the meta-analysis demonstrated no statistically significant difference in mHHS between patients treated with PRP and the controls, with a minimum follow-up of 1 year.

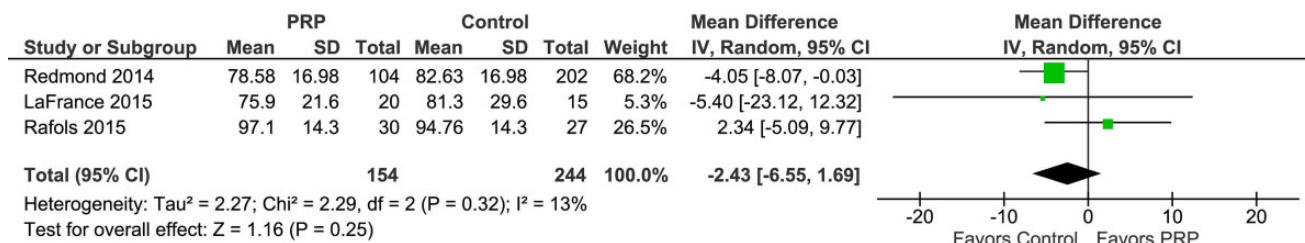
Other noteworthy findings include the heterogeneity of PRP preparation methods and the considerable deficiencies in the reporting of preparation-related factors and basic attributes of PRP preparations. Similar to the systematic review performed by Chahla et al,<sup>7</sup> the current study found no consensus in the timing or number of injections needed, nor agreement on the formulation or standardized reporting methodology of processing. This variability in the preparation and resultant end product may influence the reported outcomes; therefore, it is important to interpret the results in light of a potentially heterogeneous PRP product and deficiencies in reporting. In order to improve the reporting and ultimately the ability to assess the impact of PRP treatment, reported metrics should include, at a minimum, the starting volume, anticoagulant utilized, detailed preparation technique (including spin rate and/or gravitational forces and number of separate centrifuge events), make and model of centrifuge, use of activating agents, and final concentrations of platelets, nucleated cells, and red blood cells.<sup>7</sup>

It should be noted that evaluating the patient-reported outcomes after PRP augmentation for arthroscopic hip surgery may be challenging. It is well-documented that statistically significant changes in patient-reported outcome instruments may in fact have little clinical significance.<sup>25</sup> Additionally, it is difficult for these studies to differentiate between the clinical impact of PRP alone and the clinical impact of the PRP plus the associated arthroscopic techniques, which in 1 study<sup>42</sup> included labral repair or labral debridement with or without acetabuloplasty, femoroplasty, microfracture, and/or capsular repair. These concomitant procedures may confound analysis and the identification of any clinical benefit directly attributable to the PRP injection. In addition to pathology-specific





**Figure 2.** Forest plot depicting visual analog scale (VAS) score summary estimate (center of the diamond) and 95% CI (width of diamond) comparing platelet-rich plasma (PRP) and hyaluronic acid (HA) injections for hip osteoarthritis at the short-term (up to 2 months), midterm (between 4 and 6 months), and long-term (1 year) follow-ups. Means and SDs are reported for the VAS scale. IV, inverse variance.



**Figure 3.** Forest plot depicting modified Harris Hip Score (mHHS) summary estimate (center of the diamond) and 95% CI (width of diamond) comparing platelet-rich plasma (PRP) and controls for femoroacetabular impingement syndrome and labral surgery with a minimum 12-month follow-up. Means and SDs are reported in points on the mHHS scale. IV, inverse variance.

outcome scores, there is a need for sensitive and specific objective outcome tools and advanced imaging modalities to enable the accurate assessment of outcomes for musculoskeletal conditions.

The results of this study must be interpreted in the context of the following limitations. First, no attempt was made to correlate PRP preparation methods with the patient-reported outcomes. Such evaluation is currently confounded by the different time points used in individual studies, as well as the deficiencies in the reporting of PRP preparation methods and composition characteristics. Second, although there is high-quality evidence suggesting that the use of PRP is associated with the

improvement of select patient-reported outcome measures, the use of different outcome instruments in the included RCTs did not allow for a quantitative effect estimate to be calculated. With the exception of the VAS for OA and the mHHS for FAIS and labral surgery patients, the results presented are largely qualitative. Furthermore, the strength of this systematic review was limited by the available literature, including both articles that were identified for inclusion and those that were potentially omitted or missed during the query. For example, search terms did not specifically include “labrum” or “labral,” which may have resulted in the potential omission of relevant studies. In the articles that were identified

TABLE 4

Patient-Reported Outcome Scores for PRP Augmentation for Femoroacetabular Impingement Syndrome and Labral Surgery<sup>a</sup>

Author (Year)	Outcome Score	Group	Pretreatment	Short-term FU	Midterm FU	Long-term FU	Extended FU
LaFrance (2015) <sup>29</sup>	mHHS	PRP	51.9	66.6	78.4	75.9	
		Normal saline	50.3	59.6	83.4	81.3	NR
	HOS-ADL	PRP	59.1	68.4	79.6	84.1	
		Normal saline	55.7	58.9	88.3	85.0	
	HOS-SS	PRP	35.1	31.6	61.7	65.4	
		Normal saline	29.2	20.2	75.6	75.2	
NAHS	PRP	54.9	66.3	81.3	82.0		
	Normal saline	52.6	59.1	87.6	80.9		
Rafols (2015) <sup>41</sup>	VAS	PRP	5.04	3.04	0.71	NR	NR
		No PRP	4.94	5.20	0.77		
	mHHS	PRP	70.79	NR	94.80	NR	97.10
		No PRP	71.48		94.00		94.76
Redmond (2015) <sup>42</sup>	VAS	PRP	5.64	NR	2.62	NR	3.36
		BUP	5.44		2.58		2.52
	mHHS	PRP	62.77		82.09		78.58
		BUP	64.40		80.93		82.63
	HOS-ADL	PRP	64.49		81.63		79.77
		BUP	66.43		83.66		83.57
	HOS-SS	PRP	41.31		61.43		67.47
		BUP	43.52		61.83		69.08
	NAHS	PRP	58.02		76.62		78.34
		BUP	61.30		77.65		81.27

<sup>a</sup>Posttreatment scores are divided into short-term (up to 2 months postop), midterm (3-6 months postop), long-term (12 months postop), and extended (24 months postop) follow-up time points. BUP, bupivacaine; FU, follow-up; HOS-ADL, Hip Outcome Score Activities of Daily Living subscale; HOS-SS, Hip Outcome Score Sport-Specific subscale; mHHS, modified Harris Hip Score; NAHS: Non-Arthritic Hip Score; NR, not reported; PRP, platelet-rich plasma; VAS, visual analog scale.

for inclusion, the descriptions of PRP preparation protocols in clinical studies were inconsistent, and a large proportion of the studies did not provide sufficient information to allow the protocol to be reproduced. The current reporting of PRP preparation and composition does not enable comparison of the PRP products being delivered to patients. Last, the data describing the role of PRP as augmentation for hip arthroscopy are unclear, with a limited number of studies and controversial results, requiring additional high-quality RCTs.

## CONCLUSION

The treatment of OA with PRP demonstrated reductions in pain and improved patient-reported outcomes for up to 1 year. However, there was no statistically significant difference between PRP and HA in terms of pain reduction. Likewise, for FAIS and labral surgery, there was no statistically significant difference in mHHS between patients treated with PRP and controls. Given the limited number of studies and variability in PRP preparations, additional high-quality randomized trials are warranted.

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