Application of Platelet Rich Plasma (PRP) for Hip Related Pathologies: A Systematic Review of the Indications, PRP Processing Methods and Outcomes

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ABSTRACT

Purpose: To perform a systematic review of the available literature and analyze 1) the platelet-rich plasma (PRP) preparation methodologies reported in studies related to intraarticular hip pathologies and, 2) outcomes following PRP augmentation in the treatment of femoroacetabular impingement (FAI) and osteoarthritis of the hip.

Methods: A systematic review was performed according to PRISMA guidelines using the Cochrane Database of Systematic Reviews, the Cochrane Central Register of Controlled Trials, PubMed, Medline, and Embase, from 2000 to present. Inclusion criteria were as follows: English language, human studies reporting clinical outcomes for PRP injection for the treatment of intraarticular pathologies with or without concurrent hip arthroscopy. Exclusion criteria were: extraarticular hip pathology treatment, tendon and/or muscle application of PRP, animal studies, editorial articles, and surveys.

Results: This systematic review identified 7 articles that met inclusion criteria: 4 studies reporting on the use of PRP in the setting of hip osteoarthritis and 3 studies on the use of PRP in the treatment of FAI. The weighted mean age in the seven included studies was 46 years (range, 34-70 years). The weighted mean number of PRP injections was 2.2 injections (range, 1-3 injections). There was significant heterogeneity in the reporting of PRP preparation protocols. When reported, preparation protocols and PRP characteristics varied considerably. In three of the four studies evaluating PRP for hip osteoarthritis (254 patients), the efficacy of PRP was compared to that of hyaluronic acid (HA). In these 254 patients, there was improvement in VAS from pretreatment to early and mid, post-

treatment follow-up in all the studies. In the three studies on PRP and FAI, there was improvement in VAS and HSS from pre-treatment to post-treatment, and the improvement in HSS were maintained at long term follow-up.

Conclusions: The reporting of PRP preparation protocols in clinical studies is highly inconsistent and the majority of studies did not provide sufficient information to allow the protocol to be reproduced. Furthermore, the current reporting of PRP preparation and composition does not enable comparison of the PRP products being delivered to patients, both within and across studies. Despite these limitations, clinical studies of hip osteoarthritis indicate that PRP is viable treatment option that can produce 6-12 months improvements. Similarly, the current literature has demonstrated PRP to produce significant improvement in pain and subjective outcome scores in patients being treated for FAI.

Level of Evidence: Systematic Review of Level II/III Studies

Introduction

Hip pathologies including osteoarthritis (OA) and femoroacetabular impingement (FAI) are increasingly being recognized as a cause of morbidity in the active population. This has led to increased interest in disease modifying and hip joint preservation treatments, including orthobiologics. Platelet-rich plasma (PRP) is one of the most commonly used orthobiologics approaches and is now being used in the treatment of a wide spectrum of orthopaedic pathologies.[1-6] PRP is increasingly used to augment hip arthroscopic procedures or as an intra-articular injection to treat a variety of hip pathologies including osteoarthritis with promising results being reported.[7, 8]

The term PRP encompasses autologous preparations of peripheral blood that have undergone centrifugation to increase the platelet concentration.[9] These strategies aim to promote tissue regeneration and modify local inflammation through the effects of growth factors and cytokines released by activated platelets.[10] Despite increased utilization of PRP for orthopaedic pathologies [11], the efficacy and range of effects of PRP on tissue healing are not fully understood, and its use remains controversial.(REF: Murray, LaPrade Bone Joint Res 2016;5:92-94). In addition to being highly variable the influence of composition on the regenerative characteristics of PRP remains poorly understood.

Given current uncertainty on clinical value and the optimal preparation methods for PRP in the treatment of intraarticular hip pathologies, the purposes of this study were to perform a systematic review of the available literature and analyze 1) the PRP preparation methodologies reported in studies related to intraarticular hip pathologies and, 2)

outcomes following PRP augmentation of arthroscopic hip surgery for FAI and treatment of hip osteoarthritis. We 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.

Methods

A systematic review of PRP application in arthroscopic hip procedures was performed using the Cochrane Database of Systematic Reviews, the Cochrane Central Register of Controlled Trials, PubMed (1980-2017), Medline (1980-2017), and Embase (1980-2017). Registration of this systematic review was performed in August 2016 using the PROSPERO International prospective register of systematic reviews (registration number XXX), and the queries were performed in April 2017. The following search protocol was performed:

- **Search 1**: "Platelet Rich Plasma"[All Fields] AND "Hip Arthroscopy"[All Fields] OR "Platelet Rich Plasma"[All Fields] AND hip pathology [All Fields].

- **Search 2**: Platelet Rich Plasma[All Fields] AND ("femoracetabular impingement"[MeSH Terms] OR ("osteoarthrtis")[All Fields] biomechanics[All Fields]

Inclusion criteria were English language, human studies reporting clinical outcomes for hip arthroscopy procedures treating intraarticular pathologies. Studies were not excluded if they did not detail the preparation of the PRP injected. Exclusion criteria were:

extraarticular hip pathology treatment, non-surgical application of PRP?, tendon and/or muscle application of PRP, animal studies, editorial articles, and surveys.

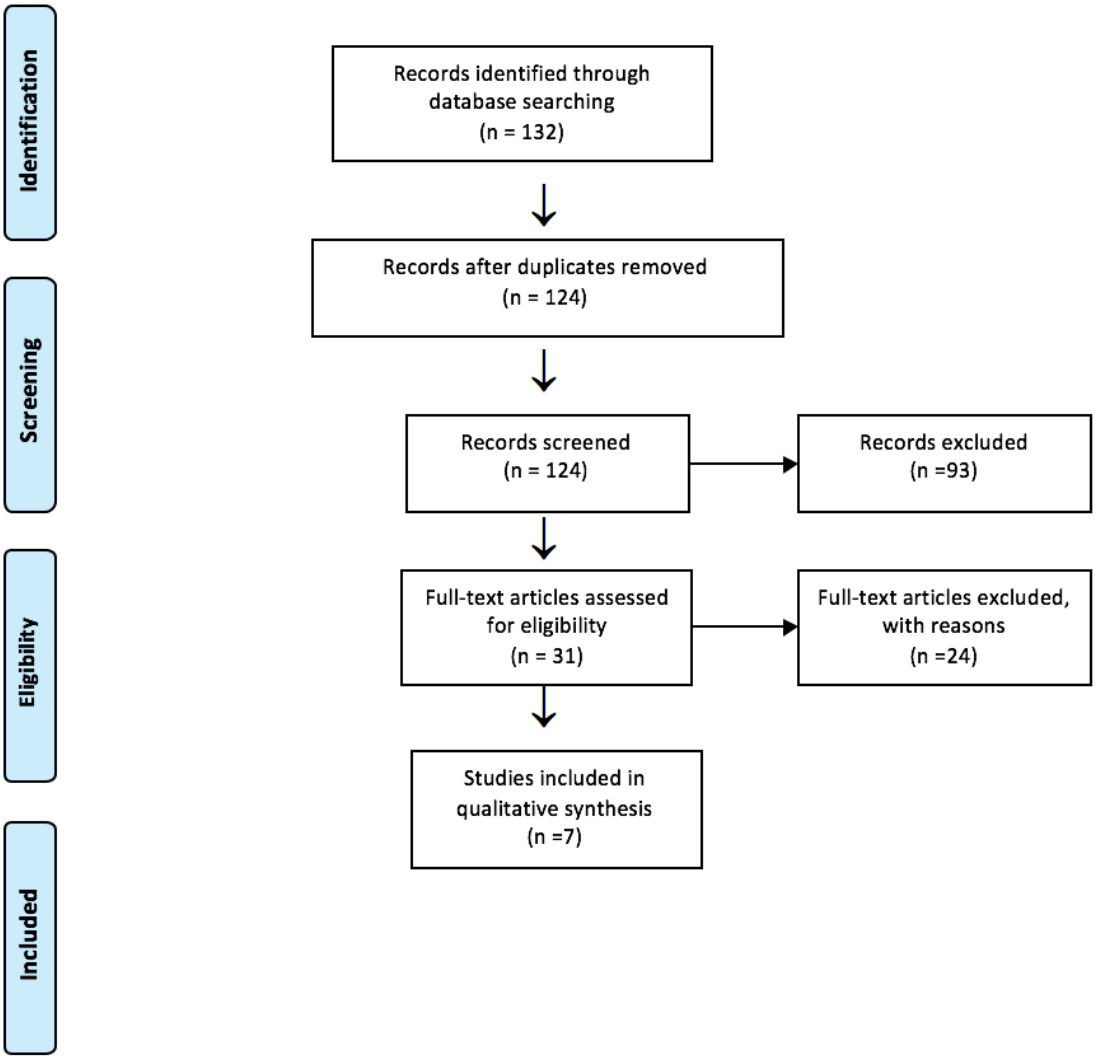
Two investigators (initials blinded for review) independently reviewed the abstracts from all identified articles. If necessary, full-text articles were obtained for review to allow for further application of inclusion and exclusion criteria. Additionally, reference lists from the included studies were reviewed and reconciled to verify that all eligible articles were considered.

Statistical analyses were primarily descriptive with means and frequencies calculated where applicable. Pooled analyses were performed where applicable for demographic and clinical variables. Data analyses were performed using Microsoft Excel (Redmond, Washington).

Results

Study Characteristics and Cohort Demographics

The literature search identified 132 studies through the initial database search. After duplicates were removed, 124 articles were screened with seven articles meeting the inclusion criteria (Fig 1). There were four studies[7, 12-14] describing the use of PRP for the management of hip osteoarthritis symptoms and 3 studies[15-17] reporting on the use of PRP in treatment of FAI. The weighted mean age in the seven included studies was 46 years (range, 34-70 years). The weighted mean number of PRP injections was 2.2 injections (range, 1-3 injections). Detailed study characteristic data is reported in Table 1 (Table 1).



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137 **Figure 1**: Preferred Reporting Items for Systematic Review and Meta-Analysis flowchart
138 showing application of selection criteria to the studies identified with the search strategy.
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Authors	Pathology / Treatment	LOE	Study Design	No. of cases	Mean Age (Range)	No. of PRP Injections (Intervals)	Control Group(s): No. of Injections (+Intervals)	Follow-Up
Osteoarthritis								
Sanchez et al. 2011	OA (Tönnis grades 2-3) – US Guided Injection	IV	Prosp. Case Series	40	56 ys. (18-33)	3 intra-articular Injection (1 inj/1 - 2 weeks)	No control	6 wks + 6 mo
Battaglia et al. 2013	OA (K-L grades 2-4) - US Guided Injection	I	RCT	100	53 ys. (25-76)	3 intra-articular Injection (1 inj/14d)	HA 3 intra-articular injection (1 injection/14d)	1, 3, 6, and 12 mo
Di Sante et al. 2016	OA (K-L grades 2-3) - US Guided Injection	II	Prosp. Comp. Case-Control Study	PRP group: 21 Ctrl group: 22	73 ys. +/- 7	3 intra-articular Injection (1 inj/week)	HA 3 intra-articular injection (1 injection/week)	4 and 16 wks
Dallari et al. 2016	OA (K-L grades 2-4) - US Guided Injection	I	RCT	PRP group: 44 PRP+HA group: 31 HA group: 36	41.5 (18-65)	3 intra-articular Injection (1 inj/week)	a) HA+PRP b) HA 3 intra-articular injection (1 injection/week)	2, 6, and 12 mo
Femoroacetabular Impingement								
Redmond et al. 2014	Hip labral tear w/ ant. Impingement. → Labral repair + acetabular and femoral osteoplasty +/- capsular repair, microfracture and ilioopsoas release (no sig, diff. between groups)	II	Prosp. Comp. Case-Control Study	PRP group: 91 Ctrl group: 180	36 ys.	1 end-OP	0.25% Bupivacaine Single 20 mL Injection	3 mo + 2 ys.
Rafols et al. 2015	Hip labral tear w/ ant. Impingement. → Labral repair + acetabular and femoral osteoplasty	II	Lesser-Quality Prospective RCT	PRP group: 30 Ctrl group: 27	35.3ys. (16-52)	1 end-OP	No PRP Group	Minimum: MRI: 6 mo
LaFrance et al 2015	Hip labral tear w/ ant. Impingement. → Labral repair + acetabular and femoral osteoplasty	I	RCT	PRP group: 20 Ctrl group: 15	34 ys. (18-63)	1 end-OP	0.9% normal saline Single 5 mL injection.	1, 3, 6 and minimum 12 mo post-OP

Table 1: Study Characteristics. (MRI, magnetic resonance imaging; US, ultrasound; K-L, Kellgren and Lawrence; OA, osteoarthritis, PRP, platelet rich plasma; HA, hyaluronic acid; OP ??; RCT, randomized controlled trial)

PRP Preparation and Processing Protocols

There was moderate heterogeneity among the included studies with regard to PRP preparation and processing protocols. The initial whole blood volume was reported in 6 studies[7, 12-15, 17] (86%) while 3 studies[12-14] reported the first and second spin time and/or rate of the first and second spins. The median rate of first spin was 1800 rpm (range, 1480-3100 rpm) and the mean duration of the first spin was 10 minutes (range, 6-15 minutes). The median second spin time was 3400 rpm (range 3100-3500 rpm) and the mean duration of the second spin was 11.3 minutes (range, 8-15 minutes). The median whole blood volume extracted was 41 mL (range, 8 to 450 mL). The volume of PRP injected into each patient was reported in all 7 seven studies, resulting in a mean injected PRP volume of 6.4 mL (range, 3-12 mL). The mean PRP platelet concentration following all preparation steps was reported in 4 studies,[12, 13, 15, 17] producing a mean platelet concentration increase of 4.6 times greater than whole blood (range, 2.3x-7.5x). Regarding leukocyte concentration, 3 studies[7, 13, 18] reported their final PRP to be leukocyte poor, 1 study[12] reported their PRP to be leukocyte rich while 3 studies[14, 16, 17] did not report on the leukocyte concentration in their final PRP product.

The activation method used to induce platelet degranulation and release of platelet growth factors into solution after first concentrating the platelets was reported in 5 studies (71%): 3 studies used calcium chloride (CaCl),[7, 12, 14] 1 study used an undisclosed

activator[17] and 1 study[15] reported not using an activator. Detailed PRP preparation information is reported in Table 2. (consider adding a column labeled as "pathology/treatment")

Authors	PRP Preparation Technique	Volume Blood Drawn in mL	PRP Volume (mL)	PRP Conc. (PLT, LEU, RBCs)	Leucocytes	Activator	PAW classificati
Osteoarthritis							
Sanchez et al. 2011	Endoret (PRGF) Technology, Spain	40	8	NR	Minimal to none	CaCl	P2-x-Bbeta
Battaglia et al 2013	Independent technique: 2-spin method (1800rpm for 15min + 3500rpm for 10min)	150	5	PLT: 6x baseline	Rich: 8300uL	CaCl	P3-x-A
Di Sante et al 2016	Regen Kit (2 x 3100rpm for 9min)	8	3	PLT: 2-2.5x baseline	Negligible	NR	P2-Na-B
Dallari et al. 2016	Independent technique: 2-spin method (1480rpm for 6min + 3400rpm for 15min)	150	5	NR. But analyzed proinflammatory and anti-inflammatory markers	NR	CaCl	Na-x-Na
Femoroacetabular Impingement							
Redmond et al. 2014	Arthrex, Naples, FL	16	4-7	PLT: 2-3x baseline	Minimal to none	None	P2-Bbeta
LaFrance et al. 2015	Accelerate Concentrating System (Exatech Biologics, Gainesville, FL)	NR	5	NR	NR	NR	P4-Na-Aalpl
Rafols et al 2015	Activated GPS III, Biomet, Warsaw, IN	52*	12*	PLT: 7-8x baseline. RBCs and LEU were present, 96.4 x103/mm3 and 275.4x103/mm3*	Present	Yes . Not specified otherwise.	P4-x-Aalpha

Table 2. Detailed reporting of platelet rich plasma (PRP) preparation and composition data. (WB, whole blood; PLT, platelets; RBC, red blood cells; NR, Not reported.)

PRP for the Management of Osteoarthritis Symptoms

There were four studies that evaluated outcomes after intraarticular injection of PRP for management of osteoarthritis symptoms (Table 1). Three studies, which included a total of 254 patients, compared the efficacy of PRP to that of hyaluronic acid (HA). There was improvement in VAS from pre-treatment to early (6 weeks) and mid-point follow-ups (12 weeks) in all the studies. In two of the studies the VAS at late follow-up was higher than

at early/mid post-treatment follow-up; however, it was still lower that pre-treatment. The two studies that documented Harris Hip Score (HSS) (change HSS to HHS throughout manuscript), reported improvement from pre-treatment to mid-term post-treatment (7-12 weeks); however, at late follow-up (6 months), the HSS was higher than at mid-term, but still lower than at pre-treatment. Two studies reported on WOMAC scores that improved from pre-treatment to post-treatment; however, in one study (Di Sante) the improvement was not maintained at longer-term follow-up. (Table 3).

Author	Outcome Score	Treatment	Pretreatment	Early	Mid	Late	Extended
Sanchez	VAS	PRP:	50 (40-63)	NR	40 (25-50)	40 (30-50)	NR
	WOMAC pain		7.5 (5-10)		5 (3-7)	5 (3-7)	
	WOMAC functional improvement		27 (20-34)		22 (14-27)	15 (18-32)	
	HHS pain		20 (17-30)		30 (25-40)	32 (0-50)	
	HHS hip function		39.5 (35-42)		43 (39-45)	44 (36.5-45)	
Battaglia	VAS	PRP:	54.7 ± 5.0	37.2 ± 6.2	38.0 ± 6.1	42.9 ± 6.1	47.5 ± 6.7
		HA:	59.7 ± 4.9	35.8 ± 6.1	38.0 ± 6.0	40.4 ± 6.1	45.9 ± 6.7
	HHS	PRP:	58.1 ± 3.9	73.7 ± 4.5	72.9 ± 4.4	70.2 ± 4.5	65.7 ± 5.1
		HA:	62.9 ± 3.9	78.0 ± 4.6	77.2 ± 4.4	75.8 ± 4.5	72.6 ± 5.1
Di Sante	VAS	PRP:	70.8 ± 20.0	47.3±34.0	NR	63.6±21.0	NR
		HA:	63.2 ± 17.0	52.7±16.0		36.3±21.0	
	WOMAC pain	PRP:	58.9 ± 22.0	44.3±28.8		53.5±22.3	
		HA:	42.4 ± 20.5	29.6±13.4		19.9±11.4	
	WOMAC functional improvement	PRP:	53.7 ± 22.7	46.4±27.5		47.2±22.7	
		HA:	57.7 ± 26.2	47.7±21.2		32.9±20.6	
	WOMAC disability	PRP:	59.9 ± 22.5	49.1±29.1		50.8±22.8	
		HA:	45.8 ± 21.7	39.1±17.2		28.4±17.2	
Dallari	VAS	PRP:	35 (20-52)	NR	15 (10-40)	15 (5-30)	20 (7-30)
		HA:	40 (30-70)		30 (20-60)	50 (20-60)	50 (20-55)
		PRP+HA:	40 (30-75)		30 (20-60)	35 (20-50)	30 (15-60)
	WOMAC	PRP:	66 (47-72)		79 (65-85)	77 (65-86)	70 (59-80)
		HA:	51 (45-60)		60 (49-76)	55 (51-71)	54 (50-69)
		PRP+HA:	47 (35-65)		56 (46-76)	56 (50-77)	60 (50-75)
	HHS	PRP:	75 (65-82)		86 (80-91)	85 (80-90)	80 (73-88)
		HA:	67 (65-75)		76 (70-88)	76 (69-84)	69 (64-79)
		PRP+HA:	73 (65-80)		80 (70-85)	79 (69-84)	75 (65-87)

Table 3. Patient reported outcomes for osteoarthritis. Post treatment scores are divided into early (0-6 weeks), mid (7-12 weeks), late (6 months) and extended (1 year or more). (PRP, platelet-rich plasma; HA, Hyaluronic acid; HSS, Harris Hip Score; VAS, visual analogue scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index;: NR: not reported.

PRP in Association with FAI treatment

Three studies evaluated the efficacy of PRP injections in patients with femoroacetabular impingement FAI). There was improvement in VAS and HSS from pre-treatment to post treatment. The improvement in HSS were maintained at long term follow-up (Table 4)

Author	Outcome Score	Treatment	Pretreatment	Early	Mid	Late	Extended
Redmond	VAS	PRP	56.4 ± NR	NR	26.2 ± NR	NR	33.6 ± NR
		BUP	54.4 ± NR		25.8 ± NR		25.2 ± NR
	HHS	PRP	62.8 ± NR		82.1 ± NR		78.6 ± NR
		BUP	64.4 ± NR		80.9 ± NR		82.6 ± NR
	HOS-ADL	PRP	64.5 ± NR		81.6 ± NR		79.8 ± NR
		BUP	66.4 ± NR		83.7 ± NR		83.6 ± NR
	HOS-SSS	PRP	41.3 ± NR		61.4 ± NR		67.5 ± NR
		BUP	43.5 ± NR		61.8 ± NR		69.1 ± NR
	NAHS	PRP	58.0 ± NR		76.6 ± NR		78.3 ± NR
		BUP	61.3 ± NR		77.7 ± NR		81.3 ± NR
LaFrance	HHS	PRP	51.9 (14.3)	66.6 (21.3)	77.0 (18.3)	78.4 (22.2)	75.9 (21.6)
		Placebo	50.3 (21.1)	59.6 (24.7)	75.0 (18.4)	83.4 (15.5)	81.3 (29.6)
	HOS-ADL	PRP	59.1 (16.6)	68.4 (22.0)	79.0 (16.4)	79.6 (22.8)	84.1 (21.8)
		Placebo	55.7 (22.9)	58.9 (24.2)	78.9 (19.5)	88.3 (7.9)	85.0 (25.4)
	HOS-SSS	PRP	35.1 (24.2)	31.6 (21.0)	55.4 (27.1)	61.7 (26.8)	65.4 (35.4)
		Placebo	29.2 (25.1)	20.2 (20.7)	47.8 (29.2)	75.6 (27.8)	75.2 (39.3)
	NAHS	PRP	54.9 (16.7)	66.3 (16.5)	74.1 (15.6)	81.3 (16.1)	82.0 (17.2)
		Placebo	52.6 (20.8)	59.1 (22.7)	77.1 (16.0)	87.6 (10.1)	80.9 (26.7)
Rafols	VAS	PRP	5.04 (5-8)	3.04 (1-4)	1.22 (1-4)	0.71 (0-3)	NR
		No PRP	4.94 (4-7)	5.2 (4-6)	1.2 (1-4)	0.77 (0-6)	NR
	HHS	PRP	70.79 (50-80)	NR	91.79 (85-95)	94.8 (90-98)	97.1 (NR)
		No PRP	71.48 (60-80)		90.97 (80-95)	94.0 (85-95)	94.8 (NR)

Table 4. Patient reported outcome scores for PRP in the treatment of FAI. FAI: femoroacetabular impingement, HHS: Harris Hip Score, VAS: visual analogue scale, NAHS: non-arthritic hip score; NR: distance neck-capsule; NR: not reported. Post treatment scores are divided into early (0-6 weeks), mid (7-12 weeks), late (6 months) and extended (1 year or more). (PRP, platelet-rich plasma; BUP, bupivicaine; HSS, Harris Hip Score; HOS-ADL, activity of daily living; HOS-SSS, score-sport-specific subscales, visual analogue scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index;: NR: not reported

Discussion

The most important finding of this systematic review is that the most frequently evaluated indications using PRP for hip related pathologies in the clinical literature are symptomatic treatment of mild-moderate osteoarthritis and as an adjuvant for arthroscopic treatment of FAI. Furthermore, a wide spectrum of PRP preparation protocols were used although considerable deficiencies in the reporting of protocol-related factors and characteristics of delivered PRP preparations that may critically affect outcomes were noted. There was no consensus in the timing, number of injections needed nor agreement on the formulation or standardized reporting methodology of processing even when considering the same clinical indication. Nevertheless, good to excellent overall outcomes in the short to medium term (up to 6 months) were reported with the use of PRP for the arthroscopic treatment of FAI and soft tissue related conditions, with few adverse effects.

There is good rationale for the use of PRP in tissue regeneration and healing (REF: Murray, LaPrade Bone Joint Res 2016;5:92-94). Growth factors released by platelets are recognized to perform a range of regenerative functions including proliferation and recruitment of stem cells, modulation of local inflammatory responses and stimulation of blood vessel formation. However, our understanding of the clinical effects of PRP in the treatment of hip pathology, and the influence of alterations in formulation, are limited. Peripheral blood from individual patients varies considerably in the concentrations of platelets, leukocytes and growth factors. [19] Patient factors that may influence PRP composition, and thus biologic activity, include age, patient diet, time of day of blood collection. (REF: Mazzocca et al. *J Bone Joint Surg [Am]* 2012;94-A:308-316) Processing factors including anticoagulation methods, centrifuge device characteristics, gravitational forces—'g-forces'—applied to the samples during centrifugation, the duration of spin cycles, the number of spin cycles, and the method of separation between serum, cell and platelet fractions have also been demonstrated to influence PRP composition.[9]. Two recent studies demonstrated[20,21] that increasing the platelet concentration to up to five times the baseline concentration did not further improve (or was even detrimental) to the

histological or biomechanical properties of the tissue in study (ACL[22] and MCL[21] studies). The studies evaluated in this systematic review failed to report a number of these key variables making accurate comparison of effectiveness based on PRP composition impossible.

The composition of PRP should be tailored to the hip pathology being treated based on best available scientific evidence. None of the studies in the present systematic review provided a comprehensive explanation for the formulation of PRP used for osteoarthritis or ~~PRP~~ (replace with FAI). Although there are limited studies to base such decisions in hip pathology, there is, however, considerably more data supporting PRP use for knee pathology.[23] For example, in the setting of knee osteoarthritis, available studies indicate that leukocyte poor preparations are advantageous.[24] A meta-analysis published in 2016 spanning 1055 patients in 6 randomized controlled trials concluded that leukocyte-poor PRP preparations demonstrated improved outcomes when compared with HA or placebo).[24] It is intuitive that therapeutic effects may be conserved across joints affected by the same pathology. Unfortunately, none of the present studies evaluating PRP for hip osteoarthritis used the systems found to be most helpful for knee OA. There is a danger that potentially beneficial treatments are dismissed as non-effective simply because suboptimised preparations were used in these studies.

In this review, PRP seems to provide favorable patient reported outcomes improvement in patients with hip osteoarthritis, without significant side effects, when compared to hyaluronic acid. Furthermore, these improvements can last for up to 12 months follow up. [14] Sanchez et al examined the effect of intra-articular PRP to treat early osteoarthritis in 40 patients and reported a clinically significant reduction in pain and improved function at mid-term followup.[7] Similar studies have suggested that PRP can reduce pain and improving functional status, especially in patients affected by early to moderate OA.[8] However, indications and results from knee OA symptoms treatment cannot be extrapolated since cartilage characteristics and biomechanics are disparate among joints.[25-27] Nonetheless, the body of literature is compelling with the fact that a high concentration of leukocytes with PRP is not beneficial for intra articular pathologies. In this

regard, Riboh et al.[24] reported that leucocyte –poor PRP resulted in improved functional scores compared to HA and placebo, while leucocyte-rich PRP did not show any difference.

Platelet rich plasma is increasingly being used an adjunct during hip arthroscopy, in particular, FAI surgery. However, the literature regarding use of PRP to augment FAI surgery is very limited. In this review, only three studies for this indication met inclusion criteria. Rafols et al reported lower postoperative pain scores at 48 hours and fewer joint effusions at six months in those receiving PRP at the time of arthroscopic FAI surgery.[17] Conversely, Redmond et al studied 306 patients for two years who received either PRP or bupivacaine injection prior to arthroscopic labral tear repair. The authors found no significant difference in the clinical results at two years' follow-up and reported a lower modified Harris Hip Score in the PRP group than the control group.[18] In a study by LaFrance et al, there was no significant difference in any of the outcome scores between the two groups at one year follow up. When evaluating the patient reported outcome of PRP as an adjuvant for surgery it is challenging to determine the clinical significance of PRP, because statistical outcome improvement may not be "clinically" important. Additionally, it is difficult for these studies to differentiate between the clinical impact of PRP alone vs the clinical impact of the PRP PLUS the associated arthroscopic techniques which, in one study, included labral repair with acetabular and femoral osteoplasty +/- capsular repair, microfracture and iliopsoas release). These concomitant procedures may mask any clinical benefit attributable to be PRP. In addition to pathology specific outcome scores, there is a need for sensitive and specific objective outcome tools and advance imaging modalities to enable accurate assessment of outcomes for musculoskeletal conditions.

We acknowledge some limitations to this systematic review. We did not attempt to correlate processing methods to the final patient reported outcomes. Such an assessment is currently confounded by the variation in clinical indications, the outcome methods and time points used in individual studies. In order to improve the reporting and ultimately the ability to assess the real effect of PRP treatment, reported metrics should include at minimum: starting volume, anticoagulant, preparation technique (including spin rate (with rotor length) and/or gravitational force (g) forces and times), make and model of

centrifuge, use of activating agents, and the final concentration of platelets, nucleated cells and red blood cells. Additionally, the strength of our review is limited by the available literature; we found a paucity of studies meeting inclusion criteria and as such we are somewhat limited in analytic assessments.

In conclusion, the most frequently evaluated indications using PRP for hip related pathologies in the clinical literature are symptomatic treatment of mild-moderate osteoarthritis and as an adjuvant for arthroscopic treatment of FAI. The reporting of PRP preparation protocols in clinical studies is highly inconsistent and the majority of studies did not provide sufficient information to allow the protocol to be reproduced. Further, the current reporting of PRP preparation and composition does not enable comparison of the PRP products being delivered to patients. Despite these limitations, clinical studies of hip osteoarthritis indicate that PRP is a viable treatment option that can produce 6-12 months improvements. Similarly, the current literature has demonstrated PRP to produce significant improvement in pain and subjective outcome scores in patients being treated for FAI. (Im not sure we want to include this last sentence regarding PRP in FAI – lets discuss).

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