

General

Orthobiologic injections for hip osteoarthritis: A systematic review of clinical outcomes

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Keywords: Hip Osteoarthritis, Orthobiologics, Hyaluronic Acid, Platelet-Rich-Plasma, Stem-Cell Therapy, Bone Marrow Aspirate Concentrate
<https://doi.org/10.52965/001c.151461>

Orthopedic Reviews

Vol. 17, 2025

Objective

The incidence of hip osteoarthritis (OA) is increasing with the aging population, leading to interest in intra-articular orthobiologic injections to alleviate symptoms and potentially slow disease progression. This systematic review aims to evaluate the clinical outcomes associated with six orthobiologic therapies for hip OA: hyaluronic acid (HA), platelet-rich plasma (PRP), autologous cells therapy (ACT), microfragmented adipose tissue (MFAT), and bone marrow aspirate (BMA) and its concentration (BMAC).

Methods

We conducted a literature search according to the PRISMA guidelines. Studies were included in our review if they used at least one of the four orthobiologic therapies and reported on the clinical outcome using patient reported outcome measures (PROMs). Since there is a large variability among clinical outcomes, we focused on the three most utilized PROMs (VAS, WOMAC, and HHS) and the latest follow-up time point.

Results

Of the 716 studies reviewed, thirty-six studies (n=36) fit inclusion criteria. There were 21 studies examining HA, 11 on PRP, 3 for MFAT, 2 for ACT, and 3 on BMA/BMAC. Eight studies were randomized controlled trials and 28 were cohort studies. The mean age of the patient population ranged from 45 ± 17.0 to 74 ± 8.0. The baseline grade of osteoarthritis ranged from 1-4 but was most reported as moderate (2-3). Overall, there was an improvement in PROMs at the latest follow-up after receiving orthobiologic interventions.

Discussion

Orthobiologic injections have shown promise for improving PROMs in patients with hip OA. Future studies should evaluate long-term efficacy and include randomized trials to establish efficacy.

INTRODUCTION

Osteoarthritis (OA) is a painful and debilitating joint disease that is characterized by the degenerative breakdown of articular cartilage and subchondral bone. The prevalence of hip OA is increasing, particularly among young adults, for whom hip replacement is often not well-suited to the needs of young, active patients.¹ This has driven and popularized advances in regenerative medicine strategies, particularly intra-articular orthobiologic injections, which are increasingly being used as treatment alternatives for painful, OA hip joints.² These injections may help modulate OA symptoms, improve pain and function, as well as potentially slow the degenerative breakdown of joint tissues.^{3,4}

Currently, there are various orthobiologic injections available for treating hip OA. In the United States, hyaluronic acid (HA), platelet-rich plasma (PRP), microfragmented adipose tissue (MFAT), bone marrow aspirate (BMA) along with its concentration (BMAC), are FDA-compliant orthobiologic therapies routinely being used to treat hip OA in clinical practice, while isolated/culture-expanded mesenchymal stromal cells (MSCs) from various tissues have been used in clinical trials. HA is a naturally occurring component of synovial fluid that has been widely used in the treatment of OA but its use in hip OA has been controversial.⁵⁻⁸ While PRP, which delivers a high concentration of growth factors derived from a patient's blood, has demonstrated sustained symptom improvement beyond six

months post-injection.^{6,7,9} MFAT is a relatively new technique that harnesses the regenerative properties of adipose tissue by mechanically microfragmenting it into smaller clusters while preserving the stromal vascular fraction, which contains reparative cells and growth factors. MSCs, derived from sources such as bone marrow or adipose tissue, have been shown to be effective in address OA symptoms and improving patient reported function.¹⁰ BMA and BMAC, which contain a mix of bone marrow-derived cells and proteins, has also shown promise, with early studies indicating safety and efficacy.¹¹ Within the literature, these orthobiologic therapies have shown to improve OA symptoms and function within patients.

Therefore, the purpose of this systematic review is to review the outcomes of these orthobiologic intra-articular injections for hip OA. Since there is large variability among clinical outcomes and follow-up time points used for these studies, we focused on the three most utilized patient reported outcomes measures (PROMs): Visual Analog Scale (VAS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and the Harris Hip Score (HHS), using the latest follow-up time point.

METHODS

ELIGIBILITY CRITERIA

A comprehensive search of several databases from 2000 to July 3rd, 2024, English language, was conducted. The databases included Ovid MEDLINE(R) and Epub Ahead of Print, In-Process & Other Non-Indexed Citations, and Daily, Ovid EMBASE, Ovid Cochrane Central Register of Controlled Trials, Ovid Cochrane Database of Systematic Reviews, and Scopus. The search strategy was designed and conducted by an experienced librarian with input from the study's principal investigator. Controlled vocabulary supplemented with keywords was used to search for orthobiologic therapies for hip cartilage defects in humans. The actual strategy listing all search terms used and how they are combined is available in the appendix.

Seven-hundred and sixteen articles were identified and screened independently by two authors (C.H, P.S.). Studies eliminated by both reviewers were removed. Disagreements were resolved between the reviewers and the senior author (M.H.). Articles excluded during screening included those regarding corticosteroids, rheumatoid arthritis, surgical procedure, not published full-text, systematic reviews, or review articles. Remaining studies were reviewed for the following inclusion criteria: (1) interventions including orthobiologic intra-articular injections such as HA, PRP, MSCs or BMAC, (2) hip joint based interventions and outcomes, (3) clinical population, and (4) one or more clinical outcomes (strength, range of motion and patient reported outcome measures). Exclusion criteria was not meeting any of the inclusion criteria and studies presented as abstract at conferences without full text available.

QUALITY ASSESSMENT

A pair of reviewers worked independently to determine the reported methodological quality of eligible randomized controlled trials (RCT) and cohort studies. For the RCTs, the authors assessed allocation concealment, blinding of patients, blinding of health care providers, and outcome assessors. In coding the methodological quality using the Newcastle-Ottawa criteria for cohort studies, the authors assessed the adequacy of the representativeness of exposed cohort and non-exposed cohort, ascertainment of exposure, comparability of cohorts, bias protection in the outcome assessment, and adequacy of outcome follow-up. The reviewers came to a consensus on bias assessment with a supervisor.

DATA EXTRACTION AND ANALYSIS

Study characteristics, patient demographics, injection type and frequency, and outcomes including PROMs at baseline and final follow-up were extracted from each study. Due to the large amount of cohort studies, heterogeneity of variables studied and reported, meta-analysis could not be performed. A descriptive review was conducted on all the studies, and outcomes reported by each study are detailed in [tables 1-4](#). Due to the variety and abundance of PROMs used between the studies, we investigated the top 3 most utilized outcome scores (VAS, WOMAC, HHS) at latest follow-up. These scores cover a range of clinical outcomes for pain, function and overall health post- injection.

RESULTS

In total, 36 studies were included in this review. Studies examining multiple treatments added to the group size but did not contribute to the overall study count. There were 21 studies examining HA, 11 on PRP, 3 for MFAT, 2 for ACT/ MSC, and 3 on BMA/BMAC. In total, 8 studies were randomized controlled trials, and 28 were cohort studies. HA and PRP injections were investigated in the randomized-controlled trials and cohort studies, whereas MSCs and BMAC injections were only described in cohort studies and case series.

HYALURONIC ACID

Of the 21 studies describing outcomes of HA for osteoarthritis, there were 15 observational cohort studies, and 6 randomized controlled trials ([Table 1](#)). In total, the mean patient age ranged from 45 ± 16.9 to 73.62 ± 7.87 years.

The ratio of men to women was 7:8 for the combined studies. The Kellgren-Lawrence (KL) grade had a range of 1-4, with the most prevalent grades being moderate (2-3) among the studies. The studies reported a follow-up as early as 1 week and as long as 7 years, but the latest reported follow-up was used when collecting outcome scores.

The Visual Analog Scale (VAS) for pain was most used among all HA outcome reporting scores, with 15 studies. WOMAC, HHS, and Lequesne Index followed close behind

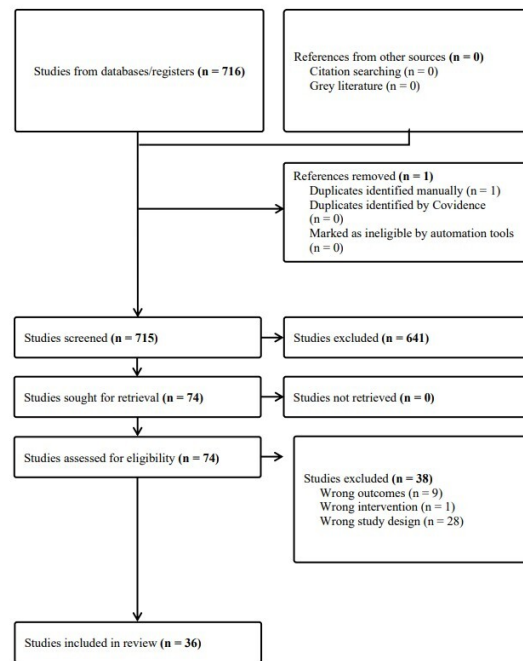


Figure 1. PRISMA flow chart of study selection. Results of the systematic review with the PRISMA flow chart of studies for eligibility into the review.

with 10, 8 and 8 studies, respectively. Non-steroidal anti-inflammatory drug (NSAID) use was reported in a total of 5 studies, and the other 7 outcome measures each were described in less than 3 studies.

VAS

15 studies reported values at baseline and at latest follow-up (3-84 months). All studies demonstrated improvement in pain following HA injection.

Nine studies used a 10 point scale to measure VAS outcomes. Nouri et al.³¹ showed a 4.2 point decrease (8.1 ± 1.2 to 3.9 ± 1.4) in hip pain 6 months post-injection. Abate et al.²⁹ (2014) reported a 3 point reduction (6.7 ± 1.3 to 1.7 ± 1.8) in pain after 12 months. Migliore et al.²³ (2017) showed a ≥ 2 point reduction in pain in their cohort aged between 70 and 80 years, (7.0 ± 2.2 to 4.8 ± 1.7) at 6 months and an even further decline to 3.54 ± 1.66 at 84 months.

DiSante et al.²⁴ reported a 2.7 point decrease (6.3 ± 1.7 to 3.6 ± 2.1) in pain after 16 weeks. Migliore et al.¹⁴ (2020), Doria et al.¹⁵ and Schiavi et al.¹⁹ all showed < 2 reduction in VAS score at 12 months: (6.4 ± 2.2 to 5.3 ± 1.9), (7.8 ± 1.9 to 6.1 ± 2.3), (7.2 ± 2.1 to 4.8 ± 1.8). Abate et al.¹⁸ (2017) saw a 1.2 point decrease in pain (4.4 ± 1.5 to 3.2 ± 1.2) at 6 months. Micu et al.²⁷ saw the greatest reduction in VAS score at a 6 point decrease (8 (range 7-8) to 2 (range 2-3)) at 6 months.

Four studies used a 100 point scale to measure VAS, all of which demonstrated improvements in mean scores.^{21, 22, 23, 17} Three studies reported postoperative reduction in pain of ≥ 40 points at latest follow-up.^{13, 16, 28} Papalia et al.¹⁶ showed a 44.7 point reduction (67.5 ± 10.8 to 22.8 ± 24.1) in VAS score at 6 months. Ometti et al.²⁸

saw a 41.1 point decrease (62.1 ± 15.2 to 21.0 ± 14.5) at 12 months. De Lucia et al.¹³ saw a 41.2 point decrease (range 31.1- 51.3) in a cohort of patients with grade 2 OA at 24 month follow-up. With a 3 month follow-up, Koyano et al.¹⁷ showed a 15.2 point decrease (49 ± 12 to 33.8 ± 15.2) in VAS score.

Rivera et al.²⁶ and Dallari et al.³² reported using VAS as a tool for pain measurement, but did not report values at follow up. However, they found that they were significant different ($p < 0.001$) after 3 and 6 months.

WOMAC

Ten studies reported using WOMAC to evaluate clinical symptoms including pain, stiffness and function following HA injection. Studies recorded values at baseline and at latest follow-up (3- 24 months). Notably, 9 out of 10 studies demonstrated improvement in mean scores following HA injection.

Six studies reported score reduction ≥ 10 points at 6 months. Doria et al.¹⁵ showed a 15 point reduction (24 ± 1.9 to 9 ± 5.6) in the pain subscale at 12 months. Nouri et al.³¹ and Pogliacomi et al.²² reported a 14.2 point decrease (41.4 ± 11.5 to 27.2 ± 9.3) and 11.9 point decrease (62.2 ± 17.0 to 50.3 ± 17.6) in total score at 6 months, respectively. Notably, Micu et al.²⁷ reported a 50 point total decrease (57, range 45.5-64.5, to 7, range 4.8-12) after 6 months. DeLucia et al.¹³ reported a 34.7 (24.7- 44.7) point decrease in WOMAC total score after 24 months. DiSante et al.²⁴ saw a 22.5 point decrease (42.36 ± 20.5 to 19.9 ± 11.4) in WOMAC pain subscale after 16 weeks.

Eymard et al.²¹ saw an 8.5 point decrease in the pain subscale (26.0, range 7.0-42.0, to 16.5, range 0.0-46.0) after

Table 1. A Summary of HA Study Outcomes Reported

Study	HHS	VAS	WOMAC	ROM	NRS	GPA	GMA	BPI II	Lequesene index	NSAID use
Long et al. 2021 ¹²	X									
De Lucia et al. 2019 ¹³		X	X							X
Migliore et al. 2020 ¹⁴		X							X	X
Doria et al. 2017 ¹⁵	X	X	X							
Papalia et al. 2021 ¹⁶		X							X	
Koyano et al. 2021 ¹⁷		X		X						
Abate et al. 2017 ¹⁸	X	X							X	
Schiavi et al. 2020 ¹⁹	X	X								
Scaturro et al. 2022 ²⁰					X				X	
Eymard et al. 2017 ²¹			X			X				
Pogliacomini et al. 2018 ²²	X		X							
Migliore et al. 2017 ²³		X				X	X		X	X
DiSante et al. 2016 ²⁴		X	X							
Brander et al. 2019 ²⁵			X							X
Rivera et al. 2016 ²⁶	X	X						X		
Micu et al. 2022 ²⁷		X	X							
Ometti et al. 2020 ²⁸	X	X							X	X
Abate et al. 2014 ²⁹	X	X							X	
Kraeutler et al. 2021 ³⁰			X							
Nouri et al. 2022 ³¹		X	X						X	
Dallari et al. 2016 ³²		X	X							

HHS, Harris-Hip Score; VAS, Visual Analogue Scale; WOMAC, Western-Ontario and McMaster Universities Osteoarthritis Index; ROM, range of motion; NRS, numeric pain rating scale; GPA, Global Patient Assessment; GMA, Global Measurement Assessment; BP II, Brief Pain Inventory; HAGOS, Hip and Groin Outcome Score; Lequesene Index, NSAID use (days per month).

3 months. Brander et al.²⁵ found a 2.21 (1.78- 2.65) point decrease in pain at 26 weeks. Dallari et al.³² used WOMAC pain as an outcome measure, did not report values, only reporting that there was significant improvement ($p<0.001$) at 6 month follow-up.

While most studies showed relative improvement at latest follow-up, Kraeutler et al.³⁰ reported a 4.2 point increase (77.9 ± 14.4 to 82.1 ± 15.1) in the WOMAC total score after 6 months.

Table 2. PRP Outcomes Reported

Study	HHS	VAS	WOMAC	iHOT	HOOS	Lequesene index
Mazzotta et al. 2022 ³³	X	X	X			
Doria et al. 2017 ¹⁵	X	X	X			
DiSante et al. 2016 ²⁴		X	X			
Ortiz-Declet et al. 2020 ³⁵	X	X		X		
Fiz et al. 2020 ³⁶		X	X		X	
Palco et al. 2021 ³⁷	X	X				
Topaloglu et al. 2024 ³⁸		X	X			
Kraeutler et al. 2021 ³⁰			X			
Nouri et al. 2022 ³¹		X	X			X
Dallari et al. 2016 ³²	X	X	X			
Singh et al. 2019 ³⁴		X		X		

HHS, Harris-Hip Score; VAS, Visual Analogue Scale; WOMAC, Western-Ontario and McMaster Universities Osteoarthritis Index; iHOT, International Hip Outcome Tool; HOOS, Hip Disability and Osteoarthritis Outcome Score; Lequesene Index.

HHS

In total, eight studies used HHS, and reported values at baseline and latest follow-up (1, 6, or 12 months). All studies demonstrated an improvement in mean values following HA injection.

Five studies showed improvements ≥ 10 points at latest follow-up. Ometti et al.,²⁸ Pogliacomini et al.,²² and Schiavi et al.¹⁹ reported a score increase by 16.5 points (71.2 ± 9.67 to 87.7 ± 9.35), 15.14 points (57.36 ± 14.76 to 72.5 ± 14.71) and 14.8 points (56.4 ± 11.9 to 78.9 ± 6.1) at 12 months, respectively. Rivera et al.²⁶ and Doria et al.¹⁵ saw a similar increase of 13.41 points (68.35 to 81.76) and 13 points (62 ± 9.8 to 75 ± 11.4) at 12 months. Long et al.¹² reported a 12.83 point increase (58.47 ± 12.82 to 71.3 ± 16.46) at 6 weeks. Two studies by Abate et al.^{18,29} showed an improvement <10 points at 6 months (65 ± 14 to 72.5 ± 12.1) and 12 months (83.3 ± 6 to 88.2 ± 4.7).

PLATELET-RICH PLASMA

Out of the 11 studies examining PRP, 7 studies were randomized controlled trials, comparing PRP with HA or to a control (Table 2). The remaining 4 were observational cohort studies measuring the effectiveness of PRP to address clinical symptoms. The mean age of patients receiving a PRP injection had a range of 45.6 ± 13.1 - 71.37 ± 6.03 years. The ratio of males to females in the studies were comparable. However, Mazzotta et al.³³ and Singh et al.³⁴ had a larger number of males to females enrolled in their studies. Latest follow-up was reported, ranging from 16 weeks to 12 months. The mean pre-operative KL grade was reported in 9 studies, ranging between grades 1-4 with the most encountered being moderate (2-3). Doria et al.¹⁵ reported the lowest mean baseline KL grade at 1.5 ± 0.5 . Three studies used a Tonnig grade to determine the level of OA, which ranged from grades 1-3.

VAS

In total, ten studies reported using VAS as a tool to measure patient pain postoperatively and reported values at baseline and latest follow-up (6 and 12 months). All studies saw improvements in mean scores following PRP injection.

Six studies demonstrated a decrease in VAS pain by < 5 points. Nouri et al.,³¹ Singh et al.,³⁴ and Topaloglu et al.³⁸ reported a reduction in VAS scores at 6 months of 4.51 points (7.63 ± 1.31 to 3.12 ± 1.29), 2.6 points (6.9 ± 0.7 to 4.3 ± 1.8) and 2.15 points (7.61 ± 1.72 to 5.46 ± 2.18), respectively. Fiz et al.³⁶ saw a decrease of 0.9 points (4.5 ± 1.4 to 3.6 ± 1.8) at 6 months.

Ortiz-Declet et al.³⁵ found a 1.7 point reduction (4.1 ± 1.9 to 2.4 ± 2.6) and Doria et al. reported a reduction of 1.1 points (7.5 ± 2.1 to 6.4 ± 2.9) at 12 months. DiSante et al.²⁴ saw a 0.72 point decrease (7.08 ± 2.0 to 6.36 ± 2.1) after 12 months. Dallari et al.³² found a significant decrease in pain in after 12 months in the PRP group.

Two studies used the 100 point scale for reporting VAS outcome. Mazzotta et al.³³ saw improvements in both comparison PRP groups, with autologous PRP seeing a 2.6 point reduction (31.8 ± 19.9 to 29.2 ± 21.0) and umbilical cord PRP seeing a 7.77 point decrease (37.17 ± 22 to 29.4 ± 24.6) in 12 months. Palco et al.³⁷ reported a 23.07 point reduction (72.69 ± 13.65 to 49.62 ± 14.53) at 12 months.

WOMAC

In total, eight studies reported using WOMAC to evaluate total pain, stiffness and function after PRP injection. Studies reported values at baseline and at latest follow-up (3, 4, 6 or 12 months), with 6 of the 8 studies showing improvement in mean values.

DiSante et al.²⁴ found a 5.4 point reduction (58.89 ± 22.0 to 53.47) in WOMAC pain subscale after 16 weeks. Topaloglu et al.³⁸ reported a reduction of 10.01 points (58.16 ± 18.54 to 48.15 ± 21.45) in their treatment group, and 23.76 (55.12 ± 19.19 to 31.36 ± 22.91) in their placebo

group at 6 months. Nouri et al.³¹ reported a 19.85 point decrease in total score (41.38 ± 9.36 to 21.53 ± 10.4) after 6 months. Dallari et al.³² did not show mean values at follow-up but reported significant improvement in WOMAC pain scores after 6 months.

Mazzotta et al.³³ showed a 3.8 point reduction (27.1 ± 17.6 to 23.3 ± 18.2) in the autologous PRP group, and a 5.4 point decrease (27.9 ± 17.2 to 22.5 ± 18.3) in the umbilical cord PRP group at 12 months. Doria et al.¹⁵ showed a 16.3 point reduction (23.7 ± 2.1 to 7.4 ± 2.5) in pain subscale at 12 months.

Two studies did not show improvement following PRP injection. Kraeutler et al. saw a 9.4 point increase (67.6 ± 19.7 to 77 ± 15.8) in WOMAC total at 6 months. Fiz et al.³⁶ showed an increase in WOMAC pain of 9.1 points (64.4 ± 16.4 to 73.5 ± 17.2) at 12 months.

HHS

In total, 5 studies used the Harris Hip Score (HHS) to report outcomes. Of those, 4 studies reported mean and SD, at baseline and at 12 months, with variable results. Mazzotta et al.³³ compared umbilical cord PRP versus autologous PRP. The umbilical cord group improved by 3.4 points (78.6 ± 11.4 to 82.0 ± 14.2), while the autologous group reported a slight decrease of 0.4 points (83.8 ± 11 to 83.4 ± 14) at 12 months. Ortiz-Declet et al.³⁵ and Doria et al.¹⁵ showed an increase of 18.6 points (70.6 ± 12.4 to 89.2 ± 10.6) and 14 points (64 ± 10.3 to 78 ± 11.3) at 12 months. Palco et al.³⁷ reported a decrease of 13.78 points (66.86 ± 9.96 to 53.08 ± 24.31) at 12 months. Dallari et al.³² used HHS as an outcome measure but did not report mean values at baseline and follow-up.

MICROFRAGMENTED ADIPOSE TISSUE

Of the three studies included in this sub-analysis, there was a prospective cohort, observational study, and a case series study (Table 3). Natali et al.³⁹ was a prospective cohort study of 55 patients (22 males, 33 females; mean age 60.6 ± 16.4 years) which observed the outcomes of MFAT injections for hip osteoarthritis. Heidari et al.⁴⁰ was an observational, intention-to-treat study of 147 patients (74 males, 73 females; mean age 52.5 ± 10.9 years) that compared outcomes of patients who received a MFAT or MFAT and PRP for their hip OA. There was one case series, conducted by Dall'Oca et al.,⁴¹ with a total of 6 patients (5 males, 1 female) receiving an MFAT injection. The KL Scale was used in these 2 studies to report baseline values of OA, which had a severity range of 1-4 with moderate being the most prevalent. Dall'Oca et al.⁴¹ used the Tonnis OA scale, with a range of 0-2 at baseline. Follow-up for the studies ranged from 6-35 months post-injection.

VAS

All 3 studies used VAS as an outcome measure and demonstrated an improvement in pain following MFAT injections. These studies reported VAS at baseline and at 6 months posttreatment.

Dall'Oca et al.⁴¹ reported a 3.1 decrease (4.6 ± 0.8 to 1.5 ± 0.5) after 6 months. Heidari et al.⁴⁰ recorded VAS on a 100 point scale and showed a score decrease 13 points (41 to 28) at 6 months. Natali et al.³⁹ saw a 2.9 point reduction (4.7 ± 1.1 to 1.8 ± 0.4) during their follow up between 29 and 41 months.

HHS

Only one study used HHS as a tool to measure hip function post injection which reported mean and SD values at baseline and at 6 months. Dall'Oca et al.⁴¹ reported a 17.4 point increase (67.2 ± 3.4 to 84.6 ± 6.3) at 6 months.

WOMAC

Dall'Oca et al.⁴¹ was the only study to use WOMAC as a tool to measure patient reported outcomes at baseline and at latest follow-up (6 months). This study reported a 16.5 point reduction in the total score (36.3 ± 4.7 to 19.8 ± 3.4) after 6 months.

AUTOLOGOUS CELL THERAPY

There were two studies that used autologous cells to treat patients with hip OA (Table 4). Onoi et al.⁴² and Mardones et al.⁴³ each conducted a prospective cohort study. Mardones et al.⁴³ used cultured expanded bone marrow-derived MSCs, and Onoi et al.⁴² used adiposederived stromal vascular fraction (SVF), which includes a variety of cells, including MSCs, blood cells, macrophages, fibroblasts, pericytes, and endothelial cells. The SVF treatment allows for a point-of-care cell therapy which doesn't require any cell expansion. Mardones et al.⁴³ treated hip OA patients with MSC injections in 10 patients (5 males, 5 females) in their studies, while Onoi et al.⁴² treated 42 patients (5 males, 37 females) with SVF injections for hip OA. The mean patient age ranged from 49.7 ± 10.3 years to 60.2 ± 9.4 . OA severity ranged from moderate to severe, and follow-up for the studies ranged from 6- 40 months post-injection.

VAS

Both studies used VAS as an outcome measure and demonstrated an improvement in pain following autologous cell injection for hip OA. Onoi et al.⁴² showed a score decrease of 29 points (75.5 ± 15.8 to 46.5 ± 27.9) at 6 months. Mardones et al.⁴³ recorded a 3.1 point reduction (4.2 ± 0.5 to $\pm 1.1 \pm 0.3$) post injection with a latest follow-up between 16-40 months.

HHS

Both studies used HHS as a tool to measure hip function post injection. Onoi et al.⁴² showed a 20.6-point increase (25.2 ± 16.6 to 46.8 ± 27.2) at 6-month follow-up. Mardones et al.⁴³ reported a 23.8-point increase (61.9 ± 6.1 to 85.7 ± 3.9) post-injection (16- 40 mos.).

Table 3. MFAT Outcomes Reported

Study	HHS	OHS	VAS	WOMAC
Heidari et al. 2022 ⁴⁰		X	X	
Natali et al. 2023 ³⁹		X	X	
Dall'Oca et al. 2019 ⁴¹	X		X	X

HHS, Harris-Hip Score; OHS, Osteoarthritis Hip Score; VAS, Visual Analogue Scale; JHEQ, Japanese Orthopaedic Association Hip Disease Evaluation Questionnaire; WOMAC, Western-Ontario and McMaster Universities Osteoarthritis Index.

Table 4. Autologous Cell Therapy Outcomes Reported

Study	HHS	VAS	JHEQ	WOMAC
Onoi et al. 2023 ⁴²	X	X	X	
Mardones et al. 2017 ⁴³	X	X		X

HHS, Harris-Hip Score; VAS, Visual Analogue Scale; JHEQ, Japanese Orthopaedic Association Hip Disease Evaluation Questionnaire; WOMAC, Western-Ontario and McMaster Universities Osteoarthritis Index.

Table 5. BMA/BMAC Outcomes Reported

Study	HHS	HOOS	HOS-ADL	SF-12	WOMAC	Pain scale	NRS	Lower Extremity Functional Scale
Darrow et al. 2018 ⁴⁵						X		X
Tsitsilianos et al. 2022 ⁴⁴		X					X	
Whitney et al. 2020 ⁴⁶	X		X	X	X		X	

HHS, Harris Hip Score; HOOS, Hip Osteoarthritis Outcome Score; HOS-ADL, Hip Outcome Score- Activities of Daily Living; SF-12, Short Form Health Survey; WOMAC, Western-Ontario and McMaster Universities Osteoarthritis Index; Pain Scale; NRS, Numerical Rating Scale; Lower Extremity Functional Scale.

WOMAC

Mardones et al.⁴³ is the only study that used the WOMAC tool to measure patient outcomes.⁴³ This study showed a 15.3 point decrease (34.5 ± 8.2 to 19.2 ± 6.1) post-injection (16- 40 mos.).⁴³

BONE-MARROW ASPIRATE AND BMA CONCENTRATION

Out of the 3 studies investigating BMA and BMAC hip injection efficacy, there was one cohort study and two case series.

A retrospective cohort study by Tsitsilianos et al.⁴⁴ examined 31 patients, 15 male and 16 female, with an average age of 62.4 ± 16.5 years, as well as a baseline KL grade of 2.9 ± 0.7 . Patients were evaluated at baseline, and at latest follow-up (12 weeks, 6 months, and 12 months). A case series by Darrow et al.⁴⁵ followed 4 patients: 3 male and 1 female, with a mean age of 67 ± 10 years. The patients had OA ranging from mild to severe. All patients had a mean follow-up of 22.75 days after the last injection. Finally, a case study by Whitney et al.⁴⁶ examined 16 patients, 7 male and 9 female, with a mean age of 57.6 ± 11 years. The patients had a baseline tonnis grade ranging from 2-3. Patients were evaluated at baseline, 6 weeks, 3 months, and 6 months following the injection.

WOMAC

Only one study used WOMAC pain for outcome reporting, which had a favorable result for BMAC. Whitney et al.⁴⁶ showed a 6-point decrease (31 ± 19 to 25 ± 13) in pain at 1 month and a 9-point reduction (31 ± 19 to 22 ± 14) in 3 months. Finally, at 6 months patients reported a 15-point reduction in WOMAC total score (31 ± 19 to 16 ± 14).⁴⁶

HHS

Additionally, one study used modified- HHS as a tool to measure outcomes post-injection. Whitney et al.⁴⁶ reported a 10-point increase (63 ± 19 to 73 ± 15) in hip function at 1 month post-injection and a 16 point increase (63 ± 19 to 79 ± 15) 3 months from injection. Finally, at 6-month follow-up, patients reported a 17-point increase in mHHS (63 ± 19 to 80 ± 15).⁴⁶

DISCUSSION

The goal of this systematic review is to provide a comprehensive evaluation of clinical outcomes following intra-articular injections for hip OA. We focused on the most commonly used biologics, including HA, PRP, MFAT, BMA/BMAC, and MSCs, all of which have been more extensively

studied in knee OA and are now being increasingly applied to the treatment of hip OA. Among the biologics used, HA and PRP were the most extensively studied, while BMAC, MFAT and MSCs report promising findings, the literature for these “cell-based therapies” in hip OA is scant. Because of the heterogeneity among the studies, our review focused on the subjective outcomes of VAS, WOMAC, and HHS at the studies respective final follow-up time points. These measures were the most frequently utilized to measure pain and function for patients at baseline and follow-up.

Our findings indicate that intra-articular orthobiologic therapies for hip OA are associated with improvements in PROMs. Zaffagnini et al.⁴⁷ also performed a systematic review of orthobiologic injections for the treatment of hip OA to evaluate the safety and efficacy of various products. These authors found that there was an overall improvement in pain and function in hip OA patients treated with orthobiologic injections and that most improvements were observed within the first 6 months.⁴⁷ While we did not evaluate safety in our study, we found similar results in that orthobiologics used to treat patients with hip OA also had improvements in pain and function at the studies final follow-up time points.⁴⁷ Acuna and colleagues⁴⁸ performed a systematic review on viscosupplementation for hip OA and focused on whether PROMS support its use. We similarly found that VAS and WOMAC outcomes focused on pain and function improved following HA administration for hip OA.⁴⁸ Interestingly, this group also found that formulation of HA did not appear to influence outcomes, and that total hip arthroplasty conversion was low, but this may be due to the range of follow-up being between 1- and 4-years of follow-up.⁴⁸ Furthermore, Xiong et al.⁴⁹ performed a systematic review and meta-analysis of randomized controlled trials that used PRP for the treatment of OA for all joints including the hip. Notably, this study found that PRP was safe and effective for knee and ankle OA, but the results for hip OA did not demonstrate a significant reduction in pain among patients.⁴⁹ This may be attributed to the only 2 studies that were included that used PRP for hip OA and the limited sample size.⁴⁹ Overall, our findings support the role for intra-articular injections of orthobiologics to alleviate hip OA symptoms.

Importantly, this review found significant heterogeneity among the studies, including using different orthobiologics with specific methodological preparations, studying a wide range of sample sizes, and having various follow-up time periods, all of which limit our ability to make direct comparisons between the studies. Of note, there were a few studies that had a long-term follow-up period, including Mazzotta and colleagues³³ who followed their patient cohort for 7 years. Additionally, each study in this systematic review followed patient reported outcomes post-treatment for various periods of time, not allowing for direct comparisons. While the PROMs have demonstrated efficacy of orthobiologic injections to improve pain and function, there is not enough evidence of sustained benefits beyond 1 year. This was also noted by Zaffagnini et al.⁴⁷ who reported in their systematic review that some authors reported a grad-

ual worsening of clinical outcomes toward the end of their study follow-up.

This review highlights several limitations in the current literature. A vast majority of the studies included were single-arm, pre-post studies with unblinded evaluations. As such, causal inferences about the effectiveness of the interventions cannot be made. Second, there was variability in duration of follow-up for the studies, ranging from 1 week to 84 months. There was also a lack of consistency regarding the types of PROMs used, and how the values were reported, making it difficult to effectively compare scores at baseline and follow-up. Also, there was a wide range of sample sizes between the studies, creating a barrier to draw conclusions about the efficacy and long-term effects of orthobiologic injections of the hip.

Although the current literature has several limitations, a strength of this study is the comprehensive and systematic review approach. We also assessed the methodological quality of the included randomized controlled trials and observational cohort studies, accordingly.

Although there have been previous reviews of the literature, to our knowledge, this is the first systematic review investigating outcomes of all biologic injections for the hip that are used in practice.

CONCLUSION

This systematic review demonstrates promising results for orthobiologic injections including HA, PRP, BMAC, MFAT and MSC injections for the treatment of hip OA. While we found a broad range of PROMs used among our included studies, focusing on the three most utilized measures (VAS, WOMAC, and HHS) allowed us to evaluate the relative impact of these intra-articular injections on pain and function in patients with hip OA. Future research should focus on conducting rigorous randomized controlled trials and assessing outcomes beyond 1 year.

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Scott: Ms. Scott led the study and was involved with screening of articles, data synthesis, and manuscript preparation and review.

Hegarty: Along with Ms. Scott, Mr. Hegarty helped lead the study with screening of articles, data synthesis, and manuscript preparation and review.

Kang: Mr. Kang helped with manuscript preparation, data review, and clinical insights.

Newcastle-Ottawa Scale Cohort Quality Assessment

Selection					Comparability	Outcome			Total Score
Author, Year	Representativeness of Cohort	Selection of Non-Exposed Cohort	Ascertainment of Exposure	Outcome of Interest	Comparability of Cohorts	Assessment of Outcome	Adequate Duration of Follow- Up	Adequate Follow- Up of Cohort	Total (9/9)
DeLucia et al. 2019	X	X	X	X	X		X	X	7
Migliore et al. 2020	X		X	X			X	X	5
Onoi et al. 2023	X		X	X		X	X		5
Mazzotta et al. 2022	X	X	X	X	X	X	X	X	8
Papalia et al. 2021	X		X	X		X	X	X	6
Koyano et al. 2021	X		X	X	X	X	X	X	7
Abate et al. 2014	X		X	X		X	X	X	6
Schiavi et al. 2020	X		X	X		X	X	X	6
Poglicomi et al. 2018	X		X	X		X	X	X	6
Scaturro et al. 2022	X	X	X	X	X	X			6
Eymard et al. 2017	X		X	X		X	X	X	6
Migliore et al. 2017	X		X	X		X	X	X	6
Ortiz-Declet et al. 2020	X		X	X			X	X	5
Palco et al. 2021	X	X	X	X	X	X	X		7
Fiz et al. 2020	X		X	X		X	X	X	6

Selection					Comparability	Outcome			Total Score
Heidari et al. 2022	X		X	X	X	X	X	X	7
Natali et al. 2023	X		X	X		X	X	X	6
Micu et al. 2022	X	X	X	X	X	X	X	X	8
Rivera et al. 2016	X		X	X		X	X	X	6
Tsitsilianos et al. 2022	X		X	X		X	X	X	6
Ometti et al. 2020	X		X	X		X	X	X	6
Abate et al. 2017	X		X	X	X	X	X	X	7
Mardones et al. 2017			X	X		X	X	X	5
Singh et al. 2019	X		X	X		X	X	X	6

ROBINS Cochrane Quality Assessment for Randomized-Controlled-Trials

Author, Year	Sequence Generation	Allocation Concealment	Blinding of Participants and Personnel for all Outcomes	Blinding of Outcome Assessors for all Outcomes	Incomplete Outcome Data for All Outcomes	Selective Outcome Reporting	Other Sources of Bias
Topaloglu et al. 2024	low	high	low	low	low	low	low
Kraeutler et al. 2021	low	low	low	low	low	low	low
Brander et al. 2019	low	low	low	low	low	low	low
Doria et al. 2017	low	unclear	low	low	low	low	low
DiSante et al. 2016	low	low	unclear	unclear	low	low	low
Dallari et al. 2016	low	high	high	low	low	low	low
Nouri et al. 2022	low	low	unclear	low	low	low	unclear

Boettcher: Dr. Boettcher was involved with clinical understanding of data, review of the manuscript, manuscript preparation, and important clinical insights.

Sellon: Dr. Sellon helped with clinical insights, review of the data, manuscript preparation and review.

Krych: Dr. Krych helped with manuscript preparation, review, and clinical insights.

Nagelli: Dr. Nagelli helped with developing the study, refining the research questions, involved with data review, manuscript preparation and review.

Hevesi: Dr. Hevesi was involved with formulating the idea for the paper, data review, manuscript preparation and review, and clinical insights.

CONFLICTS OF INTEREST

There are no conflicts of interest.

Submitted: October 24, 2025 EST. Accepted: November 22, 2025 EST. Published: December 21, 2025 EST.

REFERENCES

1. He Y, Jiang W, Wang W. Global burden of osteoarthritis in adults aged 30 to 44 years, 1990 to 2019: results from the Global Burden of Disease Study 2019. *BMC Musculoskelet Disord.* 2024;25(1):303. doi:[10.1186/s12891-024-07442-w](https://doi.org/10.1186/s12891-024-07442-w)
2. Jildeh TR, Abbas MJ, Buckley P, Okoroha KR. The Use of Biologics for Hip Preservation. *Curr Rev Musculoskelet Med.* 2021;14(2):145-154. doi:[10.1007/s12178-021-09695-7](https://doi.org/10.1007/s12178-021-09695-7)
3. Rodeo SA. Orthobiologics: Current Status in 2023 and Future Outlook. *J Am Acad Orthop Surg.* 2023;31(12):604-613. doi:[10.5435/jaaos-d-22-00808](https://doi.org/10.5435/jaaos-d-22-00808)
4. Delanois RE, Sax OC, Chen Z, Cohen JM, Callahan DM, Mont MA. Biologic Therapies for the Treatment of Knee Osteoarthritis: An Updated Systematic Review. *J Arthroplasty.* 2022;37(12):2480-2506. doi:[10.1016/j.arth.2022.05.031](https://doi.org/10.1016/j.arth.2022.05.031)
5. Bensa A, Bianco Prevot L, Peretti GM, Filardo G. Effect of corticosteroids and hyaluronic acid injections on knee osteoarthritis trajectory. *Journal of experimental orthopaedics.* 2025;12(3):e70333. doi:[10.1002/jeo2.70333](https://doi.org/10.1002/jeo2.70333)
6. Bagheri K, Shekhar A, Kwok E, Dungy D, Stewart SL, Jamali AA. Platelet rich plasma compared to viscosupplementation in the treatment of knee osteoarthritis: A systematic review and meta-analysis of randomised controlled trials with 6 month and 12 month follow-up. *Journal of experimental orthopaedics.* 2025;12(3):e70335. doi:[10.1002/jeo2.70335](https://doi.org/10.1002/jeo2.70335)
7. Li YF, Xing HH, Wei CK, et al. Platelet-Rich Plasma Is More Effective Than Hyaluronic Acid Injections for Osteoarthritis of the Knee: A Meta-Analysis Based on Randomized, Double-blinded, Controlled Clinical Trials. *Arthroscopy.* Published online July 16, 2025. doi:[10.1016/j.arthro.2025.06.033](https://doi.org/10.1016/j.arthro.2025.06.033)
8. Migliorini F, Maffulli N, Simeone F, Jeyaraman N, Ramasubramanian S, Jeyaraman M. Intra-articular Hyaluronic Acid Injections May Be Beneficial in Patients with Less Advanced Knee Osteoarthritis: A Systematic Review of Randomised Controlled Trials. *Sports Med.* Published online July 2, 2025. doi:[10.1007/s40279-025-02265-8](https://doi.org/10.1007/s40279-025-02265-8)
9. Filardo G, Previtali D, Napoli F, Candrian C, Zaffagnini S, Grassi A. PRP Injections for the Treatment of Knee Osteoarthritis: A Meta-Analysis of Randomized Controlled Trials. *Cartilage.* 2021;13(1_suppl):364s-375s. doi:[10.1177/1947603520931170](https://doi.org/10.1177/1947603520931170)
10. Chen X, Zheng J, Yin L, Li Y, Liu H. Transplantation of three mesenchymal stem cells for knee osteoarthritis, which cell and type are more beneficial? a systematic review and network meta-analysis. *J Orthop Surg Res.* 2024;19(1):366. doi:[10.1186/s13018-024-04846-1](https://doi.org/10.1186/s13018-024-04846-1)
11. El-Kadiry AE, Lumbao C, Salame N, Rafei M, Shammaa R. Bone marrow aspirate concentrate versus platelet-rich plasma for treating knee osteoarthritis: a one-year non-randomized retrospective comparative study. *BMC musculoskeletal disorders.* 2022;23(1):23. doi:[10.1186/s12891-021-04910-5](https://doi.org/10.1186/s12891-021-04910-5)
12. Long DM, Fitzpatrick J. Safety and efficacy of a single intra-articular injection of hyaluronic acid in osteoarthritis of the hip: a case series of 87 patients. *BMC Musculoskelet Disord.* 2021;22(1):797. doi:[10.1186/s12891-021-04672-0](https://doi.org/10.1186/s12891-021-04672-0)
13. De Lucia O, Pierannunzii LM, Pregnotato F, et al. Effectiveness and Tolerability of Repeated Courses of Viscosupplementation in Symptomatic Hip Osteoarthritis: A Retrospective Observational Cohort Study of High Molecular Weight vs. Medium Molecular Weight Hyaluronic Acid vs. No Viscosupplementation. *Frontiers in Pharmacology.* 2019;10:1007. doi:[10.3389/fphar.2019.01007](https://doi.org/10.3389/fphar.2019.01007)
14. Migliore A, Frediani B, Gigliucci G, et al. Efficacy of a Single Intra-Articular HYMOVIS ONE Injection for Managing Symptomatic Hip Osteoarthritis: A 12-Month Follow-Up Retrospective Analysis of the ANTIAGE Register Data. *Orthop.* 2020;12:19-26. doi:[10.2147/ORR.S239355](https://doi.org/10.2147/ORR.S239355)
15. Doria C, Mosele GR, Caggiari G, Puddu L, Ciurlia E. Treatment of Early Hip Osteoarthritis: Ultrasound-Guided Platelet Rich Plasma versus Hyaluronic Acid Injections in a Randomized Clinical Trial. *Joints.* 2017;5(3):152-155. doi:[10.1055/s-0037-1605584](https://doi.org/10.1055/s-0037-1605584)
16. Papalia R, Salini V, Voglino N, et al. Single-Dose Intra-Articular Administration of a Hybrid Cooperative Complex of Sodium Hyaluronate and Sodium Chondroitin in the Treatment of Symptomatic Hip Osteoarthritis: A Single-Arm, Open-Label, Pilot Study. *Rheumatol.* 2021;8(1):151-165. doi:[10.1007/s40744020-00255-y](https://doi.org/10.1007/s40744020-00255-y)
17. Koyano G, Jinno T, Koga D, Hoshino C, Okawa A. Intra-articular Injections of Crosslinked Hyaluronic Acid in Japanese Patients with Symptomatic Osteoarthritis of the Hip. *Progress in Rehabilitation Medicine.* 2021;6:20210038. doi:[10.2490/prm.20210038](https://doi.org/10.2490/prm.20210038)

18. Abate M, Salini V. Efficacy and safety study on a new compound associating low and high molecular weight hyaluronic acid in the treatment of hip osteoarthritis. *International Journal of Immunopathology & Pharmacology*. 2017;30(1):89-93. doi:[10.1177/0394632016689275](https://doi.org/10.1177/0394632016689275)
19. Schiavi P, Calderazzi F, Pedrini MF, Tacci F, Vaienti E, Pogliacomi F. Efficacy and safety of viscosupplementation with hyaluronic acid for hip osteoarthritis: results from a cross-sectional study with a minimum follow-up of 4 years. *Acta Biomed Ateneo Parmense*. 2020;91(14-S):e2020032. doi:[10.23750/abm.v91i14-S.11110](https://doi.org/10.23750/abm.v91i14-S.11110)
20. Scaturro D, Vitagliani F, Terrana P, et al. Hybrid Hyaluronic Acid versus High Molecular Weight Hyaluronic Acid for the Treatment of Hip Osteoarthritis in Overweight/Obese Patients. *J*. 2022;7(1):09. doi:[10.3390/jfmk7010020](https://doi.org/10.3390/jfmk7010020)
21. Eymard F, Mailliet B, Lellouche H, et al. Predictors of response to viscosupplementation in patients with hip osteoarthritis: results of a prospective, observational, multicentre, open-label, pilot study. *BMC Musculoskelet Disord*. 2017;18(1):3. doi:[10.1186/s12891-016-1359-2](https://doi.org/10.1186/s12891-016-1359-2)
22. Pogliacomi F, Schiavi P, Paraskevopoulos A, et al. When is indicated viscosupplementation in hip osteoarthritis? *Acta Biomed Ateneo Parmense*. 2018;90(1-S):67-74. doi:[10.23750/abm.v90i1-S.8000](https://doi.org/10.23750/abm.v90i1-S.8000)
23. Migliore A, Anichini S. Intra-articular therapy in hip osteoarthritis. *Clin*. 2017;14(2):179-181. doi:[10.11138/ccmbm/2017.14.1.179](https://doi.org/10.11138/ccmbm/2017.14.1.179)
24. Di Sante L, Villani C, Santilli V, et al. Intra-articular hyaluronic acid vs platelet-rich plasma in the treatment of hip osteoarthritis. *Med*. 2016;18(4):463-468. doi:[10.11152/mu-874](https://doi.org/10.11152/mu-874)
25. Brander V, Skrepnik N, Petrella RJ, Jiang GL, Accomando B, Vardanyan A. Evaluating the use of intra-articular injections as a treatment for painful hip osteoarthritis: a randomized, double-blind, multicenter, parallel-group study comparing a single 6mL injection of hylan G-F 20 with saline. *Osteoarthritis Cartilage*. 2019;27(1):5970. doi:[10.1016/j.joca.2018.08.018](https://doi.org/10.1016/j.joca.2018.08.018)
26. Rivera F. Single intra-articular injection of high molecular weight hyaluronic acid for hip osteoarthritis. *J*. 2016;17(1):21-26. doi:[10.1007/s10195015-0381-8](https://doi.org/10.1007/s10195015-0381-8)
27. Micu MC, Micu A, Bolboaca SD. Ultrasound-guided injection with hyaluronic acid in hip osteoarthritis: efficacy and safety in a real-life setting. *Clin Rheumatol*. 2022;41(8):2491-2498. doi:[10.1007/s10067-022-06154-7](https://doi.org/10.1007/s10067-022-06154-7)
28. Ometti M, Schipani D, Conte P, Pironti P, Salini V. The efficacy of intra-articular HYADD4-G injection in the treatment of femoroacetabular impingement: results at one year follow up. *J Drug Assess*. 2020;9(1):159-166. doi:[10.1080/21556660.2020.1843860](https://doi.org/10.1080/21556660.2020.1843860)
29. Abate M, Scuccimarra T, Vanni D, Pantalone A, Salini V. Femoroacetabular impingement: is hyaluronic acid effective? *Knee Surg Sports Traumatol Arthrosc*. 2014;22(4):889-892. doi:[10.1007/s00167-013-2581-1](https://doi.org/10.1007/s00167-013-2581-1)
30. Kraeutler MJ, Houck DA, Garabekyan T, Miller SL, Dragoo JL, Mei-Dan O. Comparing Intra-articular Injections of Leukocyte-Poor Platelet-Rich Plasma Versus LowMolecular Weight Hyaluronic Acid for the Treatment of Symptomatic Osteoarthritis of the Hip: A Double-Blind, Randomized Pilot Study. *Orthop*. 2021;9(1):2325967120969210. doi:[10.1177/2325967120969210](https://doi.org/10.1177/2325967120969210)
31. Nouri F, Babaee M, Peydayesh P, Esmaily H, Raeissadat SA. Comparison between the effects of ultrasound guided intra-articular injections of platelet-rich plasma (PRP), high molecular weight hyaluronic acid, and their combination in hip osteoarthritis: a randomized clinical trial. *BMC Musculoskelet Disord*. 2022;23(1):856. doi:[10.1186/s12891-022-05787-8](https://doi.org/10.1186/s12891-022-05787-8)
32. Dallari D, Stagni C, Rani N, et al. Ultrasound-Guided Injection of Platelet-Rich Plasma and Hyaluronic Acid, Separately and in Combination, for Hip Osteoarthritis: A Randomized Controlled Study. *Am J Sports Med*. 2016;44(3):664-671. doi:[10.1177/0363546515620383](https://doi.org/10.1177/0363546515620383)
33. Mazzotta A, Pennello E, Stagni C, et al. Umbilical Cord PRP vs. Autologous PRP for the Treatment of Hip Osteoarthritis. *J*. 2022;11(15):02. doi:[10.3390/jcm11154505](https://doi.org/10.3390/jcm11154505)
34. Singh JR, Haffey P, Valimahomed A, Gellhorn AC. The Effectiveness of Autologous Platelet-Rich Plasma for Osteoarthritis of the Hip: A Retrospective Analysis. *Pain Medicine*. 2019;20(8):1611-1618. doi:[10.1093/pm/pnz041](https://doi.org/10.1093/pm/pnz041)
35. Ortiz-Declet V, Iacobelli DA, Battaglia MR, et al. The effect of platelet-rich plasma in patients with early hip osteoarthritis: A pilot study. *J Hip Preserv Surg*. 2020;7(3):496-502. doi:[10.1093/jhps/hnaa044](https://doi.org/10.1093/jhps/hnaa044)
36. Fiz N, Delgado D, Garate A, et al. Intraosseous infiltrations of Platelet-Rich Plasma for severe hip osteoarthritis: A pilot study. *J*. 2020;11(Suppl 4):S585-S590. doi:[10.1016/j.jcot.2019.12.012](https://doi.org/10.1016/j.jcot.2019.12.012)

37. Palco M, Rizzo P, Basile GC, et al. Short- and Midterm Comparison of Platelet-Rich Plasma with Hyaluronic Acid versus Leucocyte and Platelet-Rich Plasma on Pain and Function to Treat Hip Osteoarthritis. A Retrospective Study. *Gels*. 2021;7(4):19. doi:[10.3390/gels7040222](https://doi.org/10.3390/gels7040222)
38. Topaloglu M, Sen EI, Sarikaya D, Diracoglu D. Effect of platelet-rich plasma injections versus placebo on pain and quality of life in patients with hip osteoarthritis: A double-blind, randomized clinical trial. *Turk J Phys Med Rehabil*. 2024;70(2):212-220. doi:[10.5606/tftrd.2024.13855](https://doi.org/10.5606/tftrd.2024.13855)
39. Natali S, Screpis D, Romeo M, et al. Is intra-articular injection of autologous microfragmented adipose tissue effective in hip osteoarthritis? A three year follow-up. *Int Orthop*. 2023;47(6):1487-1492. doi:[10.1007/s00264-02205611-x](https://doi.org/10.1007/s00264-02205611-x)
40. Heidari N, Slevin M, Zeinolabediny Y, et al. Comparison of the Effect of MFAT and MFAT + PRP on Treatment of Hip Osteoarthritis: An Observational, Intention-to-Treat Study at One Year. *J*. 2022;11(4):17. doi:[10.3390/jcm11041056](https://doi.org/10.3390/jcm11041056)
41. Dall'Oca C, Breda S, Elena N, Valentini R, Samaila EM, Magnan B. Mesenchymal Stem Cells injection in hip osteoarthritis: preliminary results. *Acta Biomed Ateneo Parmense*. 2019;90(1-S):75-80. doi:[10.23750/abm.v90i1-S.8084](https://doi.org/10.23750/abm.v90i1-S.8084)
42. Onoi Y, Matsumoto T, Sobajima S, et al. Clinical use of autologous adipose-derived stromal vascular fraction cell injections for hip osteoarthritis. *Regen Ther*. 2023;24:94-102. doi:[10.1016/j.reth.2023.06.006](https://doi.org/10.1016/j.reth.2023.06.006)
43. Mardones R, Jofre CM, Tobar L, Minguell JJ. Mesenchymal stem cell therapy in the treatment of hip osteoarthritis. *J Hip Preserv Surg*. 2017;4(2):159-163. doi:[10.1093/jhps/hnx011](https://doi.org/10.1093/jhps/hnx011)
44. Tsitsilianos N, Shirazi Z, Lu J, Singh JR. Bone marrow aspirate injection for osteoarthritis of the hip; A pilot study. *Interv Pain Med*. 2022;1(4):100163. doi:[10.1016/j.inpm.2022.100163](https://doi.org/10.1016/j.inpm.2022.100163)
45. Darrow M, Shaw B, Darrow B, Wisz S. Short-Term Outcomes of Treatment of Hip Osteoarthritis With 4 Bone Marrow Concentrate Injections: A Case Series. *Case Reports Clin Med Insights Case Rep*. 2018;11:1179547618791574. doi:[10.1177/1179547618791574](https://doi.org/10.1177/1179547618791574)
46. Whitney KE, Briggs KK, Chamness C, et al. Bone Marrow Concentrate Injection Treatment Improves Short-term Outcomes in Symptomatic Hip Osteoarthritis Patients: A Pilot Study. *Orthop*. 2020;8(12):2325967120966162. doi:[10.1177/2325967120966162](https://doi.org/10.1177/2325967120966162)
47. Zaffagnini M, Boffa A, Andriolo L, Raggi F, Zaffagnini S, Filardo G. Orthobiologic Injections for the Treatment of Hip Osteoarthritis: A Systematic Review. *J*. 2022;11(22):10. doi:[10.3390/jcm11226663](https://doi.org/10.3390/jcm11226663)
48. Acuna AJ, Samuel LT, Jeong SH, Emara AK, Kamath AF. Viscosupplementation for hip osteoarthritis: Does systematic review of patient-reported outcome measures support use? *J Sep-Oct*. 2020;21:137-149. doi:[10.1016/j.jor.2020.03.016](https://doi.org/10.1016/j.jor.2020.03.016)
49. Xiong Y, Gong C, Peng X, et al. Efficacy and safety of platelet-rich plasma injections for the treatment of osteoarthritis: a systematic review and meta-analysis of randomized controlled trials. *Frontiers in Medicine*. 2023;10:1204144. doi:[10.3389/fmed.2023.1204144](https://doi.org/10.3389/fmed.2023.1204144)