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Efficacy of ultrasound-guided glenohumeral joint injections of leukocyte-poor platelet-rich plasma versus hyaluronic acid in the treatment of glenohumeral osteoarthritis: a randomized, double-blind controlled trial

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Abstract

Objective: To compare the efficacy of ultrasound-guided hyaluronic acid (HA) vs. leukocyte-poor platelet-rich plasma (LP-PRP) injection in the treatment of glenohumeral osteoarthritis.

Design: Double-blind randomized controlled trial.

Setting: Academic institution

Patients: Seventy patients with chronic glenohumeral osteoarthritis were randomly assigned to receive a single injection of HA (n=36) or LP-PRP (n=34).

Interventions: LP-PRP was processed using Harvest/TerumoBCT Clear PRP kits. Ultrasound-guided injections of 6-mL HA or 6-mL LP-PRP into the glenohumeral joint were performed. Patients, the injecting physician, and outcomes assessor were blinded to treatment assignments.

Main Outcome Measures: Shoulder Pain and Disability Index (SPADI), American Shoulder and Elbow Surgeons (ASES) score, current/average numerical rating scale (NRS) pain scores, satisfaction, and side effects were assessed at 5 follow-up time points over 12 months.

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Results: Baseline characteristics were similar between groups. There were no significant between-group differences with regard to SPADI, ASES, and current/average NRS pain scores at any time point up to 12 months post-injection ($p>0.05$). However, significant improvements in SPADI, ASES, and current/average NRS pain scores were observed in both groups starting at 1 or 2 months ($p<0.01$, $p<0.01$, $p<0.001$, and $p<0.01$, respectively). These improvements were observed regardless of osteoarthritis severity. For patients who received LP-PRP, there was no effect of platelet yield on outcomes. Side effect and satisfaction rates were similar between groups.

Conclusions: There were no differences in pain and functional outcomes following a single injection of LP-PRP versus HA. However, significant improvements in pain and function were observed following both treatments in patients with glenohumeral osteoarthritis.

Keywords

glenohumeral osteoarthritis; pain; shoulder; hyaluronic acid; platelet-rich plasma

Introduction

Glenohumeral osteoarthritis (OA) is the third most common type of OA and causes chronic and persistent shoulder pain.[1] Primary glenohumeral OA usually affects elderly patients and is typically characterized by degenerative changes to the glenohumeral joint. Secondary glenohumeral OA is characterized by history of trauma to the shoulder or avascular necrosis.[1] There is an increased risk of shoulder pain secondary to glenohumeral OA in the elderly and in athletes or patients who engage in overhead exercises.[2-5]

Conservative treatments for glenohumeral OA include activity modification, physical therapy, non-steroidal anti-inflammatory drugs (NSAIDs), and injectable corticosteroids.[1] If these treatments fail, shoulder arthroplasty is advised and is a successful treatment option amongst elderly patients.[1] However, shoulder arthroplasty is less successful for patients younger than 50 years old.[6] Recently, hyaluronic acid (HA) and platelet-rich plasma (PRP) have been suggested as potential treatments for glenohumeral OA.[6]

HA is a glycosaminoglycan that is found in synovial joint fluid and has viscoelastic, chondroprotective, and possible anti-inflammatory properties.[7] When injected intra-articularly, it promotes endogenous HA growth and production, which increases joint lubrication and decreases mechanical stress on the affected joint.[8,9] Multiple studies have demonstrated improvements in pain and range of motion for 3-6 months following ≥3 HA injections to the subacromial space or glenohumeral joint.[10-18] Improvements in pain and function have also been demonstrated after one or two HA injections to the glenohumeral joint.[14,19-22] Although different molecular weight formulations for HA exist, there does not appear to be evidence of greater efficacy or advantage of one preparation over others in clinical studies.[8,9] Furthermore, there is inconsistency in the HA and glenohumeral OA literature in terms of recruitment, sample size, injection technique, image guidance, HA type, and presence of a control group. A few studies have compared the efficacy of HA versus placebo injections to the glenohumeral joint.[10,23-25] Blaine et al. showed significant improvements in shoulder pain at 13 weeks following a 3-injection series of HA, 5-injection series of HA, or placebo; larger improvements were observed with HA compared to placebo,

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although these were not statistically significant.[10] When looking at overall treatment effect over 26 weeks, both HA groups demonstrated significant improvements in shoulder pain compared to placebo.[10] Similarly, Kwon et al. found significant improvements in pain following 3 weekly injections of HA versus placebo, starting at 1 week and maintained up to 26 weeks. Mean improvements were greater following HA compared to placebo, but this was statistically significant only for patients with glenohumeral OA in the absence of concomitant pathologies.[11]

Alternatively, PRP involves the use of a patient's own platelets to take advantage of autologous growth factors and is increasingly being used to treat different musculoskeletal conditions.[26] Existing research has suggested benefit in pain related to knee and hip OA,[27-30] but limited-to-no data are available for its effect on glenohumeral OA. One case report reported improvement in pain and function following 3 intra-articular PRP injections in a 62-year-old woman with glenohumeral OA.[31] Another study comparing a single intra-articular steroid injection versus a PRP injection for glenohumeral OA demonstrated benefits of both, with a superior benefit coming from PRP.[32]

To our knowledge, no study in the literature has compared the efficacy of these two emerging treatments with ultrasound guidance in the treatment of glenohumeral OA. This study aimed to determine whether HA or PRP can decrease pain, restore function, and improve disability in patients suffering from chronic glenohumeral OA that is refractory to other conservative management. We hypothesized that PRP injections would be more efficacious than HA injections in patients with chronic glenohumeral OA.

Methods

Ethics

This double-blind, randomized controlled trial was approved by the Institutional Review Board. Written informed consent was obtained from all subjects prior to any research activities. This study was registered at ClinicalTrials.gov and was conducted in accordance with CONSORT guidelines.

Patient Recruitment

Patients were recruited for the study from December 2014-November 2018 by posting the study online, distributing flyers in the hospital, and receiving referrals from primary care sports medicine, orthopedic surgery, and physiatry departments. Potential patients were screened according to eligibility criteria (Table 1).

Treatment Allocation and Administration

Using a computer-generated, block-randomization scheme, patients were randomly assigned to receive a single injection of HA or leukocyte-poor PRP (LP-PRP) into the glenohumeral joint. Randomization assignments were concealed in opaque envelopes. Patients were asked to discontinue NSAIDs for 5 days pre-injection. Both groups underwent venipuncture for blinding purposes, with a blood draw of 61 mL under sterile conditions for the LP-PRP group only. A curtain enclosure was used to prevent patients from viewing the venipuncture

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and blood draw. All patients were bandaged afterwards. Patients, the treating physician, and outcomes assessors were blinded to treatment groups. Injection syringes were covered with opaque shields to preserve blinding for the patient and treating physician.

The HA group received one 6-mL injection of low-molecular-weight (average 500,000–730,000 dalton) HA (Hyalgan, Fidia Pharma, Florham Park, NJ). Needle guidance and injection were performed by a fellowship-trained, board-certified physiatrist and sports medicine physician, who is also a registered musculoskeletal sonographer, using a 3-inch, 22-gauge spinal needle under continuous ultrasound guidance (Xporte, 15-6mHz linear array transducer, Fujifilm Sonosite Inc, Bothell, WA). A posterior medial-to-lateral in-plane approach was used. Subcutaneous local anesthetic (1% lidocaine; 3mL) was used, but was not injected into the joint to minimize confounding. Once needle placement within the joint was confirmed, the blinded contents of the syringe were injected. Arthrocentesis was attempted if effusion was present prior to injection, but no significant fluid could be returned. This may be due to the 22-gauge needle or seated position the patient was in for the procedure.

The LP-PRP group underwent the same procedure as the HA group with respect to ultrasound guidance and anatomic approach and received one 6-mL injection of LP-PRP. Prior to injection, the Harvest–TerumoBCT (Plymouth, MA) SmartPReP Clear PRP system was used to prepare the samples in accordance with the manufacturer's instructions. Venipuncture, blood collection, and LP-PRP processing were performed in a sterile manner by a trained study team member not involved in the direct care and management of study subjects. A total of 61mL whole blood was drawn, and 1mL was stored at room temperature. The amount of time between blood draw and LP-PRP injection was less than 40min. After processing, LP-PRP samples were stored at room temperature. Whole-blood and LP-PRP samples were sent to the laboratory for complete blood differential analyses, and platelet yields were calculated.

Post-procedure, patients in both groups were instructed to take acetaminophen 500mg every 6 hours (maximum: 3g) for pain relief or were offered a week of Tramadol 50mg as needed. Ice applied over the affected joint was not allowed for 3 days, and NSAIDs were avoided for at least 6 weeks post-injection. Patients were also instructed to avoid taking baths and swimming for 2 days to minimize the risk of infection. Showers were allowed, and patients were encouraged to continue their usual daily activities, including exercises, as tolerated.

Outcomes and Data Collection

Demographics were collected at baseline (pre-injection). The Shoulder Pain and Disability Index (SPADI), American Shoulder and Elbow Surgeons Society-Standardized Shoulder Assessment Form (ASES), current/average NRS pain, sleep quality, and general well-being were assessed at baseline and at 1, 2, 3, 6, and 12 months post-injection. Side effects and satisfaction were also assessed at the follow-up timepoints. Current/average NRS pain were scored on 0-10 scales (0-no pain at all; 10-worst possible pain imaginable). Sleep quality was assessed on a 0-10 scale, with 0 representing "I could not sleep at all" and 10 representing "I slept perfectly well". General well-being was assessed on a 0-10 scale, with

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0 representing “I am doing the worst ever” and 10 representing “I am doing very well”. For satisfaction, patients were asked if they would do the study treatment again (yes/no).

OA Severity Grading

OA severity was determined from radiographs, magnetic resonance imaging (MRI), or computed tomography (CT) scans by a fellowship-trained musculoskeletal radiologist with 9 years of experience. The Weinstein classification was used for radiographs, along with measuring the size of the humeral osteophytes (Samilson and Prieto classifications).[33] Four stages were documented: I-normal and no joint spacing narrowing; II-minimal joint space narrowing with concentric head and glenoid; III-moderate joint space narrowing and/or early inferior osteophyte formation; and IV-severe joint space loss with osteophyte formation and loss of concentricity between glenoid and humeral head.[33] Seven shoulders were upgraded from II to III if they had osteophytes >4mm.

The Walch classification was additionally used to guide the grading of glenohumeral OA for patients with CT and/or MRI.[34] Mild-to-moderate OA included A1 and B1, where there is minor to no bony erosion, and severe OA included A2, B2, and B3 classifications. There were no dysplastic grade C glenoid configurations.

OA severity was graded as mild, moderate, or severe, based on the aforementioned classifications.

Statistical Analysis

The primary outcome was SPADI. Previous studies have utilized 10 points as the minimal clinically important difference (MCID) for SPADI.[35] A power analysis performed *a priori* showed that sample sizes of 25 patients in each group are sufficient to achieve 86% power to detect a 10-point difference in SPADI score between groups, with an estimated SD of 15 points and an alpha of 0.05.

Continuous variables are reported as means and SDs in the descriptive analysis. Discrete variables are reported as frequencies and percentages. Longitudinal analysis of SPADI scores from baseline to 12 months was conducted using a linear mixed model with repeated measures. Longitudinal analyses of secondary outcomes from baseline to 12 months were performed using generalized estimating equations (GEE). All observations were analyzed using maximum likelihood estimations. The models included time as the fixed effect and observed differences between HA and LP-PRP treatment with a random intercept for each participant for random variability between participants. A linear mixed model and GEE were used to estimate crude effects of baseline platelet yield over time. These models included time*platelet-yield as the fixed effect and a random intercept for random variability between participants. Additionally, a sensitivity analysis utilizing linear mixed models and GEE models evaluated associations between OA severity (mild/moderate vs. severe) and outcomes, adjusting for age, sex, BMI, and treatment (as-treated).

Parameter estimates are reported as means, SEs, and 95% CIs. Multiple pairwise comparisons were adjusted for using Bonferroni correction. Statistical significance was defined as $p<0.05$. All analyses were performed with Stata, version 14.2.

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Results

Patient Flow and Baseline Information

Of the 108 patients who were assessed for eligibility from December 2014–October 2019, 70 patients were consented and randomly allocated to receive HA (n=36) or LP-PRP (n=34) (Figure 1). One patient in the HA group screened out and did not receive any interventions. Two patients in the HA group received LP-PRP, and two patients in the LP-PRP group received HA.

Both intention-to-treat and as-treated analyses demonstrated similar baseline characteristics between HA and LP-PRP groups (Table 2). Most patients in both groups had severe OA. Platelet counts increased by 3.44±1.60-fold in LP-PRP samples, compared to whole-blood samples. White blood cell counts decreased from 5.45±1.58 ($\times 10^9$/L) in whole-blood samples to 0.21±0.79 ($\times 10^9$/L) in LP-PRP samples. Red blood cell counts decreased from 4.16±0.57 ($\times 10^{12}$/L) in whole-blood samples to 0.03±0.02 ($\times 10^{12}$/L) in LP-PRP samples.

Patient-Reported Outcomes

There were no between-group differences in SPADI scores (Figure 2A). However, SPADI scores significantly improved in both HA and LP-PRP groups, up to 12 months post-injection. These improvements were clinically significant starting at 2 months post-injection. The mean decreases at 12 months post-injection were 15.8 and 14.3 points in HA and LP-PRP groups, respectively. Similarly, there were no between-group differences in ASES, current NRS, and average NRS pain scores, although they significantly improved up to 12 months post-injection (Figures 2B-3). General well-being and sleep quality were unchanged over time and were similar between groups (Figure 4).

Side Effects and Satisfaction

Side effects rates were 3.9% and 2.7% in the HA and LP-PRP groups, respectively; weakness was the most common. At 12 months, 60% of patients in the HA group and 80% of patients in the LP-PRP group stated that they would repeat the treatment. Satisfaction rates ranged from 57–73% for both groups over the follow-up period.

OA Severity and Patient-Reported Outcomes

SPADI scores in the severe OA group were significantly higher at baseline (70.6[95% CI: 62.3–78.8] vs. 56.9[46.1–67.7]; p=0.030) and 12 months post-injection (51.4[95% CI: 37.9–64.9] vs. 30.8[16.0–45.7]; p=0.022), compared to those in the mild/moderate OA group; no other differences between mild/moderate and severe OA groups were observed (Figure 5A). ASES scores in the severe OA group were significantly lower at 6 months (45.8[95% CI: 36.1–55.5] vs. 64.7[51.4–78.0]; p=0.007) and 12 months only (55.5[95% CI: 42.7–66.4] vs. 71.5[58.7–84.2]; p=0.034), compared to the mild/moderate OA group (Figure 5B). Current/average NRS pain scores were similar between mild/moderate and severe OA groups (Figure 6).

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Platelet Yield and Patient-Reported Outcomes

Additional analyses evaluated the effect of platelet yield on patient-reported outcomes in patients who received a single injection of LP-PRP. Overall, there were no effects of platelet yield on SPADI, ASES, current NRS pain, and average NRS pain scores at any of the follow-up time points in the crude model (Table 3).

Need for Surgery

Sixteen patients (22.9%) underwent total shoulder replacements following their study injections. Ten had surgery during the study period, and 6 had surgery after their 12-month follow-ups. Only baseline SPADI score was significantly different between patients who did and did not need surgery (73.7±14.0 and 62.1±16.0, respectively; p=0.011) (Table 4).

Discussion

Results from this randomized controlled trial demonstrated no significant differences in outcomes between patients who received a single injection of HA versus a single injection of LP-PRP. Improvements in SPADI, NRS pain, and ASES scores were observed over time in both groups, regardless of OA severity. In patients receiving LP-PRP, platelet yield had no effect on patient-reported outcomes throughout the follow-up period. Sixteen patients underwent surgery; these patients had higher SPADI scores at baseline, demonstrating more disability. Injection-related side effects were uncommon.

Although the effects of conservative treatments for glenohumeral OA have been well characterized,[1] evidence for some treatments remains inconclusive, leading one to consider emerging treatments. HA has shown efficacy in knee OA,[36] and the use of HA for glenohumeral OA has shown promising results, although there are variabilities in factors such as image guidance.[14] A recent meta-analysis of 7 prospective and retrospective studies demonstrated improvements in pain and functional outcomes following intra-articular HA injections for the treatment of glenohumeral OA. The same meta-analysis also reported pain improvements in the control group, with the authors concluding that further studies are needed to evaluate the efficacy of HA.[14] Two studies have shown larger reductions in pain following HA injections versus placebo injections, although these were not statistically significant at the primary-outcome endpoints.[10,11] In the current study, we observed significant improvements in SPADI, ASES, and NRS pain scores over a 12-month period following a single injection of HA into the glenohumeral joint. All improvements were clinically important and supported previous studies showing that HA injections result in improvements in patients with glenohumeral OA.[10-12,14,17-22,25]

Another emerging treatment is PRP, which has shown efficacy in various musculoskeletal conditions, including rotator cuff pathology and “periarthritis shoulder”.[37,38] Only one study has investigated the efficacy of PRP in the treatment of glenohumeral OA. In a randomized controlled trial, Saif et al. demonstrated improvements in quality-of-life and pain scores following intra-articular injections with PRP or steroids, with greater improvements observed with PRP.[32] Similarly, results from our study showed statistically and clinically significant improvements in SPADI, ASES, and NRS pain scores following

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a single injection of LP-PRP. We chose to use LP-PRP instead of leukocyte-rich PRP, as LP-PRP has been shown to promote chondrogenesis and lead to better cartilage repair, compared to leukocyte-rich PRP.[39] Furthermore, leukocyte-rich PRP has been suggested to cause increased inflammation in the acute period following treatment.[40,41] Interestingly, platelet yield did not appear to have an effect on the outcomes over time. This may be due to variations in PRP preparation or the patient's physiological status, both of which may affect the efficacy of PRP.[42] It has also been shown that PRP, when prepared in the same manner, may elicit different effects in the same individual.[43]

Contrary to our study hypothesis that LP-PRP would be more effective than HA, there were no differences in outcomes between LP-PRP and HA groups at the follow-up timepoints. Improvements in outcomes following either single injections of LP-PRP or HA were sustained up to 12 months post-injection. Side effect rates for both treatments were low, and satisfaction rates were similar. This suggests that both treatments are associated with increasing function and decreasing shoulder pain and disability. No other study has compared these two treatments for glenohumeral OA. Further studies investigating longer-term outcomes with a larger sample size are warranted to confirm these findings.

This study has several limitations. Not all patients completed the follow-up questionnaires. Ten patients underwent surgery during their follow-up period; as per the study design, follow-ups were discontinued for these patients, but they were still included in the statistical analyses. This was likely because most patients had severe OA. Further studies are needed to compare outcomes in the mild/moderate OA population, although results from the current study showed improvements in both mild/moderate and severe OA cohorts. This could be because radiological abnormalities do not always correlate with clinical findings.[44] Furthermore, platelet counts could not be determined in a few whole-blood and LP-PRP samples, due to clotting, which can be caused by inadequate inverting of the tube after collection. However, there was no association between platelet yield and outcomes in this cohort. Additionally, there was no control group in the study. Placebo effects should be considered as well.

In conclusion, both LP-PRP and HA were associated with improvements in pain, disability, and functional impairments related to glenohumeral OA in this cohort of patients, and there were no differences between treatments. Similar findings were observed regardless of OA severity. In patients receiving LP-PRP, there was no association between platelet yield and outcomes. In both groups, side effects were uncommon, and satisfaction rates were high. Altogether, these findings suggest that both LP-PRP and HA can be considered as viable treatments in patients with glenohumeral OA of varying degrees of severity. Future studies should investigate different types of PRP, compare different injection volumes, or include a placebo group to further elucidate the efficacy of HA and PRP in the treatment of glenohumeral OA.

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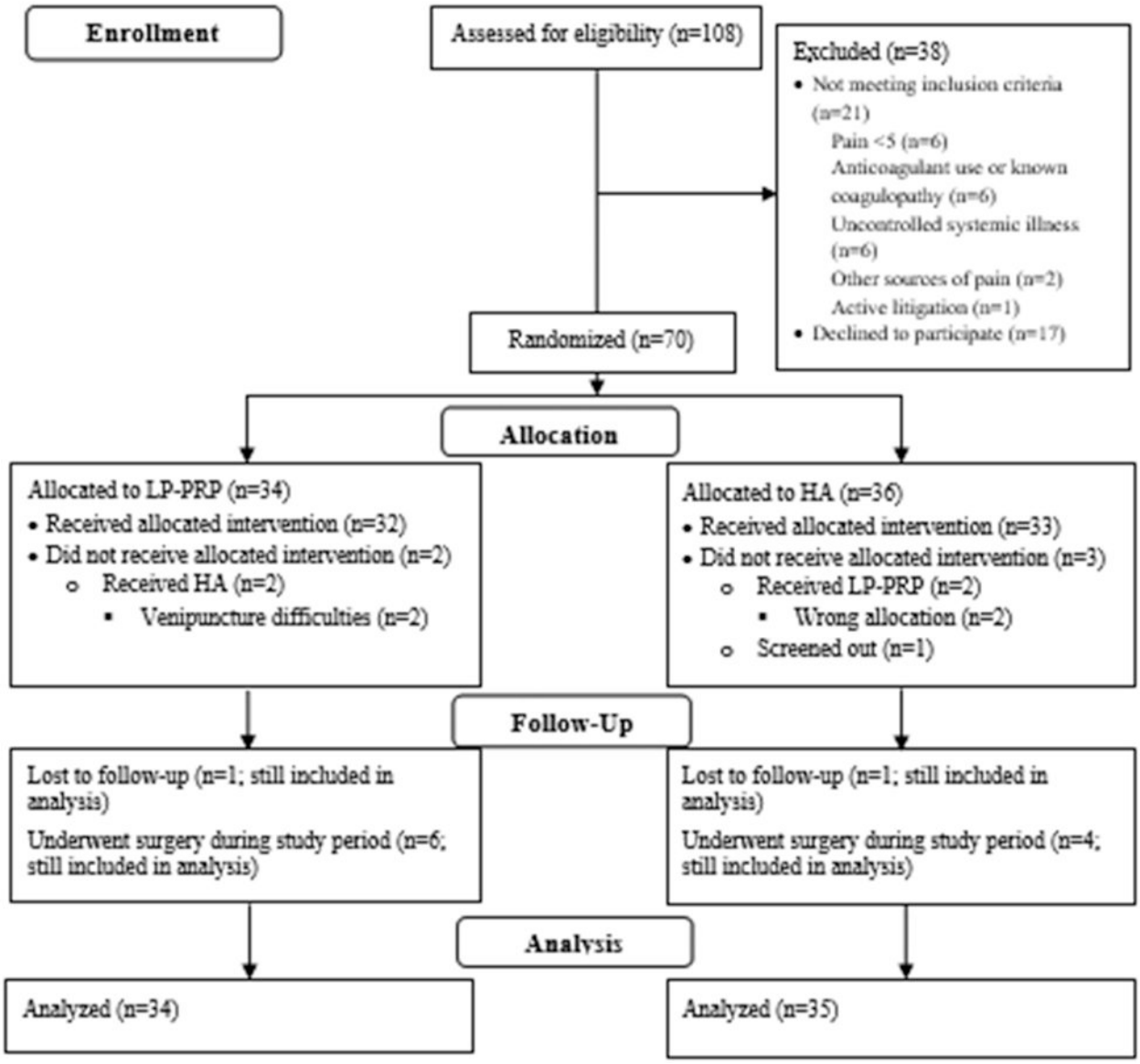

Figure 1. CONSORT Flow Diagram.

The numbers of participants who were assessed for eligibility, randomized, followed up, and analyzed are shown. HA – hyaluronic acid; LP-PRP – leukocyte-poor platelet-rich plasma.

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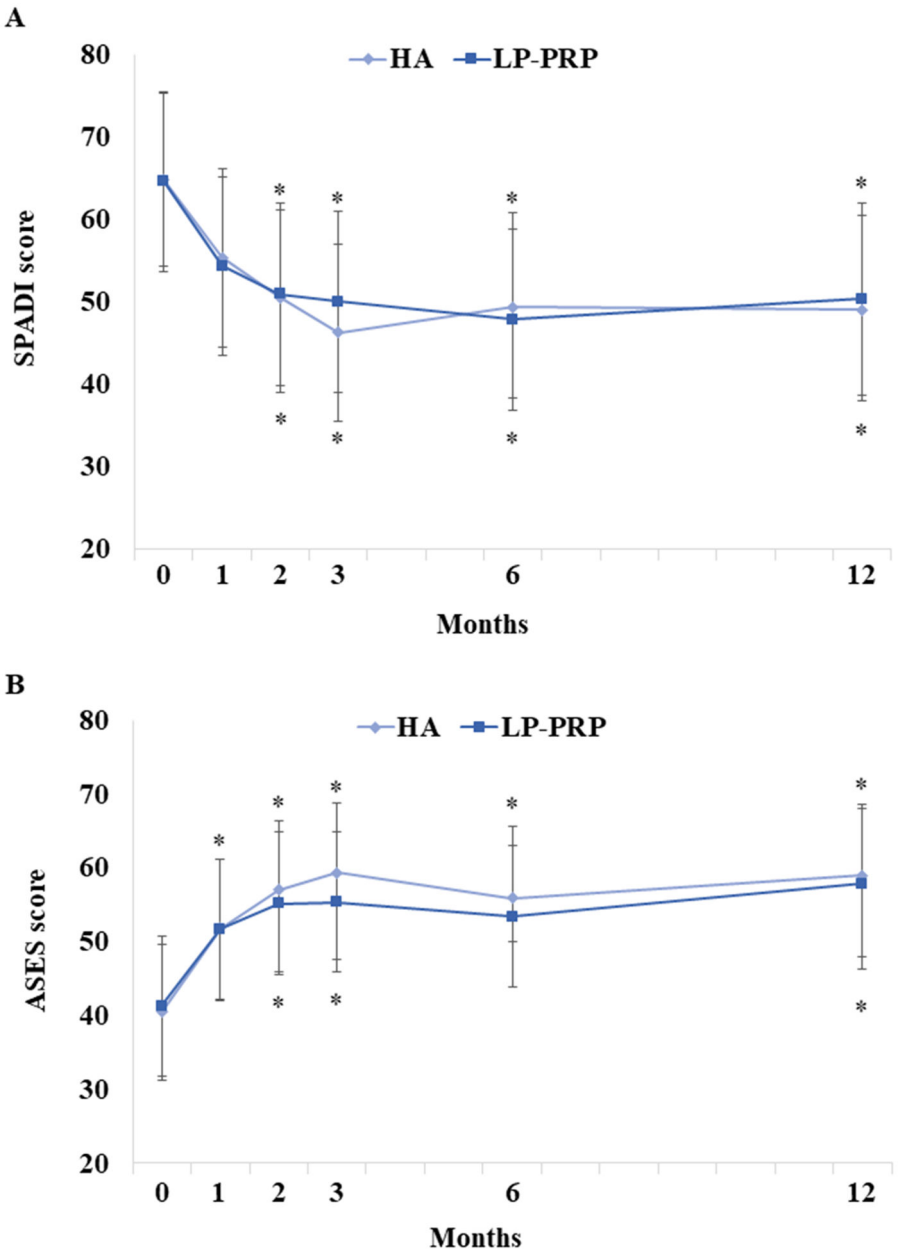

Figure 2. Patient-Reported Outcomes Following HA or LP-PRP Treatment.

Parameter estimates of (A) Shoulder Pain and Disability Index (SPADI) and (B) American Shoulder and Elbow Surgeons (ASES) scores at baseline and at 1, 2, 3, 6, and 12 months post-HA or LP-PRP are shown. Error bars are 95% confidence intervals. *P<0.05 vs. baseline.

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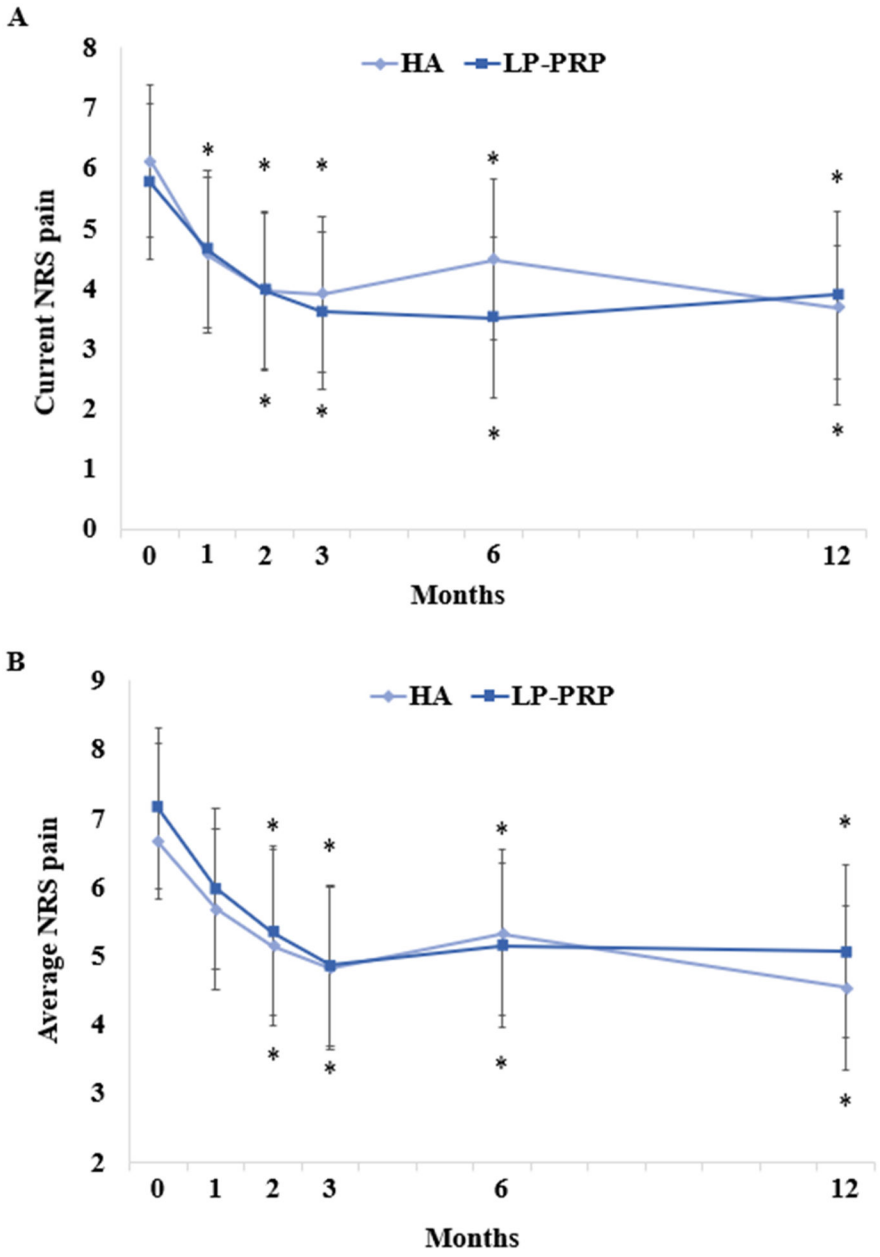

Figure 3. Pain Outcomes Following HA or LP-PRP Treatment.

Parameter estimates of (A) current numerical rating scale (NRS) pain and (B) average NRS pain scores at baseline and at 1, 2, 3, 6, and 12 months post-HA or post-LP-PRP are shown. Error bars are 95% confidence intervals. *P<0.05 vs. baseline.

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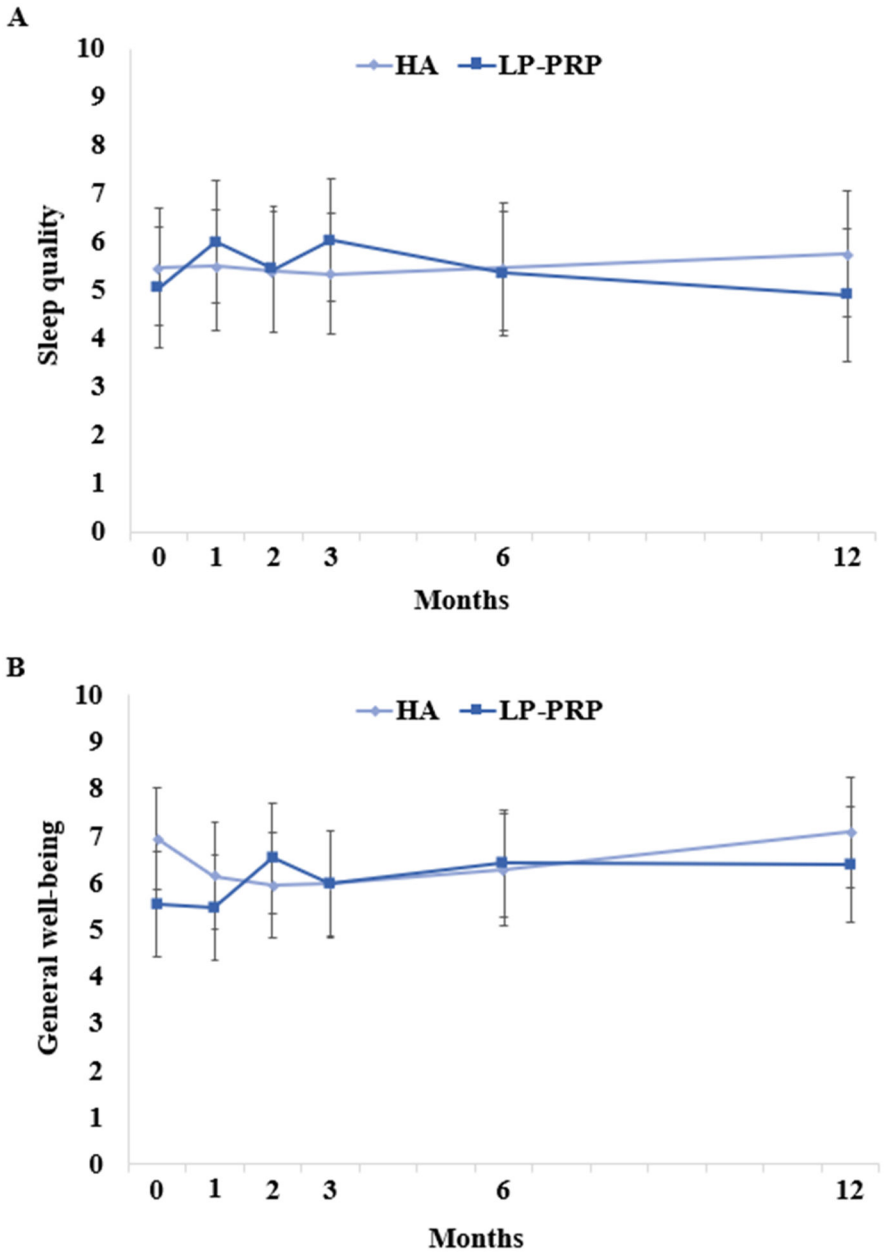

Figure 4. Sleep Quality and General Well-Being Following HA or LP-PRP Treatment.

Parameter estimates of (A) sleep quality and (B) general well-being at baseline and at 1, 2, 3, 6, and 12 months post-HA or post-LP-PRP are shown. Error bars are 95% confidence intervals. Both outcomes were measured on 0-10 scales; a higher score represented better sleep quality or better general well-being.

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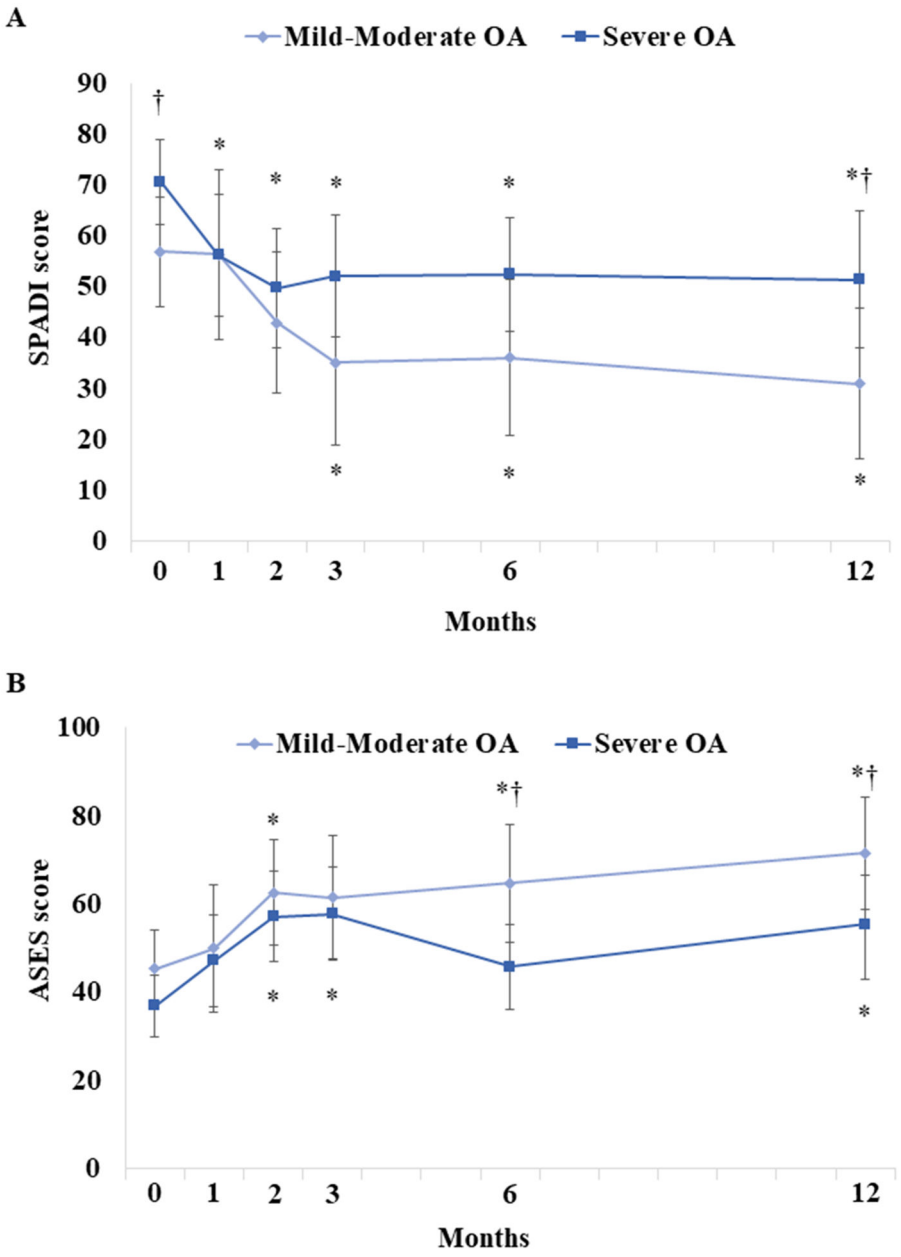

Figure 5. Patient-Reported Outcomes By OA Severity Following Treatment.

Parameter estimates of (A) SPADI and (B) ASES scores in patients with mild-moderate osteoarthritis (OA) vs. severe OA are shown. Error bars are 95% confidence intervals. *P<0.05 vs. baseline; †P<0.05 vs. mild-moderate OA.

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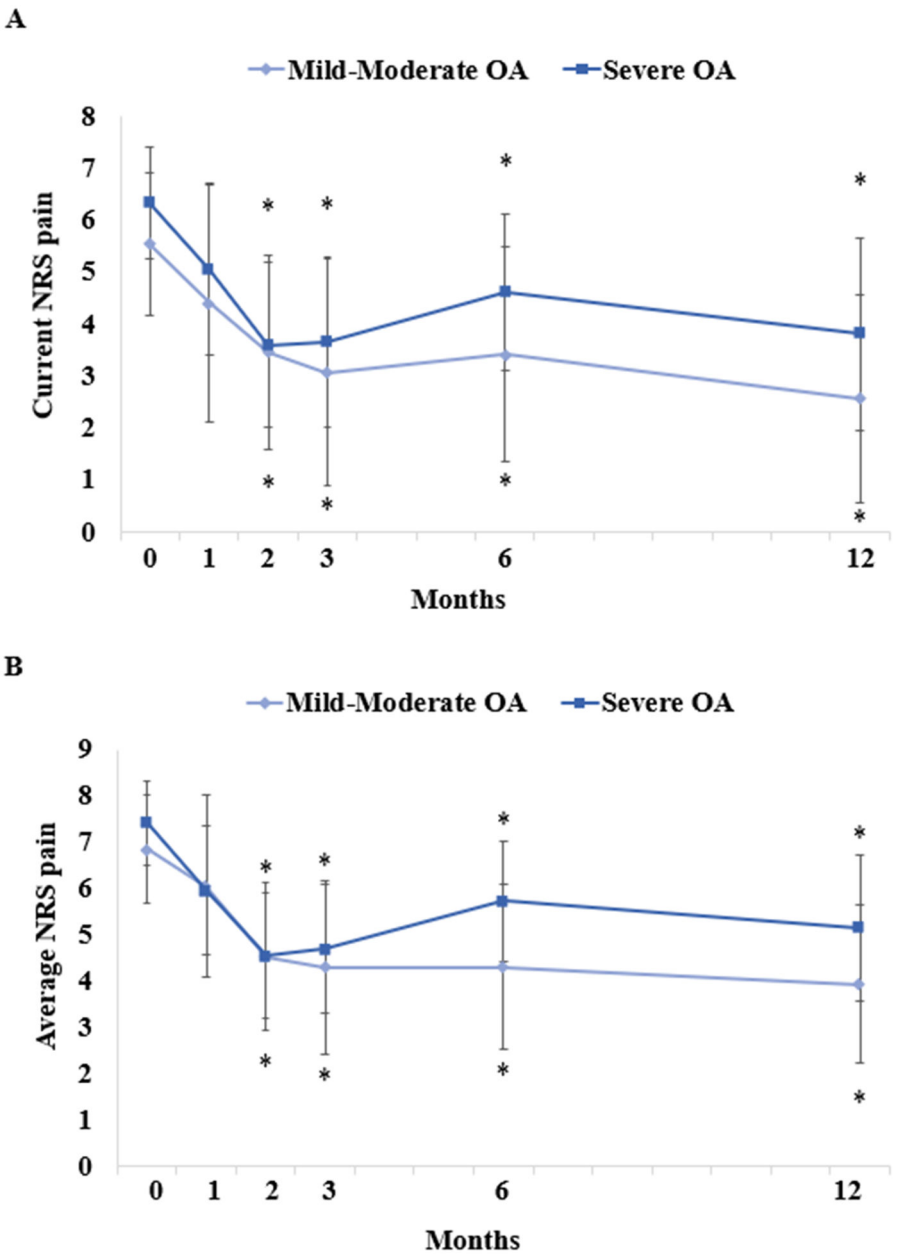

Figure 6. Pain Outcomes by OA Severity Following Treatment.

Parameter estimates of (A) current NRS pain and (B) average NRS pain in patients with mild-moderate OA vs. severe OA are shown. Error bars are 95% confidence intervals. *P<0.05 vs. baseline.

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Table 1.

Study Eligibility Criteria.

Inclusion Criteria	Exclusion Criteria
• ≥18 years old • Confirmation of glenohumeral OA on imaging • ≥5/10 VAS pain as a result of primary or secondary glenohumeral OA • ≥3 months of pain after onset of symptoms that has failed conservative treatments (e.g., medications, physical therapy) • Transient relief of symptoms (≥50% relief) after an ultrasound-guided diagnostic intra-articular injection containing local anesthetic into the glenohumeral joint	• Non-English-speaking or illiterate • Presence of painful, concurrent cervical spine conditions • Current NSAID use • Current or recent use of Coumadin or similar anticoagulants (e.g., dabigatran) • Known coagulopathy or bleeding dyscrasia • Platelet count <150,000/mm^3 • Allergic reaction to poultry or previous viscosupplementation • Involvement in worker's compensation or active litigation involving the affect shoulder • Inability to refrain from NSAID use for 5 days prior to and 6 weeks after the injection • Corticosteroid injection to the affecteds shoulder within the last 3 months • Viscosupplementation or PRP injection to the affected shoulder within the last 6 months • Presence of acute fracture • History of shoulder tumor • Known uncontrolled systemic illness (uncontrolled diabetes, HIV, vasculitis, autoimmune/inflammatory disease [e.g., gout], active infection) • Presence of functionally limiting psychiatric and somatoform disorders

HIV: human immunodeficiency virus; NSAID: non-steroidal anti-inflammatory drug; OA: osteoarthritis; PRP: platelet-rich plasma

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Table 2.

Baseline Characteristics.

Variables	HA (n=36)	LP-PRP (n=34)	P-value
Age, years; mean (SD)	68.4 (11.9)	69.1 (11.5)	0.83
Female sex; n (%)	18 (50)	20 (59)	0.46
BMI, kg/m^2; mean (SD)	27.9 (5.4)	26.8 (5.2)	0.37
Right-sided OA; n (%)	19 (53)	19 (56)	0.79
Duration of symptoms, months; mean (SD)	46 (15)	43 (7)	0.85
Use of pain medication; n (%)	27 (77)	20 (69)	0.10
Severe OA; n (%)	23 (64)	21 (62)	0.85

Abbreviations: BMI – body mass index; HA – hyaluronic acid; LP-PRP – leukocyte-poor platelet-rich plasma; OA – osteoarthritis; SD – standard deviation.

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Table 3.

Effect of Platelet Yield on Patient-Reported Outcomes.

Timepoint	Slope (SE)	95% CI	P-value
	SPADI		
Baseline	REF		
1 Month	−1.4 (2.1)	−5.6, 2.7	0.50
2 Months	0.0 (2.1)	−4.1, 4.2	0.99
3 Months	0.6 (2.1)	−3.5, 4.8	0.77
6 Months	−2.1 (2.1)	−6.3, 2.1	0.33
12 Months	3.7 (2.4)	−1.0, 8.4	0.12
	ASES score		
Baseline	REF		
1 Month	3.1 (2.2)	−1.2, 7.4	0.16
2 Months	0.0 (2.2)	−4.4, 4.2	0.96
3 Months	2.4 (2.2)	−1.9, 6.7	0.28
6 Months	2.7 (2.2)	−1.7, 7.0	0.23
12 Months	−2.2 (2.3)	−6.7, 2.4	0.35
	Current NRS Pain		
Baseline	REF		
1 Month	0.0 (0.3)	−0.6, 0.7	0.95
2 Months	0.5 (0.3)	−0.1, 1.2	0.11
3 Months	0.0 (0.3)	−0.6, 0.7	0.92
6 Months	0.2 (0.3)	−0.5, 0.8	0.61
12 Months	0.6 (0.3)	−0.1, 1.3	0.07
	Average NRS Pain		
Baseline	REF		
1 Month	−0.1 (0.3)	−0.7, 0.5	0.75
2 Months	0.2 (0.3)	−0.4, 0.8	0.57
3 Months	−0.2 (0.3)	−0.7, 0.4	0.59
6 Months	−0.1 (0.3)	−0.7, 0.5	0.65
12 Months	0.3 (0.3)	−0.3, 0.9	0.34

Abbreviations: ASES – American Shoulder and Elbow Surgeons; CI – confidence interval; NRS – numerical rating scale; REF – reference; SPADI – Shoulder Pain and Disability Index.

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Table 4.

Comparison of Baseline Characteristics Between Participants With and Without Need for Surgery

Variables	No Surgery (n=53)	Surgery (N=16)	P-value
Age, years; mean (SD)	68.8 (12.0)	68.2 (11.3)	0.86
Female sex; n (%)	25 (48)	11 (69)	0.15
BMI, kg/m^2; mean (SD)	27.2 (4.8)	28.6 (6.6)	0.38
Right-sided OA; n (%)	30 (58)	8 (50)	0.59
Duration of symptoms, months; mean (SD)	45 (75)	30 (14)	0.19
Use of pain medication; n (%)	33 (65)	12 (75)	0.10
Severe OA; n (%)	32 (62)	10 (63)	0.94
Platelet yield, fold increase; mean (SD)	3.4 (1.8)	3.5 (0.8)	0.91
SPADI score; mean (SD)	62.1 (16.0)	73.7 (14.1)	0.011

Abbreviations: BMI – body mass index; HA – hyaluronic acid; LP-PRP – leukocyte-poor platelet-rich plasma; OA – osteoarthritis; SD – standard deviation; SPADI – Shoulder Pain and Disability Index